# Final
# Feasibility Study Report
# for
# Landfill 6 Groundwater
# Building 775 Groundwater
# Building 817/Weapon Storage Area Groundwater

**April 2005**

**Prepared for:**

**U.S. ARMY ENGINEER DISTRICT, KANSAS CITY**
601 East 12th Street
Kansas City, MO  64106-2896

# Table of Contents

## Table of Contents (cont.)

**Section** **Page**

## Table of Contents (cont.)

**Section** **Page**



**Appendix**

# List of Tables

**Table** **Page**

## List of Tables (cont.)

# List of Figures

**Figure** **Page**

## List of Figures (cont.)

**Figure** **Page**

## List of Figures (cont.)

**Figure** **Page**

# List of Abbreviations and Acronyms

| | |
|---|---|
| 1,1-DCE | 1,1-dichloroethene |
| 1,2-DCE | 1,2-dichloroethene |
| 2,3,7,8-TCDD | 2,3,7,8-tetrachlorodibenzodioxin |
| AFB | Air Force Base |
| AOC | area of concern |
| ARAR | applicable or relevant and appropriate requirement |
| BGS | below ground surface |
| BMP | bimetallic particle |
| $CaCO_3$ | calcium carbonate |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| cis-1,2-DCE | cis-1,2-dichloroethene |
| COC | contaminant of concern |
| COPC | chemical of potential concern |
| DAA | detailed analyses of alternatives |
| DCE | dichloroethene |
| DDC | Density Driven Connection |
| DOC | dissolved organic carbon |
| E & E | Ecology and Environment, Inc. |
| ETI | EnviroMetal Technologies, Inc. |

## List of Abbreviations and Acronyms (cont.)

| | |
|---|---|
| EPA | Environmental Protection Agency |
| FS | feasibility study |
| ft/ft | feet per foot |
| gpm | gallons per minute |
| GRA | General Response Action |
| HRC | hydrogen releasing compound |
| IDW | investigation-derived waste |
| $KMnO_4$ | potassium permanganate |
| MCL | maximum containment level |
| MCLG | maximum containment level goal |
| µg/L | micrograms per liter |
| µmol/L | micromoles per liter |
| mg/L | milligrams per liter |
| MNA | monitored natural attenuation |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NOD | natural oxidant demand |
| NTU | nephelometric turbidity units |
| NYCRR | New York State Code of Rules and Regulations |
| NYSDEC | New York State Department of Environmental Conservation |
| O & M | operation and maintenance |
| ORC | oxygen-releasing compounds |
| ORP | oxygen-reduction potential |
| OSWER | Office of Solid Waste and Emergency Response |
| PAH | polyaromatic hydrocarbon |
| PCB | polychlorinated biphenyl |

## List of Abbreviations and Acronyms (cont.)

| | |
|---|---|
| PCE | tetrachloroethene |
| POTW | publicly owned treatment works |
| ppb | parts per billion |
| PRB | permeable reactive barrier |
| PVC | polyvinyl chloride |
| RAO | remedial action objective |
| RI | remedial investigation |
| SAC | Strategic Air Command |
| SCG | standards, criteria, and guidance |
| SDWA | Safe Drinking Water Act |
| SI | supplemental investigation |
| SMCL | secondary maximum contaminant level |
| SPDES | State Pollutant Discharge Elimination System |
| TAGM | Technical and Administrative Guidance Memorandum |
| TAL | Target Analyte List |
| TBC | to be considered |
| TCA | trichloroethane |
| TCE | trichloroethene |
| UIC | Underground Injection Control |
| USACE | United States Army Corps of Engineers |
| USAF | United States Air Force |
| UV | ultraviolet |
| UVB | Unterdruck-Verdampfer-Brunner |
| VC | vinyl chloride |
| VOC | volatile organic compound |

## List of Abbreviations and Acronyms (cont.)

| | |
|---|---|
| WSA | Weapons Storage Area |

# 1 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 three areas of groundwater contamination at the Former Griffiss Air Force Base (Griffiss AFB) in Rome, New York. The three areas are plumes at Landfill 6 (Landfill 6 – part of the Landfill 6 Area of Concern [AOC]), Building 775 (Building 775, part of the Building 775 AOC) and at Building 817/Weapon Storage Area (Building 817/WSA, part of the On-Base Groundwater AOC). The FS is conducted in accordance with the United States Environmental Protection Agency's (EPA's) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* of 1980 (EPA 540/G-89/004) and the New York State Department of Environmental Conservation's (NYSDEC's) Technical and Administrative Guidance Memorandum (TAGM) 4030, *Selection of Remedial Actions at Inactive Hazardous Waste Sites*.

The three plumes addressed by this FS are identified as separate AOCs and generally have separate sources. They are addressed together in this one FS due to their similar contaminants and hydrogeology. In addition, the Landfill 6 and Building 775 plumes are located adjacent to each other.

The Landfill 6 plume is located downgradient of Landfill 6. Waste material disposed in the landfill is presumed to be the source of groundwater contamination. The Building 775 plume is located east of the Landfill 6 plume. This plume is believed to have been caused by a ruptured solvent storage tank at Building 774. The Building 817/WSA plume was discovered as part of a more general investigation of the on-base groundwater to identify potential plumes not associated with known sources. The source of this plume is unknown, but it is believed to have originated near Building 817. No other components of the on-base groundwater AOC are addressed in this FS.

In accordance with the Federal Facility Agreement and Resolution of Disputes between the United States Air Force (USAF), EPA Region II, and NYSDEC, a Remedial Investigation (RI) was performed for the Landfill 6, Building 775, and on-base groundwater AOCs in 1994. The purpose of the RI 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. A supplemental investigation (SI) was performed in 1997 after basewide groundwater contours and flow directions were re-evaluated after gaps were identified in the RI data. The SI was conducted in locations where the groundwater exceeded applicable or relevant and appropriate requirements (ARARs) but where the extent of potential plumes was not defined and included investigations at the Landfill 6 and Building 775 plumes. Another supplementary investigation was conducted in 2000 to further delineate the Landfill 6 and Building 775 plumes and to investigate the Building 817/WSA section of the on-base groundwater AOC. Results of these sampling events are presented in detail in Section 2. As concluded in the Bedrock Groundwater Study for Landfill 6, Building 775, and Building 817/WSA (E & E 2002), groundwater contamination observed in the overburden aquifer does not appear to have migrated downward into the underlying bedrock at these sites and therefore will not be addressed as part of this FS. For purposes of this FS, on-site groundwater in this report refers to overburden groundwater.

This submittal includes an introduction, (Section 1), the development of remedial action objectives (RAOs) (Section 2), the identification and screening of technologies (Section 3), and the detailed analyses of alternatives (DAA) (Sections 4, 5, and 6).

# 2 Remedial Action Objectives

## 2.1 Introduction

Groundwater contamination has been identified at each of the three areas evaluated in this FS. This contamination could pose a human health risk if groundwater is used as a source of drinking water. In general, aquifer yields in the area of the base are low and not expected to be suitable for municipal wells. However, since the aquifer thickens to greater than 60 feet in the southernmost part of the base (including the region near the Landfill 6 and Building 775 plumes), well yields in this area may yield enough water to be used for private water supply wells. Because future uses planned for these sites are limited to open space/recreational, industrial/commercial reuse, or aviation uses, the installation of drinking water wells is not likely. Public water supplies are already available and in use at each of these three areas.

Other potential exposure routes from contaminated groundwater include the inhalation of volatiles that migrate from shallow groundwater into buildings or the atmosphere and exposure to surface water and sediment contaminated by the discharge of groundwater. However, given the low concentrations of volatiles in the groundwater, this is not considered a significant pathway.

For the three plumes addressed in this FS, the RAO is to make the groundwater potable for domestic or municipal use, or to prevent exposure to groundwater until groundwater standards are achieved while maintaining institutional controls to prevent groundwater use, and to prevent contaminated groundwater from adversely impacting surface water and sediment.

Chemical-specific cleanup goals are developed to define the area and volume of groundwater that must be addressed for each plume to meet RAOs. These cleanup goals are based on the evaluation of ARARs and other criteria and guidelines to be considered (TBCs) and may be supplemented by the findings of site-specific risk assessments presented as part of the RI. These evaluations are used to determine contaminant levels that will not endanger human health or the environment.

ARARs and TBCs encompass the term SCGs (standards, criteria, and guidance) defined by the New York State Department of Environmental Conservation (NYSDEC). ARARs and standards are promulgated and legally enforceable rules or regulations. TBCs, criteria, and guidance are policy documents that are not promulgated and not legally enforceable standards. To distinguish between enforceable and non-enforceable values, the terms ARARs and TBCs will be used rather than the term SCGs.

The ARARs and TBCs presented in this report are in accordance with Section 121(d)(2) of the CERCLA of 1980. They are also consistent with EPA guidance set forth in the CERCLA National Contingency Plan (40 CFR 300); the two-part guidance document entitled *CERCLA Compliance with Other Laws Manual* (Office of Solid Waste and Emergency Response [OSWER] Directives 9234.1-01 [Draft], August 8, 1988, and 9234.1-02, August 1989); and the guidance document *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA-540/G-89/004).

## 2.2 Selection of Groundwater Cleanup Goals

### 2.2.1 ARARs

The federal Safe Drinking Water Act (SDWA) (42 USC 300(f) et seq., 40 CFR 141.147), protects public health by establishing primary and secondary drinking water standards for public and community water supplies. The primary drinking water standards known as maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) address toxicity. According to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), an MCL or non-zero MCLG is generally a relevant and appropriate chemical-specific requirement for groundwater that is a current or potential source of drinking water. As such, MCLs and MCLGs are ARARs for on-base groundwater.

The NYSDEC Class GA groundwater standards, set forth in the New York State Code of Rules and Regulations (NYCRR), Part 703.5, and the New York Sanitary Code Drinking Water Standards (State Sanitary Code, Part 5), are also considered ARARs. These regulations establish the maximum allowable concentrations for contaminants found in groundwater. ARARs for the contaminants detected in groundwater are presented in Table 2-1. Federal MCLs, nonzero MCLGs, and the NYSDEC Class GA groundwater standards are, therefore, relevant and appropriate ARARs for on-base groundwater.

### 2.2.2 TBCs

Additional TBCs include EPA Region III risk-based concentrations for tap water, secondary maximum contaminant levels (SMCLs) promulgated under the SDWA, and NYSDEC Class GA groundwater guidance values. Risk-based concentrations have been calculated by EPA Region III for nearly 500 chemicals. These toxicity constants have been combined with generic exposure scenarios to calculate chemical concentrations corresponding to a hazard quotient of 1 or a lifetime

## Table 2-1 Cleanup Goal Selection Process for Groundwater (concentrations in μg/L unless noted)

| Contaminant | ARARs | | | TBCs | | | | Preliminary Screening Value | Maximum Concen-tration[d] | Cleanup Goal |
|---|---|---|---|---|---|---|---|---|---|---|
| | Federal MCL | NYSDEC Class GA Groundwater Standards | New York Sanitary Code Drinking Water Standards | Federal SMCL | NYSDEC Class GA Groundwater Guidance Values | EPA Region III Tap Water Criteria | RCRA Corrective Action Level | | | |
| **Volatiles** | | | | | | | | | | |
| 1,1,1-Trichloroethane | 200 | 5 | 5 | — | — | 3,200 | 3,000 | 5 | 6.63 | 5 |
| 1,1-Dichloroethene | 7 | 5 | 5 | — | — | 0.044 | — | 5 | 0.73 | NA |
| 1,2-Dichlorobenzene | 600 | 3 | 5 | — | — | 550 | — | 3 | 0.23 | NA |
| 1,2-Dichloroethane (total) | 70[a] | 0.6 | 5 | — | — | 0.12 | — | 5 | 1.14 | NA |
| 1,4-Dichlorobenzene | 75 | 3 | 5 | — | — | 0.47 | — | 3 | 0.034 | NA |
| Acetone | — | — | 50 | — | 50 | 6,100 | 4,000 | 50 | 130 | 50 |
| Benzene | 5 | 1 | 5 | — | — | 0.32 | — | 1 | 3.9 | 1 |
| Bromodichloromethane | 100 | — | 100 | — | 50 | 0.17 | — | 100 | 2.7 | NA |
| Chlorobenzene | — | 5 | 5 | — | — | 1,100 | 700 | 5 | 1.1 | NA |
| Chloroform | 80 | 7 | 100 | — | — | 0.15 | 6 | 7 | 60 | 7 |
| Cis-1,2-Dichloroethene | 70 | 5 | 5 | — | — | 61 | — | 5 | 190 | 5 |
| Ethylbenzene | 700 | 5 | 5 | — | — | 1,300 | 4,000 | 5 | 3.1 | NA |
| Isopropylbenzene | — | 5 | 5 | — | — | — | — | 5 | 1.2 | NA |
| Methylene chloride | 5 | 5 | 5 | — | — | 4.1 | 5 | 5 | 15 | 5 |
| n-Butylbenzene | — | 5 | 5 | — | — | 240 | — | 5 | Trace | NA |
| n-Propylbenzene | — | 5 | 5 | — | — | 240 | — | 5 | 1.0 | NA |
| Naphthalene | — | — | 50 | — | 10 | 6.5 | — | 50 | 0.11 | NA |
| p-Cymene (p-Isopropyltoluene) | — | 5 | 5 | — | — | — | — | 5 | Trace | NA |
| sec-Butylbenzene | — | 5 | 5 | — | — | 240 | — | 5 | 1.8 | NA |
| t-Butylbenzene | — | 5 | 5 | — | — | 240 | — | 5 | 2.2 | NA |
| Tetrachloroethene | 5 | 5 | 5 | — | — | 1.1 | 0.7 | 5 | 218 | 5 |
| Toluene | 1,000 | 5 | 5 | — | — | 750 | 10,000 | 5 | 9 | 5 |
| trans-1,2-Dichloroethene | 100 | 5 | 5 | — | — | 120 | — | 5 | 2.2 | NA |
| Trichloroethene | 5 | 5 | 5 | — | — | 1.6 | — | 5 | 100 | 5 |
| Trichlorofluoromethane | — | 5 | 5 | — | — | 1,300 | 10,000 | 5 | 0.61 | NA |
| Vinyl chloride | 2 | 2 | 2 | — | — | 0.081 | — | 2 | 36 | 2 |
| Xylenes (total) | 10,000 | 5 | 5 | — | — | 12,000 | 70,000 | 5 | 10 | 5 |
| **Semivolatiles** | | | | | | | | | | |
| Acenaphthene | — | — | 50 | — | 20 | 370 | — | 50 | 0.33 | NA |
| Benzyl butyl phthalate | — | — | 50 | — | 50 | — | 7,000 | 50 | 0.04 | NA |
| Bis(2-ethylhexyl)adipate | — | 20 | 50 | — | — | — | — | 20 | 0.7 | NA |
| Bis(2-ethylhexyl)phthalate | 6 | 5 | 50 | — | — | 4.8 | 3 | 5 | 16 | 5 |
| Butylbenzylphthalate | — | — | 50 | — | 50 | 7,300 | | 50 | 1.2 | NA |
| Di-n-butylphthalate | — | 50 | 50 | — | — | 3,700 | — | 50 | 0.05 | NA |
| Dibenzo(a,h)anthracene | — | — | 50 | — | — | 0.0092 | — | 50 | 0.61 | NA |
| Dibenzofuran | — | — | 50 | — | — | 24 | — | 50 | 0.16 | NA |
| Diethylphthalate | — | — | 50 | — | 50 | 29,000 | 30,000 | 50 | 0.73 | NA |
| Fluoranthene | — | — | 50 | — | 50 | 1,500 | — | 50 | 0.34 | NA |

## Table 2-1 Cleanup Goal Selection Process for Groundwater (concentrations in µg/L unless noted)

| | ARARs | | | TBCs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Contaminant | Federal MCL | NYSDEC Class GA Groundwater Standards | New York Sanitary Code Drinking Water Standards | Federal SMCL | NYSDEC Class GA Groundwater Guidance Values | EPA Region III Tap Water Criteria | RCRA Corrective Action Level | Preliminary Screening Value | Maximum Concentration[d] | Cleanup Goal |
| Pentachlorophenol (PCP) | 1 | 1 | 1 | — | — | 0.56 | 1,000 | 1 | 0.3 | NA |
| Phenanthrene | — | — | 50 | — | 50 | — | — | 50 | 0.61 | NA |
| Pyrene | — | — | 50 | — | 50 | 180 | — | 50 | 0.28 | NA |
| **Pesticides** | | | | | | | | | | |
| Aldicarb | 7 | 0.35 | 3 | — | — | 37 | 50 | 0.35 | 7.5 | 0.35 |
| Baygon | — | — | 50 | — | — | 150 | — | 50 | 0.5 | NA |
| Carbaryl | — | 29 | 50 | — | — | 3,700 | — | 29 | 33 | 29 |
| Carbofuran | 40 | — | 40 | — | 15 | — | — | 40 | 0.5 | NA |
| Coumaphos | — | — | 50 | — | — | — | — | 50 | 0.2 | NA |
| Dalapon | 200 | 50 | 50 | — | — | 1100 | — | 50 | 0.6 | NA |
| Dichlorvos | — | — | 50 | — | — | 0.23 | — | 50 | 0.012 | NA |
| **Inorganics** | | | | | | | | | | |
| Aluminum | — | — | — | 50-200 | — | 37,000 | — | 200 | 965 | 200 |
| Arsenic | 50 | 25 | 50 | — | — | 0.045 | — | 25 | 0.6 | 25 |
| Barium | 2,000 | 1,000 | 2,000 | — | — | 2,600 | — | 1,000 | 83,000 | 1,000 |
| Calcium | — | — | — | — | — | — | — | — | 182,000 | NA |
| Chromium | 100 | 50 | 100 | — | — | 110 | — | 50 | 1,700 | 50 |
| Cobalt | — | — | — | — | — | 2,200 | — | 2,200 | 10 | 2,200 |
| Copper | 1,300[b] | 200 | — | 1,000 | — | 1,500 | — | 200 | 65 | 200 |
| Iron | — | 300 | 300 | 300 | — | 11,000 | — | 300 | 14,100 | 300 |
| Lead | 15[c] | 25 | — | — | — | — | 90 | 15 | 3.4 | 15 |
| Magnesium | — | — | — | — | 35,000 | — | — | 35,000 | 51,400 | 35,000 |
| Manganese | — | 300 | 300 | 50 | — | 730 | — | 50 | 250 | 50 |
| Mercury | 2 | 0.7 | 2 | — | — | — | — | 0.7 | 2.2 | 0.7 |
| Molybdenum | — | — | — | — | — | 180 | — | 180 | 0.06 | 180 |
| Nickel | 100 | 100 | — | — | — | 730 | 700 | 100 | 380 | 100 |
| Potassium | — | — | — | — | — | — | — | — | 24,400 | NA |
| Selenium | 50 | 10 | 10 | — | — | 180 | — | 10 | 1,700 | 10 |
| Sodium | — | 20,000 | — | — | — | — | — | 20,000 | 104,000 | 20,000 |
| Strontium | — | — | — | — | — | 22,000 | — | — | 2,600 | NA |
| Thallium | 0.5[c] | — | — | — | 4 | 2.6 | 3 | 0.5 | 0.7 | 0.5 |

## Table 2-1  Cleanup Goal Selection Process for Groundwater (concentrations in µg/L unless noted)

| | ARARs | | | TBCs | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Contaminant | Federal MCL | NYSDEC Class GA Groundwater Standards | New York Sanitary Code Drinking Water Standards | Federal SMCL | NYSDEC Class GA Groundwater Guidance Values | EPA Region III Tap Water Criteria | RCRA Corrective Action Level | Preliminary Screening Value | Maximum Concen-tration[d] | Cleanup Goal |
| Zinc | — | 300 | 5,000 | 5,000 | — | 11,000 | — | 300 | 285 | NA |

[a] Value for cis isomer.
[b] Action level in lieu of MCL
[c] MCLG rather than MCL presented, as this compound has a non-zero MCLG lower than its MCL.
[d] Maximum concentration listed from monitoring well data only.

Key:

C = Level has not been established.
ARAR = Applicable or relevant and appropriate requirements.
EPA = United States Environmental Protection Agency.
MCL = Maximum contaminant level.
µg/L = Micrograms per liter.
NA = Not applicable.
ND = Non detect.
NYSDEC = New York State Department of Environmental Conservation.
PQL = Practical Quantitation Limit.
RCRA = Resource Conservation and Recovery Act.
SML = Secondary maximum contaminant level.
TBC = To be considered

cancer risk of $10^{-6}$, whichever value is lower. SMCLs, risk-based concentrations, and groundwater guidance values are classified as TBCs rather than ARARs because they are not enforceable at state or federal levels.

### 2.2.3 Summary of Site Risk Assessment

Site risk assessments were prepared for the Landfill 6 and Building 775 AOCs during the RI, using only the data from the RI (and thus not including data from later supplementary investigations). The Landfill 6 risk assessment estimated potential future risk from groundwater above $10^{-3}$ excess cancers. These risks were primarily from three compounds: 1,1-dichloroethene (1,1-DCE), vinyl chloride (VC), and 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD). VC accounts for the most risks, including 9.9 x $10^{-4}$ excess cancers from ingestion, 4.35 x $10^{-4}$ excess cancers from inhalation, and 1.1 x $10^{-5}$ excess cancers from dermal contact. Contributions from 1,1-DCE and 2,3,7,8-TCDD were lower but were above $10^{-5}$ excess cancers for one or more pathways. The 2,3,7,8-TCDD risk is based on an exposure-point concentration of only 4.7 picograms/L (4.6 x $10^{-6}$ [micrograms per liter]µg/L), which is the limit of detection. No excess cancers above $10^{-5}$ were estimated to result from contamination in the Building 775 water.

Samples collected during the SI showed levels of contamination somewhat higher than the concentrations observed during the RI and, therefore, higher risks may result from the industrial scenario direct contact and inhalation exposure routes evaluated in the RI. While these estimated risks underscore the need to address at a minimum the Landfill 6 plume in this FS, these estimates will not be used to set cleanup goals or identify extents of contamination, as this is adequately addressed by ARARs and TBCs.

### 2.2.4 Selection of Groundwater Cleanup Goals

The candidate cleanup goals are presented in Table 2-1. These goals were selected in the following manner: where ARARs were available, the lowest of the federal or state ARARs was selected as a preliminary screening value. If neither federal nor NYSDEC ARARs were available, the lowest of the TBC values was used as the preliminary screening value. Preliminary screening values are compared to the maximum observed concentrations for each compound to determine whether a goal needs to be set for each compound. If so, the preliminary screening value is set as the cleanup goal.

In this evaluation, only data from monitoring wells are used. For these plumes, there was considerable additional data generated through on-site analysis of Geoprobe and hydropunch grab groundwater samples. These data, however, indicated the presence of the same chemicals found in the wells. Thus, excluding this data from this analysis does not lead to exclusion of compounds from consideration for remediation. The grab groundwater sample results are included in the evaluation of the extent of the plume and in developing and evaluating of alternatives.

All of the potential criteria discussed above are presented in Table 2-1. According to the analytical results presented in this table, a variety of organic and inorganic chemicals were present in these three plumes at concentrations exceeding cleanup goals. In the next two sections, the usability of the data is discussed in order to focus on the actual chemicals of concern that are addressed in this FS.

## 2.3 Metals Data Usability

Most groundwater samples collected during the RI were unfiltered; however, this did not affect their usability provided that they contained low levels of suspended solids (i.e., turbidity less than 50 nephelometric turbidity units [NTU]). If the samples were turbid and contained elevated levels of suspended solids, their metals concentrations, especially common metals such as aluminum, iron, and manganese, may have been elevated due to interference from turbidity.

Based on the results of the Quarterly Groundwater Sampling Program (November 1992 through October 1993) and the RI well sampling program (metals were not analyzed during the following investigations: SI; SI Addendum Technical Memorandum No. 1: On-base Groundwater; and Landfill 6 and Building 775 AOCs Groundwater Study Technical Memorandum No. 1: Field Investigation Conducted in spring 2000), groundwater at Building 775, Landfill 6, and Building 817/WSA areas contains aluminum concentrations that equal or exceed groundwater cleanup goals in seven wells; barium concentrations that equal or exceed cleanup goals in one well; chromium concentrations that equal or exceed cleanup goals in one well; iron concentrations that equal or exceed cleanup goals in 10 wells; magnesium concentrations that equal or exceed cleanup goals in one well; manganese concentrations that equal or exceed cleanup goals in eight wells; mercury concentrations that equal or exceed cleanup goals in one well; nickel concentrations that equal or exceed cleanup goals in one well; selenium concentrations that equal or exceed cleanup goals in one well; sodium concentrations that equal or exceed cleanup goals in four wells; and thallium concentrations that equal or exceed cleanup goals in one well. Table 2-2 summarizes the wells where metals concentrations exceeded cleanup goals, with the exception of the three wells that contained only elevated concentrations of sodium (all three of the elevated sodium levels occurred at the Landfill 6 AOC). Less than 50% (seven out of 16) of the tabulated wells show only one analyte at concentrations exceeding cleanup goals.

Typically, aluminum, iron, and manganese are present at elevated concentrations. Because aluminum has a low solubility, concentrations exceeding 1 micromole per liter (µmol/L) or 27 µg/L in natural water at a pH greater than 6 are unlikely to be dissolved (Sposito 1989). During the sampling of the monitoring wells at Griffiss AFB installed by Law Environmental and E & E, pH measurements ranged from 6.22 to 8.56, with a mean of 7.64. None of the 36 wells had a pH below 6; therefore, high concentrations of dissolved aluminum are not likely to occur. The presence of high aluminum, iron, and manganese concentrations suggests the presence of suspended particulates due to the high turbidity of the

**Table 2-2  Metals Concentrations Exceeding Cleanup Goals**

| Metals | Cleanup Goal mg/L | Landfill 6 | | | Building 775 | | | | | | | | | | Building 817/WSA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LF6MW-2 RI LF6 5/29/94 | LF6MW-4-1 RI LF6 Duplicate 5/31/94 | TMCMW-9 RI LF6 5/31/94 | 775MW-3-01 RI (OBG) Duplicate 9/2/94 | 773MW-2 RI (OBG) 9/3/94 | 773MW-1 Quarterly Sampling QTR I 11/92 | 773MW-2 Quarterly Sampling QTR I 11/92 | 773MW-3 Quarterly Sampling QTR I 11/92 | 775MW-1 Quarterly Sampling QTR I 11/92 | 775MW-2 Quarterly Sampling QTR I 11/92 | 775MW-3 Quarterly Sampling QTR I 11/92 | 773MW-1 Quarterly Sampling QTR II 3/93 | 775MW-3 Quarterly Sampling QTR IIII 9/93 | LAWMW-9 RI 8/30/94 | WSAMW-2 SI 7/30/97 | WSATW-5 SI Duplicate 8/4/97 |
| Aluminum | 0.2 | 0.21 | U | 0.13 | U | U | 0.37 | U | 0.965 | U | 0.285 | 0.62 | U | 0.67 JL | 0.53 | U | U |
| Barium | 1 | 0.079 | U | 0.033 | 0.0045 J | 0.0093 J | U | U | U | U | U | U | U | U | 0.025 | U | 83 J |
| Calcium | NA | 74.6 | 24.7 | 182 | 43.7 | 55.7 | 39.4 | 62.7 | 53 | 60.3 | 52.8 | 39.5 | 29.8 | 45 | 76.3 | U | U |
| Chromium | 0.05 | 0.012 | U | U | U | U | U | U | U | U | U | U | U | U | 0.002 J | 1.7 | U |
| Iron | 0.3 | 14.1 | 0.057 J | 0.3 J | U | U | 1.12 | 0.78 | 2.26 | 0.57 | 0.975 | 1.71 | 0.33 | 1.3 JH | 0.92 | U | U |
| Magnesium | 35 | 6 | 1 | 51.4 | 6.56 | 7.76 | 1.6 | 9.4 | 9.96 | 8.21 | 10.5 | 5.65 | 1.06 | 7.1 | 7.23 | U | U |
| Manganese | 0.05 | U | 0.25 | 1.1 | U | 0.0038 J | 0.099 | 0.082 | 0.16 | 0.05 | 0.084 | 0.14 | U | 0.12 | 0.048 | U | U |
| Mercury | 0.0007 | U | U | U | 0.00003 J | 0.0022 J | 0.0002 | U | U | U | U | U | U | U | 0.00006 J | U | U |
| Nickel | 0.1 | 0.38 | U | U | U | U | U | U | U | U | U | U | U | U | U | U | U |
| Potassium | NA | U | U | 8.6 | 3.02 | 1.61 | 1.28 | 1.41 | 2.06 | 2 | 0.925 | 0.99 | 1.14 | 1.6 | 1.5 | U | U |
| Selenium | 0.01 | 1.7 | U | U | 0.0002 J | U | U | U | U | U | U | U | U | U | U | U | U |
| Sodium | 20 | 15.2 | 2.5 | 23.5 | 2.97 | 2.91 | 5.9 | 2.7 | 5.5 | 9.71 | 1.09 | 1.52 | 6.5 | 2.2 | 19.5 | U | U |
| Thallium | 0.0005 | U | U | U | 0.0007 J | U | U | U | U | U | U | U | U | U | U | U | U |

J = Estimated Concentration
JH = Estimated Concentration, possibly biased high based upon QC data
JL = Estimated Concentration, possibly biased low based upon QC data
U = Analyte not detected

aquifer at Griffiss AFB. The fact that many of the wells installed all across Griffiss AFB during the RI are not located downgradient of any known AOC on the base suggests that the elevated concentrations of aluminum, iron, and manganese are naturally occurring.

Only one well, 773MW-2, showed an elevated mercury concentration (2.2 μg/L, estimated during the RI) and did not show elevated concentrations of aluminum, iron, or manganese. This well was sampled several times after the RI and subsequent analyses did not indicate an elevated concentration of mercury. The mercury in this well is therefore attributed to natural levels. Sodium levels are erratic and irregularly distributed, but they tend to be highest in wells located in areas where road salt is used for deicing. Detected sodium levels do not correspond to iron, aluminum, or manganese levels. Because road deicing will be an ongoing source of sodium, groundwater cleanup for sodium alone will not be considered.

The levels of iron, aluminum, and manganese found in some wells can also be attributed to particulates because of the nonreproducible nature of the results for some duplicate analyses. For example, during the On-base Groundwater AOC RI, the sample duplicate for LAWMW-2, taken at the same time as the original, shows a 533% increase in aluminum, an 883% increase in iron, and a 1,754% increase in manganese, while the value for mercury decreases by 50% and the value for sodium decreases by 88.3%. These contrasting values for samples collected from the same well at the same time demonstrate how particulates make unfiltered groundwater samples "unreproducible and unrepresentative" (Puls et al. 1992).

In 1991 filtered and unfiltered samples were collected from wells at Buildings 773, 775, 779, and 781. Analysis of the samples indicated iron concentrations in filtered samples decreased from an average of 64.58 milligrams per liter (mg/L) to 0.213 mg/L, and 10 of 12 wells indicated nondetectable levels after filtering. Manganese concentrations decreased from an unfiltered average of 261 mg/L to 2.14 mg/L after filtering, and the average concentration for zinc, a relatively soluble metal, decreased from 0.129 mg/L to 0.002 mg/L. Lead concentrations decreased from 0.07 mg/L to 0.001 mg/L, with 10 of 12 wells indicating nondetectable levels after filtering.

Except for the sodium found throughout the base, the data indicate that the elevated metals on-site are naturally occurring. Sodium concentrations will continue to exceed cleanup goals as long as road deicing continues; therefore, the presence of sodium will not be used as the basis for remediation, nor will the naturally occurring metals.

## 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 polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins, dibenzofurans, and pesticides. However, for purposes of this evaluation, all organic data reported in the 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 it is typical to find low levels of some organic compounds, especially pesticides (and in some cases solvents), in wells that are unaffected by any known release or source and that are not found on a reproducible basis.

These findings indicate that, throughout the detailed review of groundwater data in the following sections, low-level, isolated hits of organics exceeding ARARs are not always candidates for remediation. In cases where pesticides (and in some cases solvents) were detected, levels are very low (typically below the quantitation limit and/or in the parts-per-trillion range), isolated, and often ephemeral, the groundwater may not be deemed a candidate for consideration of remedial alternatives for the specific analyte, despite exceeding an ARAR at least once. Rather, they are present in a pattern of water quality observed throughout the region and are not a result of contamination from the base.

## 2.5 Contaminated Groundwater

In this section, contamination at each of the three plumes addressed by this FS—Landfill 6, Building 775, and Building 817/WSA, as examined under the Quarterly Groundwater Monitoring Program, RI, SI, SI Addendum, Technical Memorandum No. 1: On-base Groundwater, and Landfill 6 and Building 775 AOCs Groundwater Study Technical Memorandum No. 1: Spring 2000 Field Investigation—are evaluated considering the ARAR-based cleanup goals identified in Section 2.2. This evaluation defines the extent of the plume at these areas where remedial action should be considered. Contaminant screening was performed using groundwater monitoring well sample data only in order to reduce the uncertainties created by analytical anomalies associated with analyzing turbid samples such as suspended particulates and analytes sorbed to suspended particulates. However, other analytical data, in addition to the monitoring well data, exist for the three AOCs. These data, which were derived from hydropunch/Geoprobe samples, were used in conjunction with well data in order to determine the extent of the plumes.

### 2.5.1 Landfill 6

At Landfill 6, the RI results showed that Landfill 6 MW-2 was clearly contaminated with cis-1,2-dichloroethene (170 µg/L) and VC (30 µg/L). Because both the chlorinated compounds are products of the reductive dechlorination of trichloroethene (TCE) and because the well is hydraulically downgradient of the landfill, it may have been contaminated either as the result of spills or discharges of TCE upgradient or by disposal in the landfill. In addition, localized detections of low concentrations of aldicarb and benzene were also detected but do not constitute a plume.

The SI involved the installation of one vertical profiling well, Landfill 6VMW-6, downgradient of Landfill 6MW-2. This well was then sampled, and existing wells Landfill 6MW-1, Landfill 6MW-2, TMC-USGS-3, and TMCMW-9 were resampled. Analyses of the resampling data confirmed that concentrations of 1,2-dichloroethene (1,2-DCE) (total) (83 μg/L) and VC (20 μg/L) in Landfill 6MW-2 exceed cleanup goals. Analysis of the sample from Landfill 6VMW-6, installed southwest of Landfill 6MW-2, indicated 180 μg/L of 1,2-DCE, 26 μg/L TCE, and 29 μg/L VC, indicating that there is no obvious decline in concentration in the southwest. Because Geoprobe results were nondetect in all cases, the new well, Landfill 6VMW-6, was placed within 200 feet directly downgradient of Landfill 6MW-2 and screened across the interval (35 to 45 feet BGS) that showed the highest level of chlorinated solvents (i.e., 27 μg/L TCE) in hydropunch samples collected during drilling.

A groundwater study was performed in spring 2000 at the Landfill 6 AOC to define the vertical and lateral extent of the Landfill 6 TCE plume. The investigation consisted of drilling and vertically profiling 16 boreholes, including 105 hydropunch samples, the installation and sampling of eight new wells, and the sampling of two preexisting Landfill 6 wells and two preexisting Three Mile Creek wells. The Landfill 6 contamination plume was delineated both vertically and horizontally using hydropunch data. Three chlorinated solvents were detected at levels exceeding cleanup goals in the hydropunch samples: cis-1,2-DCE, which was detected in eight of 16 boreholes with a maximum concentration of 983 μg/L in Landfill 6VMW-12; TCE, which was detected in nine of 16 boreholes with a maximum concentration of 1,587 μg/L in Landfill 6VMW-12; and VC, which was detected in one of 16 boreholes with a maximum concentration of 8.4 μg/L in Landfill 6VMW-11.

Three contaminants were detected at levels exceeding cleanup goals in the groundwater samples collected from the Landfill 6 wells during the spring 2000 investigation: cis-1,2-DCE, which was detected in four of 12 wells with concentrations ranging from 0.254 μg/L to 35.4 μg/L and at levels exceeding cleanup goals in three wells, Landfill 6MW-2, Landfill 6VMW-6, and Landfill 6VMW-11; TCE, which was detected in three of 12 wells, with concentrations ranging from 0.864 μg/L to 26.3 μg/L and at levels exceeding cleanup goals in two wells, Landfill 6VMW-6, and Landfill 6VMW-11; and VC, which was detected in three of 12 wells with concentrations ranging from 0.247 μg/L to 6.21 μg/L and at levels exceeding cleanup goals in one well, Landfill 6VMW-6. The concentrations of the compounds in the spring 2000 samples were lower than the 1997 SI samples from the same wells. This decrease in contaminant concentration appears to correspond with the direction of groundwater flow and expected plume migration.

Figure 2-1 illustrates the lateral extent of contamination and the cross sections in Figure 2-2 and 2-3 illustrate the vertical extent of contamination. The data obtained from the vertical profiling of the Landfill 6 AOC indicate that there does not appear to be a single-point source of contamination. Because landfills are heterogeneous, it is likely multiple sources exist within the landfill and from surficial dumping on or near the landfill. The contamination has traveled both laterally, approximately 800 feet to the south/southwest, and vertically, approximately 80 feet downward from the surface to the top of bedrock. The width of the plume is approximately 200 feet near the top of Landfill 6 and 700 feet at the leading edge (approximately 100 feet from Three Mile Creek). The base of the plume beneath the top of Landfill 6 appears to merge or nearly merges with the leading edge of the Building 775 plume. The water table exhibits a very low gradient across the site (0.001 feet per foot [ft/ft]). The depth to groundwater ranges from 2.6 feet to 64.7 feet with an average of about 19 feet across the site.

A Bedrock Groundwater Study for Landfill 6 (E & E 2002) conducted in 2002 consisted of the installation of two new downgradient bedrock wells (LF6MW-12RBr and LF6MW-14Br) and one new overburden monitoring well (LF6MW-12) at the most contaminated portion of the plume, based on the Landfill 6 and Building 775 groundwater study results (E & E August 2000) (see Figure 4-1). An upgradient well was not installed because the Building 775 groundwater plume is immediately upgradient of the Landfill 6 plume. Groundwater was collected and sampled for VOCs, methane, ethane, ethene, anions, and dissolved organic carbon (DOC) from each of the wells. Based on analytical results, groundwater contamination observed in the overburden aquifer does not appear to have migrated downward into the underlying bedrock.

Contaminated groundwater volume calculations provided in Appendix A utilize the 5 µg/L contour interval for total VOCs as a conservative boundary for capturing on-site groundwater contamination. E & E estimated approximately 47.3 x $10^6$ gallons of groundwater would require remediation. This volume was calculated based on contour interval take-offs (from Figure 2-1) and assuming a saturated depth of 50 feet. Proposed groundwater remedial actions consider this groundwater volume and assume multiple groundwater flushes of the plume, where applicable.

### 2.5.2 Building 775

The 1993 and 1994, quarterly sampling analysis indicated the presence of TCE, acetone, and chloroform in groundwater from wells around Building 773, and tetrachloroethene (PCE) was detected in wells around Building 775. Acetone was detected in four wells and exceeded cleanup goals in one well. Benzene was detected in four wells and only marginally exceeded cleanup goals in those four wells. Xylenes were detected only once and at a concentration marginally above the cleanup goal. Chloroform, detected in five wells, exceeded cleanup goals in only one well. Methylene chloride marginally exceeded cleanup goals in all six wells. These isolated contaminants are considered to be only minor contaminants, do not represent a plume, and are not addressed directly in this FS.

Building 774 was identified as a TCE storage area and subsequent soil gas and Geoprobe samples found widespread TCE contamination in the vicinity of, and downgradient of, Buildings 774 and 775. PCE was detected in five wells and marginally exceeded cleanup goals in two wells. TCE was detected in five wells and exceeded cleanup goals in the Building 775 wells only.

Two wells were sampled during the RI in 1994, 773MW-2 and 775MW-3. TCE was detected in 775MW-3 and PCE was detected in 773MW-2 at levels above cleanup goals.

The SI involved the resampling of wells 773MW-1, -2, and -3, and well 775MW-2, and the installation and sampling of seven new wells downgradient (southwest) of Buildings 775/774. Well 775MW-1 could not be resampled because the submersible pump did not function, and well 775MW-3 could not be resampled because the well casing was broken and the well was filled with sand. The seven new wells installed and sampled during the SI are: 775MW-6 and vertical profile wells 775VMW-4, 775VMW-5, 775VMW-7, 775VMW-8, 775VMW-9 and 775VMW-10. TCE was detected in all wells sampled during the SI wells at levels ranging from 2.9 to 100 µg/L except 773MW-2, 773MW-3, and 775VMW-9. Two other analytes were detected at concentrations exceeding cleanup goals, chloroform and PCE. Each was detected in one well and only marginally exceeded cleanup goals.

An additional investigation was conducted in spring 2000 in order to define the vertical and lateral extent of the Building 775 TCE plume. Additional wells were installed farther downgradient to determine if this plume is connected to the adjacent Landfill 6 plume. A total of 13 new wells were installed and sampled and 19 boreholes were drilled and vertically profiled and included 104 hydropunch samples. Eight pre-existing wells were also sampled. The Building 775 contamination plume was delineated both vertically and horizontally using hydropunch data. Three chlorinated solvents were detected in the hydropunch samples: cis-1,2-dichloroethene (cis-1,2-DCE), which was detected in one of the 19 boreholes with a maximum concentration of 12.1 µg/L in 775VMW-15R; PCE, which was detected in 13 of 19 boreholes with a maximum concentration of 5.2 µg/L in 775VMW-13; and TCE, which was detected in 12 of 19 boreholes with a maximum concentration of 608 µg/L in 775VMW-20R.

Three contaminants were detected at levels exceeding cleanup goals in the groundwater samples collected from the Building 775 wells: 1,2-DCE, which was detected in one of 21 wells at a concentration of 1.14 µg/L exceeding cleanup goals in 775VMW-18R; 1,1,1-trichloroethane (TCA), which was detected in 10 of 21 wells at concentrations ranging from 0.23 µg/L to 7.1 µg/L and exceeded cleanup goals in one well, 775VMW-22; and TCE, which was detected in 12 of

21 wells at concentrations ranging from 0.429 μg/L to 218 μg/L and exceeded cleanup goals in seven wells, 775MW-2, 775VMW-5, 775MW-6, 775VMW-7, 775VMW-8, 775VMW-10, and 775VMW-16. The concentration of the compounds detected in the spring 2000 samples was lower than the 1997 SI samples in 775MW-2, 775VMW-4, 775MW-6, and 775VMW-9. The concentrations of TCE, however, were detected in higher concentrations in the spring 2000 samples from 775VMW-5, 775VMW-8, and 775VMW-10.

Vertical profiling data indicate that the source area for the Building 775 site is the area around former Buildings 773 and 775 and current Building 774 (see Figure 2-1). The contamination has traveled both laterally, approximately 1,000 feet to the south/southwest, and vertically, a total of 120 feet downward from the surface (including 60 feet through vadose and 60 feet through the water table to the top of bedrock) (see Figures 2-1, 2-2, and 2-3). The width of the plume is approximately 500 feet in the source area and 800 feet in the leading edge. These data indicate that the leading edge of the Building 775 plume appears to merge or nearly merges with the base of the Landfill 6 plume (see Figure 2-1).

The groundwater flow beneath the site is predominantly to the southwest with a slight southerly component in localized areas. The average depth to groundwater is about 60 feet. The water table exhibits a very low hydraulic gradient (0.005 ft/ft) across the site, with an even lower gradient (0.001 ft/ft) to the northeast between the Nose Dock area and the northeast edge of the Strategic Air Command (SAC) Hill.

A Bedrock Groundwater Study for Building 775 (E & E 2002) conducted in 2002 consisted of the installation of two new downgradient bedrock wells (775MW-20RBr and 775MW-22Br) and three new overburden monitoring wells (775MW-20, 775MW-20D, and 775MW-22D) (see Figure 5-1). Overburden well 775MW-20 was installed in the most contaminated portion of the plume, based on the Landfill 6 and Building 775 groundwater study results (E & E August 2000). The other two overburden wells (775MW-20D and 775MW-22D) were installed in the till zone beneath the overlying silty fine sands and underlying bedrock. This zone was determined to be thicker than originally suspected; therefore, wells were screened in this zone to determine the presence or absence of contamination. An upgradient bedrock well was not installed because the Apron 2 site is upgradient of this plume. Groundwater was collected and sampled for VOCs, methane, ethane, ethene, anions, and DOC from each of the wells. Based on analytical results, groundwater contamination observed in the overburden aquifer does not appear to have migrated downward into the underlying till zone or bedrock.

Contaminated groundwater volume calculations provided in Appendix A utilize the 5 μg/L contour interval for total VOCs as a conservative boundary for capturing on-site groundwater contamination. E & E estimated approximately 95.2 x $10^6$ gallons of groundwater would require remediation. This volume was calculated based on contour interval take-offs (from Figure 2-1) and assuming a saturated depth of 60 feet. Proposed groundwater remedial actions consider this groundwater volume and assume multiple groundwater flushes of the plume, where applicable.

### 2.5.3 Building 817/Weapons Storage Area (WSA)

The Building 817/WSA plume is located on the north side of the main runway between Perimeter Road and the culverted section of Six Mile Creek south of the former WSA. In general, the groundwater flow in this area eventually discharges to Six Mile Creek or to its tributaries that flank the WSA to the north and south. All these streams cut down close to Utica shale bedrock, so that the WSA outwash material within which the water table occurs is isolated from all directions, except upgradient, and discharges to surface water within a short distance in all downgradient directions. TCE detected in the groundwater in well LAWMW-9 (7.6 µg/L) during the RI indicated that this area could be a source of contamination.

An SI was performed in which three temporary monitoring wells were installed around this well. Only one temporary well, WSATW-6, which is located east of LAWMW-9, showed low levels of TCE (31 µg/L). It also showed 9 µg/L of chloroform and 7.5 µg/L of PCE. The source and aerial extent of the TCE contamination was not determined during the SI, and therefore, an additional SI was warranted.

The additional SI was conducted in spring 2000 to complete the lateral and vertical delineation of the contaminant plume. This investigation included 56 Geoprobe samples at 36 locations and 13 of the 36 locations were vertically profiled. The estimated size and shape of the plume is depicted in Figures 2-4 (lateral extent of contamination) and 2-5 (vertical extent of contamination). The contaminants of concern include TCE, which was detected in 30 of 56 Geoprobes with a maximum concentration and location of 98.5 µg/L in WSA-GP09I; PCE, which was detected in 20 of 56 Geoprobes with a maximum concentration of 56.9 µg/L in WSA-GP04S; VC, which was detected in one of 56 Geoprobes with a maximum concentration of 3.4 µg/L in WSA-GP1D; and benzene, which was detected in seven of 56 Geoprobes with a maximum concentration of 1.7 µg/L in WSA-GP04I.

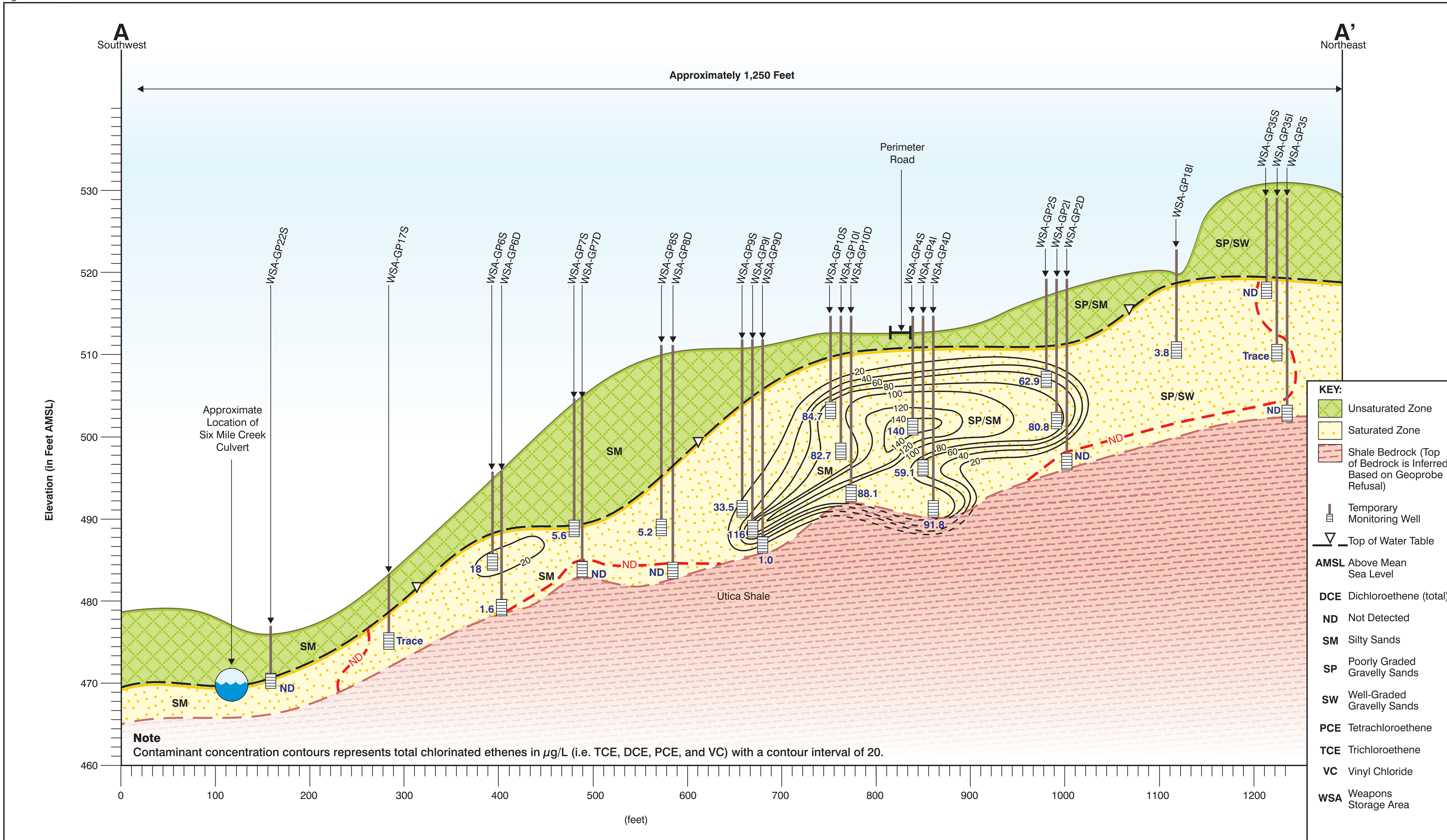
Because Building 817 is the only facility near the upgradient edge of the contaminant plume, the data obtained from the vertical profiling indicate that contaminants may have originated in its vicinity. The contamination has traveled both laterally (approximately 1,000 feet to the southwest) and vertically (25 feet downward to the top of bedrock). The width of the plume is approximately 250 feet. The Building 817/WSA contamination plume is migrating southwest but has not reached the culverted section of Six Mile Creek. The leading edge of the plume is currently located about 140 feet northeast of the culvert (see Figures 2-4 and 2-5). Based on the contaminant concentration distribution within the plume, contamination appears to have resulted from several spill or disposal events, creating several hot spots of contamination within the water column (one in the shallow zone centered around WSA-GP10S; two in the intermediate zone between WSA-GP09I and WSA-GP04I, and WSA-GP10I and WSA-GP02S; and one in the deep zone between WSA-GP04D and WSA-GP02I).

Since the three new monitoring wells (WSAMW-8, -9, and -10) were installed either close to or outside the plume area delineated by the Geoprobe survey, none of the contaminants detected in the groundwater samples from the monitoring wells exceeded cleanup goals. The concentration of TCE in the spring 2000 sample from LAWMW-9 (3.89 µg/L) was lower than the 1994 RI sample (7.6 µg/L) from the same well. This decrease in contaminant concentration corresponds with the direction of groundwater flow and expected plume migration.

A Bedrock Groundwater Study for Building 817/WSA (E & E 2002) conducted in 2002 consisted of the installation of three new bedrock wells (WSA-MW12Br [upgradient], WSA-MW13Br [downgradient], and WSA-MW14Br [downgradient]) and one new overburden monitoring well (WSA-MW11) (see Figure 6-1). Bedrock groundwater was collected and sampled for VOCs, methane, ethane, ethene, anions, and DOC from each of the bedrock wells. Based on analytical results, groundwater contamination observed in the overburden aquifer does not appear to have migrated downward into the underlying bedrock.

Contaminated groundwater volume calculations provided in Appendix A utilize the 5 µg/L contour interval for total VOCs as a conservative boundary for capturing on-site groundwater contamination. E & E estimated approximately 13.8 x $10^6$ gallons of groundwater would require remediation. This volume was calculated based on contour interval take-offs (from Figure 2-4) and assuming a saturated depth of 15 feet. Proposed groundwater remedial actions consider this groundwater volume and assume multiple groundwater flushes of the plume, where applicable.

02:001515_UK01_02_01_-B1466
Fig2-5.CDR-9/8/04-GRA




SOURCE: Ecology and Environment, Inc. 2001

**Figure 2-5 B817/WSA**
**CROSS SECTION A-A'**
**(TOTAL CHLORINATED ETHENES)**

# 3 Identification and Screening of Technologies

## 3.1 General Response Actions

Seven types of general response actions (GRAs) are applicable to the On-base Groundwater AOC at Griffiss AFB. Each of the following response actions will be discussed:

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

A no-action response must be evaluated during the course of the FS. As prescribed by the NCP, no action is only an acceptable alternative when it does not result in an unacceptable risk to human health and the environment.

Natural attenuation is a response that uses ongoing natural biological processes to reduce the concentrations of contaminants within an aquifer. There are often aerobic and anaerobic processes occurring within a plume that will eventually reduce contaminant concentrations to cleanup levels. The natural attenuation response action includes documentation of how these processes occur.

Institutional controls are implemented to reduce or prevent human exposure to contaminated groundwater. Deed restrictions, for example, may be placed on affected property to prohibit a landowner from installing drinking water wells within designated areas, or state or local health districts may issue notifications to prohibit well installation or water use for specified purposes unless it is treated to remove the contaminants.

Contaminated groundwater can be extracted through wells or collection trenches. Pumping wells (vertical, inclined, or horizontal) are usually preferred for locations where the water table is deeper, and collection trenches are applicable to shallower plumes. Typically, groundwater collection systems are combined with an ex situ treatment technology to remediate the contaminated groundwater. Contaminated groundwater may be controlled by installing relatively impervious barriers to intercept and divert the groundwater flow. Behind the barriers (e.g., slurry walls, pilings, etc.) trenches may be installed with pumped collection systems such as pipes and sumps.

In situ treatment of contaminated groundwater allows the groundwater to be treated in the aquifer without being captured. In situ treatment consists of biological, chemical, or physical treatment processes.

Ex situ treatment requires 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 establishing the physical, chemical, or biological conditions, or any combination of these conditions, that are required to remove or destroy the contaminants.

Disposal refers to the discharge of 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 some form of treatment at that facility prior to discharge. Disposal to surface water is typically direct, but it can be disposed of indirectly through a storm drain or a ditch.

## 3.2 Technology Selection

### 3.2.1 Limiting Considerations

The range of potential treatment technologies for use at the three plumes considered in this FS has been 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 three plumes are discussed below; they are presented in the same order as the general response categories discussed above.

### 3.2.2 No-action Alternative

The no-action alternative is included for consideration at each site for use as the basis of comparing the other alternatives, as required by the NCP.

### 3.2.3 Monitored Natural Attenuation (MNA)

Current Air Force policy requires the evaluation of natural attenuation. Monitored natural attenuation (MNA) 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 biological processes. Under the right conditions, anaerobic microorganisms can reductively dechlorinate organic solvents (including PCE and TCE observed at one or more of the three plumes), 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 (including DCE and VC observed at one or more of the three plumes). 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 EPA to document the natural attenuation process. This protocol provides the methods needed to verify natural attenuation is occurring, and the conditions under which it can be applied. MNA can be used to clean up a site if the existing processes are suitable to reduce contaminants as fast as they are released and if the plume would not migrate to potential future receptors.

MNA would be most applicable at the Landfill 6 plume where there are indications that reductive dechlorination is occurring. The landfill at Landfill 6 may provide sufficient electron donor material to allow this process to occur throughout the plume. Therefore, MNA will be retained for further consideration.

### 3.2.4 Institutional Actions

Institutional controls are not technologies. They consist of cultural factors 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 control can be used as a stand-alone alternative or can be used in conjunction with other technologies to achieve site RAOs. The Three Mile Creek and Six Mile Creek Records of Decision (RODs) (E & E December 2003) were considered in developing institutional actions to be used as a stand-alone alternative or to be used in conjunction with other technologies. Because groundwater in the vicinity of the identified plumes is not used as a drinking water source, institutional controls are effective in preventing exposure to groundwater contaminants and are readily implemented. Therefore institutional controls will be retained for further consideration.

### 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 from surface soil 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. Based on subsurface conditions, the depth of the slurry wall may be limited. For example, the excavation of slurry walls in dense, hard, fractured rock is difficult and often precludes implementation.

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. However, because the groundwater plumes at Landfill 6 and Building 775 sites are at depths greater than 40 feet below ground surface (BGS), and the depth to bedrock exceeds 60 feet in some areas, subsurface barriers would be technically difficult to construct. Furthermore, because the plumes are located so far below ground surface, with cleaner water closer to the ground surface in most areas, barrier walls could divert the plume into less contaminated zones above or below the plumes. While pumping the plumes would prevent divergence into less contaminated areas, pumping could be implemented effectively without the barriers. As there is no apparent threat of migration of the plumes into Three Mile Creek or other potential receptors, installation of barriers would not increase effectiveness of this treatment technology at these two plumes. For the relatively shallower plume at the Building 817/WSA, subsurface barriers may be cost-effective and may be effective in combination with a collection or in situ treatment technology. However, because the plume at Building 817/WSA is not expected to be approaching Six Mile Creek, there is no need to supplement treatment technologies with a subsurface barrier, and thus this technology is not retained for further consideration.

### 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 for the groundwater AOC include the use of trenching (with or without barriers to enhance control) and pumping wells.

### Collection Trenches

Groundwater collection trenches can be constructed inexpensively in areas of shallow groundwater. 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 at the Building 817/WSA site is relatively shallow (<20 ft BGS), 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 with 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 at all three plume sites. However, they will be retained for further consideration at Landfill 6 and Building 775 only because extraction wells are more cost-effective than collection trenches at depths contamination was observed at these sites (>50 feet BGS).

## 3.2.6 Ex situ Treatment

After groundwater is captured and pumped out of the subsurface, it can be treated by a wide variety of on-site and off-site systems.

### Physical/Chemical Treatment

The six technologies below are 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.

- **Filtration** is a well-established unit operation for achieving supplemental removal of residual suspended solids from wastewater. Filtration may be employed prior to air stripping 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** 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 usually pumped out continuously or intermittently. Oil and grease and other floating materials may be skimmed off the surface. For low-flow applications as would be considered in this study, filtration is more appropriate than sedimentation. Thus, this technology will not be retained for further consideration.

- **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 concentration range. 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 absorbs 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 part per billion (ppb). This process will be retained for further consideration.

- **Air Stripping/Steam Stripping** 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 trough 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 for 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.

### 3.2.7 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

**Bioremediation.** 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 does not occur naturally, it can be promoted by artificially providing the required conditions. Biological treatment, or biodegradation, can be enhanced aerobically using oxygen-releasing compounds (ORCs) and anaerobically using hydrogen-releasing compounds

(HRCs). Biodegradation of chlorinated organic compounds (including PCE/TCE) will occur if the proper anaerobic conditions are established. This process involves the injection of products into the subsurface to establish conditions favorable for existing microorganisms. If favorable anaerobic conditions are established, degradation of PCE/TCE would occur over time. The PCE/TCE degradation process would result in the attenuation of PCE/TCE (parent compounds) and the formation of other compounds (daughter compounds), including dichloroethene (DCE) and VC. VC is of concern as it is more toxic than PCE/TCE and is not degraded under anaerobic conditions. Thus, aerobic conditions would be necessary for VC degradation.

Based on a preliminary evaluation, biodegradation appears to occur at Landfill 6, due to the concentrations of daughter compounds found in groundwater during the 2000 SI. Biodegradation likely occurs on a limited basis at Building 817/WSA and Building 775. Further, the presence of daughter products at Landfill 6 suggests anaerobic conditions. Use of enhanced biodegradation would result in the formation of higher concentrations of PCE daughter compounds. These daughter compounds are expected to continue to migrate downgradient. The formation of daughter compounds may pose problems as these daughter products (i.e., formation of VC) do not readily biodegrade in anaerobic conditions. Therefore, this technology will not be further addressed in this report, due to limitations regarding effectiveness.

**Phytoremediation.** Phytoremediation is a process that uses plants to remove, transfer, stabilize, or destroy contaminants in groundwater and other media. The mechanisms of phytoremediation include:

- Enhanced biodegradation - takes place in soil or groundwater immediately surrounding plant roots;
- Phytoextraction - the uptake of contaminants by plant roots and the translocation/accumulation of contaminants into plant shoots and leaves;
- Phytodegredation - metabolism of contaminants within plant tissue; and
- Phytostabilization - production of chemical compounds by plants to immobilize contaminants at the interface of roots and soil.

Phytoremediation applies to all biological, chemical, and physical processes that are influenced by plants and that aid in cleanup of the contaminated substances. Similar to the COCs at these sites, this technology has been successfully utilized at several sites to remediate organic compounds in groundwater. However, this technology is typically applied for remediation of soil contamination above the water table. Use of this technology is limited to shallow groundwater plumes because, among other considerations, high concentrations of contaminants may be hazardous to the plants, and seasonal conditions may interfere/inhibit plant growth. Considering these factors, phytoremediation appears to be viable at Building 817/WSA only and will be discussed further in conjunction with other technologies.

### 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 carbon dioxide ($CO_2$) 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 ($O_2$). 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 the abundance and low cost of iron and hydrogen peroxide. 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 $O_2$.

Potassium permanganate is also an effective oxidizing agent for some, but not all, organic contaminants. The 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 into the environment is generally not a concern. However, the production of $MnO_2$ particles may result in reduction of permeability.

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 delivery of the aqueous chemical oxidants to the contaminated region. This is especially important with $H_2O_2$ because it is relatively unstable in the environment. Field demonstrations of in situ oxidation technologies have shown treatment efficiencies for VOCs ranging between 70% and 99%. Several commercial in situ oxidation technologies have been successfully field tested in recent years, including the ISOTEC$^{TM}$ and Geo-Cleanse Technology$^{TM}$ systems, which use a Fenton's-type reagent to oxidize organic contaminants. Both of these technologies could also use $KMnO_4$ as an oxidant instead of $H_2O_2$ or a Fenton's-type reagent. The use of $H_2O_2$ or $KMnO_4$ could be evaluated during bench- or pilot-scale studies. ISOTEC$^{TM}$ reportedly uses a modified Fenton's reagent that does not require a low pH environment and results in a lesser exothermic reaction and groundwater temperature change. In addition to the different oxidizing reagents used, the two technologies differ in the design of the mixing or injection heads.

Limitations of this technology include reduced levels of natural attenuation through reductive dechlorination for some time after active treatment. However, it is expected that these natural processes would re-establish themselves over time after active treatment has occurred.

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 quantity. Upon successful completion of the lab 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 site's 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 studies were performed on contaminated groundwater samples from Landfill 6, B775, and B817/WSA, and an on-site pilot study was performed at Landfill 6 and B817/WSA (E & E June 2004). (Pilot studies were not performed at B775 because of the challenges associated with oxidant distribution due to the depth of the plume and because the geology and contaminants of concern (COCs) at B775 are similar to Landfill 6.) Bench-scale test results indicated that TCE (contaminant of concern at the three sites) was effectively destroyed by chemical oxidation with permanganate. Pilot studies were located in the vicinity of Landfill 6VMW-12 and WSA-MW11 at Landfill 6 and B817/WSA, respectively, and exhibited a general decrease of total VOCs including site-specific COCs. (See Sections 4.1.4, 5.1.3, and 6.1.3 for further discussion.) Therefore, in situ chemical oxidation will be retained as an applicable technology at all three sites.

**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 and is considered a manipulation of redox in the groundwater. 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. The funnel and gate system uses impermeable funnel sections that are installed to direct groundwater to the reactive permeable gate sections containing the zero-valent iron. The continuous permeable wall system uses a reactive wall section that 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 cleanup levels.

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™. 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. 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 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 technical- and cost-effective up to depths of about 45 feet. This technology would therefore be more appropriate for the shallow plume (20 feet) at Building 817/WSA. Because the depth to bedrock near the southern end of the plume is approximately 6 feet, a reactive wall anchored to the bedrock and placed in a collection trench may be an appropriate remedial alternative for this site. Therefore, this technology is retained for further consideration at Building 817/WSA.

**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 and is also considered a manipulation of redox in the groundwater. To implement this technology, iron (doped with some deposits of palladium catalyst to increase reaction rates) is introduced into the aquifer 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 would travel from the injection spot to have a sufficient radius of influence but also ideally 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 situated in relatively slow-moving groundwater that would minimize the effect of continued BMP migration following injection, indicating in situ BMP treatment may be a viable technology at the three sites.

Bench-scale and pilot studies were performed at two or more of these sites in 2002-2003 using in situ chemical oxidation as it is a more proven technology than in situ BMP treatment. During these studies, in situ chemical oxidation has proven to be effective in reducing contaminant mass; therefore, additional investigation of another innovative in situ technology, such as BMP treatment, is not warranted. This technology will not be further addressed in this FS.

### Physical In situ Treatment

Although air sparging is another physical in situ treatment technology, its effectiveness and implementability are similar to in-well air stripping. Therefore for simplicity, one technology is presented below, in-well air stripping.

**In-well Air (Vapor) Stripping.** In-well air stripping, also known as groundwater circulating wells and in-well aeration, is a technology that combines the concepts of groundwater recirculation and air stripping to remediate VOCs. In-well air stripping differs from the traditional in situ air sparging concept in that the air stripping process occurs within the well casing rather than the aquifer formation.

The in-well air stripping process involves injecting air into a double-cased (well-within-a-well) double-screened well, thus decreasing the density of groundwater and allowing it to rise within the inner well casing. VOCs in the groundwater are transferred from the dissolved to the vapor phase by rising air bubbles through an air stripping process. Contaminated vapors either rise or are drawn off to the surface where they undergo further treatment or are directly discharged to the atmosphere if compliant with state air regulations. The groundwater that has been partially stripped of VOCs is discharged through the upper screen into the vadose zone and back to the water table. The continuous extraction and re-introduction of groundwater above the water table creates a circulation pattern in the subsurface, which continuously circulates water through the system until sufficient contaminant removal is achieved. Typically, the lower screen of the double-cased well is placed at or near the bottom of the contaminated aquifer, and the upper screen, through which groundwater is discharged, is placed above the water table.

Different variations of the in-well air stripping systems have been patented and implemented in the United States. The most common in-well air stripping systems include NoVOCs™, Unterdruck-Verdampfer Brunner (UVB), and Density Driven Convection (DDC) systems. Both the NoVOCs and DDC systems are similar to the generic description above. Air is injected into the inner well casing via an air blower or compressor that creates a density gradient that lifts water within the well and through the upper screen to the vadose zone. Contaminated vapors are captured by a vacuum system and treated if required. Contaminated vapors may be exhausted to the atmosphere, collected for treatment, or exhausted via the upper screen into the vadose zone for bioremediation (if applicable) in the DDC system. The UVB system uses a submersible pump in the well to supplement the air-lifting mechanism and provide a more constant pumping extraction rate from the well. A stripper reactor is also used with the UVB system to promote VOC transfer from the aqueous to the vapor phase by increasing the contact time between the two phases.

Similar to in situ oxidation, limitations of this technology include reduced levels of natural attenuation through reductive dechlorination for some time after active treatment. However, it is expected that these natural processes would re-establish themselves overtime after active treatment has occurred.

In-well air stripping is a relatively new technology in the United States, although operational success of this technology has been demonstrated in at least 50 sites. Treatment efficiencies for in situ air stripping systems range from 85% to 99%, depending on site-specific conditions. A pilot-scale implementation of this technology is generally required to assess its applicability to the site prior to full-scale implementation. In-well air stripping may be applicable to the three groundwater plumes. Therefore, this technology will be retained for further consideration at the three sites.

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

## 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 POTW, whether 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 treated groundwater can be disposed of indirectly through a storm drain or a ditch.

**Table 3-1 Summary of Groundwater Treatment Technologies**

| Section Reference | Technology | Viable | | | Further Considered | | |
|---|---|---|---|---|---|---|---|
| | | Landfill 6 | B775 | B817 | Landfill 6 | B775 | B817 |
| 3.2.2 | No Action | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3.2.3 | Monitored Natural Attenuation | ✓ | | | ✓ | | |
| 3.2.4 | Institutional Actions | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Capture and Control** | | | | | | | |
| 3.2.5 | Subsurface Barriers | | | ✓ * | | | |
| 3.2.5 | Collection Trenches | | | ✓ | | | ✓ |
| 3.2.5 | Extraction Wells | ✓ | ✓ | ✓ | ✓ | ✓ | |
| **Ex Situ Treatment** | | | | | | | |
| 3.2.6 | Precipitation/Coagulation/ Flocculation | ✓ * | ✓ * | ✓ * | | | |
| 3.2.6 | Filtration | ✓ * | ✓ * | ✓ * | | | |
| 3.2.6 | Sedimentation | | | | | | |
| 3.2.6 | Activated Carbon Adsorption | ✓ * | ✓ * | ✓ * | ✓ | ✓ | ✓ |
| 3.2.6 | Air Stripping/Steam Stripping | ✓ * | ✓ * | ✓ * | | | |
| 3.2.6 | Ultraviolet Oxidation | ✓ * | ✓ * | ✓ * | | | |
| **In Situ Treatment** | | | | | | | |
| 3.2.7 | Bioremediation | ✓ | | | | | |
| 3.2.7 | Phytoremediation | | | ✓* | | | ✓ |
| 3.2.7 | Chemical In situ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3.2.7 | In situ Zero-valent Iron Reactive Walls | | | ✓ | | | ✓ |
| 3.2.7 | In situ Nano-scale Bimetallic Particles | ✓ | ✓ | ✓ | | | |
| 3.2.7 | In-Well Air (Vapor) Stripping | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

* Technology applicable when combined with other technology(ies).

### 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. Griffiss AFB has a system of sanitary sewer pipes that discharges to the city of Rome sewer treatment plant, the only facility available to receive (treated or untreated) discharged groundwater. The POTW must verify that it will continue to meet its permitted discharge levels while receiving the groundwater captured from the site. This technology will be considered further.

### Reinjection Into the Aquifer

Treated groundwater can be returned to the aquifer through the use of injection wells. 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. Special permits are also typically required for reinjection. Therefore, this technology will not be considered further.

### Surface Water Discharge

Discharge to surface water may be performed directly or indirectly by discharge to a storm drain. In either case, a discharge permit 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 Landfill 6 Plume Treatment Alternatives

## 4.1 Development of Alternatives

In this section, technologies retained in Section 3 are assembled into alternatives appropriate for the Landfill 6 plume. The Three Mile Creek ROD (E & E December 2003) was considered in developing these alternatives. In general, the ROD selects excavation of contaminated sediments with long-term monitoring (and source control) as the selected remedy, in which remediation of the Landfill 6 plume is not mentioned. As discussed in Section 2.5, the Landfill 6 groundwater plume consists of a relatively deep plume that has migrated southwest from the Landfill 6 and Hardfill 49C area. To address this contamination, six alternatives have been developed:

- Alternative 1: No Action
- Alternative 2: Institutional Actions
- Alternative 3: Monitored Natural Attenuation
- Alternative 4: In situ Oxidation
- Alternative 5: In-Well Air Stripping
- Alternative 6: Extraction, Treatment, and Disposal

Each of these alternatives are described in detail in the following sections.

### 4.1.1 Alternative 1: No Action

Under this alternative no action would be taken for treatment of the Landfill 6 plume. The plume would be allowed to migrate and naturally attenuate. However, no monitoring would be conducted to evaluate the progress of these natural processes.

### 4.1.2 Alternative 2: Institutional Actions

To prevent future exposure to contaminated groundwater, this alternative calls for implementing restrictions on the use of groundwater at the Landfill 6 AOC. The groundwater use restrictions would include deed restrictions to prevent future use of the groundwater. In addition, fencing would be installed to limit site access and a groundwater monitoring program would be implemented to evaluate the extent of migration and attenuation of the plume. This alternative would not provide for cleanup in a reasonable and predictable timeframe; therefore, the potential need for a waiver would need to be discussed with the appropriate regulatory agency(ies).

In order to properly monitor the plume, biannual groundwater sampling would be performed to determine and monitor seasonal water table and contaminant concentration fluctuations. Although the contaminant plume at this site was adequately delineated both horizontally and vertically during the 2000 Groundwater Study (E & E August 2000), 50% of the data was obtained from temporary hydropunch borings. Therefore, the location of the existing monitoring wells at the site are not adequate to properly monitor the plume on a long-term basis. Five wells (LF6VMW9R, LF6MW-12RD, -13RD, -14D, and LF6VMW-27) would be installed (see Figure 4-1) and sampled in the long-term monitoring program in addition to sampling seven existing permanent wells (LF6VMW-8, 10R2, 12R, -13R, -14, -15R, and LF6MW-12). New programs at the base may result in the installation of new wells at this site, whereas installation of the Landfill 6 cap may result in monitoring well decommissioning. Therefore, monitoring wells proposed for the long-term monitoring program at this site may be impacted and the numbering/locations of the proposed wells may be modified during the design stage. To monitor the potential discharge of site groundwater to Three Mile Creek, the identification of potential seeps shall be performed. If a seep is identified during the inspection a surface water sample shall be collected. Other programs at the base such as the approved Three Mile Creek LTM efforts may already be performing this sampling and efforts should be coordinated during the design phase to eliminate redundancy.

One well (LF6VMW-9R) would be installed southwest of hydropunch boring LF6VMW-9 and another well (LF6VMW-27) would be installed between LF6VMW-14 and LF6VMW-15R because there are no downgradient wells defining the edge of the plume in these areas. Vertical profiling would be performed during the installation of these wells to determine the optimal screen interval. LF6VMW-9R well would monitor the southwest downgradient edge of the plume and LF6VMW-27 would monitor the southeast downgradient edge of the plume. The three remaining wells (LF6MW-12RD, -13RD, and -14D) would be installed as deep wells (i.e., with 10-foot screens at the top of bedrock) adjacent to LF6VMW-12R, -13R, and -14, respectively. The purpose of these wells would be to monitor the aquifer zone beneath the currently screened interval of the wells

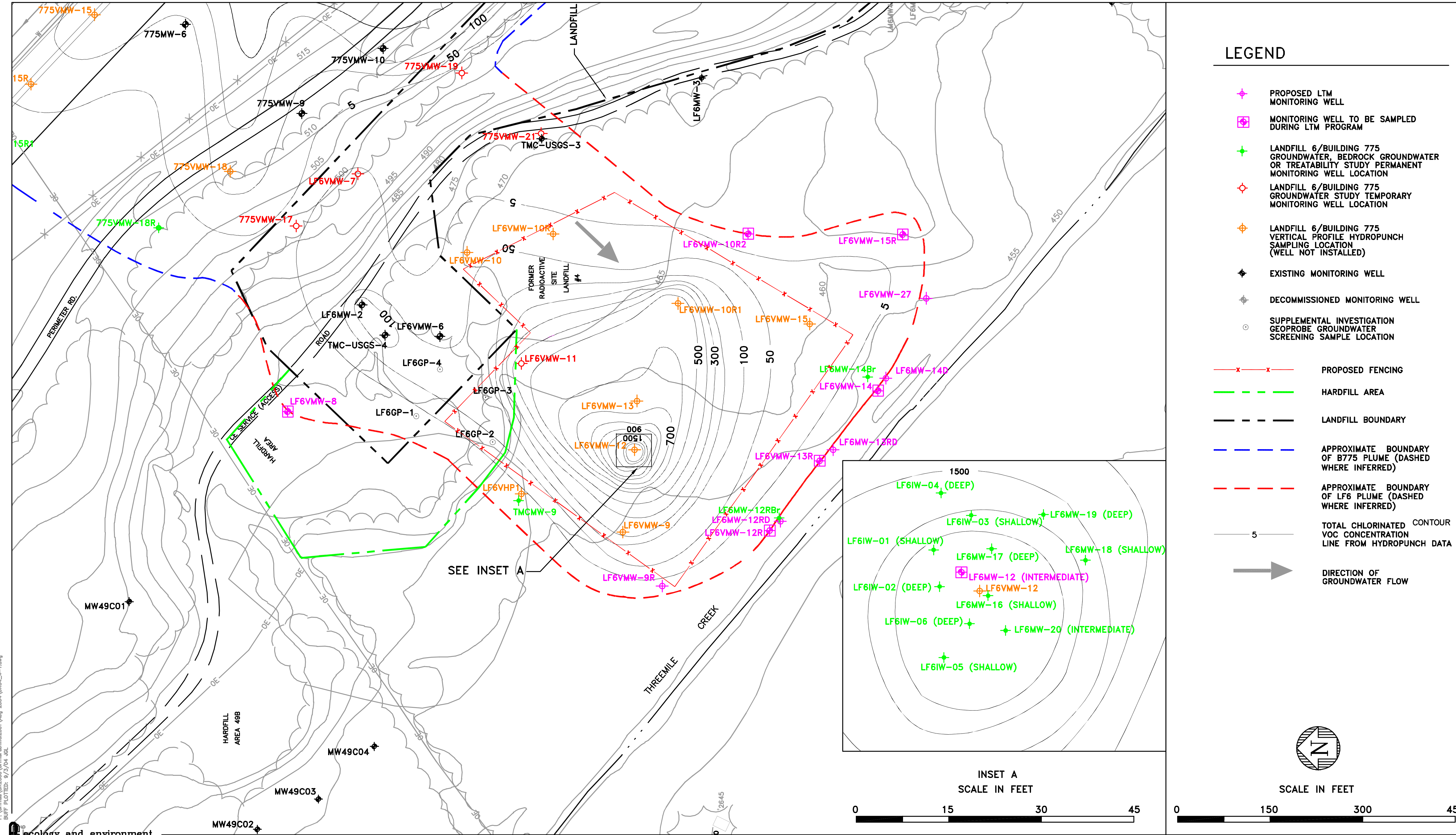





FIGURE 4-1 LANDFILL 6 ALTERNATIVE 2
INSTITUTIONAL ACTIONS
FORMER GRIFFISS AFB
ROME, NEW YORK

along Three Mile Creek to ensure that the plume does not go undetected if it becomes deeper in the aquifer as it migrates further downgradient.

The 12 wells (seven existing and five new) would be tested for the contaminants of concern (PCE/TCE/DCE/VC) through analysis of a suite of VOCs using low-level method SW8260B. This low-level method could produce detection limits that are five times less than the standard method, enabling quicker detection of contaminants migrating downgradient into wells that are currently clean.

Because contaminants would remain above groundwater standards for the foreseeable future, a deed restriction would have to applied to the area where contamination above ARARs is present to minimize the potential for future uses of groundwater.

For purposes of this FS, it is assumed that on-site contaminant concentrations would remain above ARARs for the 30-year alternative duration and that remedial actions at the site may require a re-evaluation at that time. However, if concentrations observed on-site achieve ARARs, this alternative would no longer be needed, monitoring would be reduced or eliminated, and a report written requesting site closure.

### 4.1.3 Alternative 3: Monitored Natural Attenuation

This alternative would employ natural processes to reduce contaminant concentrations within the aquifer. In a broad sense, monitored natural attenuation refers to a range of physical and biological processes that may occur within the aquifer that result in reduced contaminant concentrations. For example, the physical processes of volatilization and dispersion may serve to reduce concentrations of volatile contaminants, as observed at Landfill 6. However, contaminant transformation by biological mechanisms is an important consideration when using natural attenuation as a viable alternative to reduce groundwater contamination levels. The Air Force, through its *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater* (Wiedemeier et al. 1995) (for fuel-related volatiles), and the draft *Overview of the Technical Protocol for Natural Attenuation of Chlorinated Aliphatic Hydrocarbons in Ground Water Under Development for the U.S. Air Force Center for Environmental Excellence* (Wiedemeier et al. 1996) (for chlorinated contaminants) has defined natural attenuation more narrowly to specifically describe situations in which biological transformation is the primary mechanism in the removal of contaminants in the aquifer.

To implement monitored natural attenuation in accordance with the Air Force protocols, a fairly rigorous field effort is required to scientifically demonstrate that contaminants on the site are degrading at rates sufficient to be protective of human health and the environment. This field effort would include studies to document loss of contaminant mass at the field scale or microbiological laboratory data to support the occurrence and measure the rate of biodegradation. To implement these studies, additional wells would have to be installed to perform the following functions:

- Evaluate contaminant and natural attenuation parameter concentrations within the plume, and

- Gather additional data required for evaluating site hydraulics and in situ natural attenuation parameters.

For the Landfill 6 plume, implementation of the monitored natural attenuation protocols is assumed to require the installation of eight new monitoring wells located within the plume and sampling of eight existing wells as indicated on Figure 4-2. The new wells consist of the five wells described for long-term monitoring (Alternative 2) and three additional wells. The first additional well is a deep well, LF6MW-11D, located adjacent to LF6VMW-11. This well would be installed to measure vertical hydraulic gradients in this area of the plume. The other two additional wells would be a deep-and-shallow well pair near the hydropunch LF6VMW-10R1 sampling location. No well was installed in this location, but hydropunch samples indicated total VOC concentrations were >500 µg/L in this portion of the plume. The shallow well would be installed in the region where the contamination was detected (approximately halfway down the water column), while the deep well would be screened near bedrock and used for determining vertical hydraulic gradients, which is required for accurate flow modeling. New programs at the base may result in the installation of new wells at this site, whereas installation of the Landfill 6 cap may result in monitoring well decommissioning. Therefore, monitoring wells proposed for the long-term monitoring program at this site may be impacted and the numbering/locations of the proposed wells may be modified during the design stage.

Groundwater samples would be collected from all newly installed wells and from the existing wells identified on Figure 4-2. Groundwater samples would be analyzed for VOCs and the natural attenuation parameters summarized in Table 4-1.

Based on a comparison of the 1997 and 2000 sampling results, it appears that there is no major source area continuing as a source at the Landfill 6 plume and that concentrations are decreasing in upgradient wells. Downgradient sampling was conducted only in the most recent groundwater investigation; therefore, it is not known whether downgradient concentrations are increasing or decreasing. However, based on the decreasing concentrations observed in the upgradient wells, it is possible that the plume may not be in a steady condition (i.e., potentially slowly moving downgradient). At least two years of quarterly groundwater sampling would be required to acquire the data needed to assist in determining the state of the plume.

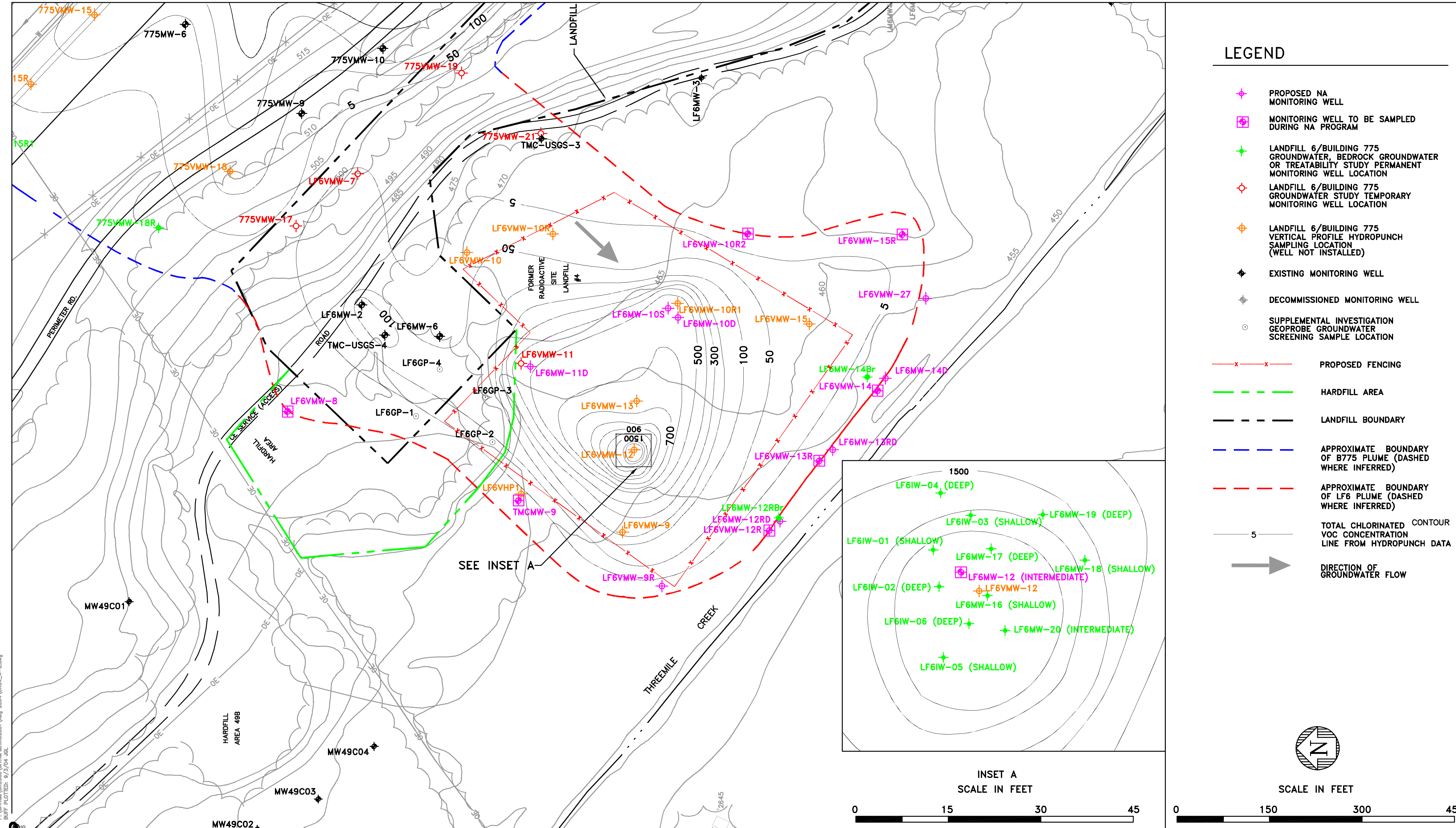





FIGURE 4-2 LANDFILL 6 ALTERNATIVE 3 MONITORED NATURAL ATTENUATION FORMER GRIFFISS AFB ROME, NEW YORK

In addition to submitting the groundwater samples for testing, the analytical data, hydrogeologic data, site-specific permeabilities, and gradient information would also be collected in the field. These data are required for further ongoing evaluation of the plume. Water-level measurements and slug testing would be performed for each well. Additional data from a pump test conducted in the center of the plume would be collected. Groundwater elevation measurements would enable the calculation of flow gradients, and slug testing would provide permeability estimates. These parameters would be used in the development of models that estimate biodegradation rate constants. Because groundwater elevations can vary seasonally and with extreme precipitation events, the water levels would be measured monthly for one full year.

**Table 4-1 Parameters that Evaluate the Presence of Biological Activity**

| Parameter | How Parameter Impacts or Reflects Bioactivity |
|---|---|
| Total organic carbon | Organic carbon is needed either as an electron donor in reductive dechlorination or as a principle substrate in co-metabolism. |
| Oxygen[a] | Elevated oxygen precludes reductive dechlorination, but promotes co-metabolism and direct oxidation. |
| Redox potential[a] | Direct oxidation requires higher redox potentials. Lower potentials are useful in evaluating whether other electron acceptors are being used or are capable of being used. |
| Nitrate, sulfate | Potential electron acceptor in anaerobic environments |
| Ferrous iron[a], sulfide | Presence may indicate use of ferric iron or sulfate, respectively, as electron acceptors in anaerobic environments. |
| Methane, ethane, and ethene | Presence suggests reductive dechlorination or biodegradation via methanogenesis. |
| Chloride | Presence suggests reductive dechlorination. |
| Alkalinity[a] | Elevated alkalinity suggests generation of carbon dioxide from direct oxidation. |
| pH[a] | Microbial activity tolerated in pH environments ranging from 5 to 9 S.U. |
| Temperature[a] | Directly affects the solubility of dissolved gasses and other geochemical species and the metabolic activity of bacteria. |
| Conductivity[a] | Measures the ability of a solution to conduct electricity. Conductivity increases as ion concentration increases. |

[a] Natural attenuation parameters to be performed in the field using portable equipment.

Based on the data collected as described above, modeling would be conducted and a conceptual model of the plume developed. This model would include consideration of the degradation of the contaminants of concern. At a minimum, a two-dimensional flow model would be required, using a model such as MODFLOW. If nested wells show that a vertical component of flow is also present, then a three-dimensional model may be needed. The model would be calibrated with the hydraulic properties measured during the investigations described above.

A microcosm study will be completed if natural attenuation parameters do not conclusively demonstrate that biodegradation is occurring. It is assumed that the need for a microcosm study will be discussed with the appropriate regulatory agency(ies) after the natural attenuation parameter evaluation is completed. For purposes of the FS (i.e., costing), it is assumed a microcosm study will be needed.

The results of this monitoring would be used to predict whether potential human and environmental receptors at Three Mile Creek or potential users of the groundwater off-site in the future could be impacted. Future users of groundwater would not be considered as potential future receptors as it is already known that groundwater is contaminated in areas where new wells would be located for future groundwater usage. Thus, this alternative would have to be combined with deed restrictions prohibiting future use of groundwater in the zone where contamination observed is above ARARs.

Following the program outlined above, the plume would require ongoing monitoring to ensure that the plume does not migrate and impact potential future receptors. The monitoring program would be the same as described for Alternative 2, Long-term Monitoring (although wells installed for the monitored natural attenuation program would be used rather than the new wells called for by that alternative). In addition, samples will be collected and analyzed for natural attenuation parameters. It is assumed that such monitoring would be required for 30 years.

For purposes of this FS, it is assumed that on-site contaminant concentrations would remain above ARARs for the 30-year alternative duration and that remedial actions at the site may require a re-evaluation at that time. However, if concentrations observed on-site achieve ARARs, this alternative would no longer be needed, monitoring would be reduced or eliminated, and a report written requesting site closure.

### 4.1.4 Alternative 4: In situ Oxidation

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 cleanup goals were achieved. During this action there would be continued monitoring of the extent of migration or natural attenuation of the plume.

Between February 2002 and March 2004, 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, potassium permanganate ($KMnO_4$) was selected as the most effective oxidizing agent. The use of $KMnO_4$ produces $MnO_2$ particles as a by-product, which are not a concern as they are naturally present in the soils. However, the formation of $MnO_2$ from the oxidation reaction may result in reduction of permeability and clogging, thus reducing the treatment efficiency. (Observations made during the pilot study indicated that elevated levels of metals in groundwater were detected between pre- and post-injection sampling rounds; however, these levels are expected to be localized to the treatment area.) Based on the results of the bench-scale study, a pilot study was conducted at the site in two phases in November 2002 and November 2003, which targeted an area in the vicinity of LF6VMW-12, where one of the highest total VOC concentrations (primarily TCE; greater than 2,500 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 using $KMnO_4$ were performed for groundwater at Landfill 6 by ENVIROX LLC in June 2002 (E & E June 2004). Results from the tests on the groundwater indicated that TCE was effectively destroyed by $KMnO_4$. It should be noted that the soil sample used in the bench-scale study was obtained from a borehole near LF6MW-12, where the highest TCE concentrations were detected. A contaminated groundwater sample was inadvertently not collected; therefore, a TCE-spiked water sample was used for the bench-scale test. The successful bench-scale results using $KMnO_4$ 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, three well clusters, each consisting of two injection points for a total of six new injection wells, were installed at the site perpendicular to the groundwater flow direction in the vicinity of LF6VMW-12 because this area exhibited the highest TCE concentrations. The well cluster approach was used to provide adequate distribution of the oxidant into the contaminated zone and to minimize potential short-circuiting or preferential pathways of the oxidant. At this location, the total saturated thickness is approximately 80 feet, with the highest contaminant concentrations between 41 and 51 feet below ground surface. With the well cluster approach, each injection point targeted a separate 10-foot saturated interval with a 2-foot overlap, ranging between 37 to 55 feet below ground surface. The injection point clusters (i.e., consisting of one shallow and one deep injection point) were spaced 15 feet apart. Injection activities occurred in November 2002 and consisted of delivering 12,000 gallons of 0.6% by weight of $KMnO_4$ by gravity. In November 2003, a second injection event occurred in which 39,000 gallons of 1.5% by weight of $KMnO_4$ was gravity-fed into the same six injection wells.

One existing monitoring well (LF6MW-12) and five new monitoring wells downgradient of the injection location were selected to monitor VOCs, DOC, and Target Analyte List (TAL) metals levels during the baseline and one or more of the five subsequent sampling rounds. Baseline groundwater sampling was conducted in October 2002 prior to injection activities, while the first and second rounds of post-injection sampling were conducted at two and six weeks, respectively. A second baseline sampling round (Round 3) was conducted in November 2003, prior to the second injection event. Two additional sampling rounds were conducted two weeks and four months following the second injection (Round 4 and 5, respectively).

The results of the pilot study generally indicated a general decrease in VOC concentrations from the study area. Although initially there was no indication of contaminant reduction in the treatment area within a six-week performance-monitoring period after the first injection, there was an approximately 30% to 50% reduction of VOCs in all of the injection wells and some of the monitoring wells one year after the first injection event (but before the second injection event). The poor response of the oxidant after the first injection is believed to have been the result of a higher natural oxidant demand (NOD) in the treatment area than anticipated, which consumed most of the oxidant before it could reduce site contaminants (not enough oxidant mass was injected to overcome the NOD). The results of the second injection exhibited a full reduction of TCE in the injection wells within two weeks of the injection, followed by a rebound four months after the injection. Two injection wells sustained a 50% to 77% overall TCE reduction and approximately 50% total VOC reduction after the second injection from baseline conditions (prior to the first injection) (E & E June 2004). In general, the pilot study results indicated that conditions at the site are conducive to treating TCE and other VOCs at the site; however, considerations about the oxidant delivery system may be further refined in the design stage if this alternative is selected.

This alternative assumes a 15-foot radius of influence in areas with total VOC concentrations greater than 50 μg/L. Permanent injection wells were advanced during the pilot study. However, for costing purposes it was assumed that temporary injection wells would be advanced using the Geoprobe method at this site. One-inch PVC casing with a 10-foot screen at various depths, depending on well location, would be left in place as the Geoprobe rod is pulled out. By installing these temporary wells, the drilling crew can work independently of the injection crew, allowing more flexibility with scheduling than if the Geoprobe unit were used to directly inject the oxidant as the rod is pulled out. In addition, pressure injection up to 10 gallons per minute (gpm) of the oxidant is proposed to further reduce time spent in the field. This approach would result in significant cost savings, considering the size and depth of the plume, compared to installing well clusters. Although previous on-base work involving Geoprobes showed a total penetration depth of 60 feet BGS, discussions with drilling contractors have indicated penetration depths of up to 120 feet. Since the plume exhibits localized areas of high contamination, and because the cost of implementing in situ type technologies is proportional to the area, a more cost-effective approach would involve targeting the areas with high levels of VOC contamination.

This FS assumes full-scale remediation using this technology for the area contained within the 50-µg/L total VOC concentrations contour line (see Figure 4-3). Remediating this area would remove about 99% of the contaminant mass and approximately 57% (or 4.8 acres) of the plume area (see Table 4-2). Although biological activity would be reduced in those areas directly affected by the oxidant, contaminant concentrations remaining on-site above cleanup levels after injection event(s) have occurred are expected to continue to attenuate naturally (by biological and other processes).

**Table 4-2 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at Landfill 6**

| Contour Interval (µg/L) | Lower Bound Concentration of Contour Interval (µg/L) | Area of Contour Interval ($ft^2$) | Cumulative Percentage 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 (%) |
|---|---|---|---|---|---|
| >2500 | 2500 | 635 | 0 | 0.10 | 3 |
| 2000-2500 | 2000 | 365 | 0 | 0.05 | 4 |
| 1500-2000 | 1500 | 1,000 | 1 | 0.09 | 6 |
| 1000-1500 | 1000 | 1,384 | 1 | 0.09 | 9 |
| 900-1000 | 900 | 2,174 | 2 | 0.12 | 12 |
| 800-900 | 800 | 2,684 | 2 | 0.13 | 16 |
| 700-800 | 700 | 5,919 | 4 | 0.26 | 23 |
| 600-700 | 600 | 15,154 | 8 | 0.57 | 38 |
| 500-600 | 500 | 29,837 | 16 | 0.93 | 63 |
| 400-500 | 400 | 16,975 | 21 | 0.42 | 74 |
| 300-400 | 300 | 15,470 | 25 | 0.29 | 82 |
| 200-300 | 200 | 18,717 | 30 | 0.23 | 88 |
| 100-200 | 100 | 28,282 | 38 | 0.18 | 93 |
| 50-100 | 50 | 68,926 | 57 | 0.22 | 99 |
| 5-50 | 5 | 154,181 | 100 | 0.05 | 100 |
| **Total** | | **361,703** | | | |

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

The number of temporary injection wells required to effectively cover this area is approximately 231 wells, which will be installed to target two to four separate saturated intervals depending on the plume thickness in the area (the pilot study targeted two separate intervals). One scenario may be installation of the wells in rows perpendicular to the groundwater flow with each row targeting a different interval (i.e., starting with deeper wells upgradient). Another scenario may be installation of the wells in rows perpendicular to the groundwater flow but with each well in the same row targeting a different interval. Each well would be offset horizontally as well as vertically from adjacent wells to facilitate complete distribution of the oxidant throughout the aquifer. For costing purposes, average well depths were assumed for well installations. The injection well configuration and target intervals will be refined during the design stage. Field parameters such as ORP, conductivity, and water levels will be collected during the injection activities to assess oxidant distribution in the subsurface.

For purposes of costing this alternative, one primary injection event was assumed and one secondary event. The secondary injection event is intended as a polishing step to target areas where contaminant concentrations and mass were not reduced to acceptable levels (approximated at 50% of the treatment area). The primary and secondary injection events are assumed to occur within one year.

Monitoring the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2. Two additional sampling rounds will be collected during the first year (for a total of four) to adequately monitor the plume during treatment. Metals are not expected to mobilize within the plume; therefore metals analysis is not included in the long-term monitoring program. Since this alternative involves active treatment of and destruction of contaminants of concern, maintenance of institutional controls and the long-term monitoring program was assumed for 10 years only. If contaminants of concern remain above proposed cleanup goal concentrations after the assumed 10-year long-term monitoring period based on data evaluation, additional monitoring may be needed.

### 4.1.5 Alternative 5: In-Well Air Stripping

This alternative involves the installation of groundwater-circulating/air-stripping wells to strip the contaminated groundwater of contaminants (see Figure 4-4). The contaminated vapors can be drawn off and treated above ground, discharged directly into the atmosphere, or discharged into the vadose zone to be degraded in situ via bioremediation. The treated groundwater is not removed from the subsurface but is cycled through a groundwater circulation cell that is created around the well. This circulation cell is a result of the continuous extraction of contaminated groundwater at the bottom of the aquifer or polluted portion thereof and reintroduction of the treated/stripped groundwater into the top of the aquifer or above into the vadose zone.

In-well air stripping systems can be a cost-effective approach for remediating VOC-contaminated groundwater at sites with deep water tables because the water does not need to be brought to the surface. In addition, treatment durations for this technology are expected to be shorter because treatment wells can be strategically located throughout the plume actively treating a smaller volume of groundwater per well as opposed to pump and treat which relies on contaminated groundwater to flow to the treatment wells. This results in reduced energy demands and thus a significant energy cost savings. At Landfill 6, the average depth to groundwater contamination is 19 feet. Based on the results of the Spring 2000

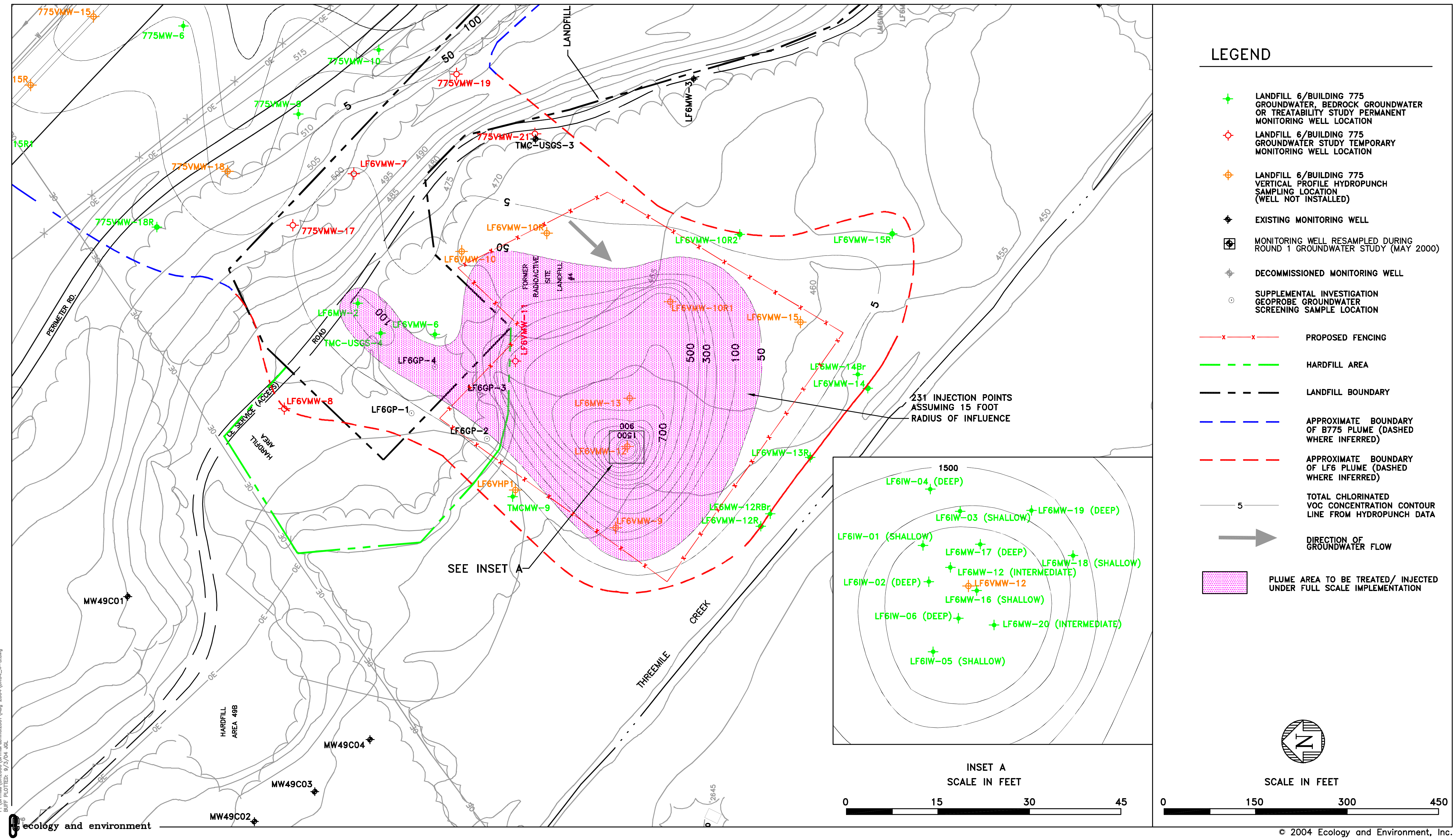
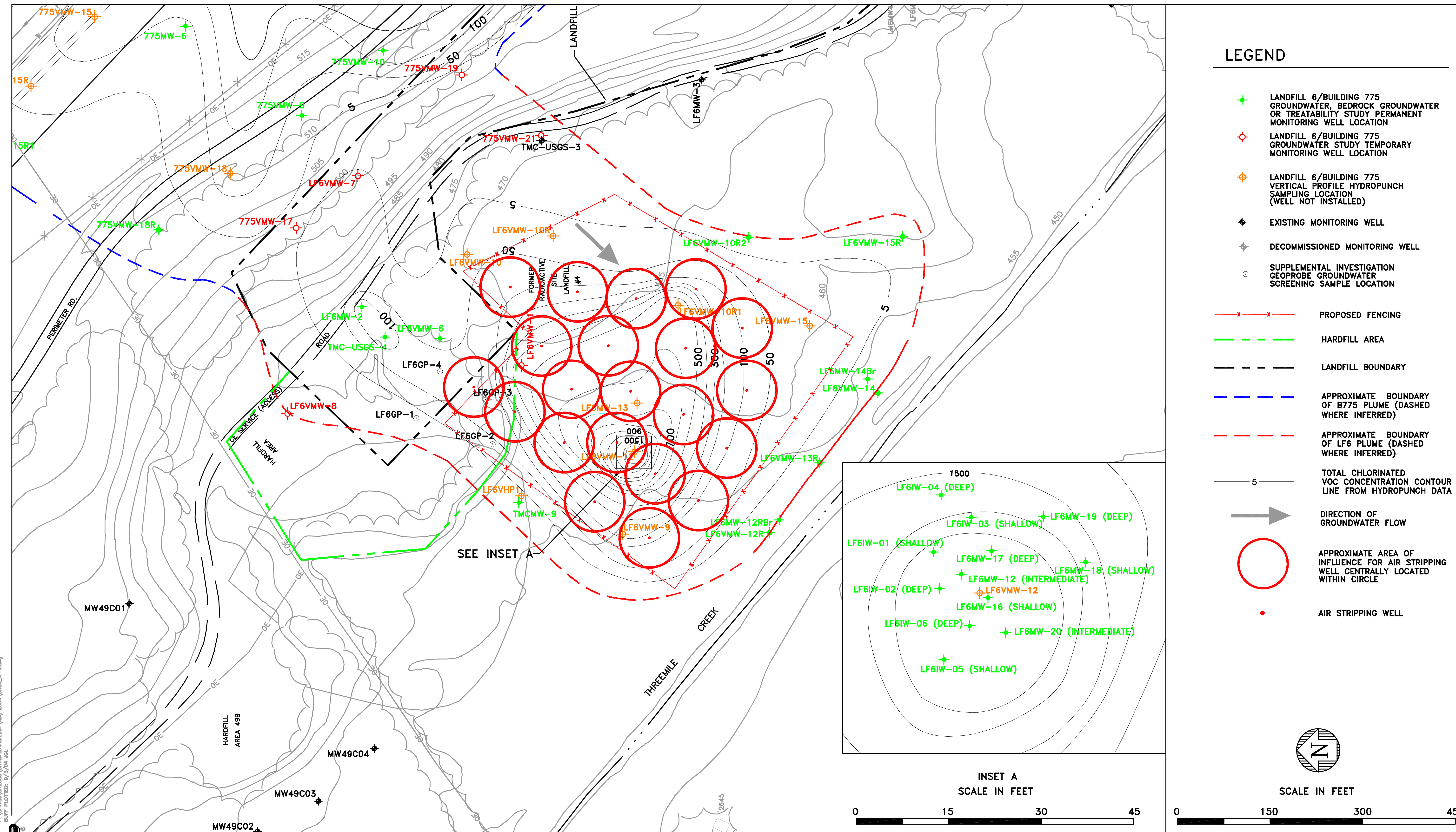





FIGURE 4-3 LANDFILL 6 ALTERNATIVE 4
IN-SITU OXIDATION
FORMER GRIFFISS AFB
ROME, NEW YORK




ecology and environment

© 2004 Ecology and Environment, Inc.

FIGURE 4-4 LANDFILL 6 ALTERNATIVE 5
IN-WELL STIRPPING
FORMER GRIFFISS AFB
ROME, NEW YORK

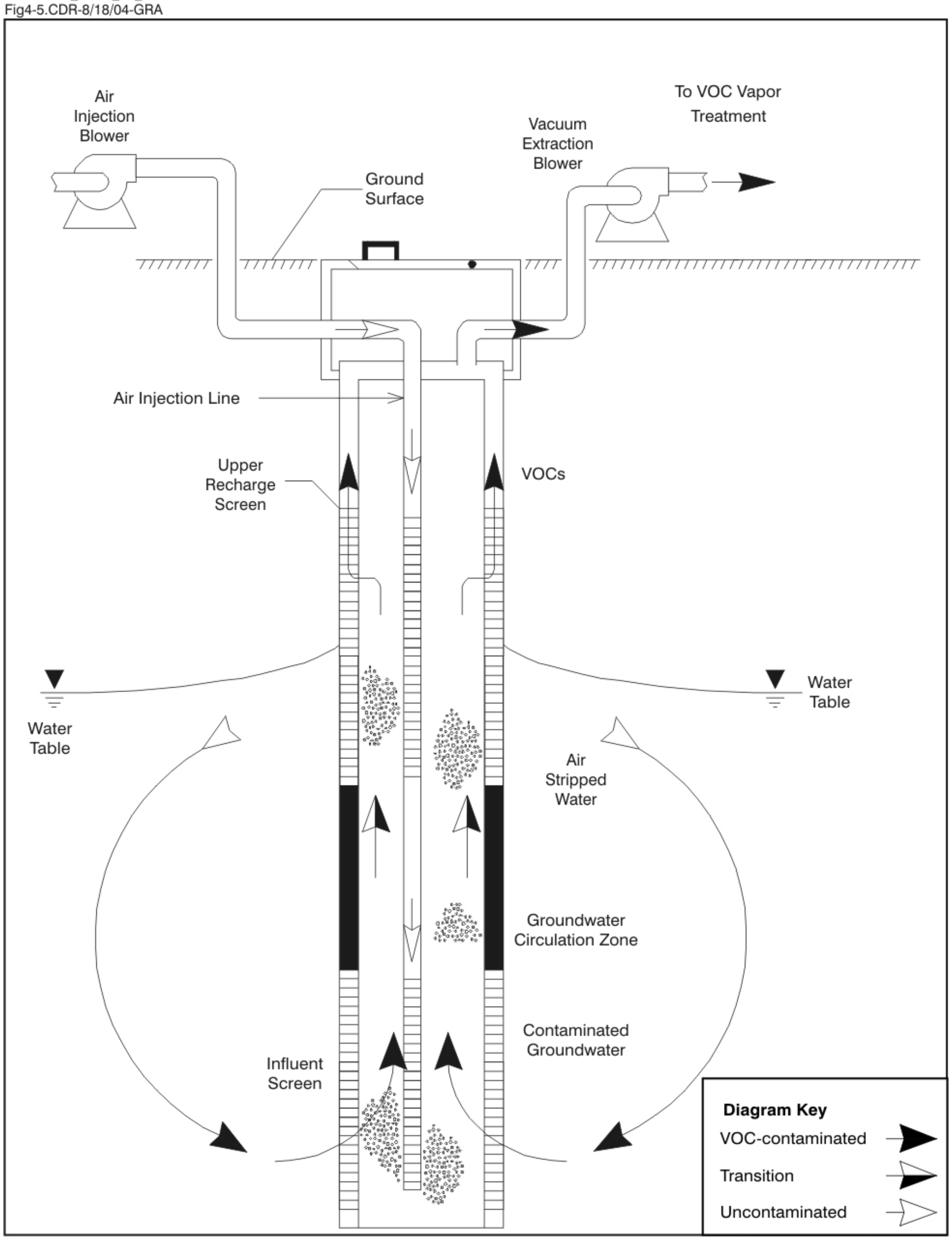
SI conducted by E & E, the geologic conditions correspond with the design and operating parameters for optimum performance of this technology. The average hydraulic conductivity (K) and hydraulic gradient at the Landfill 6 site are $10^{-4}$cm/sec and 0.001 ft/ft respectively. The site consists of uniform mixtures of silty sands and sand/silt mixtures with no adverse stratigraphy, such as the presence of low permeability layers continuous over large areas. The hydraulic conductivity, which is within the desired operating limit of K > $10^{-5}$cm/sec (see the Federal Remediation Technologies Roundtable, which can be accessed at http://www.frtr.gov/matrix2/section4/4-40.html, and the very low hydraulic gradient would enable the wells to capture and sufficiently treat the water several times, via recirculation, before it flows out of the treatment zone.

Geochemical characteristics of the site can affect the performance of the system if not properly controlled. No leachate was identified during groundwater sampling in previous studies. The high dissolved oxygen concentrations caused by air stripping can cause precipitates to develop in the air stripping well and in the aquifer at locations away from the well. This is caused by the oxidation of iron and manganese and can clog the recharge zone and well screens. Iron was detected at 2,450 µg/L, manganese was detected at 200 µg/L (obtained from the averages of all positive analytical results during the 1996 RI for the Landfill 6 area), and ferrous iron was detected at 1.16 mg/L (determined from the Landfill 6 wells sampled during the spring 2000 SI). Also, air stripping removes dissolved carbon dioxide from the water, increasing the pH. Increased pH levels can cause the precipitation of calcium carbonates, especially if the alkalinity is high. Heavy metal concentrations have also been shown to decrease as a result of scavenging by calcium carbonate ($CaCO_3$) precipitation. Therefore, the stripping of carbon dioxide from groundwater may also lead to the precipitation of larger amounts of metals than would normally occur from the oxygenation of the aquifer. It is relatively safe to assume that there will be minimal calcium carbonate precipitation when the alkalinity is 200 mg/L $CaCO_3$ or less. The average alkalinity of the Landfill 6 wells sampled during the spring 2000 SI was 290 mg/L $CaCO_3$. Although alkalinity may be a slight concern at this site, it is unknown whether or not metals precipitate will be a concern. Laboratory tests can be conducted to more accurately determine how much, if any, calcium carbonate and metal will precipitate. These parameters can also be confirmed during a single-well pilot study at the site. If calcium carbonate or metals precipitation at the site becomes a problem, there are processes that can be implemented to prevent precipitation from occurring, such as implementing a closed loop system, which leaks in small amounts of carbon dioxide to the stripping air. Another option is to employ an open loop system with an acid drip, which will decrease the pH to background levels, therefore preventing precipitates from forming. For costing purposes, the process of discharging carbon dioxide into the air stripping wells was included in this alternative.

There are three patented in-well air stripping technologies available, with slight variations in design. However, these technologies all employ the same principle of air-lift pumping to create a groundwater-circulation pattern and simultaneous aeration within the stripping well to volatize VOCs from the groundwater. The DDC system (see Figure 4-5) is developed, patented, and is currently available from Wasatch Environmental, Inc. The contaminated vapors can be drawn out of the well and treated aboveground. The NoVOCs system (see Figure 4-6), patented by Stanford University and available from Metcalf & Eddy, is very similar to the DDC system. The NoVOCs system uses a vacuum to draw off contaminated vapors for treatment. The NoVOCs system can be retrofitted to allow for the removal of metals from groundwater through in situ fixation (adsorption and/or precipitation) using common water treatment chemicals. A UVB or vacuum vaporizer well system (see Figure 4-7) was developed by IEG Technologies Corp. and is available from Legette, Brashers and Graham, Inc. The UVB system supplements air-lift pumping with a submersible pump and employs a stripper reactor that increases contact between the two phases, which facilitates the transfer of volatiles from the aqueous to gas phase before the water is returned to the aquifer. The technologies directly considered for the implementation of in-well air stripping at the Landfill 6 site were the NoVOCs and DDC systems. The UVB well system was not further considered in this FS because it is more complex and expected to have a higher overall cost. The ranges for all parameters considered during the assessment for both of these technologies are presented in the following discussion.

Based on implementation assumptions using geological and geotechnical data collected during the Spring 2000 SI and design assumptions developed through communication with vendors of DDC and NoVOCs technologies, the estimated effective treatment radius for an air-stripping well at the Landfill 6 plume ranges from 85 to 120 feet. Therefore, using the total area of the plume derived during the spring 2000 SI it is estimated that 7 to 15 wells would be required to treat the entire contamination plume. However, since the plume exhibits localized areas of high contamination and because the cost of implementing in situ type technologies is proportional to the area, a more cost-effective approach would involve targeting the areas with high levels of contamination. Similar to the analysis performed for the in situ oxidation alternative (Alternative 4), full-scale implementation of this technology was assumed for the area contained within the 50 µg/L total VOC concentration contour line. Remediating this area could potentially remove 99% of the contaminant mass but would address only approximately 57% of the area, or 4.8 acres (see Table 4-2). In order to account for overlap and uncertainties, vendor estimates of the effective treatment radius were reduced to approximately 50 feet. This radius of influence will be refined during the pilot study. Based on this 50-foot radius of influence, approximately 21 stripping wells would be required to address this area of the plume (see Figure 4-4). The well system (i.e., spacing, placement, construction) presented in this FS should be refined accordingly during the design stage to address the leading edge of the plume and reduce the potential for contaminating uncontaminated groundwater within the aquifer. Furthermore, a polishing step such as enhanced biodegradation should be

02:001515_UK01_02_01-B1466
Fig4-5.CDR-8/18/04-GRA

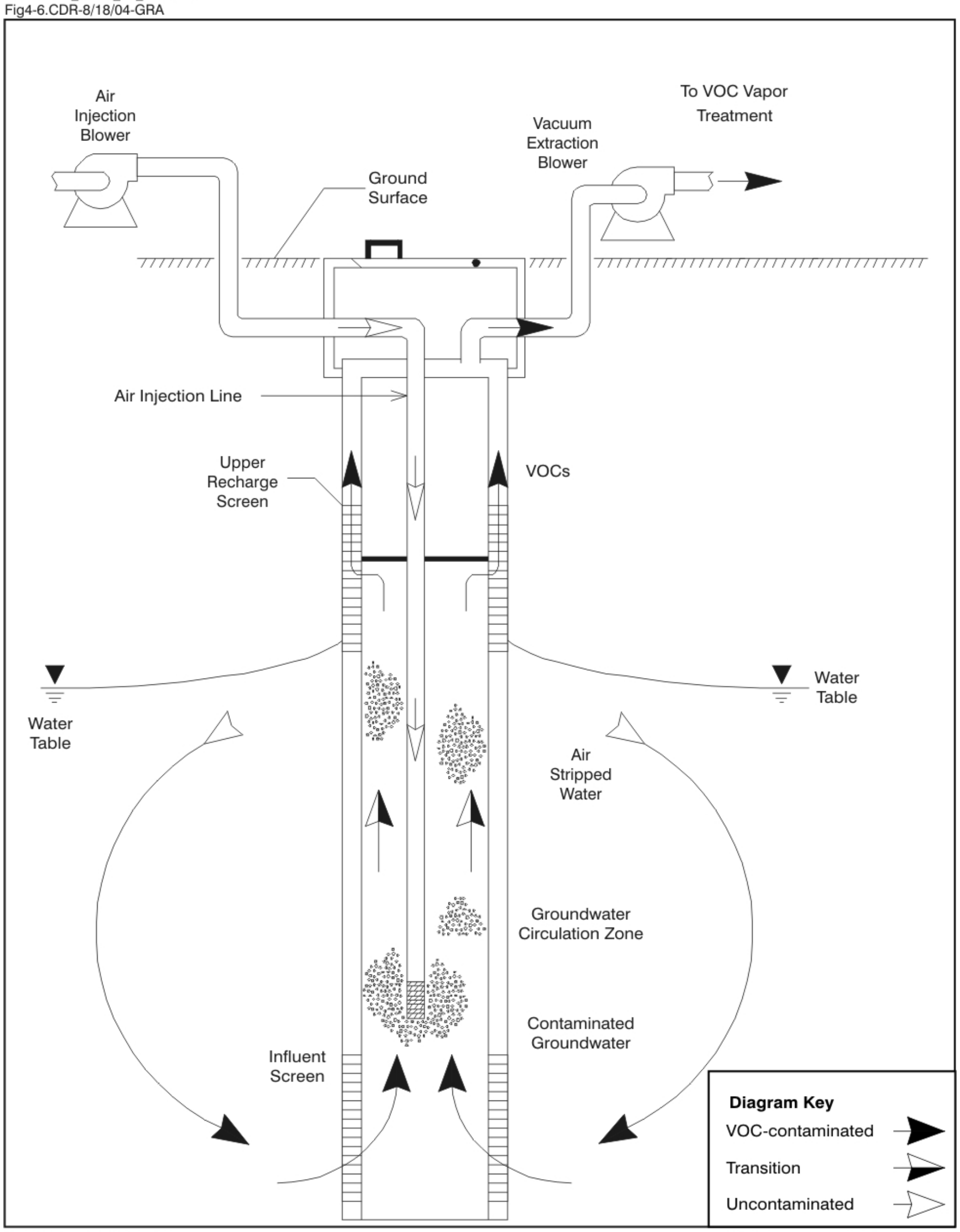



SOURCE: GWRTAC, 2001



**Figure 4-5 Typical Density-Driven Connection (DDC) Well Construction**

02:001515_UK01_02_01-B1466
Fig4-6.CDR-8/18/04-GRA

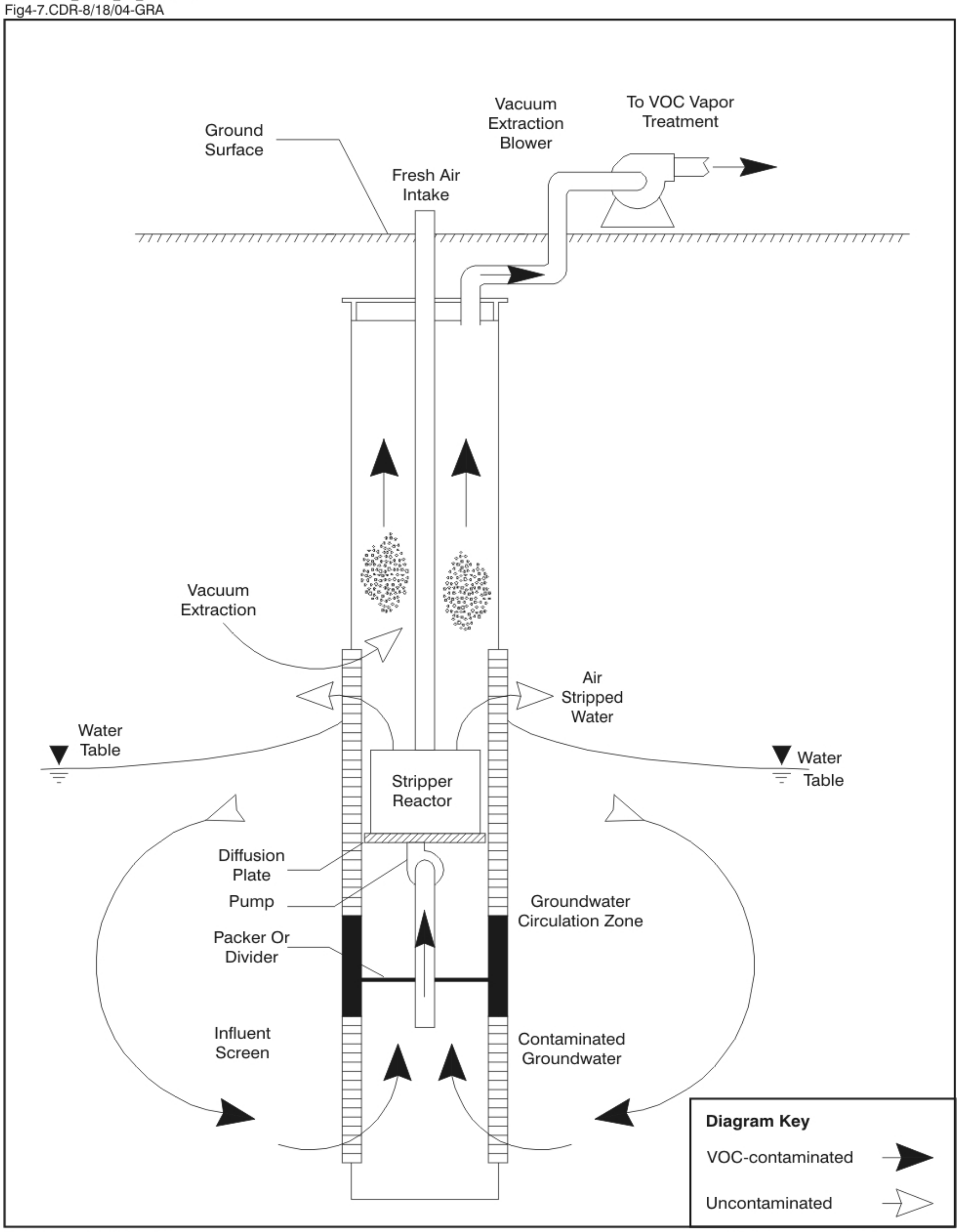



SOURCE: GWRTAC, 2001



**Figure 4-6 Typical NoVOCs Well Construction**

02:001515_UK01_02_01-B1466
Fig4-7.CDR-8/18/04-GRA




SOURCE: GWRTAC, 2001



**Figure 4-7 Typical Unterdruck-Verdampfer Brunner (UVB) Well Construction**

considered upon completion of the full-scale implementation of this technology to address residual contamination, as necessary. Costs for such a treatment are not included in this FS.

Stripping efficiencies of about 85% to 99% are anticipated in a single well for the chlorinated compounds but require field test verification. In order to eliminate emissions to the atmosphere, the system would be a closed-loop design. Contaminated vapors would be collected at each well head and routed back to two 1,800-pound carbon vessels connected in series. The clean air discharged from the carbon vessels would then be routed to the air intake of the air injection blower. In order to counteract the formation of calcium carbonate and metal precipitates, a compressed-gas cylinder would be used to bleed small quantities of carbon dioxide into the recirculated air. This will prevent the stripping of carbon dioxide from the groundwater. If oxidized metals precipitate due to the oxygenation of the aquifer, it will be addressed by in-well sequestering and/or acid treatment of the aquifer water. The final design criteria will be established through the implementation of a single-well pilot study centrally located in the Landfill 6 contamination plume with consideration given to the location of the chemical oxidation pilot study performed at this site in 2002-2003. Residual oxidant and any precipitate from the 2002-2003 pilot study injections is not expected to have an effect on the in-well air stripping pilot study. During the pilot study, the following should be addressed: estimation of the vertical hydraulic conductivity of the aquifer (circulating wells operate efficiently when the ratio of horizontal to vertical hydraulic conductivity is between 3 and 10; the circulation time may be too long if the ratio is greater than 10), determination of the optimum well screen design (e.g., slot size, filter pack, etc.); and identification of the presence of preferential pathways within the stratified drift should be ascertained, particularly in the deep portions of the plume near the gravelly till layer (where applicable).

The system components outside the stripping wells such as the air injector, carbon vessels, carbon dioxide cylinder, etc., would be housed in a dedicated, insulated, temperature-controlled structure in order to prevent freezing and to facilitate operations and maintenance activities. Source and return air piping lines would be trenched underground. Based on contaminant concentrations and site geological and geochemical conditions, it is assumed that the air-stripping wells will need to be in service for approximately four to six years before the contaminant concentrations satisfy cleanup goals. Annual operational costs include energy, possible chemical (precipitate) control, and maintenance activities, which are assumed to included two changeouts of the carbon vessels and one changeout of the carbon dioxide cylinder, as well as air sample acquisition. For costing purposes, it is assumed that treatment would be required for approximately five years.

Monitoring of the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2. Metals are not expected to mobilize within the plume; therefore, metals analysis is not included in the long-term monitoring program. Monitoring is assumed to be required for 15 years (5 years during operation of the air stripping system and 10 years into the future). If contaminants of concern remain above proposed cleanup goal concentrations after the assumed 15-year long-term monitoring period, based on data evaluation, additional monitoring may be needed.

### 4.1.6 Alternative 6: Extraction, Treatment and Disposal

This alternative involves installing recovery wells to extract groundwater from the Landfill 6 plume, treating the groundwater with a carbon adsorption system, and then discharging the treated water to Three Mile Creek via a new dedicated underground pipeline.

Given a hydraulic conductivity at the site of $10^{-4}$ cm/s and a hydraulic gradient of 0.001 ft/ft (E & E October 2000), and assuming a porosity of 25%, the groundwater velocity in the plume was estimated using Darcy's law at $4 \times 10^{-7}$ cm/s or $7.9 \times 10^{-7}$ ft/min. Using an average width of the plume of 450 feet and an average thickness of 50 feet, the volumetric flow rate of the plume is estimated at $2.3 \times 10^{4}$ $ft^3$/yr. Capturing this flow would require pumping at a rate of 0.04 gpm. Since an aquifer (pump) test was not performed during the E & E SI, a capture zone analysis was performed to estimate the capture zone of a typical extraction well and develop a preliminary extraction scheme for the pump and treat system. Note that the objective of this simplified analysis was to develop a preliminary layout of the extraction system and a cost estimate for this alternative. Further refining of the capture zone to optimize well spacing and pumping rate would be required using numerical modeling tools and/or aquifer and pilot tests if this alternative is selected.

A total of three extraction wells perpendicular to the ground flow direction and downgradient of the highest total VOC concentration detected at Landfill 6 (LF6VMW-12) were initially assumed for the extraction scheme in order to provide sufficient overlap and redundancy in the system. The wells were spaced approximately 175 feet apart with each pumping at 0.04 gpm. Solving the non-equilibrium Theis equation for each well for one year of pumping, and then using the principle of superposition, the initial pumping rate was adjusted until 0.5 feet of drawdown was obtained at the edge of the plume. Based on this analysis, the required pumping rate for each well was estimated at 0.6 gpm. Because of the difficulty of capturing only the contaminated water, it is assumed that three times the volume would need to be pumped, or approximately 1.8 gpm. The total pumping rate from the three wells is therefore estimated at a rate of 6 gpm. The proposed layout of the recovery wells is shown in Figure 4-8; these locations may be modified during the design stage.

The maximum total VOC concentration of 2,570 µg/L (comprising 1,587 µg/L TCE and 983 µg/L DCE) detected in the Landfill 6 plume occurred at LF6VMW-12 (a hydropunch point). However, because of the general plume mixing that naturally occurs with less contaminated groundwater during pumping, the maximum VOC concentration expected in the extracted groundwater was assumed to be half of the maximum total VOC concentration detected in the plume, which is 1,285 μg/L. The extracted groundwater would be pumped to a carbon treatment system located near the existing service road, which provides access to the system as shown in Figure 4-8. The existing overhead electric lines are assumed to be sufficient to power the treatment building and the extraction wells. The pipes from the recovery wells would be connected to a common underground header that would convey the contaminated groundwater to the treatment system.

The carbon treatment system would consist of two treatment trains, each with two prefiltered 55-gallon drums of granular activated carbon (200 lbs per drum) in series. The second in-series carbon drum would provide redundancy in the system if breakthrough occurs in the first unit. The system would be housed in a prefabricated protective and insulated enclosure. Temperature control inside the enclosure would prevent system components freezing. A flow meter would be installed at the influent and effluent sides to monitor flow through the system. External exposed piping would be heat-traced.

Based on the anticipated pumping rates and VOC concentrations in the extracted groundwater, and assuming continuous pumping and an even contaminant mass and flow split between the two trains, the carbon usage per treatment train per day was estimated at 3.1 lbs. The expected lifetime of the carbon drums is therefore estimated at two months. Spent carbon drums would be removed, properly disposed of, and replaced with new carbon drums. Long-term maintenance of the system would also require replacing the filters on a weekly basis and monthly sampling of the influent and effluent VOC concentrations. Long-term monitoring of the groundwater plume is also included in this alternative**.** Treated groundwater from the system would be discharged to Three Mile Creek via a dedicated 4-inch PVC underground pipeline. Requirements of a SPDES permit would need to be achieved before discharge of treated water to the creek. Sampling may be increased based on permit requirements.

Monitoring the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2.

For purposes of this FS, it is assumed that on-site contaminant concentrations would remain above ARARs for the 30-year alternative duration and that remedial actions at the site may require a re-evaluation at that time. However, if concentrations observed on-site achieve ARARs, this alternative would be terminated, monitoring would be reduced or eliminated, and a report written requesting site closure.

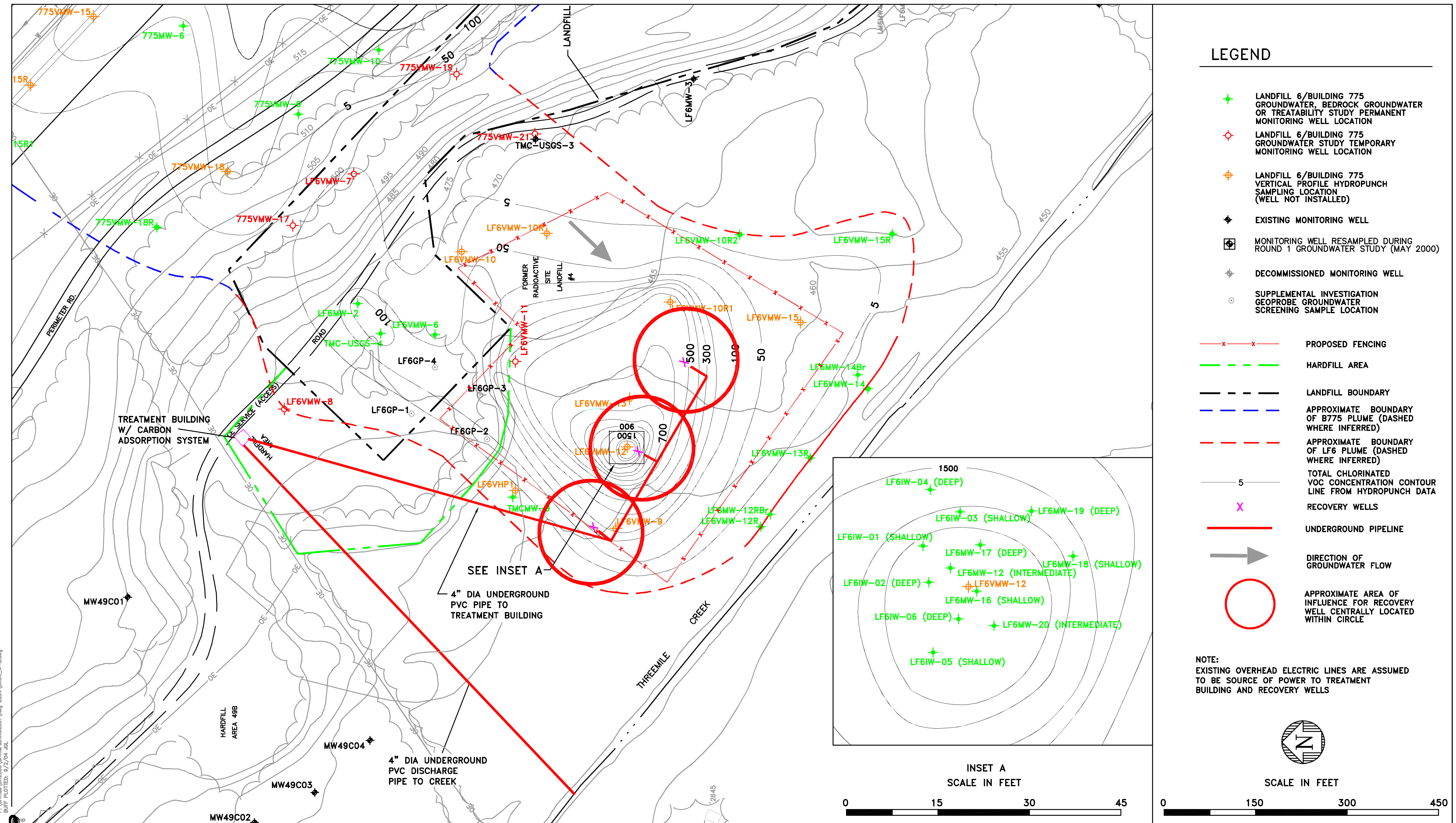





FIGURE 4-8 LANDFILL 6 ALTERNATIVE 6 EXTRACTION TREATMENT AND DISPOSAL FORMER GRIFFISS AFB ROME, NEW YORK

## 4.2 Detailed Analysis of Alternatives

### 4.2.1 Alternative 1: No Action

#### Overall Protection of Human Health and the Environment

This alternative is not protective of human health and the environment. Although there are no current receptors of contamination at the Landfill 6 plume, this alternative does not prevent future exposures through groundwater wells or construction in soils above the plume. It is not known whether the plume may eventually migrate to the adjacent Three Mile Creek. If the plume were to migrate to the creek, receptors there may be impacted.

#### Compliance with ARARs

This alternative does not comply with groundwater standards and thus does not comply with chemical-specific ARARs. Because no action would be taken, no action-specific ARARs would apply.

#### Long-term Effectiveness

Because no action is taken by this alternative, it is not effective in the long-term.

#### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative employs no treatment techniques and thus does not reduce toxicity, mobility, or volume.

#### Short-term Effectiveness

Property transfer may be impacted until RAOs have been achieved. There are no additional short-term impacts posed from the implementation of this alternative.

#### Implementability

There are no technical barriers to implementing this alternative.

#### Cost

Because this alternative calls for no action, no costs are incurred.

### 4.2.2 Alternative 2: Institutional Actions

#### Overall Protection of Human Health and the Environment

Because this alternative would prevent future uses of contaminated groundwater, it is protective of human health. There are currently no human or environmental receptors impacted by this plume. It is anticipated the shallow groundwater near Three Mile Creek may flow into the creek. However, during high flows, it is possible that flow reverses and surface water from the creek flows into groundwater. Therefore, although it is possible for groundwater contamination to reach the creek under certain circumstances, the levels in the groundwater are expected to be low. Given the flow in the creek and aerobic creek conditions, it is unlikely that contamination would be detectable in the creek. However, further study and evaluation is needed to confirm this assumption and will be performed with long-term monitoring as part of this alternative. Overall protection of human health and environment are achieved for subsurface groundwater using institutional controls, but future input to Three Mile Creek could result in potential impact to human health and the environment.

### Compliance with ARARs

This alternative does not comply with groundwater standards and thus does not comply with chemical-specific ARARs. Although a deed restriction would be placed and monitoring conducted, no action-specific ARARs would apply.

### Long-term Effectiveness

Deed restrictions are an effective mechanism limiting the potential for future exposures to contaminated groundwater. Because municipal water is available in this area and there are no plans for development at this time, this alternative would be effective in the long-term.

### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative employs no treatment techniques, and thus does not reduce toxicity, mobility, or volume.

### Short-term Effectiveness

Property transfer may be impacted until RAOs have been achieved. There are no additional short-term impacts posed from the implementation of this alternative.

### Implementability

This alternative is readily implemented.

### Cost

The 2004 total present worth cost of this alternative of $635,400 was based on the calculated 2001 total present worth cost of $597,600 using RS Means Historical Cost Index (see Table 4-3). The capital cost of $120,000 includes the drilling, installation, and development of two vertical profile monitoring wells and three standard monitoring wells, along with characterization and disposal of associated investigation-derived waste. The operation and maintenance (O & M) cost of $25,000 includes two events of groundwater sampling of seven existing wells and the five new wells per year. The 30-year present worth of the annual sampling is $477,600.

**TABLE 4-3**
**COST ESTIMATE**
**Former Griffiss AFB - Landfill 6**
**Alternative 2 - Institutional Actions**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Work Plan | Includes submittals, reporting, meetings | 1 | LS | NA | $8,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 2,000 | LF | $14 | $28,900 |
| **Well Installations** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 3 | EA | $4,500 | $13,500 |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 2 | EA | $8,400 | $16,800 |
| Well Development | | 5 | EA | $750 | $3,800 |
| IDW Sampling and Disposal | | 1 | LS | NA | $10,500 |
| Subtotal | | | | | $86,500 |
| | | | | Capital Cost Subtotal: | $86,500 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $79,926 |
| | | | | 25% Legal, administrative, engineering fees, construction management: | $20,000 |
| | | | | 20% Contingencies: | $20,000 |
| | | | | **Capital Cost Total:** | **$120,000** |
| **Annual Costs** | | | | | |
| Bi-Annual Groundwater Sampling | Total 12 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $5,200 | $10,400 |
| Analytical Costs (VOCs) | VOC samples from 12 wells | 2 | Events | $1,200 | $2,400 |
| Data Evaluation and Reporting | | 60 | HR | $85 | $5,100 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 100 | LF | $14 | $1,500 |
| Subtotal | | | | | $20,400 |
| | | | | Annual Cost Subtotal: | $20,400 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $18,850 |
| | | | | 10% Legal, administrative, engineering fees: | $1,900 |
| | | | | 20% Contingencies: | $4,200 |
| | | | | **Annual Cost Total:** | **$25,000** |
| | | | | **30-year Present Worth of Annual Costs:** | **$477,600** |
| | | | | **2001 Total Present Worth Cost:** | **$597,600** |
| | | | | **2004 Total Present Worth Cost:** | **$635,400** |

**Notes:**
1. Twelve monitoring wells will be sampled during the long-term monitoring program (5 new + 7 existing).
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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
3. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

4. Costs presented are based on conventional contracting methods.

### 4.2.3 Alternative 3: Monitored Natural Attenuation

#### Overall Protection of Human Health and the Environment

This alternative exploits naturally occurring contaminant destruction mechanisms to remove contamination from the subsurface. During the period of contaminant destruction, this alternative would prevent future uses of contaminated groundwater through deed restrictions and monitoring. It is thus protective of human health.

There are currently no human or environmental receptors impacted by this plume. As noted above under Alternative 2, although it is possible for groundwater contamination to reach the creek under certain circumstances, the levels in the groundwater are expected to be low.

#### Compliance with ARARs

As natural attenuation processes are relatively slow, groundwater standards (chemical-specific ARARs) will be exceeded in the short-term. However, natural attenuation processes would bring concentrations to levels below ARARs eventually.

#### Long-term Effectiveness

The deed restriction components of this alternative are an effective mechanism to prevent future exposures to contaminated groundwater. Because municipal water is available in this area and there are no plans for development, this alternative would be effective in the long term.

Currently data are insufficient to determine whether natural attenuation would be effective in the long term for removing contaminants to levels below groundwater standards. During the 1997 and 2000 site investigations, the natural attenuation parameters outlined in Table 4-1 were analyzed to determine to what extent these processes are occurring. The findings from the most recent analyses are discussed below.

Increases of degradation products (e.g., cis-1,2-DCE and VC) in relation to parent compounds (such as PCE and TCE) are the absolute requirements for evidence of natural attenuation. Evaluation of the concentrations at the plume are complicated by the fact that there are few wells located directly in the plume itself. However, it is possible to evaluate the progress of degradation by evaluating contaminant concentrations in the hydropunch samples and well samples LF6MW-2, LF6VMW-6, LF6VMW-11, and TMC-USGS-4, which are in the plume. LF6MW-2 and TMC-USGS-4 were installed during the earliest investigations and may have been screened primarily above the plume. These wells contain low levels of contaminants but, notably, LF6MW-2 was found to contain only the degradation product cis-1,2-DCE. The other two wells, installed more recently using vertical profiling techniques, each contain TCE, 1,2-DCE, and VC, with 1,2-DCE at the highest concentration in each sample. These data are evidence that natural attenuation is occurring in the plume. Similar observations were made in previous sampling events and led to the greater evaluation of natural attenuation parameters at this site. Furthermore, review of the hydropunch data reveals similar patterns of degradation products throughout this plume. The presence of these degradation products is evidence that natural attenuation is occurring.

Dissolved organic carbon (DOC) (see Figure 4-9) is a measure of the source of electrons needed to reduce chlorinated compounds. Higher concentrations indicate favorable conditions for natural attenuation, and DOC concentrations are elevated in the Landfill 6 area in both in-plume wells (TMC-USGS-4 and LF6VMW-6) and upgradient wells (LF6VMW-7).

Chloride (see Figure 4-10) is produced during reductive dechlorination. The data indicates that there is a background level of about 30 to 40 mg/L at the site. The highest levels of chloride are found in wells 775VMW-8 and 775VMW-10.

Oxygen levels, measured during low-flow purging of wells indicates fairly aerobic conditions (see Figure 4-11). Anaerobic conditions were observed in areas outside the plume, including southwest of the plume (along Three Mile Creek) and upgradient of the plume (wells 775VMW-17 and 775VMW-9).

The oxidation-reduction potential (ORP) measures the availability of electrons, although measurements can only be evaluated comparatively unless they are at the extreme ends of the typical ranges (e.g., -300 to -400 mV or +300 mV). Such extreme readings were found only in areas outside the plume (see Figure 4-12) that also exhibited very low dissolved oxygen levels, such as southwest of the plume (along the creek). Higher values in wells near the center of the plume were measured.

The presence of ferrous iron suggests conditions needed to support reductive dechlorination. However, ferrous iron concentrations were uniformly quite low (see Figure 4-13), with two exceptions at TMC-USGS-4 and LF6VMW-12R beyond the plume by Three Mile Creek. This parameter does not provide evidence of natural attenuation.

Sulfate is an electron acceptor under anaerobic conditions. A localized depletion of this anion compared to background levels suggests the occurrence of active anaerobic metabolism. Concentrations of this compound varied widely throughout the area and no apparent pattern was noted (see Figure 4-14).

Nitrate has a role similar as sulfate regarding natural attenuation. Nitrate concentrations (see Figure 4-15) were lower in areas of greater contamination (i.e., LF6MW-2 and TMC-USGS-4) but higher at LF6VMW-6 and LF6VMW-1, which are located deeper in the aquifer and probably more fully in the plume.

Methane presence suggests strong reducing conditions conducive to reductive dechlorination. A localized area of high methane concentrations was detected at LF6VMW-6 (see Figure 4-16); however, its concentration was still relatively low (0.093J mg/L). Concentrations were somewhat elevated throughout the plume, but the differences in concentrations between these samples and background samples are probably not sufficient to indicate a trend.

No ethane or ethene was detected. These are ultimate end products of reductive dechlorination but require reducing conditions to be produced.

In summary, these studies indicate degradation products are present at the site, which suggests that natural attenuation is actively occurring within the Landfill 6 plume. Natural attenuation may be enhanced at this site by the landfill (i.e., carbon source) and anaerobic aquifer conditions. Additional well installations and sampling would be needed to determine and evaluate the extent to which natural attenuation is occurring on-site due to the landfill. This is not included as part of this alternative.

### Reduction of Toxicity, Mobility, or Volume through Treatment

The biodegradative mechanisms inherent in natural attenuation are destructive mechanisms that results in the reduction of toxicity.

### Short-term Effectiveness

Property transfer may be impacted until RAOs have been achieved. There are no additional short-term impacts posed from the implementation of this alternative.

### Implementability

This alternative is readily implemented.

### Cost

The 2004 total present worth cost of this alternative of $1,651,800 was based on the calculated 2001 total present worth cost of $1,553,600 using RS Means Historical Cost Index (see Table 4-4). The capital cost of $787,500 includes the drilling, installation, and development of two vertical profile monitoring wells and six standard monitoring wells, initial well sampling over eight quarters for conventional and natural attenuation parameters, 12 additional rounds of water-level measurements to help support modeling, and evaluation of the data, including hydrogeologic and reaction modeling. It also includes $208,400 for microcosm studies at six locations in the plume. The O & M cost of $40,100 includes two events of groundwater sampling of eight existing wells and the eight new wells per year. The 30-year present worth of the annual sampling is $766,100.

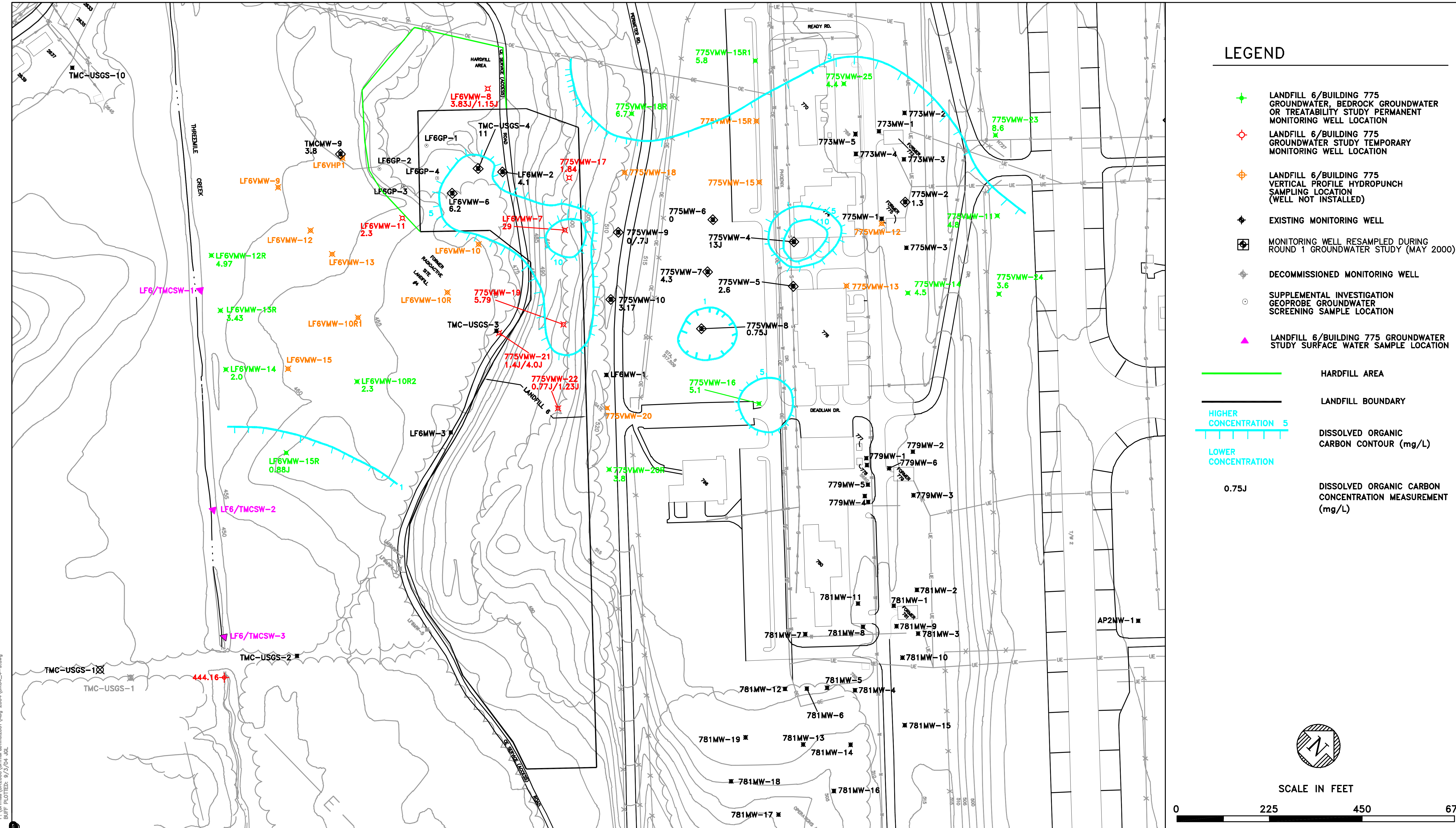
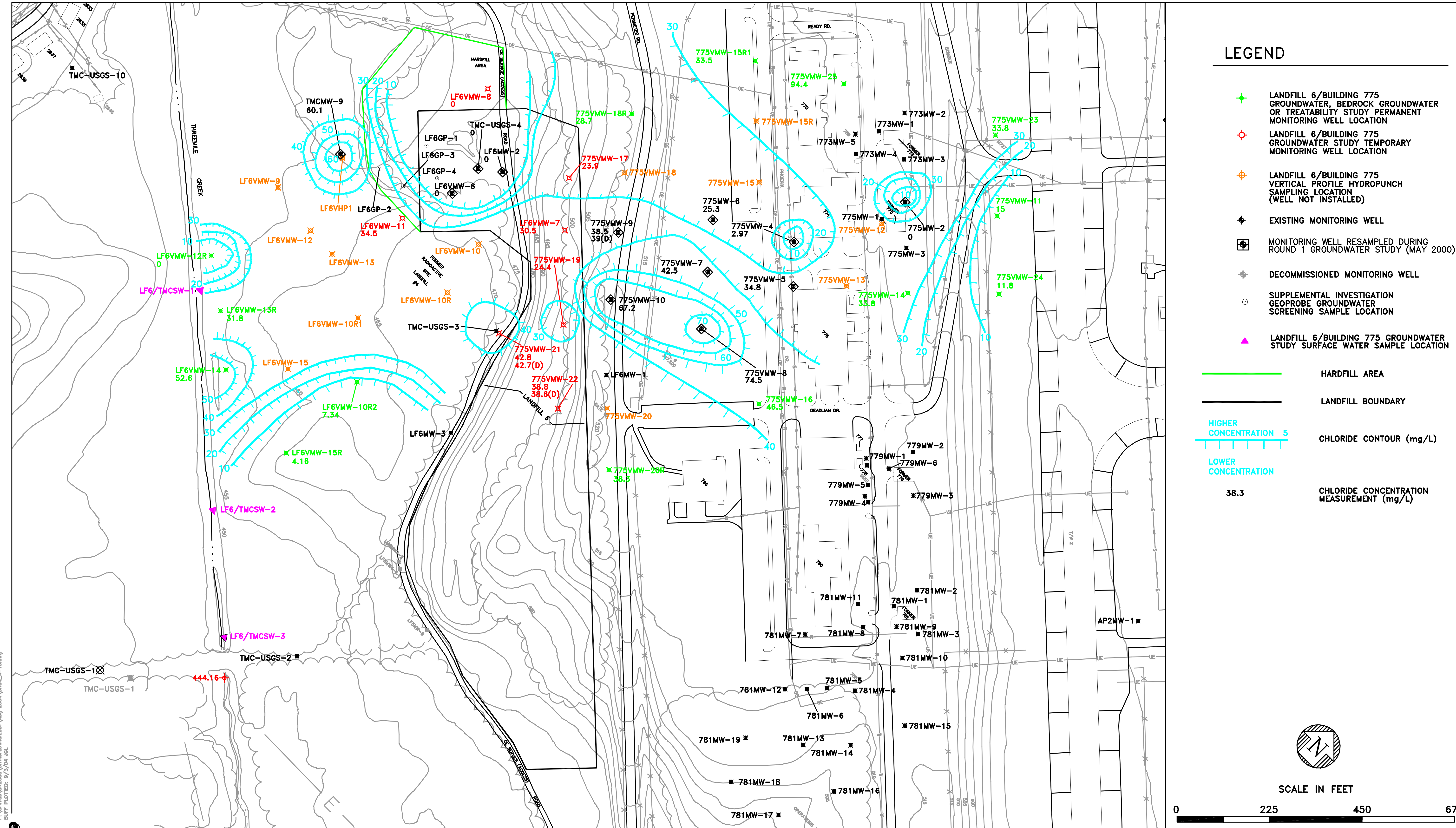






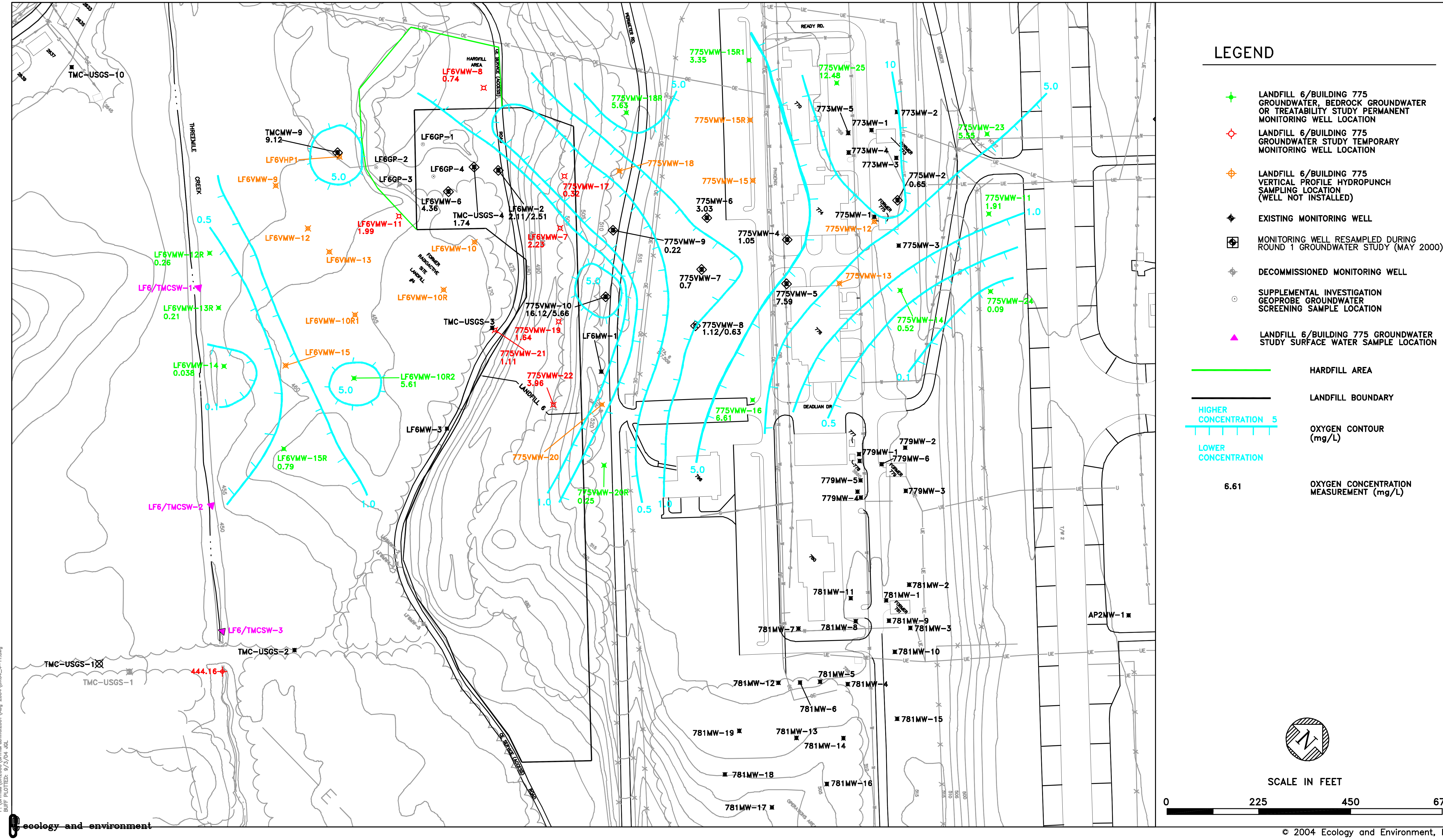

FIGURE 4-9 LANDFILL 6 DISSOLVED ORGANIC CARBON MEASUREMENTS, SPRING 2000 FORMER GRIFFISS AFB ROME, NEW YORK




ecology and environment

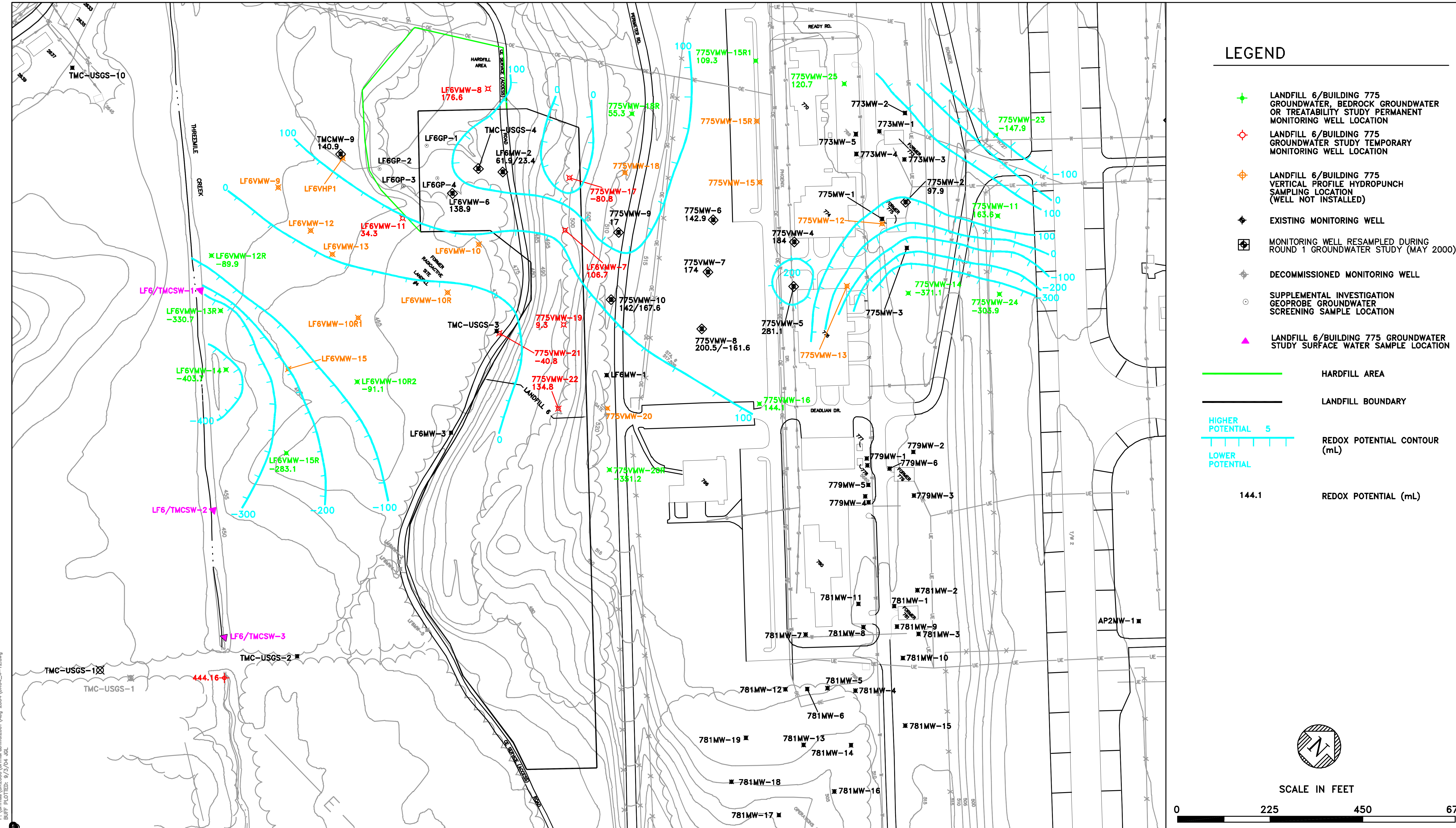


FIGURE 4-10 LANDFILL 6
CHLORIDE MEASUREMENTS
SPRING 2000
FORMER GRIFFISS AFB
ROME, NEW YORK



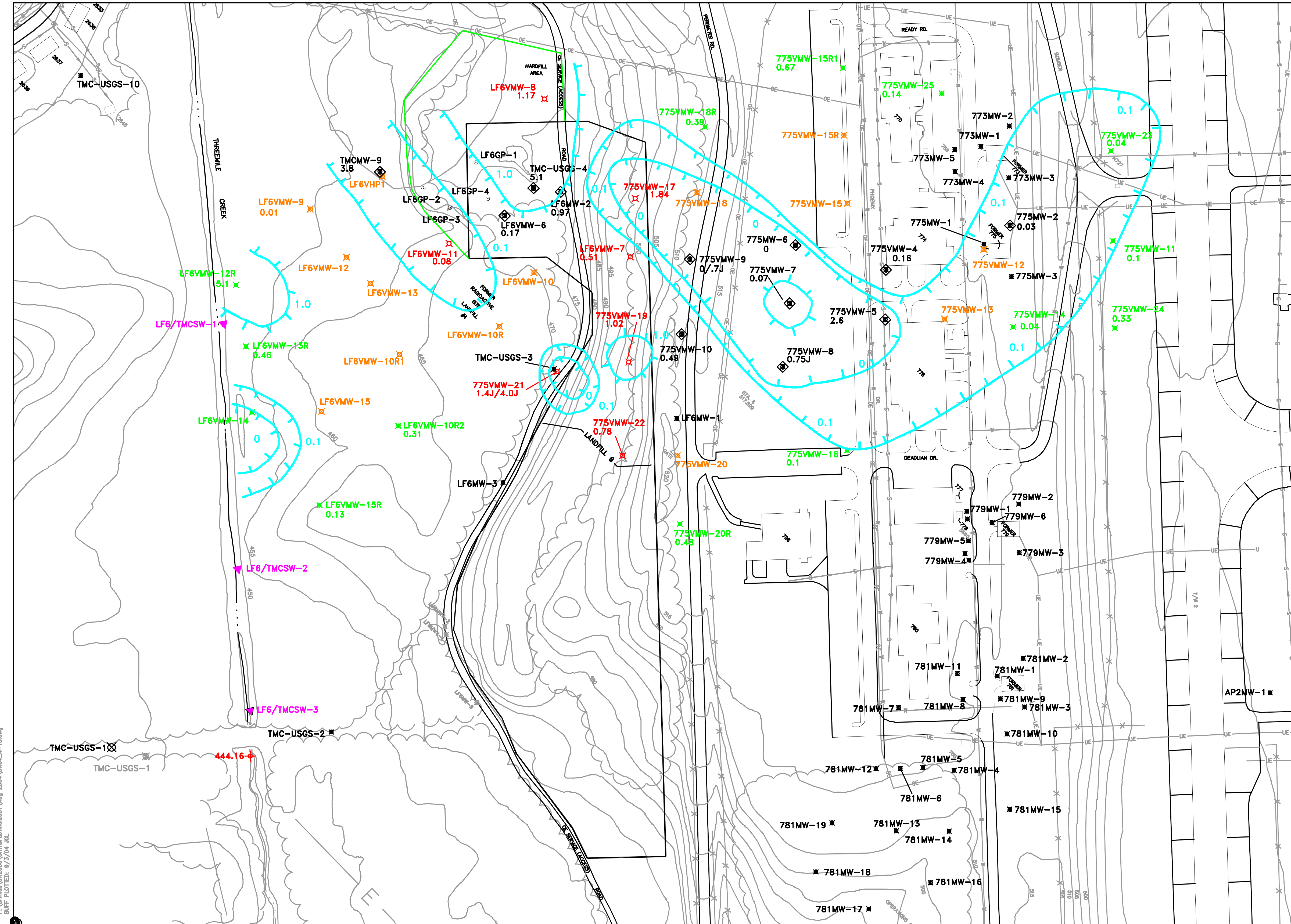

© 2004 Ecology and Environment, Inc.

FIGURE 4-11 LANDFILL 6 OXYGEN MEASUREMENTS SPRING 2000 FORMER GRIFFISS AFB ROME, NEW YORK




© 2004 Ecology and Environment, Inc.

FIGURE 4-12 LANDFILL 6
OXIDATION REDUCTION POTENTIAL
SPRING 2000
FORMER GRIFFISS AFB
ROME, NEW YORK




## LEGEND

- LANDFILL 6/BUILDING 775 GROUNDWATER, BEDROCK GROUNDWATER OR TREATABILITY STUDY PERMANENT MONITORING WELL LOCATION
- LANDFILL 6/BUILDING 775 GROUNDWATER STUDY TEMPORARY MONITORING WELL LOCATION
- LANDFILL 6/BUILDING 775 VERTICAL PROFILE HYDROPUNCH SAMPLING LOCATION (WELL NOT INSTALLED)
- EXISTING MONITORING WELL
- MONITORING WELL RESAMPLED DURING ROUND 1 GROUNDWATER STUDY (MAY 2000)
- DECOMMISSIONED MONITORING WELL
- SUPPLEMENTAL INVESTIGATION GEOPROBE GROUNDWATER SCREENING SAMPLE LOCATION
- LANDFILL 6/BUILDING 775 GROUNDWATER STUDY SURFACE WATER SAMPLE LOCATION
- HARDFILL AREA
- LANDFILL BOUNDARY
- HIGHER CONCENTRATION 5 / LOWER CONCENTRATION — FERROUS IRON CONTOUR (mg/L)
- 0.78 — FERROUS IRON CONCENTRATION MEASUREMENT (mg/L)

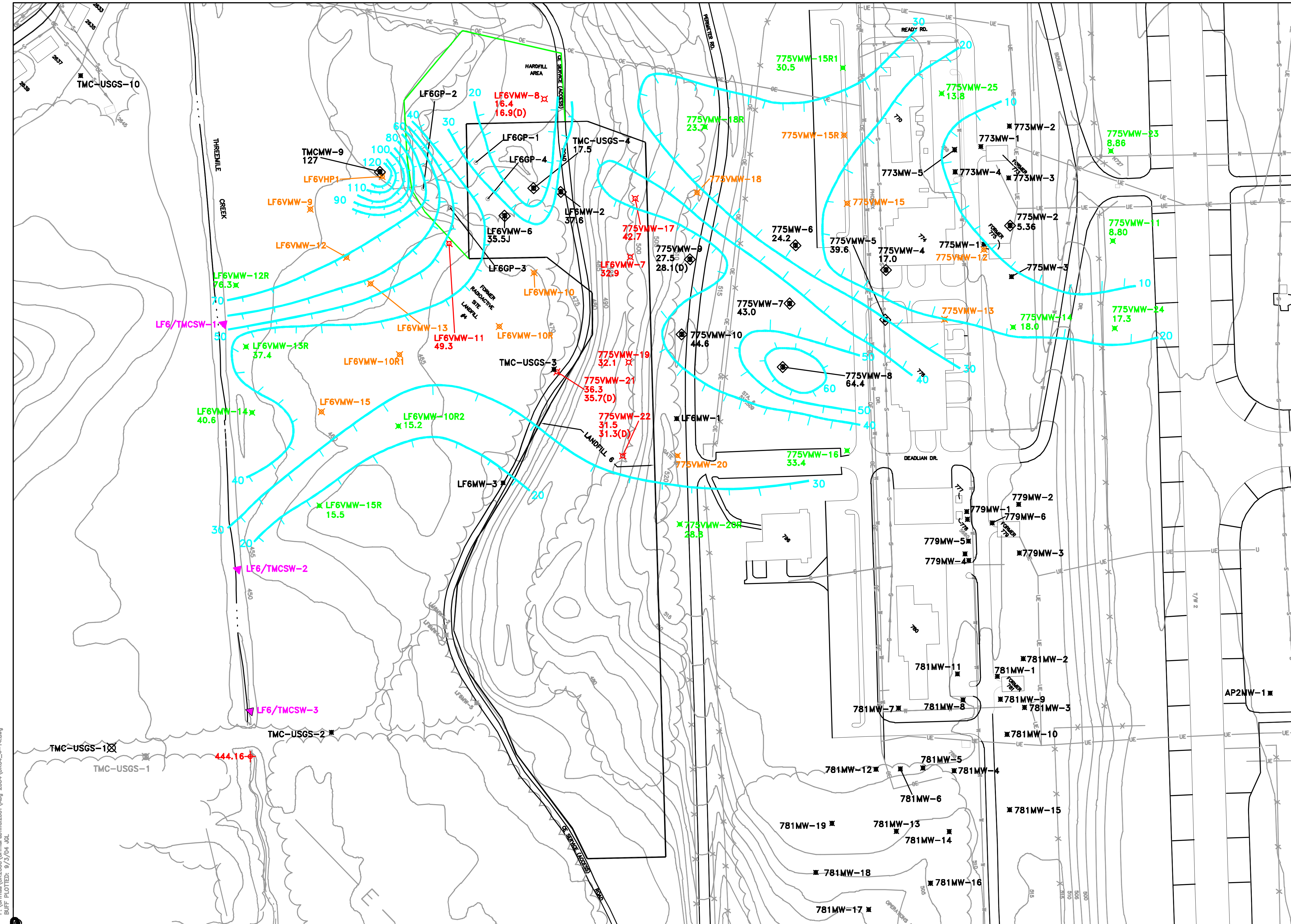
SCALE IN FEET

0 225 450 675

ecology and environment



FIGURE 4-13 LANDFILL 6
FERROUS IRON MEASUREMENTS
SPRING 2000
FORMER GRIFFISS AFB
ROME, NEW YORK




## LEGEND

- LANDFILL 6/BUILDING 775 GROUNDWATER, BEDROCK GROUNDWATER OR TREATABILITY STUDY PERMANENT MONITORING WELL LOCATION
- LANDFILL 6/BUILDING 775 GROUNDWATER STUDY TEMPORARY MONITORING WELL LOCATION
- LANDFILL 6/BUILDING 775 VERTICAL PROFILE HYDROPUNCH SAMPLING LOCATION (WELL NOT INSTALLED)
- EXISTING MONITORING WELL
- MONITORING WELL RESAMPLED DURING ROUND 1 GROUNDWATER STUDY (MAY 2000)
- DECOMMISSIONED MONITORING WELL
- SUPPLEMENTAL INVESTIGATION GEOPROBE GROUNDWATER SCREENING SAMPLE LOCATION
- LANDFILL 6/BUILDING 775 GROUNDWATER STUDY SURFACE WATER SAMPLE LOCATION
- HARDFILL AREA
- LANDFILL BOUNDARY
- HIGHER CONCENTRATION 5 LOWER CONCENTRATION — SULFATE CONTOUR (mg/L)
- 28.8 — SULFATE CONCENTRATION MEASUREMENTS (mg/L)

SCALE IN FEET

0 225 450 675



FIGURE 4-14 LANDFILL 6
SULFATE MEASUREMENTS
SPRING 2000
FORMER GRIFFISS AFB
ROME, NEW YORK

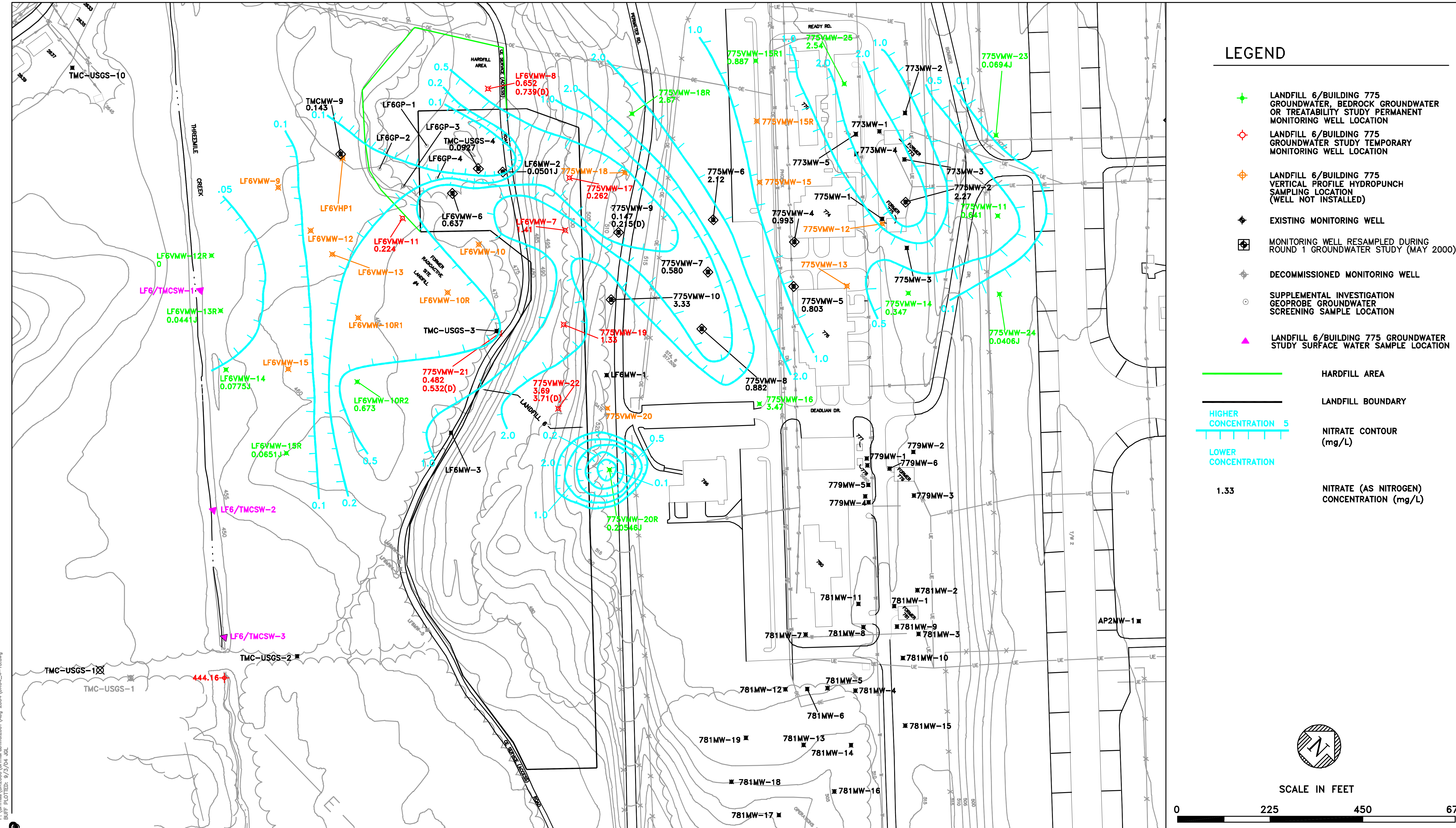





FIGURE 4-15 LANDFILL 6
NITRATE MEASUREMENTS
SPRING 2000
FORMER GRIFFISS AFB
ROME, NEW YORK

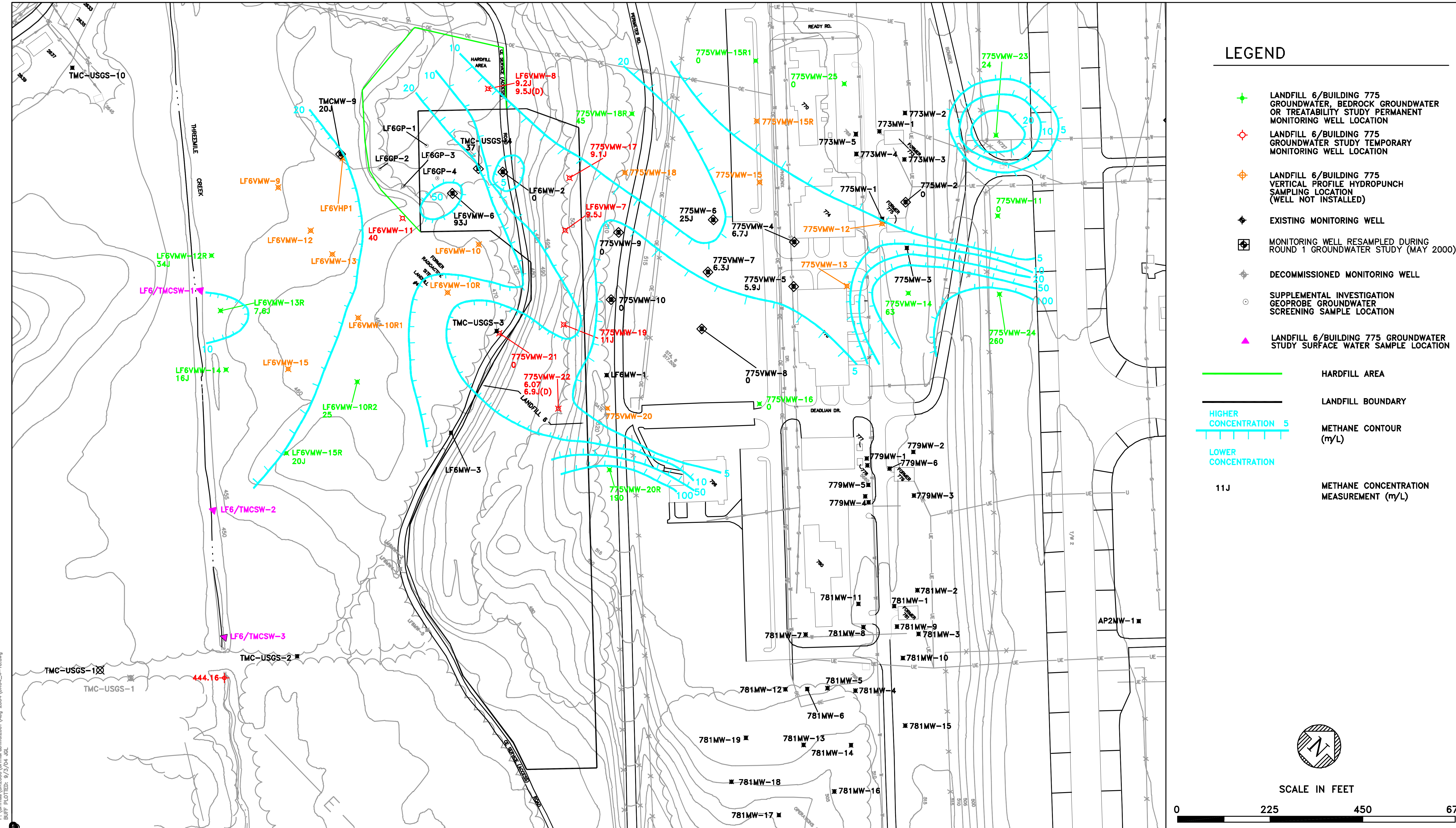





FIGURE 4-16 LANDFILL 6
METHANE MEASUREMENTS
SPRING 2000
FORMER GRIFFISS AFB
ROME, NEW YORK

**TABLE 4-4**
**COST ESTIMATE**
**Former Griffiss AFB - Landfill 6**
**Alternative 3 - Monitored Natural Attenuation**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $15,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 2,000 | LF | $14 | $28,900 |
| **Well Installations** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 6 | EA | $4,500 | $27,000 |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 2 | EA | $8,400 | $16,800 |
| Well Development | | 8 | EA | $750 | $6,000 |
| IDW Sampling and Disposal | | 1 | LS | NA | $10,500 |
| Subtotal | | | | | $109,200 |
| **Initial Investigation** | | | | | |
| Conventional Groundwater Sampling | Total 16 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 8 | Events | $6,500 | $52,000 |
| Analytical Costs (VOCs) | | 8 | Events | $1,600 | $12,800 |
| Analytical Costs (Natural Attenuation Parameters) | | 8 | Events | $4,800 | $38,400 |
| Water Level Measurements | | 12 | Events | $650 | $7,800 |
| Subtotal | | | | | $111,000 |
| **Microcosm Studies** | | | | | |
| Shelby tube collection | | 162 | Each | $340 | $55,100 |
| Shelby tube collection oversight | | 1 | LS | NA | $2,000 |
| Microcosm Study Labor | | 350 | HR | $85 | $29,800 |
| Analytical Costs (VOCs) | | 486 | Each | $100 | $48,600 |
| Analytical Costs (Natural Attenuation Parameters) | Excluding MEE | 486 | Each | $150 | $72,900 |
| Subtotal | | | | | $208,400 |
| **Data Evaluation** | | | | | |
| Data Summary | | 240 | HR | $85 | $20,400 |
| Modeling | | 800 | HR | $85 | $68,000 |
| Reporting | | 400 | HR | $85 | $34,000 |
| Meetings | | 200 | HR | $85 | $17,000 |
| Subtotal | | | | | $139,400 |
| | Capital Cost Subtotal: | | | | $568,000 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $524,832 |
| | 25% Legal, administrative, engineering fees, construction management: | | | | $131,300 |
| | 20% Contingencies: | | | | $131,300 |
| | **Capital Cost Total:** | | | | **$787,500** |
| **Annual Costs** | | | | | |
| Bi-Annual Groundwater Sampling | Total 16 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $6,500 | $13,000 |
| Analytical Costs (VOCs) | | 2 | Events | $1,600 | $3,200 |
| Analytical Costs (Natural Attenuation Parameters) | Excluding MEE | 3 | Events | $2,400 | $7,200 |
| Data Evaluation and Reporting | | 80 | HR | $85 | $6,800 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 100 | LF | $14 | $1,500 |
| Subtotal | | | | | $32,700 |
| | Annual Cost Subtotal: | | | | $32,700 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $30,215 |
| | 10% Legal, administrative, engineering fees: | | | | $3,100 |
| | 20% Contingencies: | | | | $6,700 |
| | **Annual Cost Total:** | | | | **$40,100** |
| | **30-year Present Worth of Annual Costs:** | | | | **$766,100** |
| | **2001 Total Present Worth Cost:** | | | | **$1,553,600** |
| | **2004 Total Present Worth Cost:** | | | | **$1,651,800** |

**Notes:**

1. 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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
2. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

3. Costs presented are based on conventional contracting methods.

### 4.2.4 Alternative 4: In situ Oxidation

#### Overall Protection of Human Health and the Environment

There are currently no human or environmental receptors impacted by this plume. This alternative would destroy contaminants in the plume through chemical oxidation, resulting in removal of contaminants from the subsurface and eliminating future potential exposure threats.

#### Compliance with ARARs

Through destruction of contaminants via oxidation, concentrations in the aquifer would be reduced to levels below groundwater standards, meeting chemical-specific ARARs. By focusing on treatment of the plume defined by the 50 µg/L contaminant contour interval, this alternative would immediately remove approximately 99% of the contaminant mass. Some areas would remain with contamination concentrations between 5 and 50 µg/L; however, these would represent less than 1% of the original contaminant mass and would likely naturally attenuate to within ARARs over time.

#### Long-term Effectiveness

Because the majority of the contaminants would be permanently destroyed, this alternative is effective in the long-term.

#### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative employs reductive dechlorination via chemical oxidation to destroy the contaminants, thus resulting in toxicity reduction through treatment.

#### Short-term Effectiveness

Implementation of this alternative would require the installation of 231 temporary wells over the plume during the primary injection event and 50% of that amount during the second injection event, which would require clearing some vegetation and associated well drilling activities. These oxidant injection events are expected to be completed within one year. Monitoring is assumed for 10 years (including the assumed one year for oxidant injections at this site). Property transfer may be impacted until RAOs have been achieved.

#### 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 oxidant) requirements necessary to treat the contaminants of concern at this site.

#### Cost

The 2004 total present worth cost of this alternative of $4,102,500 was based on the calculated 2001 total present worth cost of $3,858,800 using RS Means Historical Cost Index (see Table 4-5). The capital cost of $3,647,700 includes the full-scale implementation of the technology. For purposes of this FS, it was assumed that the injection wells during full-scale implementation would be temporary-type wells installed using the direct-push method. The O & M cost of $211,100 includes 10 years of monitoring and sampling.

### 4.2.5 Alternative 5: In-Well Air Stripping

#### Overall Protection of Human Health and the Environment

There are currently no human or environmental receptors impacted by this plume. This alternative would remove contaminants from the subsurface as a vapor, limiting future potential exposure threats.

#### Compliance with ARARs

Through removal of contaminants as vapors, concentrations in the aquifer would be reduced to levels below groundwater standards, thus meeting chemical-specific ARARs. By focusing on treatment of the plume defined by the 50 µg/L contaminant-contour interval, this alternative would remove approximately 99% of the contaminant mass. Some areas with contamination between 5 and 50 µg/L would remain; however, these would represent less than 1% of the original contaminant mass and would likely naturally attenuate to within ARARs over time.

Although the system would recirculate air and remove VOCs with gas-phase carbon, some discharge of VOCs into the air may occur, and application for an air permit may be required. This action-specific ARAR would be met.

#### Long-term Effectiveness

Because the majority of the contaminants would be removed from the aquifer and would be permanently destroyed, this alternative is effective in the long-term.

#### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative removes contaminants from the aquifer through in-well stripping, reducing the volume of contaminated media through treatment. It also employs carbon adsorption of the stripped air, which during carbon regeneration contaminants would be destroyed, resulting in toxicity reduction through treatment.

#### Short-term Effectiveness

Implementation of this alternative would require installing 21 wells over the plume. Although maneuvering around the site to install these wells may affect some wetland areas, the short-term impacts are considered minor. O & M of the air stripping system is expected to be five years. Long-term monitoring would be required for an assumed 15 years (includes five years during the O & M of the air stripping system). Property transfer may be impacted until RAOs have been achieved.

**TABLE 4-5**
**COST ESTIMATE**
**Former Griffiss AFB - Landfill 6**
**Alternative 4 - In situ Oxidation**

| Description | Comment | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $50,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 2,000 | LF | $14 | $28,900 |
| Subtotal | | | | | $83,900 |
| **Health and Safety** | | | | | |
| Construct Decontamination Pad & Containment | For equipment & personnel | 2 | Setups | $1,900 | $3,800 |
| Air Monitoring | Organic Vapor Analyzer (4 units) | 12 | months | $3,800 | $45,600 |
| Health and Safety Plan and Management | Includes development of plan and medical surveillance of on-site personnel | 1 | LS | NA | $9,500 |
| Site Safety Officer | 10 hrs/day, 5days/wk, $65/hr | 48 | manweeks | $3,250 | $156,000 |
| Personal Protective Equipment | Includes coveralls, hard hats, safety glasses, reusable boots, gloves | 1 | LS | NA | $7,100 |
| Subtotal | | | | | $222,000 |
| **Full-scale Implementation** | | | | | |
| *Geoprobe Installation* | | | | | |
| Mobilization/Demobilization (Geoprobes) | | 1 | LS | NA | $50,000 |
| Installation of Injection Points, Primary Injection | Assumes average Geoprobe depth to 50', 2 drill rigs, see Notes | 49 | day | $4,000 | $196,000 |
| Installation of Injection Points, Secondary Injection | Assumes average Geoprobe depth to 50', 2 drill rigs, see Notes | 25 | day | $4,000 | $100,000 |
| PVC Piping for Injection Points | 1" PVC pipe to depth of each injection point | 347 | Each | $21 | $7,500 |
| Injection Point Caps | 1" locking cap | 347 | Each | $9 | $3,300 |
| *Chemical Oxidation Injection* | | | | | |
| Reagent Injection, Pump (Equipment) | Assume pressure inject around 10gpm | 2 | Each | $5,000 | $10,000 |
| Reagent Injection, Primary Injection | Includes vendor oversight | 128 | days | $3,500 | $449,200 |
| Reagent Injection, Secondary Injection | Includes vendor oversight | 64 | days | $3,500 | $224,600 |
| Reagent Material incl. Transportation | $KMnO_4$, see Notes | 346,500 | lb | $2.60 | $900,900 |
| Electrical Fee | Provided by generator | 193 | day | $100 | $19,300 |
| Oversight | Duration of injection point installation and reagent injection; Assume 1-person @ $65/hr, 5days/week, 8hr/day | 267 | day | $520 | $138,600 |
| Water Truck | Assume 2 trucks 6,000 gallon capacity; includes operating costs | 9 | months | $15,294 | $137,700 |
| Injection Point Abandonment | Abandon injection points in place | 347 | Each | $50 | $17,400 |
| Subtotal | | | | | $2,254,500 |
| **Full-scale Monitoring** | | | | | |
| *Well Installation* | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 3 | Each | $4,500 | $13,500 |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 2 | Each | $8,400 | $16,800 |
| Well Development | | 5 | Each | $750 | $3,800 |
| IDW Sampling and Disposal | | 1 | LS | NA | $10,500 |
| *Treatment Monitoring* | | | | | |
| Groundwater Sampling (Labor) | 2-person @ $65/hr, 10hr/day; 11 total wells - assume 3 wells per day, 2 | 2 | Events | $5,200.00 | $10,400 |
| Groundwater Sampling (Equipment) | Groundwater level indicator, multi-parameter instrument, low-flow pump | 2 | Events | $800.00 | $1,600 |
| Parameter Analyses (VOC) | Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample per well per well for 2 additional sampling rounds | 2 | Events | $1,200.00 | $2,400 |
| Parameter Analyses (Metals and DOC) | Includes TAL Metals and DOC; assume 1 groundwater sample per well/piezometer for 11 wells for 2 additional sampling rounds | 2 | Events | $3,600.00 | $7,200 |
| Data Evaluation and Reporting | | 60 | HR | $85.00 | $5,100 |
| Subtotal | | | | | $71,300 |
| | | | | Capital Cost Subtotal: | $2,631,700 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $2,431,691 |
| | | | | 25% Legal, administrative, engineering fees, construction management: | $608,000 |
| | | | | 20% Contingencies: | $608,000 |
| | | | | **Capital Cost Total:** | **$3,647,700** |

**TABLE 4-5**
**COST ESTIMATE**
**Former Griffiss AFB - Landfill 6**
**Alternative 4 - In situ Oxidation**

| Description | Comment | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Annual Costs (For First 10 Years)** | | | | | |
| Bi-Annual Groundwater Sampling | Total 12 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $5,200 | $10,400 |
| Analytical Costs (VOCs) | VOC samples from 12 wells | 2 | Events | $1,200 | $2,400 |
| Data Evaluation and Reporting | | 60 | HR | $85 | $5,100 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 100 | LF | $14 | $1,500 |
| Subtotal | | | | | $20,400 |
| | | | | Annual Cost Subtotal: | $20,400 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $18,850 |
| | | | | 10% Legal, administrative, engineering fees: | $1,900 |
| | | | | 20% Contingencies: | $4,200 |
| | | | | **Annual Cost Total:** | **$25,000** |
| | | | | **10-year Present Worth of Annual Costs:** | **$211,100** |
| | | | | **2001 Total Present Worth Cost:** | **$3,858,800** |
| | | | | **2004 Total Present Worth Cost:** | **$4,102,500** |

**Notes:**

1. Assume radius of influence (ft) = 15
2. Assume treatment area (acre) = 4.8
   Assume treatment area (ft2) = 207,522
3. Assume number injection points for Primary Injection based on treatment area = 231
4. Assume percentage of this area would require a second injection = 50%
5. Assume installation of Geoprobes per day at this site = 6
6. Assume downtime during Geoprobe installation due to refusal, maneuvering around site = 25%
7. Based on pilot study, quantity of $KMnO_4$ in 1.5% solution required per injection point = 1,000 lb
8. 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).
9. Twelve monitoring wells will be sampled during the long-term monitoring program (5 new + 7 existing).
10. 10-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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
11. Total present worth costs presented were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

12. Costs presented are based on conventional contracting methods.

### Implementability

This alternative would require pilot-scale testing to demonstrate its effectiveness prior to implementation. There is a possibility that this testing would reveal technical problems that may limit the ability to implement this technology or require changes in the assumptions that have been made regarding, for example, radius of influence, that then may increase or decrease costs of implementation.

### Cost

The 2004 total present worth cost of this alternative of $1,917,300 was based on the calculated 2001 total present worth cost of $1,803,400 using RS Means Historical Cost Index (see Table 4-6). The capital cost of $940,100 includes the installation of in-well air stripping wells, long-term monitoring wells, the carbon adsorption system, carbon dioxide/pH control systems, compressors/blowers, trenching, electrical drops, pilot study and full-scale implementation costs. The annual cost of $109,200 for the first five years is for the O & M of the in-well stripping system. Annual monitoring costs of $31,100 were assumed for the first 15 years. The present worth value of the O & M and monitoring annual costs is $863,300.

## 4.2.6 Alternative 6: Extraction, Treatment and Disposal

### Overall Protection of Human Health and the Environment

No human or environmental receptors are currently impacted by this plume. This alternative would remove contaminants from the subsurface through direct extraction of contaminated groundwater, eliminating future potential exposure threats. However, complete removal of the contaminants would require many years, making deed restrictions necessary where contamination observed is above ARARs to prevent exposures during cleanup.

### Compliance with ARARs

Through removal of contaminants via extraction, concentrations in the aquifer would be reduced to levels below groundwater standards, meeting chemical-specific ARARs.

To discharge the treated water into Three Mile Creek, the requirements of a SPDES permit would have to be met. This action-specific ARAR would be complied with.

### Long-term Effectiveness

Because contaminants would be removed from the aquifer, this alternative is effective in the long-term.

**TABLE 4-6**
**COST ESTIMATE**
**Former Griffiss AFB - Landfill 6**
**Alternative 5 - In-well Air Stripping**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Pilot Study Program | | 1 | LS | NA | $100,000 |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $50,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 2,000 | LF | $14 | $28,900 |
| Subtotal | | | | | $183,900 |
| **Well Installation** | | | | | |
| Mobilization/Demobilization | | 1 | LS | NA | $15,000 |
| Well Install/Developed | | 21 | Each | $7,000 | $147,000 |
| Surface Completion /Well Heads | | 21 | Each | $650 | $13,700 |
| Waste Disposal | | 21 | Each | $376 | $8,000 |
| **Aboveground In-Well Stripping System** | | | | | |
| Trenching/Piping | | 4,000 | LF | $40 | $160,000 |
| Carbon Vapor Adsorption System | 1800lb. Carbon Units | 4 | Each | $7,500 | $30,000 |
| Blower/Compressor | | 2 | Each | $6,500 | $13,000 |
| Vacuum | | 2 | Each | $6,500 | $13,000 |
| Carbon Dioxide/pH Control | | 2 | Each | $4,000 | $8,000 |
| Pre-Fabricated Enclosure | | 2 | Each | $10,000 | $20,000 |
| Electrical Panel | | 2 | Each | $6,000 | $12,000 |
| Electrical Service Connection | | 2 | Each | $5,000 | $10,000 |
| Subtotal | | | | | $449,700 |
| **Monitoring** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 3 | Each | $4,500 | $13,500 |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 2 | Each | $8,400 | $16,800 |
| Well Development | | 5 | Each | $750 | $3,800 |
| IDW Sampling and Disposal | | 1 | LS | NA | $10,500 |
| Subtotal | | | | | $44,600 |
| | | | | Capital Cost Subtotal: | $678,200 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $626,657 |
| | | | | 25% Legal, administrative, engineering fees, construction management: | $156,700 |
| | | | | 20% Contingencies: | $156,700 |
| | | | | **Capital Cost Total:** | **$940,100** |
| **Annual Costs** | | | | | |
| **Operation (For First 5 Years)** | | | | | |
| Energy Consumption (Electric) | | 112,000 | KWH | $0.09 | $10,100 |
| Carbon Drum Replacement (Biannual) | | 8 | Each | $2,070 | $16,600 |
| Carbon Disposal (Biannual) | | 8 | Each | $1,900 | $15,200 |
| Carbon Dioxide Replacement/pH Control | | 12 | Mo | $960 | $11,520 |
| General O & M | | 12 | Mo | $3,000 | $36,000 |
| Subtotal | | | | | $89,420 |
| | | | | Annual Cost Subtotal: | $89,500 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $82,698 |
| | | | | 10% Legal, administrative, engineering fees: | $8,300 |
| | | | | 20% Contingencies: | $18,200 |
| | | | | **Annual Cost Total:** | **$109,200** |
| | | | | **5-year Present Worth of Annual Costs:** | **$497,300** |

**TABLE 4-6**
**COST ESTIMATE**
**Former Griffiss AFB - Landfill 6**
**Alternative 5 - In-well Air Stripping**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Monitoring (For First 15 Years)** | | | | | |
| Bi-Annual Groundwater Sampling | Total 12 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $5,200 | $10,400 |
| Analytical Costs (VOCs) | VOC samples from 12 wells | 2 | Events | $1,200 | $2,400 |
| Air Samples Analysis - VOCs | | 4 | Events | $1,250 | $5,000 |
| Data Evaluation and Reporting | | 60 | HR | $85 | $5,100 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 100 | LF | $14 | $1,500 |
| Subtotal | | | | | $25,400 |
| | | | | Annual Cost Subtotal: | $25,400 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $23,470 |
| | | | | 10% Legal, administrative, engineering fees: | $2,400 |
| | | | | 20% Contingencies: | $5,200 |
| | | | | **Annual Cost Total:** | **$31,100** |
| | | | | **15-year Present Worth of Annual Costs:** | **$366,000** |
| | | | | **2001 Total Present Worth Cost:** | **$1,803,400** |
| | | | | **2004 Total Present Worth Cost:** | **$1,917,300** |

**Notes:**

1. Assume radius of influence (ft) = 50
2. Assume treatment area (acre) = 4.8
   Assume treatment area (ft2) = 207,522
3. Assume number wells based on treatment area = 21
4. Twelve monitoring wells will be sampled during the long-term monitoring program (5 new + 7 existing).
5. 5 and 15-year present worth of costs assume 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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
6. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

7. Costs presented are based on conventional contracting methods.

### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative removes contaminants from the aquifer and concentrates them onto activated carbon, reducing volume through treatment. When the carbon is spent, it is sent off-site for regeneration, where the contaminants are destroyed. Thus, this alternative is effective for reducing toxicity through treatment.

### Short-term Effectiveness

Implementation of this alternative would require the installation of three wells to recover the groundwater and a small treatment building and discharge pipeline. This would require clearing some vegetation and associated well drilling activities. However, these impacts would be minor. Property transfer may be impacted until RAOs have been achieved.

### Implementability

Fouling issues must be considered upon implementation of this alternative. Otherwise, this alternative is readily implemented.

### Cost

The 2004 total present worth cost of this alternative of $2,436,500 was based on the calculated 2001 total present worth cost of $2,291,700 using RS Means Historical Cost Index (see Table 4-7). The capital cost of $463,500 includes the carbon adsorption system, extraction and monitoring wells, underground piping, and electrical distribution. The 30-year present worth O & M cost of $1,828,200 includes the carbon treatment system maintenance, carbon drum replacement and disposal, and long-term monitoring.

## 4.3 Comparison of Alternatives

### 4.3.1 Overall Protection of Human Health and the Environment

No human or environmental receptors are currently impacted by this plume. Although there are no current receptors of contamination at the Landfill 6 plume, Alternative 1 does not include any provisions to prevent future exposures through installation of drinking water wells or construction in soils above the plume. Alternative 2 includes deed restrictions and a monitoring program to ensure that there are no future exposures to contaminants. Because the future use of the area above the plume is intended to be open space, this approach would be protective. However, without flow modeling it is not currently known whether the plume may eventually migrate to Three Mile Creek. If the plume were to migrate to the creek, receptors there may be impacted. Alternative 3 builds on Alternative 2, including predictive modeling and increased plume analysis to verify that no future exposures would occur. Alternatives 4 through 6 employ active treatment mechanisms to destroy contaminants, providing the highest level of protection to human health and the environment.

**TABLE 4-7**
**COST ESTIMATE**
**Former Griffiss AFB - Landfill 6**
**Alternative 6 - Extraction, Treatment and Disposal**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Pre-Design Investigation | Numerical modeling or aquifer test | 1 | LS | NA | $45,000 |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $65,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 2,000 | LF | $14 | $28,900 |
| **Site Preparation** | | | | | |
| Mob/demob | | 1 | LS | NA | $15,000 |
| Clearing -Medium brush w/o Grub | | 1 | Acre | $209 | $200 |
| **Subtotal** | | | | | $159,100 |
| **Pump & Treat System** | | | | | |
| 8" Recovery Wells | Includes well construction, pump, controls, and enclosure; no split spoon sampling- up to 75 ft deep | 3 | Each | $10,900 | $32,700 |
| Carbon Adsorption System | (4) 55-gal drums including installation | 4 | Each | $818 | $3,300 |
| Pre-filter and Internal Piping Kit | | 2 | Each | $1,740 | $3,500 |
| Delivery of Carbon Drums to Site | | 1 | LS | NA | $1,500 |
| Pre-Fabricated Enclosure (200 sf) | For Carbon System; including installation, insulation, piping etc. | 1 | LS | NA | $30,000 |
| **Subtotal** | | | | | $71,000 |
| **Piping Installation** | | | | | |
| Pipe Trenching (Influent) | Influent piping from wells to Building; assume 2'wide, 4' deep; including backfill and compaction | 1,000 | LF | $10 | $10,400 |
| Pipe bedding- Influent Piping | | 1,000 | LF | $6 | $5,600 |
| 3" PVC Pipe -Influent Piping | | 1,000 | LF | $7 | $6,900 |
| Pipe Trenching (Discharge) | 2'wide, 4'deep; including backfill and compaction | 800 | LF | $10 | $8,400 |
| Pipe bedding- Discharge Piping | | 800 | LF | $6 | $4,500 |
| 3" PVC Pipe -Discharge Piping | | 800 | | $7 | $5,600 |
| **Subtotal** | | | | | $41,400 |
| **Electric Distribution- to building and extraction wells** | | | | | |
| Underground Electrical Distribution | Trenching including backfill and | 245 | CY | $7 | $1,700 |
| 3" PVC conduit | | 1,100 | LF | $7 | $7,600 |
| Feed Cable | | 1,100 | LF | $5 | $6,000 |
| Panel Board | | 1 | Each | $1,325 | $1,400 |
| Electrical connection fee and meter | Assume source of power is overhead electric from southeast corner of the site | 1 | LS | NA | $1,500 |
| **Subtotal** | | | | | $18,200 |
| **Monitoring Wells** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 3 | Each | $4,500 | $13,500 |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 2 | Each | $8,400 | $16,800 |
| Well Development | | 5 | Each | $750 | $3,800 |
| IDW Sampling and Disposal | | 1 | LS | NA | $10,500 |
| Subtotal | | | | | $44,600 |
| | | | | Capital Cost Subtotal: | $334,300 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $308,893 |
| | 25% Legal, administrative, engineering fees, construction management: | | | | $77,300 |
| | | | | 20% Contingencies: | $77,300 |
| | | | | **Capital Cost Total:** | **$463,500** |

**TABLE 4-7**
**COST ESTIMATE**
**Former Griffiss AFB - Landfill 6**
**Alternative 6 - Extraction, Treatment and Disposal**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Annual Costs** | | | | | |
| **Operation** | | | | | |
| Filter Replacement | Assume 1-person @ $65/hr; 2.5 hr/week (130 hr/yr) | 130 | HR | $65 | $8,500 |
| Pump & Motor Maintenance | Assume 6 events/year; 1-person @$65/hr; 8hr/event, $100 for materials | 6 | Events | $620 | $3,800 |
| Monthly System Sampling | Influent & effluent for VOCs | 12 | Events | $200 | $2,400 |
| Electric Charge | | 20,000 | KWH | $0.06 | $1,200 |
| Carbon Drum Replacement | Assume 6 events/year; assume 4 drums | 6 | Events | $4,000 | $24,000 |
| Carbon Drum Sampling and Disposal | Assume 6 events/year; assume 4 drums | 6 | Events | $3,000 | $18,000 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 100 | LF | $14 | $1,500 |
| Subtotal | | | | | $60,400 |
| **Monitoring** | | | | | |
| Bi-Annual Groundwater Sampling | Total 12 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $5,200 | $10,400 |
| Analytical Costs (VOCs) | VOC samples from 12 wells | 2 | Events | $1,200 | $2,400 |
| Data Evaluation and Reporting | | 60 | HR | $85 | $5,100 |
| Subtotal | | | | | $17,900 |
| | | | | Annual Cost Subtotal: | $78,300 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $72,349 |
| | | | | 10% Legal, administrative, engineering fees: | $7,300 |
| | | | | 20% Contingencies: | $16,000 |
| | | | | **Annual Cost Total:** | **$95,700** |
| | | | | **30-year Present Worth of Annual Costs:** | **$1,828,200** |
| | | | | **2001 Total Present Worth Cost:** | **$2,291,700** |
| | | | | **2004 Total Present Worth Cost:** | **$2,436,500** |

**Notes:**
1. Twelve monitoring wells will be sampled during the long-term monitoring program (5 new + 7 existing).
2. Carbon drum replacement unit costs based on life cycle of activated carbon. Here, carbon drums assumed to be replaced once every 2 months
Therefore, carbon replacement adjusted to account for these costs annually.
3. 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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
4. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

5. Costs presented are based on conventional contracting methods.

### 4.3.2 Compliance with ARARs

Groundwater standards comprise the chemical-specific ARARs for this plume. Alternatives 4 through 6 provide active treatment mechanisms for removing contaminants from the groundwater, decreasing the time required for compliance with these ARARs. Alternatives 4 and 5 employ in situ treatment technologies to meet ARARs in the shortest period. Alternative 6 uses extraction and treatment that would require a longer treatment duration before ARARs are met. Alternative 3 also uses degradation techniques to eventually meet ARARs, although in a time frame longer than Alternative 6. ARARs would not be achieved with Alternatives 1 and 2.

Alternatives 4 and 5 apply in situ treatment approaches over an area that covers about 99% of the contamination on a mass basis. Increasing the extent of coverage of these technologies to the entire plume area defined by groundwater standards would increase area, and thus costs, by about 50%. While there would be some area in the 5 to 50 µg/L concentration range remaining initially above ARARs, this area would represent only a small fraction of the plume and would likely reduce to levels below ARARs over time after treatment of the plume was complete.

### 4.3.3 Long-term Effectiveness

Alternatives 4 and 5 use active in situ treatment technologies. The chemical oxidation pilot study at this site was effective in reducing contaminant mass; thus, it is effective in the long-term. The effectiveness of the in-well air stripping technology presented in Alternative 5 cannot be accurately predicted until after pilot studies and/or initial implementations of the technology. However, this technology has been applied at other sites with similar contaminants of concern and is therefore expected to be reasonably effective. Pending successful use of this alternative, this technology would represent an effective long-term solution.

Alternative 6 employs a more established, proven technology and thus its effectiveness is more predictable. Extraction and treatment is a well-established technology that is known to control plume migration. It would, over the long-term, provide effective protection. However, its ability to completely reduce concentrations to groundwater standards throughout the aquifer is somewhat limited by the long period required to reduce concentrations.

Alternative 3 relies entirely on passive treatment processes to bring groundwater concentrations to within standards. Natural attenuation is an accepted solution for effectively protecting human health and the environment. A complete evaluation of its effectiveness for this plume cannot be determined until the program outlined as part of its implementation (see Section 4.1.3) has been completed.

The use of deed restrictions and the ongoing monitoring called for by Alternative 2 provides an effective long-term mechanism to protect human health and the environment. However, in the absence of treatment mechanisms, this alternative is less protective than Alternatives 3 through 6.

### 4.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 through 6 employ treatment mechanisms to reduce toxicity of contaminants in the plume. Alternative 3 relies on naturally occurring treatment processes within the plume. Alternative 4 treats the contaminants directly in situ, thus providing the most effective and rapid toxicity reduction. Alternatives 5 and 6 rely on migration of contaminated groundwater to air stripping/extraction wells followed by extraction of vapors/groundwater to the surface for treatment. This provides effective treatment, but at a slower rate (Alternative 6 assumes longer treatment duration). Alternative 3 relies on naturally occurring processes within the plume. The adequacy of these treatment mechanisms would have to be verified through the evaluation program described in Section 4.1.3.

### 4.3.5 Short-term Effectiveness

None of the alternatives considered would have significant short-term impacts. Until RAOs have been achieved for any of the alternatives, property transfers may be impacted. In addition, the active in situ treatment of Alternative 4 would require surface access throughout the area of the plume, which would require clearing some vegetation, but this is not a significant impact. Alternative 4 would also provide the shortest duration of implementation (assumed to be one year). Monitoring for this alternative would span an assumed 10-year period.

Alternative 5 would provide the next shortest duration of implementation/ operation, estimated at five years with monitoring events performed during operation activities and extending an assumed 10 years beyond. Alternatives 2 and 3 require essentially continuous ongoing monitoring that would likely extend for decades. The duration of the extraction called for by Alternative 6 is assumed to require decades before standards are met.

### 4.3.6 Implementability

Alternative 5 would require pilot-scale testing to demonstrate effectiveness prior to implementation. It is possible that this testing would reveal technical problems that may limit the ability to implement the technology or require changes from the assumptions that have been made regarding, for example, radius of influence, that may increase or decrease costs of implementation.

Similarly, the implementability of natural attenuation for Alternative 3 can only be fully evaluated after the completion of the investigative activities outlined in this alternative’s description in section 4.1.3. There are no actions to implement for Alternative 1. Alternatives 2, 4, and 6 are readily implementable.

### 4.3.7 Cost

Alternative 1 calls for no action and thus incurs no costs. Alternative 2, which comprises long-term monitoring, is the least expensive of the remaining alternatives at a 2004 present-worth cost of $635,400. Natural attenuation, the primary component of Alternative 3, is estimated at a 2004 present-worth cost of $1,651,800. The cost for this alternative is greater than long-term monitoring due to the greater number of wells installed and monitored, a wider variety of parameters analyzed, and the addition of up-front investigation, including a potential microcosm study to better ascertain the effectiveness of natural attenuation, including developing flow and degradation modeling.

Alternatives 4 and 5 both call for in situ treatment. Since the chemical oxidation pilot study has been performed at this site, the implementation methodology for Alternative 4 has been evaluated to the point where the cost estimate presented in this FS is expected to have less potential to vary. On the other hand, the cost estimates for full-scale implementation of Alternative 5 obtained from the in-well air stripping vendors are conceptual and may not fully represent site-specific conditions. Additionally, the cost estimate for Alternative 5 could vary based on bench- and/or pilot-scale testing.

Considering these issues, the 2004 present-worth cost of Alternative 4 is $4,102,500, which is the most expensive alternative primarily due to the amount of oxidant required to reduce contaminant mass and to obstacles with oxidant delivery methods. Alternative 5 is the least expensive of the active treatment alternatives with a 2004 present-worth cost of $1,917,300.

Alternative 6 employs extraction and treatment to treat the plume. Its 2004 present-worth cost is estimated as the next most expensive alternative. Most of its $2,436,500 estimated 2004 present-worth is due to 30 years of operation of the treatment system.

Cost estimates for Landfill 6 groundwater remediation alternatives are summarized in Table 4-8.

## 4.4 Recommendation

Considering the RAOs for Landfill 6 and the remedial alternative evaluation completed in this section, the recommended remedy for the Landfill 6 plume is in-well air stripping (Alternative 5).

In-well air stripping technology, when used to remediate contaminated groundwater, represents an active remedial approach to permanently reduce the toxicity, mobility, and volume of site contaminants of concern, which is the preferred approach, when practical. This alternative also provides for protection of human health and the environment and has the ability to have one of the shortest treatment durations of the alternatives presented. However, it should be noted that

## Table 4-8 Summary of Total Present Values of Alternatives at Landfill 6
## Former Griffiss AFB, Rome, New York

| Description | Alternative 1<br>No Action | Alternative 2<br>Institutional Actions | Alternative 3<br>Natural Attenuation | Alternative 4<br>In Situ Oxidation | Alternative 5<br>In Well Air Stripping | Alternative 6<br>Extraction, Treatment, and Disposal |
|---|---|---|---|---|---|---|
| Total Project Duration (Years) | 0 | 30 | 30 | 10 | 15 | 30 |
| Capital Cost | $0 | $120,000 | $787,500 | $3,647,700 | $940,100 | $463,500 |
| Annual O&M Cost | $0 | $25,000 | $40,100 | $25,000 | $109,200<br>(for first 5 years)<br>$31,100<br>(for first 15 years) | $95,700 |
| **2001 Total Present Value of Alternatives** | **$0** | **$597,600** | **$1,553,600** | **$3,858,800** | **$1,803,400** | **$2,291,700** |
| **2004 Total Present Value of Alternatives** | **$0** | **$635,400** | **$1,651,800** | **$4,102,500** | **$1,917,300** | **$2,436,500** |

during the remediation process, deed restrictions would be required that could affect property transfer.

Taking into consideration the possible impact on property transfer until RAOs have been achieved, an active treatment approach (which has an expected shorter cleanup duration than non- active approaches) appears most desirable. Several active treatment technologies have been presented in this FS, including Alternatives 4, 5, and 6. Although a chemical oxidation (Alternative 4) pilot study performed at the site illustrated that contaminant mass can be reduced within the shortest treatment duration, the estimated present-worth cost to implement this technology full-scale is approximately double the next most expensive alternative (Alternative 6 – Extraction, Treatment, and Disposal). Full-scale implementation costs of Alternatives 5 and 6 are on the same order of magnitude. However, unlike Alternative 4, Alternatives 5 and 6 require some form of preliminary testing prior to full-scale implementation. RAOs for Alternative 5, In-well Air Stripping, are expected to be achieved within five years of operation, with long-term monitoring continuing into the future for 10 years. This duration is expected to be less than that of Alternative 6 due to the number/placement of treatment wells and assumed well efficiency rates. Uncertainties associated with the effectiveness must be determined with a pilot-scale study before full-scale implementation. In-well air stripping is a proven technology and has been conducted successfully at similar sites. For Alternative 6 (Extraction, Treatment, and Disposal), which is expected to meet RAOs some time after the 30-year evaluation period assumed for this FS, continuous operation and maintenance of a treatment system would be required.

Alternatives 1, 2, and 3 represent the least expensive alternatives; however, treatment technologies would not be implemented and RAOs are not expected to be achieved within the assumed 30-year period used for evaluation purposes for this FS.

# 5 Building 775 Plume Treatment Alternatives

## 5.1 Development of Alternatives

In this section, technologies noted as retained in Section 3 are developed into alternatives appropriate for the Building 775 plume. The Three Mile Creek ROD (E & E December 2003) was considered in developing these alternatives. In general, the ROD selects excavation of contaminated sediments with long-term monitoring (and source control) as the selected remedy, in which remediation of the Building 775 plume is not mentioned. As discussed in Section 2.5, the Building 775 plume consists of a relatively deep plume that has migrated southwest from its apparent original source area near Buildings 774 and 775. To address this contamination, five alternatives have been developed:

- Alternative 1: No Action
- Alternative 2: Institutional Actions
- Alternative 3: In situ Oxidation
- Alternative 4: In-well Air Stripping
- Alternative 5: Extraction, Treatment, and Disposal

Each of these alternatives are described in detail in the following sections.

### 5.1.1 Alternative 1: No Action

Under this alternative no action would be taken to remediate the Building 775 plume. The plume would be allowed to migrate and attenuate naturally. No monitoring would be conducted to evaluate the progress of these natural processes.

### 5.1.2 Alternative 2: Institutional Actions

To prevent future exposure to contaminated groundwater, this alternative calls for implementing restrictions on the use of groundwater at the Building 775 AOC. The groundwater use restrictions would include deed restrictions that would prevent future use of the groundwater. In addition, fencing would be installed to limit site access and a groundwater monitoring program would be implemented to evaluate the extent of migration and attenuation of the plume. This alternative would not provide for cleanup in a reasonable and predictable timeframe; therefore, the potential need for a waiver would need to be discussed with the appropriate regulatory agency(ies).

In order to properly monitor the plume, biannual groundwater sampling would be performed to determine and monitor any seasonal water table and contaminant concentration fluctuations. Although the contaminant plume at this site was adequately delineated both horizontally and vertically during the 2000 groundwater study (E & E August 2000), 30% of the data was obtained from temporary hydropunch borings. Therefore, locations of permanent monitoring wells at the site are not adequate to properly monitor the plume. Under the long-term monitoring program, one well (775VMW-26) would be installed and sampled (see Figure 5-1) and ten existing permanent wells (775VMW-17, -18R, -19, -20R, -22, -22D, -23, 775MW-20, -20D, and LF6VMW-7) would be sampled. New programs at the base may result in the installation of new wells at this site, whereas installation of the Landfill 6 cap may result in monitoring well decommissioning. Therefore, monitoring wells proposed for the long-term monitoring program at this site may be impacted and the numbering/locations of the proposed wells may be modified during the design stage.

Proposed monitoring well 775VMW-26 would be installed to the southeast of the hot spot between wells 775VMW-22 and 775VMW-20R because there is a chance that contamination may migrate or has already migrated between these two wells. Vertical profiling would be performed during the installation of this well to determine the optimal screen interval.

Eleven wells (ten existing and one new) would be tested for the contaminants of concern (PCE/TCE/DCE) through analysis of a suite of VOCs using a low-level method of SW8260B. This low-level method could produce detection limits that are five times lower than the standard method, enabling earlier detection of any contaminants migrating downgradient into wells that are currently clean.

Because contaminants would remain above groundwater standards for the foreseeable future, a deed restriction would have to be applied to the area where contamination above ARARs is present to minimize the potential for future uses of groundwater in this area.

For purposes of this FS, it is assumed that on-site contaminant concentrations would remain above ARARs for the 30-year alternative duration and that remedial actions at the site may require a re-evaluation at that time. However, if concentrations observed on-site achieve ARARs, this alternative would no longer be needed, monitoring would be reduced or eliminated, and a report written requesting site closure.

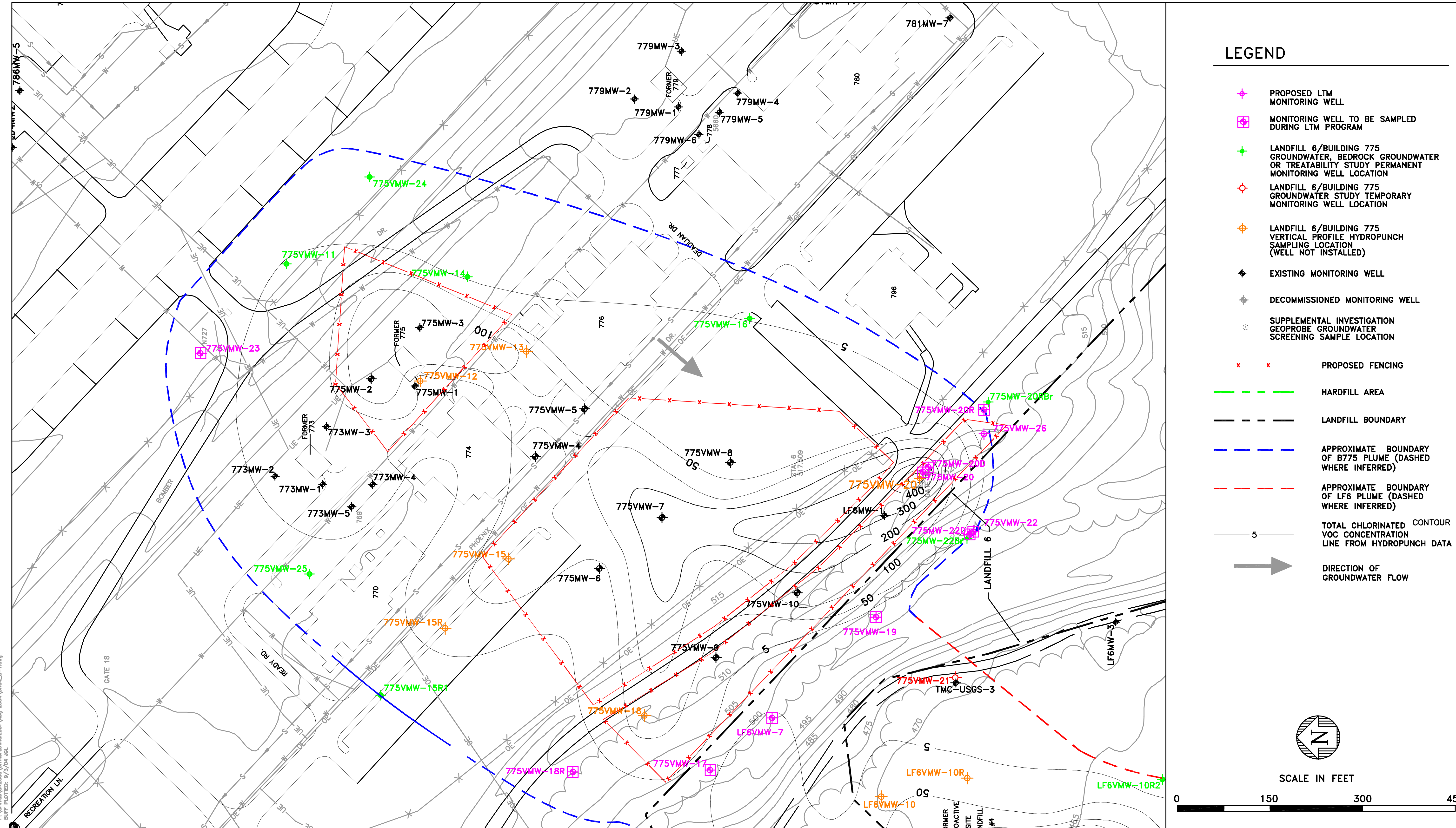





FIGURE 5–1 BUILDING 775 ALTERNATIVE 2
INSTITUTIONAL ACTIONS
FORMER GRIFFISS AFB
ROME, NEW YORK

### 5.1.3 Alternative 3: In situ Oxidation

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 cleanup goals were achieved. During this action there would be continued monitoring of the extent of migration or natural attenuation of the plume.

Between February and June 2002, bench-scale studies were performed on site soil and groundwater 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, $KMnO_4$ was selected as the most effective oxidizing agent. The use of $KMnO_4$ produces $MnO_2$ particles as a by-product, which are not a concern as they are naturally present in the soils. However, the formation of $MnO_2$ from the oxidation reaction may result in reduction of permeability and clogging, thus reducing the treatment efficiency. (Observations made during the pilot study indicated that elevated levels of metals in groundwater were detected between pre- and post-injection sampling rounds. However, these levels are expected to be localized to the treatment area.) Based on the results of the bench-scale study, a pilot study was conducted at the adjacent Landfill 6 site (see Section 4.1.4). Pilot studies were not performed at Building 775 because of the challenges associated with oxidant distribution (due to the depth of the plume) and because the geology and contaminants of concern at Building 775 are similar to Landfill 6. Information collected during the pilot study for Landfill 6 was used to evaluate the viability of full-scale implementation of this technology at Building 775. 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 using $KMnO_4$ were performed for groundwater at Building 775 by ENVIROX LLC in June 2002 (E & E June 2004). Results from the tests on the groundwater indicated that TCE was effectively destroyed by $KMnO_4$. It should be noted that soil samples and groundwater used in the bench scale study were obtained from the 775MW-20 borehole and well, respectively, where the highest TCE concentrations previously had been detected.

Based on pilot study results at the adjacent Landfill 6 site, this alternative assumes a 15-foot radius of influence in areas with total VOC concentrations greater than 50 $\mu$g/L. For costing purposes it was assumed temporary injection wells would be advanced using the Geoprobe method at this site. One-inch PVC tubing with a 10-foot screen at various depths, depending on well location, would be left in place as the Geoprobe rod is pulled out. By installing these temporary wells, the drilling crew can work independently of the injection crew, allowing more flexibility with scheduling than if the Geoprobe unit were used to directly inject the oxidant as the rod is pulled out. In addition, pressure injection up to 10 gpm of the oxidant is proposed to further reduce time spent in the field. This approach would result in significant cost savings, considering the size and depth of the plume, compared to installing well clusters. Although previous on-base work at Landfill 6 involving Geoprobes showed a total penetration depth of 60 feet BGS, discussions with drilling contractors have indicated penetration depths of up to 120 feet. Since the plume exhibits localized areas of high contamination and because the cost of implementing in situ type technologies is proportional to the area, a more cost-effective approach would involve targeting the areas with high levels of VOC contamination.

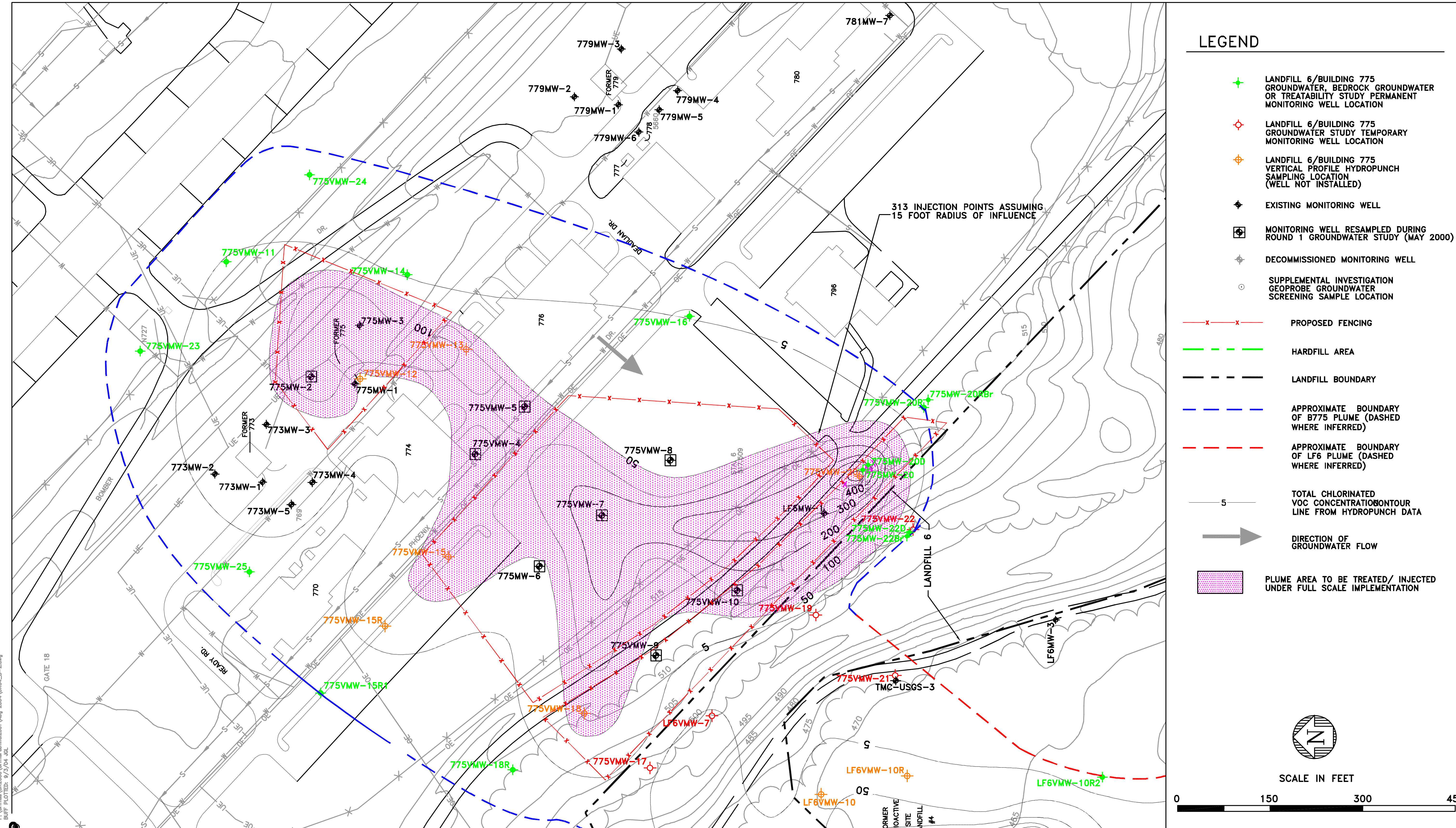
This FS assumes full-scale remediation using this technology for the area contained within the 50-µg/L total VOC concentrations contour line (see Figure 5-2). Remediating this area would remove about 95% of the contaminant mass and approximately 46% (or 6.5 acres) of the plume area (see Table 5-1). Although biological activity would be reduced in those areas directly affected by the oxidant, contaminant concentrations remaining on-site above cleanup levels after injection event(s) have occurred are expected to continue to attenuate naturally (by biological and other processes).

**Table 5-1 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at Building 775**

| Contour Interval (µg/L) | Lower Bound Concentration of Contour Interval (µg/L) | Area of Contour Interval ($ft^2$) | Cumulative Percentage 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 (%) |
|---|---|---|---|---|---|
| >600 | 600 | 301 | 0 | 0.01 | 1 |
| 500-600 | 500 | 539 | 0 | 0.02 | 1 |
| 400-500 | 400 | 1,674 | 0 | 0.04 | 4 |
| 300-400 | 300 | 17,155 | 3 | 0.32 | 20 |
| 200-300 | 200 | 37,394 | 9 | 0.47 | 45 |
| 100-200 | 100 | 82,936 | 23 | 0.52 | 72 |
| 50-100 | 50 | 141,534 | 46 | 0.44 | 95 |
| 5-50 | 5 | 324,455 | 100 | 0.10 | 100 |
| **Total** | | **605,988** | | | |

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

Temporary injection wells required to effectively cover this area number approximately 313. These will be installed to target two to four separate saturated intervals, depending on the plume thickness in the area. (The Landfill 6 pilot study targeted two separate intervals.) One scenario may be installation of the wells in rows perpendicular to the groundwater flow, with each row targeting a different interval (i.e., starting with deeper wells upgradient). Another scenario may be installation of the wells in rows perpendicular to the groundwater flow but with each well in the same row targeting a different interval. Each well would be




© 2004 Ecology and Environment, Inc.

FIGURE 5-2 BUILDING 775 ALTERNATIVE 3
IN-SITU OXIDATION
FORMER GRIFFISS AFB
ROME, NEW YORK

offset horizontally as well as vertically from adjacent wells to facilitate complete distribution of the oxidant throughout the aquifer. For costing purposes, average well depths were assumed for well installations. The injection well configuration and target intervals will be refined during the design. Field parameters such as ORP, conductivity, and water levels will be collected during the injection activities to assess oxidant distribution in the subsurface.

For purposes of costing this alternative, one primary injection event was assumed and one secondary event. The secondary injection event is intended as a polishing step to target areas where contaminant concentrations and mass were not reduced to acceptable levels (approximated at 50% of the treatment area). The primary and secondary injection events are assumed to occur within one year.

Monitoring the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2. Two additional sampling rounds will be collected during the first year (for a total of four) to adequately monitor the plume during treatment. Metals are not expected to mobilize within the plume and so metals analysis is not included in the long-term monitoring program. Since this alternative involves active treatment and destruction of contaminants of concern, maintenance of institutional controls and the long-term monitoring program was assumed for 10 years only. If contaminants of concern remain above proposed cleanup goal concentrations after the assumed 10-year long-term monitoring period, based on data evaluation, additional monitoring may be needed.

### 5.1.4 Alternative 4: In-well Air Stripping

This alternative involves the installation of groundwater-circulating/air-stripping wells to strip the contaminated groundwater of contaminants. The contaminated vapors can be drawn off and treated aboveground, discharged directly into the atmosphere, or discharged into the vadose zone to be degraded in situ via bioremediation. The treated groundwater is not removed from the subsurface but is cycled through a groundwater circulation cell that is created around the well. This circulation cell is a result of the continuous extraction of contaminated groundwater at the bottom of the aquifer or polluted portion thereof and reintroduction of the treated/stripped groundwater into the top of the aquifer or above into the vadose zone.

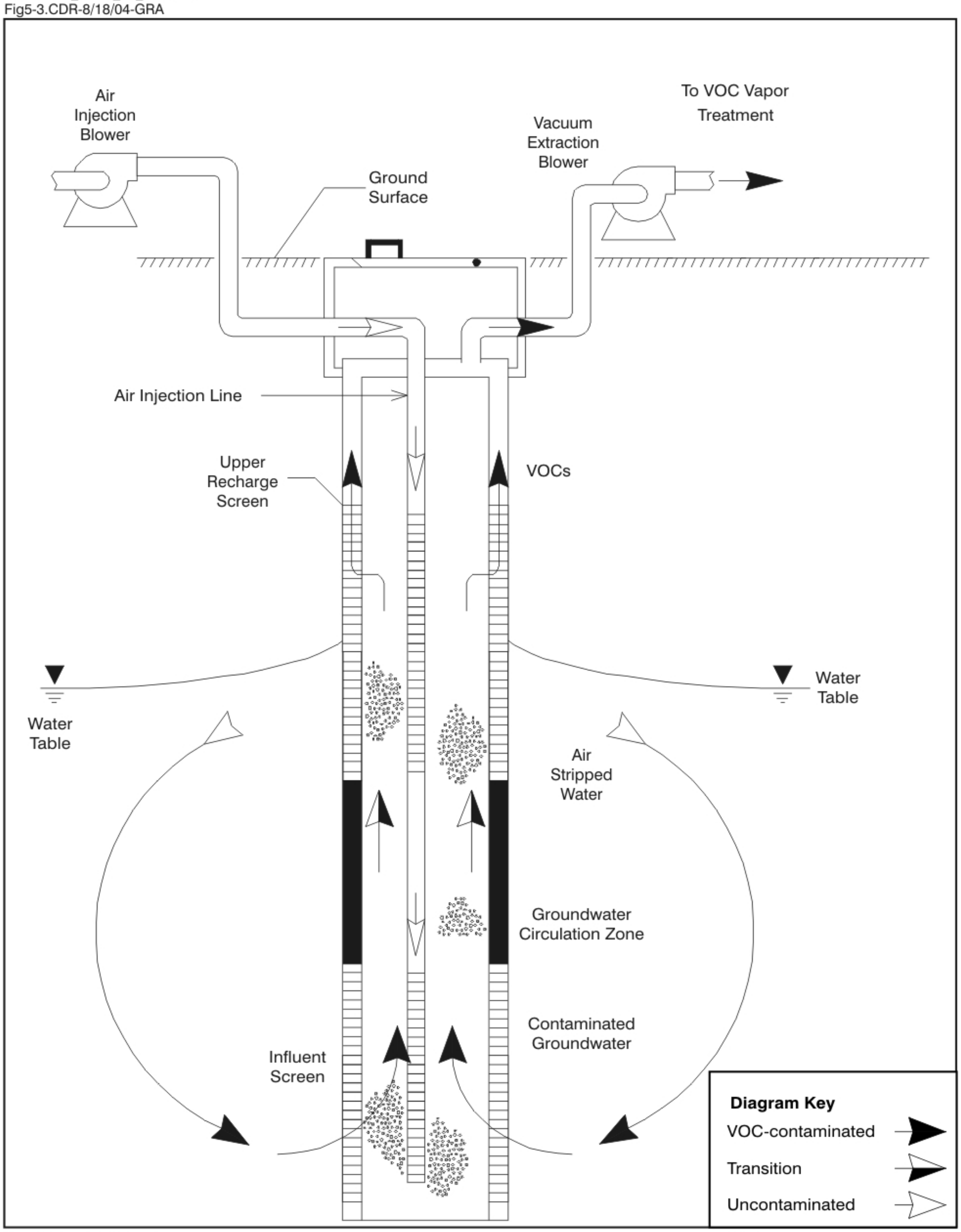
In-well air stripping systems can be a cost-effective approach for remediating VOC-contaminated groundwater at sites with deep water tables because the water does not need to be brought to the surface. In addition, treatment durations for this technology are expected to be shorter because treatment wells can be strategically located throughout the plume actively treating a smaller volume of groundwater per well as opposed to pump and treat which relies on contaminated groundwater to flow to the treatment wells. This results in reduced energy demands and thus a significant energy cost savings. At Building 775, the depth to groundwater is about 50 feet. Based on the results of the spring 2000 SI conducted by E & E, the geologic conditions correspond with the design and operating parameters for optimum performance of this technology. The average hydraulic conductivity (K) and hydraulic gradient at the Building 775 site are $5.5x10^{-4}$ cm/sec and 0.005 ft/ft, respectively. The site also consists of uniform mixtures of silty sands and sand/silt mixtures with no adverse stratigraphy such as the presence of low permeability layers continuous over large areas. The hydraulic conductivity, which is within the desired operating limit of $K > 10^{-5}$cm/sec (see the Federal Remediation Technologies Roundtable which can be accessed at http://www.frtr.gov/matrix2/section4/4-40.html), and the very low hydraulic gradient would enable the wells to capture and sufficiently treat the water several times, via recirculation, before it flowed out of the treatment zone.

Geochemical characteristics of the site can affect the performance of the system if not properly controlled. The high dissolved oxygen concentrations caused by air stripping can cause precipitates to develop in the air stripping well and in the aquifer at locations away from the well. This is caused by the oxidation of iron and manganese, which can clog the recharge zone and well screens. Iron was detected at 590 µg/L, manganese was detected at 69 µg/L (obtained from the averages of all positive analytical results for the Building 773/775 area), and ferrous iron was detected at an average of 0.22 mg/L (determined from all Building 775 wells sampled during the spring 2000 SI). Also, air stripping removes dissolved carbon dioxide from the water, increasing the pH. Increased pH levels can cause the precipitation of calcium carbonates, especially if the alkalinity is high. Heavy metal concentrations have also been shown to decrease as a result of scavenging by calcium carbonate precipitation. Therefore, the stripping of carbon dioxide from groundwater may also lead to the precipitation of larger amounts of metals than would normally occur from the oxygenation of the aquifer. It is relatively safe to assume that there will be minimal calcium carbonate precipitation when the alkalinity is 200 mg/L $CaCO_3$ or less. However, even though the average alkalinity of the Building 775 wells sampled during the spring 2000 SI was 147 mg/L, there were a considerable number of locations that exhibited alkalinities that were close to 200 mg/L. In addition, the average alkalinity of the Landfill 6 aquifer, which is located only about 300 feet away (see Figure 5-6) more than 250 mg/L. Therefore, although alkalinity may be a slight concern at this site, it is unknown whether or not metals precipitate will be a concern. Laboratory tests can be conducted to more accurately determine how much, if any, calcium carbonate and metals will precipitate. These parameters can also be field tested during a single-well pilot study at the site. If calcium carbonate or metals precipitation at the site become a problem, processes such as chemical treatment or the addition of carbon dioxide to the stripping air can be implemented to prevent precipitation. For costing purposes, the process of discharging carbon dioxide into the air stripping wells was included in this alternative.

There are three patented in-well air stripping technologies available, with slight variations in design. However, these technologies all employ the same principle of air-lift pumping to create a groundwater-circulation pattern and simultaneous aeration within the stripping well to volatize VOCs from the groundwater. The DDC system (see Figure 5-3) is developed and patented and is currently available from Wasatch Environmental, Inc. The contaminated vapors can be drawn out of the well and treated aboveground. The NoVOCs system (see Figure 5-4), patented by Stanford University and available from Metcalf & Eddy, is very similar to the DDC system. The NoVOCs system uses a vacuum to draw off contaminated vapors for treatment. The NoVOCs system can be retrofitted to allow for the removal of metals from groundwater through in situ fixation (adsorption and/or precipitation) using common water-treatment chemicals. UVB or vacuum vaporizer well system (see Figure 5-5) was developed by IEG Technologies Corp. and is available from Legette, Brashers and Graham, Inc. The UVB system supplements air-lift pumping with a submersible pump and employs a stripper reactor that increases contact between the two phases, which facilitates the transfer of volatiles from the aqueous to gas phase before the water is returned to the aquifer. The technologies directly considered for the implementation of in-well air stripping at the Building 775 site were the NoVOCs and DDC systems. The UVB well system was not considered further in this FS because it is more complex and expected to have a higher overall cost. The ranges for all parameters considered during the assessment for both of these technologies are presented in the following discussion.

Based on implementation assumptions using geological and geotechnical data collected during the spring 2000 SI and design assumptions developed through communication with vendors of DDC and NoVOCs technologies, the estimated effective treatment radius for an air-stripping well at the Building 775 plume ranges from 85 to 120 feet. Therefore, using the total area of the plume derived during the spring 2000 SI, it is estimated that 14 to 30 wells would be required to treat the entire contamination plume. However, since the plume exhibits localized areas of high contamination and because the cost of implementing in situ type technologies is proportional to the area, a more cost-effective approach would involve targeting the areas with high levels of contamination. Similar to the analysis performed for the Landfill 6 plume, full-scale implementation of this technology was assumed for the area contained within the 50 μg/L total VOC concentration contour line. Remediating this area could potentially remove 95% of the contaminant mass but would address approximately 46% of the area, or 6.5 acres (see Table 5-1). In order to account for overlap and uncertainties, vendor estimates of the effective treatment radius were reduced to 50 feet. This radius of influence will be refined during the pilot study. Based on this 50-foot radius of influence, approximately 29 stripping wells would be required to address this area of the plume (see Figure 5-6). The well system (i.e., spacing, placement, construction) presented in this FS should be refined accordingly during the design stage to address the leading edge of the plume and reduce the potential for contaminating uncontaminated groundwater within the aquifer. Furthermore, a polishing step such as enhanced biodegradation should be considered upon completion of the full-scale implementation of this technology to address residual contamination, as necessary. Costs for such a treatment are not included in this FS.

02:001515_UK01_02_01-B1466
Fig5-3.CDR-8/18/04-GRA

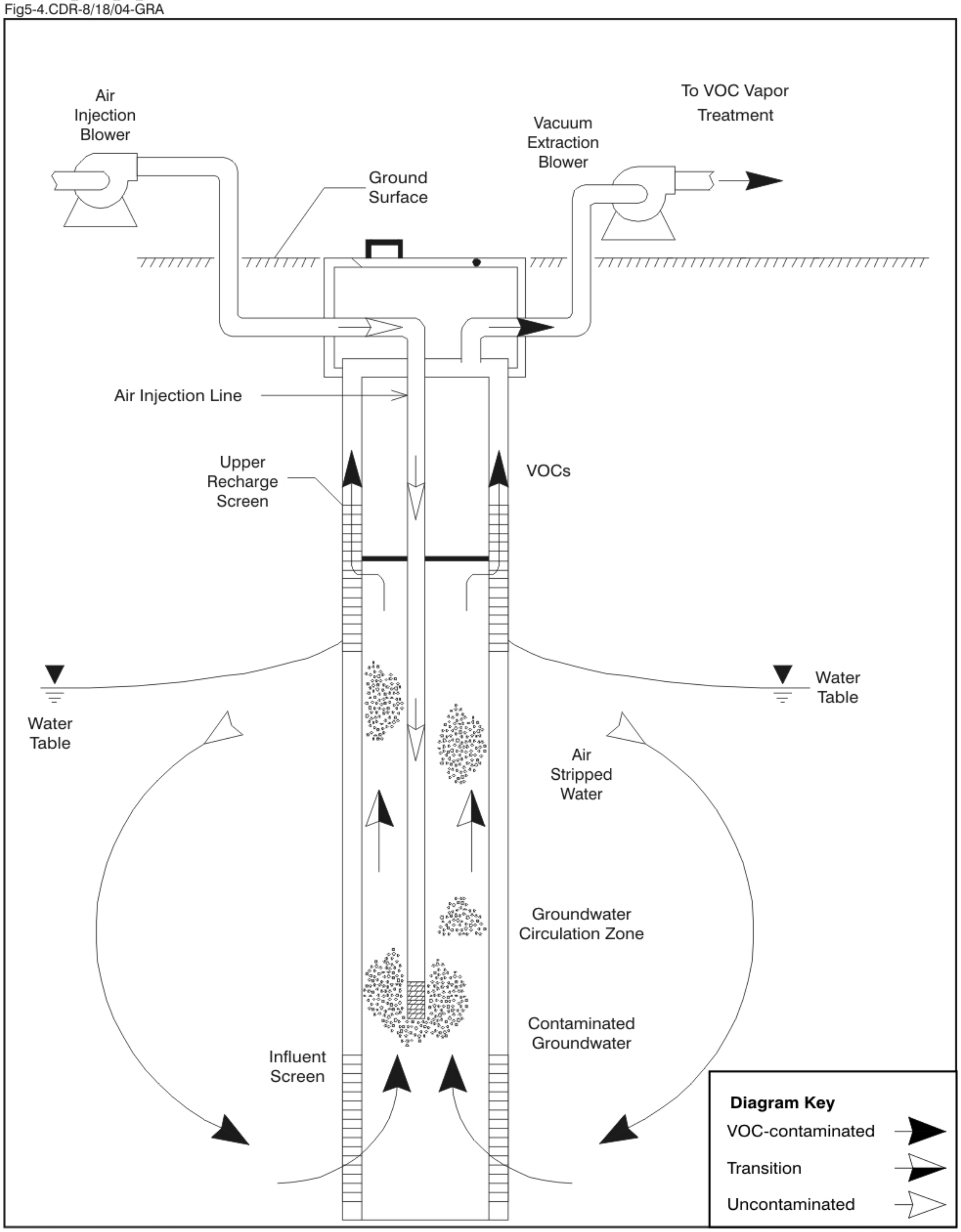



SOURCE: GWRTAC, 2001



**Figure 5-3 Typical Density-Drive Convection (DDC) Well Construction**

02:001515_UK01_02_01-B1466
Fig5-4.CDR-8/18/04-GRA

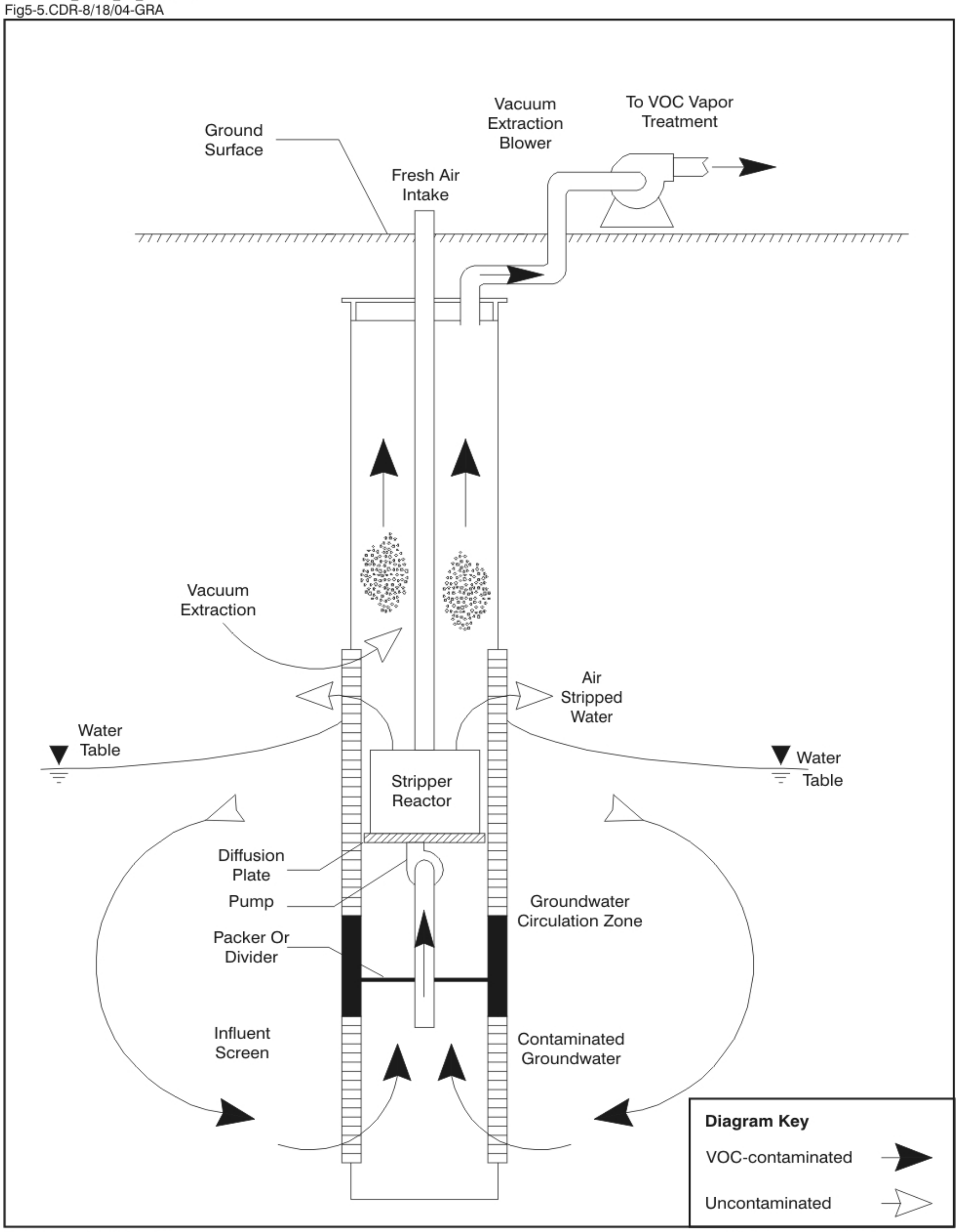



SOURCE: GWRTAC, 2001



**Figure 5-4 Typical NoVOCs Well Construction**

02:001515_UK01_02_01-B1466
Fig5-5.CDR-8/18/04-GRA




SOURCE: GWRTAC, 2001



**Figure 5-5 Typical Unterdruck-Verdampfer Brunner (UVB) Well Construction**

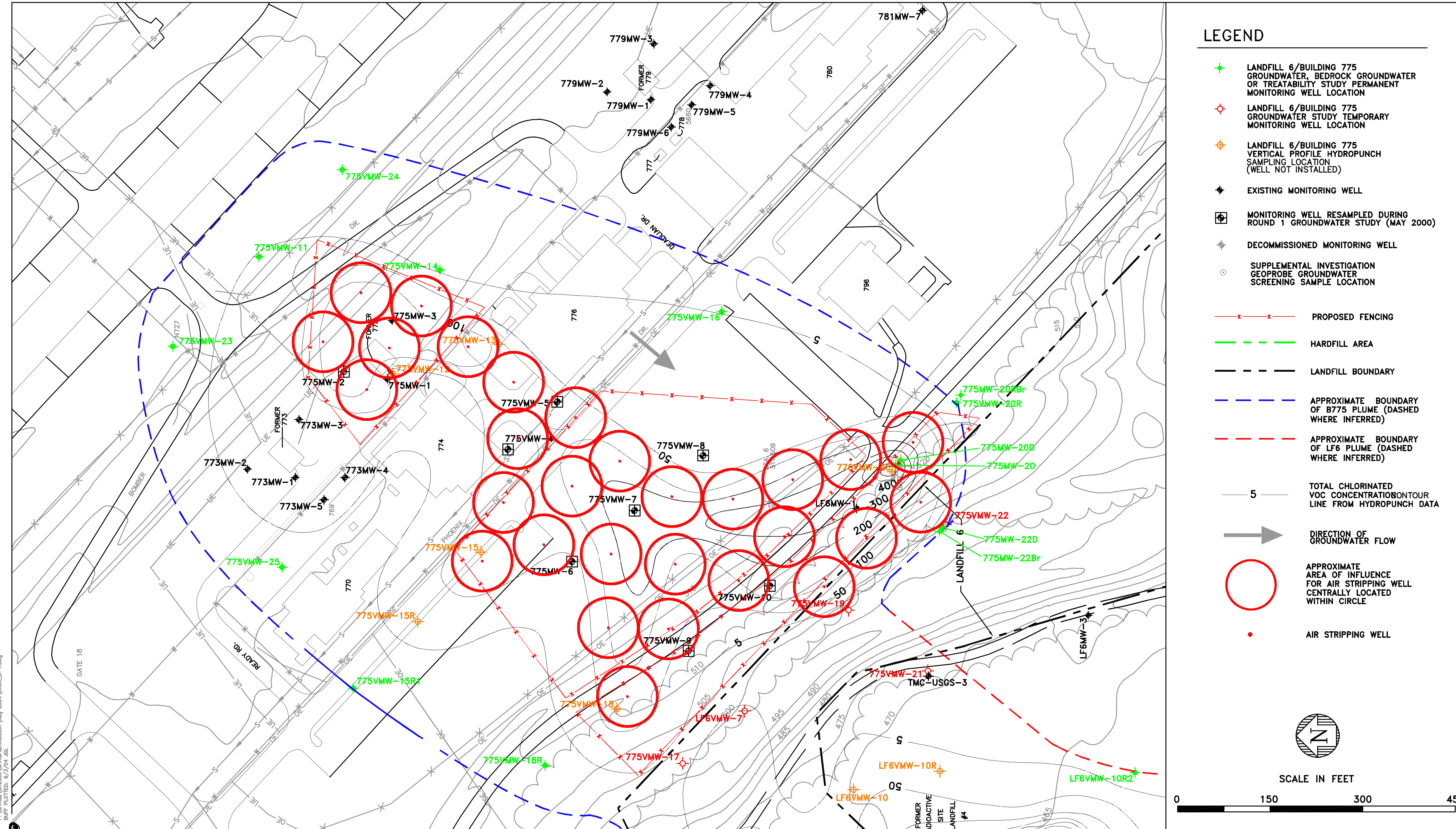





FIGURE 5-6 BUILDING 775 ALTERNATIVE 4
IN-WELL AIR STRIPPING
FORMER GRIFFISS AFB
ROME, NEW YORK

Stripping efficiencies of about 85% to 99% are anticipated in a single well for the chlorinated compounds but require field test verification. In order to eliminate emissions to the atmosphere, the system would be closed-loop in design. Contaminated vapors would be collected at each well head and routed back to two 1,800-pound carbon vessels connected in series. The clean air discharged from the carbon vessels would then be routed to the air intake of the air injection blower. In order to counteract the formation of calcium carbonate and metal precipitates, a compressed-gas cylinder would be used to bleed small quantities of carbon dioxide into the recirculated air. This will prevent the stripping of carbon dioxide from the groundwater. If oxidized metals precipitate due to the oxygenation of the aquifer, it will be addressed by in-well sequestering and/or acid treatment of the aquifer water. The final design criteria will be established through the implementation of a single-well pilot study centrally located in the Building 775 contamination plume. During the pilot study, the following should be addressed: estimation of the vertical hydraulic conductivity of the aquifer (circulating wells operate efficiently when the ratio of horizontal to vertical hydraulic conductivity is between 3 and 10; the circulation time may be too long if the ratio is greater than 10), determination of the optimum well screen design (e.g., slot size, filter pack, etc.); and identification of the presence of preferential pathways within the stratified drift should be ascertained, particularly in the deep portions of the plume near the gravelly till layer (where applicable).

The system components outside the stripping wells such as the air injector, carbon vessels, carbon dioxide cylinder, etc. would be housed in a dedicated, insulated, temperature-controlled structure in order to prevent freezing and to facilitate operations and maintenance activities. Source- and return-air piping lines would be trenched underground. Based on contaminant concentrations and site geological and geochemical conditions, it is assumed that the air-stripping wells will need to be in service for approximately four to six years before the contaminant concentrations satisfy cleanup goals. Annual operational costs include energy and possible chemical (precipitate) control, and maintenance activities are assumed to include two changeouts of the carbon vessels and one changeout of the carbon dioxide cylinder, as well as air sample acquisition. For costing purposes, it is assumed that treatment would be required for approximately five years.

Monitoring of the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2. Metals are not expected to mobilize within the plume; therefore, metals analysis is not included in the long-term monitoring program. Monitoring is assumed to be required for 15 years (five years during operation of the air stripping and 10 years in the future). If contaminants of concern remain above proposed cleanup goal concentrations after the assumed 15-year long-term monitoring period, based on data evaluation, additional monitoring may be needed.

### 5.1.5 Alternative 5: Extraction, Treatment, and Disposal

This alternative involves installing recovery wells to extract groundwater from the Building 775 plume and treatment by carbon adsorption. The treated groundwater is then discharged to Three Mile Creek via a new dedicated underground pipeline.

The results of the SI conducted by E & E in 2000 showed an average hydraulic conductivity of $5.5 \times 10^{-4}$ cm/s across the plume area and a hydraulic gradient of 0.005 ft/ft. Given this hydraulic conductivity and gradient, and assuming a porosity of 25%, the groundwater velocity in the plume was estimated using Darcy's law at $1.1 \times 10^{-5}$ cm/s or $2.17 \times 10^{-5}$ ft/min. Using an average width of the plume of 650 feet and an average thickness of 50 feet, the volumetric flow rate of the plume is estimated at $9.3 \times 10^{4}$ $ft^3$/yr. Capturing this flow would require pumping at a rate of 1.5 gpm. Similar to the capture zone analysis performed for the Landfill 6 plume, a one-foot drawdown was obtained at the edge of the plume for three extraction wells, each pumping at a rate of 1.5 gpm, as shown in Figure 5-7. Well locations may be modified during the design stage. Because of the difficulty of capturing only the contaminated water, it is assumed that three times the volume would need to be pumped, or approximately 4.5 gpm.

The maximum total VOC concentration of 600 µg/L (TCE) detected at the Building 775 plume was detected at 775VMW-20 (a hydropunch point). However, because of the general plume mixing that naturally occurs with less contaminated groundwater during pumping, the maximum VOC concentration expected in the extracted groundwater was assumed to be half of the maximum total VOC concentration detected in the plume, which is 300 µg/L. The extracted groundwater is pumped to a carbon treatment system, as shown in Figure 5-7.

The carbon treatment system would consist of two treatment trains, each with two defiltered 55-gallon drums of granular activated carbon (200 lbs per drum) in series. The second in-series carbon drum would provide redundancy in the system if breakthrough occurs in the first unit. The system would be housed in a prefabricated protective and insulated enclosure. Temperature control of the enclosure would prevent freezing of system components. A flow meter would be installed at the influent and effluent sides to monitor flow through the system. External exposed piping would be heat-traced.

Based on the anticipated pumping rates and VOC concentrations in the extracted groundwater, carbon usage per treatment train per day was estimated at 0.43 lbs. The estimated lifetime of the carbon drums prior to requiring replacement is therefore calculated to be 15 months. Spent carbon drums would be removed, properly disposed of, and replaced with new carbon drums. Long-term maintenance of the system would also require replacing the filters on weekly basis and monthly sampling of the influent and effluent VOC concentrations. Treated groundwater from the system would be discharged to Three Mile Creek through a dedicated 4-inch PVC underground pipeline. Requirements of a SPDES permit would need to be

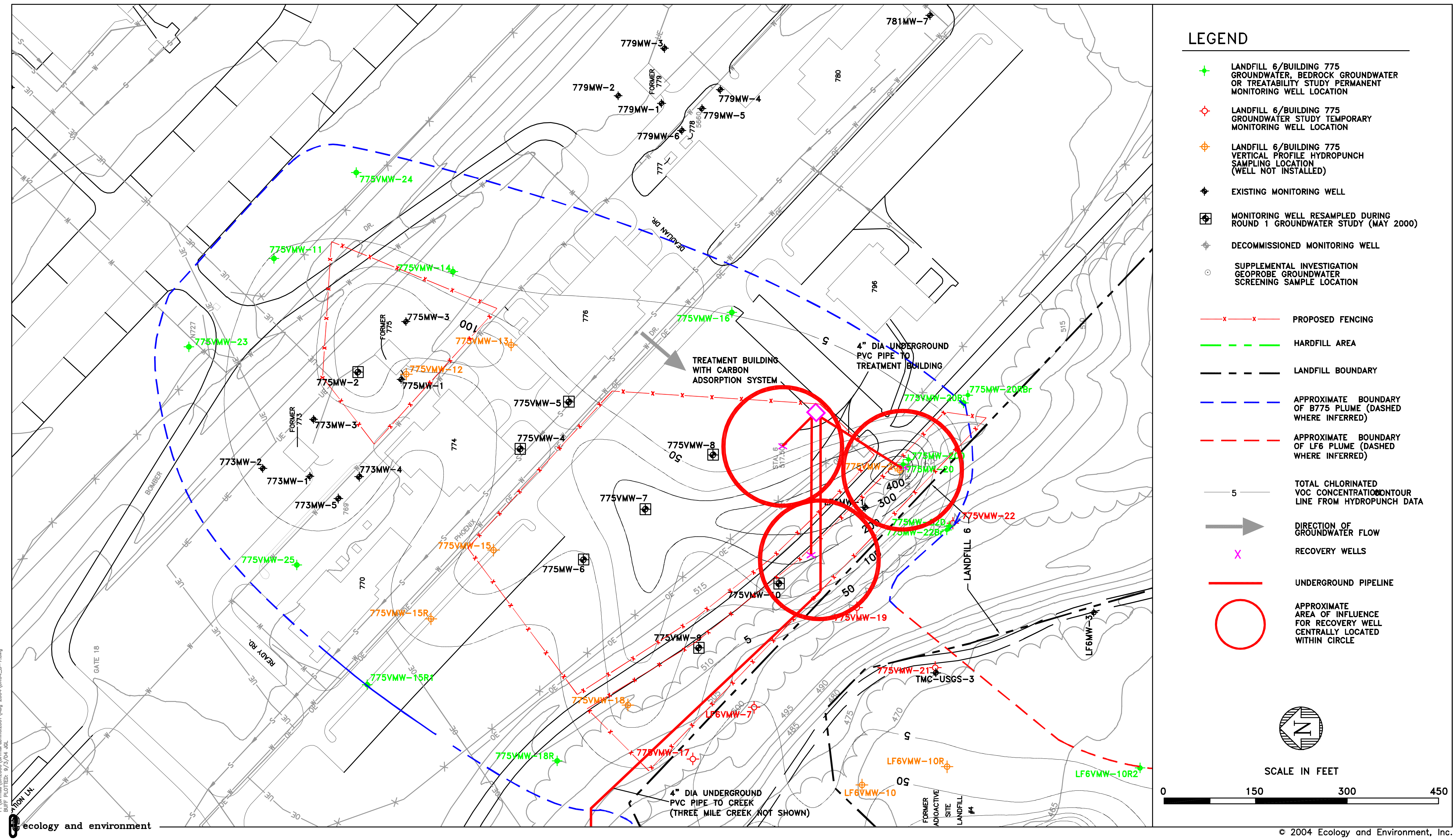





FIGURE 5–7 BUILDING 775 ALTERNATIVE 5
EXTRACTION, TREATMENT
AND DISPOSAL
FORMER GRIFFISS AFB
ROME, NEW YORK

achieved before discharge of treated water to the creek. Sampling may be increased based on permit requirements. Discharge of treated water to the sanitary sewer is an option at this site and will be addressed at the design stage if this alternative is selected.

Monitoring the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2.

For purposes of this FS, it is assumed that on-site contaminant concentrations would remain above ARARs for the 30-year alternative duration and that remedial actions at the site may require a re-evaluation at that time. However, if concentrations observed on-site achieve ARARs, this alternative would be terminated, monitoring would be reduced or eliminated, and a report written requesting site closure.

## 5.2 Detailed Analysis of Alternatives

### 5.2.1 Alternative 1: No Action

#### Overall Protection of Human Health and the Environment

This alternative is not protective of human health and the environment. Although there are no current receptors of contamination at the Building 775 plume, this alternative does not prevent future exposures through installation of groundwater wells or construction in soils above the plume.

#### Compliance with ARARs

This alternative does not comply with groundwater standards and thus does not comply with chemical-specific ARARs. Because no action would be taken, no action-specific ARARs would apply.

#### Long-term Effectiveness

Because no action is taken by this alternative, it is not effective in the long-term.

#### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative employs no treatment techniques and thus does not reduce toxicity, mobility, or volume.

#### Short-term Effectiveness

Property transfer may be impacted until RAOs have been achieved. There are no additional short-term impacts from implementation of this alternative.

#### Implementability

There are no technical barriers to implementing this alternative.

#### Cost

Because this alternative calls for no action, no costs are incurred.

### 5.2.2 Alternative 2: Institutional Actions

#### Overall Protection of Human Health and the Environment
Because this alternative would prevent future uses of contaminated groundwater, it is protective of human health. There are currently no human or environmental receptors impacted by this plume. No environmental receptors are anticipated in the foreseeable future.

#### Compliance with ARARs
This alternative does not comply with groundwater standards and thus does not comply with chemical-specific ARARs. Although a deed restriction would be placed and monitoring conducted, no action-specific ARARs would apply.

#### Long-term Effectiveness
Deed restrictions are an effective mechanism for limiting the potential for future exposures to contaminated groundwater. Because municipal water is available in this area and there are no plans for development at this time, this alternative would be effective in the long-term.

#### Reduction of Toxicity, Mobility, or Volume through Treatment
This alternative employs no treatment techniques and thus does not reduce toxicity, mobility, or volume.

#### Short-term Effectiveness
Property transfer may be impacted until RAOs have been achieved. There are no additional short-term impacts from implementation of this alternative. Monitoring would be required to continue for the foreseeable future.

#### Implementability
This alternative is readily implemented.

#### Cost
The 2004 total present-worth cost of this alternative of $665,600 was based on the calculated 2001 total present-worth cost of $626,000 using RS Means Historical Cost Index (see Table 5-2). The capital cost of $129,300 includes the drilling, installation, and development of one vertical profile monitoring well along with characterization and disposal of associated investigation-derived waste. The O & M cost of $26,000 includes two events of groundwater sampling of ten existing wells and one new well per year. The 30-year present worth of the annual sampling is $496,700.

**TABLE 5-2**
**COST ESTIMATE**
**Former Griffiss AFB - Building 775**
**Alternative 2 - Institutional Actions**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Work Plan | Includes submittals, reporting, meetir | 1 | LS | NA | $8,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 4,500 | LF | $14 | $65,000 |
| **Well Installations** | | | | | |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 1 | EA | $10,000 | $10,000 |
| Well Development | | 1 | EA | $750 | $800 |
| IDW Sampling and Disposal | | 1 | LS | NA | $4,300 |
| Subtotal | | | | | $93,100 |
| | | | | Capital Cost Subtotal: | $93,100 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $86,024 |
| | | | | 25% Legal, administrative, engineering fees, construction management: | $21,600 |
| | | | | 20% Contingencies: | $21,600 |
| | | | | **Capital Cost Total:** | **$129,300** |
| **Annual Costs** | | | | | |
| Bi-Annual Groundwater Sampling | Total 11 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $4,800 | $9,600 |
| Parameter Analysis (VOCs) | VOC samples from 11 wells | 2 | Events | $1,100 | $2,200 |
| Data Evaluation and Reporting | | 60 | HR | $85 | $5,100 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 225 | LF | $14 | $3,300 |
| Subtotal | | | | | $21,200 |
| | | | | Annual Cost Subtotal: | $21,200 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $19,589 |
| | | | | 10% Legal, administrative, engineering fees: | $2,000 |
| | | | | 20% Contingencies: | $4,400 |
| | | | | **Annual Cost Total:** | **$26,000** |
| | | | | **30-year Present Worth of Annual Costs:** | **$496,700** |
| | | | | **2001 Total Present Worth Cost:** | **$626,000** |
| | | | | **2004 Total Present Worth Cost:** | **$665,600** |

**Notes:**
1. Eleven monitoring wells will be sampled during the long-term monitoring program (1 new + 10 existing).
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
3. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

4. Costs presented are based on conventional contracting methods.

### 5.2.3 Alternative 3: In situ Oxidation

#### Overall Protection of Human Health and the Environment

There are currently no human or environmental receptors impacted by this plume. This alternative would destroy contaminants in the plume through chemical oxidation, resulting in removal of contaminants from the subsurface and thus eliminating future potential exposure threats.

#### Compliance with ARARs

Through destruction of contaminants via oxidation, concentrations in the aquifer would be reduced to levels below groundwater standards, meeting chemical-specific ARARs. By focusing on treatment of the plume defined by the 50 μg/L contaminant contour interval, this alternative would remove approximately 95% of the contaminant mass. Some areas would remain with contamination between 5 and 50 μg/L; however, these would represent less than 5% of the original contaminant mass and would likely naturally attenuate to levels to within ARARs over time.

#### Long-term Effectiveness

Because the majority of the contaminants would be permanently destroyed, this alternative is effective in the long-term.

#### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative employs reductive dechlorination via chemical oxidation to destroy the contaminants, thus resulting in toxicity reduction through treatment.

#### Short-term Effectiveness

Implementation of this alternative would require the installation of 313 wells over the plume during the primary injection event and 50% of that amount during the second injection event. However, the area above the plume is relatively open, and the oxidant injections are expected to be completed within one year, resulting in only minor short-term impacts. Monitoring is assumed for 10 years (including the assumed one year for oxidant injections at this site). Property transfer may be impacted until RAOs have been achieved.

#### Implementability

This alternative is readily implemented using standard construction means and methods. Since a chemical oxidation pilot study has already been performed at the adjacent site Landfill 6 that exhibits similar site characteristics, there is a better understanding of the physical (topography and stratigraphy) and chemical (type and amount of oxidant) requirements necessary to treat the contaminants of concern at this site.

#### Cost

The 2004 total present worth cost of this alternative of $4,944,200 was based on the calculated 2001 total present worth costs of $4,650,500 using RS Means Historical Cost Index (see Table 5-3). The capital cost of $4,430,900 includes the full-scale implementation of the technology. For purposes of this FS, it was assumed that the injection wells during full-scale implementation would be temporary-type wells installed using the direct-push method. The O & M cost of $219,600 includes 10 years of monitoring and sampling.

### 5.2.4 Alternative 4: In-well Air Stripping

#### Overall Protection of Human Health and the Environment
No human or environmental receptors are currently impacted by this plume. This alternative would remove contaminants from the subsurface as a vapor, limiting future potential exposure threats.

#### Compliance with ARARs
Through removal of contaminants as vapors, concentrations in the aquifer would be reduced to levels below groundwater standards, thus meeting chemical-specific ARARs. By focusing on treatment of the plume defined by the 50 µg/L contaminant-contour interval, this alternative would remove approximately 95% of the contaminant mass. Some areas with contamination between 5 and 50 µg/L would remain; however, these would represent less than 5% of the original contaminant mass and would likely naturally attenuate to within ARARs over time.

Although the system would recirculate air and remove VOCs with gas-phase carbon, some discharge of VOCs into the air would occur, and application for an air permit would be required. This action-specific ARAR would be met.

#### Long-term Effectiveness
Because the vast majority of the contaminants would be removed from the aquifer and be permanently destroyed, this alternative is effective in the long-term.

#### Reduction of Toxicity, Mobility, or Volume through Treatment
This alternative removes contaminants from the aquifer through in-well stripping, reducing the volume of contaminated media through treatment. It also employs carbon adsorption of the stripped air, which during carbon regeneration would destroy contaminants, resulting in toxicity reduction through treatment.

#### Short-term Effectiveness
Implementation of this alternative would require installing 29 wells over the plume. Because the area is already developed, this alternative would have no short-term impacts. O & M of the air stripping system is expected to be five years. Long-term monitoring would be required for an assumed 15 years (including five years during the O & M of the air stripping system). Property transfer may be impacted until RAOs have been achieved.

**TABLE 5-3**
**COST ESTIMATE**
**Former Griffiss AFB - Building 775**
**Alternative 3 - In-Situ Oxidation**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $50,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 4,500 | LF | $14 | $65,000 |
| Subtotal | | | | | $120,000 |
| **Health and Safety** | | | | | |
| Construct Decontamination Pad & Containment | For equipment & personnel | 2 | Setups | $1,900 | $3,800 |
| Air Monitoring | Organic Vapor Analyzer (4 units) | 13 | months | $3,800 | $49,400 |
| Health and Safety Plan and Management | Includes development of plan and medical surveillance of on-site personnel | 1 | LS | NA | $9,500 |
| Site Safety Officer | 10 hrs/day, 5days/wk, $65/hr | 52 | manweeks | $3,250 | $169,000 |
| Personal Protective Equipment | Includes coveralls, hard hats, safety glasses, reusable boots, gloves | 1 | LS | NA | $7,100 |
| Subtotal | | | | | $238,800 |
| **Full-Scale Implementation** | | | | | |
| *Geoprobe Installation* | | | | | |
| Mobilization/Demobilization (Geoprobes) | | 1 | LS | NA | $50,000 |
| Installation of Injection Points, Primary Injection | Assumes average Geoprobe depth to 90', 2 drill rigs, see Notes | 98 | day | $4,000 | $392,000 |
| Installation of Injection Points, Secondary Injection | Assumes average Geoprobe depth to 90', 2 drill rigs, see Notes | 49 | day | $4,000 | $196,000 |
| PVC Piping for Injection Points | 1" PVC pipe to depth of each injection point | 470 | Each | $30 | $14,000 |
| Injection Point Caps | 1" locking cap/flush mounted | 470 | Each | $71 | $33,200 |
| *Chemical Oxidation Injection* | | | | | |
| Reagent Injection, Pump (Equipment) | Assume pressure inject around 10gpm | 2 | Each | $5,000 | $10,000 |
| Reagent Injection, Primary Injection | Includes vendor oversight | 87 | day | $3,500 | $304,400 |
| Reagent Injection, Secondary Injection | Includes vendor oversight | 43 | day | $3,500 | $152,200 |
| Reagent Material incl. Transportation | KMnO4, see Notes | 563,400 | lb | $2.60 | $1,464,900 |
| Electrical Fee | Provided by generator | 130 | day | $100 | $13,100 |
| Oversight | Duration of injection point installation and reagent injection; Assume 1-person @ $65/hr, 5days/week, 8hr/day | 277 | day | $520 | $144,300 |
| Injection Point Abandonment | Abandon injection points in place | 470 | Each | $50 | $23,500 |
| Subtotal | | | | | $2,797,600 |
| **Full-Scale Monitoring** | | | | | |
| *Well Installation* | | | | | |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 1 | EA | $10,000 | $10,000 |
| Well Development | | 1 | EA | $750 | $800 |
| IDW Sampling and Disposal | | 1 | LS | NA | $4,300 |
| *Treatment Monitoring* | | | | | |
| Groundwater Sampling (Labor) | 2-person @ $65/hr, 10hr/day; 9 total wells assume 3 wells per day, 2 additional sampling rounds | 2 | Events | $4,800.00 | $9,600 |
| Groundwater Sampling (Equipment) | Groundwater level indicator, multi-parameter instrument, low-flow pump | 2 | Events | $600.00 | $1,200 |
| Parameter Analyses (VOC) | Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample per well for 9 wells for 2 additional sampling rounds | 2 | Events | $1,100.00 | $2,200 |
| Parameter Analyses (Metals and DOC) | Includes TAL Metals and DOC; assume 1 groundwater sample per well/piezometer for 9 wells for 2 additional sampling rounds | 2 | Events | $3,600.00 | $7,200 |
| Data Evaluation and Reporting | | 60 | HR | $85.00 | $5,100 |
| Subtotal | | | | | $40,400 |
| | | | | Capital Cost Subtotal: | $3,196,800 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $2,953,843 |
| | | | | 25% Legal, administrative, engineering fees,construction management: | $738,500 |
| | | | | 20% Contingencies: | $738,500 |
| | | | | **Capital Cost Total:** | **$4,430,900** |

**TABLE 5-3**
**COST ESTIMATE**
**Former Griffiss AFB - Building 775**
**Alternative 3 - In-Situ Oxidation**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Annual Costs (For First 10 Years)** | | | | | |
| Bi-Annual Groundwater Sampling | Total 11 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $4,800 | $9,600 |
| Parameter Analysis (VOCs) | VOC samples from 11 wells | 2 | Events | $1,100 | $2,200 |
| Data Evaluation and Reporting | | 60 | HR | $85 | $5,100 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 225 | LF | $14 | $3,300 |
| Subtotal | | | | | $21,200 |
| | | | | Annual Cost Subtotal: | $21,200 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $19,589 |
| | | | | 10% Legal, administrative, engineering fees: | $2,000 |
| | | | | 20% Contingencies: | $4,400 |
| | | | | **Annual Cost Total:** | **$26,000** |
| | | | | **10-year Present Worth of Annual Costs:** | **$219,600** |
| | | | | **2001 Total Present Worth Cost:** | **$4,650,500** |
| | | | | **2004 Total Present Worth Cost:** | **$4,944,200** |

**Notes:**

| | |
|---|---|
| 1. Assume radius of influence (ft) = | 15 |
| 2. Assume treatment area (acre) = | 6.5 |
| Assume treatment area (ft2) = | 281,533 |
| 3. Assume number injection points for Primary Injection based on treatment area = | 313 |
| 4. Assume percentage of this area would require a second injection = | 50% |
| 5. Assume installation of injection wells per day at this site = | 4 |
| 6. Assume downtime during well installation due to refusal, maneuvering around site = | 25% |
| 7. Based on LF6 pilot study, quantity of $KMnO_4$ in 1.5% solution required per injection point | 1,200 lb |

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

9. Assume water will be provided by nearby hydrant at no cost.

10. Eleven monitoring wells will be sampled during the long-term monitoring program (1 new + 10 existing).

11. 10-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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).

12. Total present worth costs presented were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

13. Costs presented are based on conventional contracting methods.

#### Implementability

This alternative would require pilot-scale testing to demonstrate its effectiveness prior to implementation. There is a possibility that this testing would reveal technical problems that may limit the ability to implement this technology or that may require changes in the assumptions that have been made regarding, for example, radius of influence, that may then increase or decrease costs of implementation.

#### Cost

The 2004 total present-worth cost of this alternative of $2,195,700 was based on the calculated 2001 total present-worth cost of $2,065,200 using RS Means Historical Cost Index (see Table 5-4). The capital cost of $1,189,000 includes the installation of in-well air stripping wells, long-term monitoring wells, the carbon adsorption system, carbon dioxide/pH control systems, compressors/blowers, trenching, electrical drops, pilot study and full-scale implementation costs. The annual cost of $109,200 for the first five years is for the O & M of the in-well stripping system. Annual monitoring costs of $32,200 were assumed for the first 15 years. The present-worth value of the O & M and annual monitoring costs is $876,200.

### 5.2.5 Alternative 5: Extraction, Treatment, and Disposal

#### Overall Protection of Human Health and the Environment

No human or environmental receptors are currently impacted by this plume. This alternative would remove contaminants from the subsurface through direct extraction of contaminated groundwater, eliminating future potential exposure threats. However, complete removal of the contaminants would require many years. Deed restrictions would be required in the interim on the property where contamination is above ARARs to prevent exposures during cleanup.

#### Compliance with ARARs

Through removal of contaminants via extraction, concentrations in the aquifer would be reduced to levels below groundwater standards, meeting chemical-specific ARARs.

To discharge treated water into Three Mile Creek, the requirements of a SPDES permit would have to be met. This action-specific ARAR would be complied with.

#### Long-term Effectiveness

Because contaminants would be removed from the aquifer, this alternative is effective in the long-term.

#### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative removes contaminants from the aquifer and concentrates them onto activated carbon, reducing volume through treatment. When the carbon is

**TABLE 5-4**
**COST ESTIMATE**
**Former Griffiss AFB - Building 775**
**Alternative 4 - In-well Air Stripping**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Pilot Study Program | | 1 | LS | $100,000 | $100,000 |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $50,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 4,500 | LF | $14 | $65,000 |
| Subtotal | | | | | $220,000 |
| **Well Installation** | | | | | |
| Mobilization/Demobilization | | 1 | LS | NA | $15,000 |
| Well Install/Developed | | 29 | Each | $10,000 | $290,000 |
| Surface Completion /Well Heads | | 29 | Each | $650 | $18,900 |
| Waste Disposal | | 29 | Each | $376 | $11,000 |
| **Aboveground In-Well Stripping System** | | | | | |
| Trenching/Piping | | 4,350 | LF | $40 | $174,000 |
| Carbon Vapor Adsorption System | 1800lb. Carbon Units | 4 | Each | $7,500 | $30,000 |
| Blower/Compressor | | 2 | Each | $6,500 | $13,000 |
| Vacuum | | 2 | Each | $6,500 | $13,000 |
| Carbon Dioxide/pH Control | | 2 | Each | $4,000 | $8,000 |
| Pre-Fabricated Enclosure | | 2 | Each | $10,000 | $20,000 |
| Electrical Panel | | 2 | Each | $6,000 | $12,000 |
| Electrical Service Connection | | 2 | Each | $5,000 | $10,000 |
| Subtotal | | | | | $614,900 |
| **Monitoring** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 1 | Each | $7,000 | $7,000 |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 1 | Each | $10,000 | $10,000 |
| Well Development | | 2 | Each | $750 | $1,500 |
| IDW Sampling and Disposal | | 1 | LS | NA | $4,300 |
| Subtotal | | | | | $22,800 |
| | Capital Cost Subtotal: | | | | $857,700 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $792,515 |
| | 25% Legal, administrative, engineering fees, construction management: | | | | $198,200 |
| | 20% Contingencies: | | | | $198,200 |
| | **Capital Cost Total:** | | | | **$1,189,000** |
| **Annual Costs** | | | | | |
| **Operation (For First 5 Years)** | | | | | |
| Energy Consumption (Electric) | | 112,000 | KWH | $0.09 | $10,100 |
| Carbon Drum Replacement (Biannual) | | 8 | Each | $2,070 | $16,600 |
| Carbon Disposal (Biannual) | | 8 | Each | $1,900 | $15,200 |
| Carbon Dioxide Replacement/pH Control | | 12 | Mo | $960 | $11,520 |
| General O & M | | 12 | Mo | $3,000 | $36,000 |
| Subtotal | | | | | $89,420 |
| | Annual Cost Subtotal: | | | | $89,500 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $82,698 |
| | 10% Legal, administrative, engineering fees: | | | | $8,300 |
| | 20% Contingencies: | | | | $18,200 |
| | **Annual Cost Total:** | | | | **$109,200** |
| | **5-year Present Worth of Annual Costs:** | | | | **$497,300** |

**TABLE 5-4**
**COST ESTIMATE**
**Former Griffiss AFB - Building 775**
**Alternative 4 - In-well Air Stripping**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Monitoring (For First 15 Years)** | | | | | |
| Bi-Annual Groundwater Sampling | Total 11 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $4,800 | $9,600 |
| Parameter Analysis (VOCs) | VOC samples from 11 wells | 2 | Events | $1,100 | $2,200 |
| Air Samples Analysis - VOCs | | 4 | Events | $1,250 | $5,000 |
| Data Evaluation and Reporting | | 60 | HR | $85 | $5,100 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 225 | LF | $14 | $3,300 |
| Subtotal | | | | | $26,200 |
| | | | | Annual Cost Subtotal: | $26,200 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $24,209 |
| | | | | 10% Legal, administrative, engineering fees: | $2,500 |
| | | | | 20% Contingencies: | $5,400 |
| | | | | **Annual Cost Total:** | **$32,200** |
| | | | | **15-year Present Worth of Annual Costs:** | **$378,900** |
| | | | | **2001 Total Present Worth Cost:** | **$2,065,200** |
| | | | | **2004 Total Present Worth Cost:** | **$2,195,700** |

**Notes:**

1. Assume radius of influence (ft) = 50
2. Assume treatment area (acre) = 6.5
   Assume treatment area (ft2) = 281,533
3. Assume number wells based on treatment area = 29
4. Eleven monitoring wells will be sampled during the long-term monitoring program (1 new + 10 existing).
5. 5 and 15-year present worth of costs assume 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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
6. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

7. Costs presented are based on conventional contracting methods.

spent, it is sent off-site for regeneration, where the contaminants are destroyed, reducing toxicity through treatment.

#### Short-term Effectiveness

Implementation of this alternative would require installing three wells to recover the groundwater and a small treatment building and discharge pipeline. This would require clearing some vegetation and associated well drilling activity. However, these impacts would be minor. Property transfer may be impacted until RAOs have been achieved.

#### Implementability

Fouling issues must be considered upon implementation of this alternative. Otherwise, this alternative is readily implemented.

#### Cost

The 2004 total present-worth cost of this alternative of $1,566,600 was based on the calculated 2001 total present-worth cost of $1,473,500 using RS Means Historical Cost Index (see Table 5-5). The capital cost of $476,300 includes the carbon adsorption system, extraction and monitoring wells, underground piping, and electrical distribution. The 30-year present-worth O & M cost of $997,200 includes carbon system maintenance, carbon drum replacement and disposal, and long-term monitoring.

## 5.3 Comparison of Alternatives

### 5.3.1 Overall Protection of Human Health and the Environment

No human or environmental receptors currently are impacted by this plume. Although there are no current receptors of contamination at the Building 775 plume, Alternative 1 does not prevent future exposures through installation of drinking water wells or construction in soils above the plume. Alternative 2 includes deed restrictions and a monitoring program to ensure that there are no future exposures to contaminants. Because the future use of the area above the plume would be for offices, open space, and other nonresidential purposes, this approach would be protective. Alternatives 3 through 5 employ active treatment mechanisms to destroy contaminants, providing the highest level of protection of human health and the environment.

### 5.3.2 Compliance with ARARs

Groundwater standards comprise the chemical-specific ARARs for this plume. Alternatives 3 through 5 provide active treatment mechanisms for removing contaminants from the groundwater, decreasing the time required for compliance with these ARARs. Alternatives 3 and 4 employ in situ treatment technologies to meet ARARs in the shortest period of time. Alternative 5 uses extraction and treatment that would require longer treatment durations before ARARs are met. ARARs would not be achieved with Alternatives 1 and 2.

**TABLE 5-5**
**COST ESTIMATE**
**Former Griffiss AFB - Building 775**
**Alternative 5 - Extraction, Treatment and Disposal**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Pre-Design Investigation | Numerical modeling or aquifer test | 1 | LS | NA | $45,000 |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $65,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 4,500 | LF | $14 | $65,000 |
| **Site Preparation** | | | | | |
| Mob/demob | | 1 | LS | $15,000 | $15,000 |
| Clearing -Medium brush w/o Grub | | 1 | AC | $209 | $300 |
| Subtotal | | | | | $195,300 |
| **Pump & Treat System** | | | | | |
| 8" Recovery Wells | Includes well construction, pump, controls, and enclosure. No split spoon sampling - up to 90 ft deep | 3 | EA | $13,300 | $39,900 |
| Carbon Adsorption System | (4) 55-gal drums and installation | 4 | LS | $818 | $3,300 |
| Pre-filter and Internal Piping Kit | | 2 | EA | $1,740 | $3,500 |
| Delivery of Carbon Drums to Site | | 1 | LS | $1,500 | $1,500 |
| Pre-Fabricated Enclosure (200 sf) | For Carbon System; includes installation, insulation, piping etc. | 1 | LS | $30,000 | $30,000 |
| Subtotal | | | | | $78,200 |
| **Piping Installation** | | | | | |
| Pipe Trenching (Influent) | Influent piping from wells to enclosure; assume 2'wide, 4' deep; includes backfill and compaction | 450 | LF | $10 | $4,700 |
| Pipe bedding- Influent Piping | | 450 | LF | $6 | $2,500 |
| 3" PVC Pipe -Influent Piping | | 450 | LF | $7 | $3,200 |
| Pipe Trenching (Discharge) | 2'wide, 4'deep; includes backfill and compaction | 1,150 | LF | $10 | $12,000 |
| Pipe bedding- Discharge Piping | | 1,150 | LF | $6 | $6,400 |
| 3" PVC Pipe -Discharge Piping | | 1,150 | LF | $7 | $8,000 |
| Subtotal | | | | | $36,800 |
| **Electric Distribution- to building and extraction wells** | | | | | |
| Underground Electrical Distribution | Trenching includes backfill and compaction | 245 | CY | $7 | $1,700 |
| 3" PVC conduit | | 1,100 | LF | $7 | $7,600 |
| Feed Cable | | 1,100 | LF | $5 | $6,000 |
| Panel Board | | 1 | EA | $1,325 | $1,400 |
| Electrical connection fee and meter | Assume source of power is overhead electric from southeast corner of the site | 1 | LS | NA | $1,500 |
| Subtotal | | | | | $18,200 |
| **Monitoring Wells** | | | | | |
| Drilling/Installation of Vertical Profile Monitoring Wells | | 1 | EA | $10,000 | $10,000 |
| Well Development | | 1 | EA | $750 | $800 |
| IDW Sampling and Disposal | | 1 | LS | NA | $4,300 |
| Subtotal | | | | | $15,100 |
| | | | | Capital Cost Subtotal: | $343,600 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $317,486 |
| | 25% Legal, administrative, engineering fees, construction management: | | | | $79,400 |
| | | | | 20% Contingencies: | $79,400 |
| | | | | **Capital Cost Total:** | **$476,300** |

**TABLE 5-5**
**COST ESTIMATE**
**Former Griffiss AFB - Building 775**
**Alternative 5 - Extraction, Treatment and Disposal**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Annual Costs** | | | | | |
| Filter Replacement | Assume 1-person @ $65/hr; 2.5 hr/week (130 hr/yr) | 130 | HR | $65 | $8,500 |
| Pump & Motor Maintenance | Assume 6 events/year; 1-person @$65/hr; 8hr/event, $100 for materials | 6 | Events | $620 | $3,800 |
| Monthly System Sampling | Influent & effluent for VOCs | 12 | Events | $200 | $2,400 |
| Electric Charge | | 20,000 | KWH | $0.06 | $1,200 |
| Carbon Drum Replacement | Assume every 15 months; assume 4 drums | 0.8 | Events | $4,000 | $3,200 |
| Carbon Drum Sampling and Disposal | Assume every 15 months; assume 4 drums | 0.8 | Events | $3,000 | $2,400 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 225 | LF | $14 | $3,300 |
| Subtotal | | | | | $25,800 |
| **Monitoring** | | | | | |
| Bi-Annual Groundwater Sampling | Total 11 wells; assume 3 wells/day, 2-persons @ $65/hr, 10hr/day | 2 | Events | $4,800 | $9,600 |
| Parameter Analysis (VOCs) | VOC samples from 11 wells | 2 | Events | $1,100 | $2,200 |
| Data Evaluation and Reporting | | 60 | HR | $85 | $5,100 |
| Subtotal | | | | | $16,900 |
| | | | | Annual Cost Subtotal: | $42,700 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $39,455 |
| | | | | 10% Legal, administrative, engineering fees: | $4,000 |
| | | | | 20% Contingencies: | $8,700 |
| | | | | **Annual Cost Total:** | **$52,200** |
| | | | | **30-year Present Worth of Annual Costs:** | **$997,200** |
| | | | | **2001 Total Present Worth Cost:** | **$1,473,500** |
| | | | | **2004 Total Present Worth Cost:** | **$1,566,600** |

**Notes:**
1. Eleven monitoring wells will be sampled during the long-term monitoring program (1 new + 10 existing).
2. Carbon drum replacement unit costs based on life cycle of activated carbon. Here, carbon drums assumed to be replaced once every 15 months
   Therefore, carbon replacement adjusted to account for these costs annually.
3. 30-year present worth of costs assumes 3.2% annual interest rate per "A Guide to Developing and Documenting Cost Estimates During the
4. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

5. Costs presented are based on conventional contracting methods.

Alternatives 3 and 4 apply in situ treatment approaches over an area that covers about 95% of the contamination on a mass basis. Increasing the extent of coverage of these technologies to the entire plume area would increase the area, and thus costs, by about 50%. While there would be some area in the 5 to 50 µg/L concentration range remaining initially above ARARs, this area would represent only a small fraction of the plume and would likely be reduced to levels below ARARs over time after treatment of the plume was complete.

### 5.3.3 Long-term Effectiveness

Alternatives 3 and 4 use active in situ treatment technologies. The chemical oxidation pilot study at the adjacent Landfill 6 site was effective in reducing contaminant mass, and since conditions at Building 775 are similar, it is also expected to be effective in the long-term. The effectiveness of the in-well air stripping technology presented in Alternative 4 cannot be well predicted until after pilot studies and/or initial implementations of the technology. However, this technology has been applied at other sites with similar contaminants of concern and is therefore expected to be reasonably effective. Pending successful use of this technology, this alternative would represent an effective long-term solution.

Alternative 5 employs a more-established technology and thus its effectiveness is more predictable. Extraction and treatment is a well-established, proven technology that is known to control plume migration. Over the long-term it would provide effective protection.

The use of deed restrictions combined with ongoing monitoring as called for by Alternative 2 provides an effective long-term mechanism to protect human health and the environment. However, in the absence of treatment mechanisms, protection is less than that provided in Alternatives 3 through 5.

### 5.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 through 5 employ treatment mechanisms to reduce toxicity of contaminants in the plume. Alternative 3 treats the contaminants directly in situ, thus providing the most effective and rapid toxicity reduction. Alternatives 4 and 5 rely on migration of contaminated groundwater to air stripping/extraction wells followed by extraction of vapors/groundwater to the surface for treatment. This provides effective treatment, but at a slower rate (Alternative 5 assumes longer treatment duration).

### 5.3.5 Short-term Effectiveness

None of the alternatives considered would have significant short-term impacts. Until RAOs have been achieved for any of the alternatives, property transfers may be impacted. In addition, the active in situ treatment, Alternative 3, would require surface access throughout the area of the plume, but this area is currently relatively open. Alternative 3 would also provide the shortest duration of implementation (assumed to be one year). Monitoring for this alternative would span over an assumed 10-year period.

Alternative 4 would provide the next shortest duration of implementation/operation, estimated at five years, with monitoring events performed during operation activities and extending an assumed 10 years beyond. Alternative 2 requires continuous monitoring that would likely extend for decades. The duration of the extraction called for by Alternative 5 is assumed to require decades before standards are met.

### 5.3.6 Implementability

Alternative 4 would require pilot-scale testing to demonstrate effectiveness prior to implementation. There is a possibility that this testing would reveal technical problems that may limit the ability to implement the technology or require changes in the assumptions that have been made regarding, for example, radius of influence, that then may increase or decrease costs of implementation. There are no actions to implement for Alternative 1. Alternatives 2, 3, and 5 are readily implementable.

### 5.3.7 Cost

Alternative 1 calls for no action and thus incurs no costs. Alternative 2, which comprises long-term monitoring, is the least expensive of the remaining alternatives at a 2004 present worth cost of $665,600.

Alternatives 3 and 4 both call for in situ treatment. Since the chemical oxidation pilot study has been performed at the adjacent Landfill 6 site, the implementation methodology for Alternative 3 has been evaluated to the point where the cost estimate presented in this FS is expected to have less potential to vary. On the other hand, the cost estimates for full-scale implementation of Alternative 4 obtained from the in-well air stripping vendors are conceptual and may not fully represent site-specific conditions. Additionally, the cost estimate for in situ treatment could vary based on the bench- and/or pilot-scale testing.

Considering these issues, the 2004 present-worth cost of Alternative 3 is $4,944,200, which is the most expensive alternative primarily due to the amount of oxidant required to reduce contaminant mass and to obstacles with oxidant delivery methods. Alternative 4 is the least expensive of the in situ treatment alternatives with a 2004 present worth cost of $2,195,700.

Alternative 5 employs extraction and treatment to treat the plume. Its present-worth cost is estimated to be less than any of the in situ treatment technologies. Most of its $1,566,600 estimated 2004 present worth is due to 30 years of operation of the treatment system.

Cost estimates for Building 775 groundwater remediation alternatives are summarized in Table 5-6.

## Table 5-6 Summary of Total Present Values of Alternatives at Building 775
## Former Griffiss AFB, Rome, New York

| Description | Alternative 1<br>No Action | Alternative 2<br>Institutional Actions | Alternative 3<br>In Situ Oxidation | Alternative 4<br>In-Well Air Stripping | Alternative 5<br>Extraction, Treatment, and Disposal |
|---|---|---|---|---|---|
| Total Project Duration (Years) | 0 | 30 | 10 | 15 | 30 |
| Capital Cost | $0 | $129,300 | $4,430,900 | $1,189,000 | $476,300 |
| Annual O&M Cost | $0 | $26,000 | $26,000 | $109,200<br>(for first 5 years)<br>$32,200<br>(for first 15 years) | $52,200 |
| **2001 Total Present Value of Alternative** | **$0** | **$626,000** | **$4,650,500** | **$2,065,200** | **$1,473,500** |
| **2004 Total Present Value of Alternative** | **$0** | **$665,600** | **$4,944,200** | **$2,195,700** | **$1,566,600** |

## 5.4 Recommendation

Considering the RAOs for Building 775 and the remedial alternative evaluation completed in this section, the recommended remedy for the Building 775 plume is in-well air stripping (Alternative 4).

In-well air stripping technology, when used to remediate contaminated groundwater, represents an active remedial approach to permanently reduce the toxicity, mobility, and volume of site contaminants of concern, which is the preferred approach, when practical. This alternative also provides for protection of human health and the environment and has the ability to have one of the shortest treatment durations of the alternatives presented. However, it should be noted that during the remediation process, deed restrictions would be required that could affect property transfer.

Taking into consideration the possible impact on property transfer until RAOs have been achieved, an active treatment approach (which has an expected shorter cleanup duration than non-active approaches) appears most desirable. Several active treatment technologies have been presented in this FS including Alternatives 3, 4, and 5. Although a chemical oxidation (Alternative 3) pilot study performed at the adjacent Landfill 6 site illustrated that contaminant mass can be reduced within the shortest treatment duration, the estimated present-worth cost to implement this technology full-scale is more than double the next most expensive alternative (Alternative 4 - In-Well Air Stripping). Full-scale implementation costs of Alternatives 4 and 5 are on the same order of magnitude. However, unlike Alternative 3, Alternatives 4 and 5 require some form of preliminary testing before full-scale implementation. For Alternative 4, In-well Air Stripping, RAOs are expected to be achieved within five years of operation, with long-term monitoring continuing into the future for 10 years. This duration is expected to be less than that of Alternative 5 due to the number/placement of the treatment wells and assumed well efficiency rates. Uncertainties associated with effectiveness must be determined with a pilot scale study before full-scale implementation. In-well air stripping is a proven technology and has been conducted successfully at similar sites. For Alternative 5 (Extraction, Treatment, and Disposal), which is expected to meet RAOs some time after the 30-year evaluation period assumed for this FS, continuous operation and maintenance of a treatment system would be required.

Alternatives 1 and 2 represent the least expensive alternatives; however, treatment technologies would not be implemented and RAOs are not expected to be achieved within the assumed 30-year period used for evaluation purposes for this FS.

# 6 Building 817/WSA Plume Treatment Alternatives

## 6.1 Development of Alternatives

In this section, technologies noted as retained in Section 3 have been assembled into alternatives appropriate for the Building 817/WSA plume. The ROD for Six Mile Creek (E & E December 2003) was considered in developing these alternatives. In general, the ROD states that sources of contamination will be remediated and potential sources such as Building 817/WSA may be remediated if recommended by this FS. As discussed in Section 2.5, the Building 817/WSA plume consists of a relatively shallow plume that has migrated southwest from its assumed original source area near Building 817. To address this contamination, the following six alternatives have been developed:

# Alternative 1: No Action

# Alternative 2: Institutional Actions

# Alternative 3: In situ Oxidation

# Alternative 4: In-well Air Stripping

# Alternative 5: Zero-valent Iron Wall

# Alternative 6: Extraction, Treatment, and Disposal

Each of these alternatives are described in detail in the following sections.

### 6.1.1 Alternative 1: No Action

No action would be taken in this alternative for the Building 817/WSA plume. The plume would be allowed to migrate and possibly attenuate naturally. However, no monitoring would be conducted to evaluate the progress of these natural processes.

### 6.1.2 Alternative 2: Institutional Actions

To prevent future exposure to contaminated groundwater, this alternative calls for implementing restrictions on groundwater use at the Building 817/WSA AOC.

The groundwater-use restrictions would include deed restrictions to prevent future use of the groundwater. In addition, fencing would be installed to limit site access and a groundwater monitoring program would be implemented to evaluate the extent of migration and attenuation of the plume. This alternative would not provide for cleanup in a reasonable and predictable timeframe. Therefore, the potential need for a waiver would need to be discussed with the appropriate regulatory agency(ies).

In order to properly monitor the plume, biannual groundwater sampling would be performed to determine and monitor seasonal water table and contaminant concentration fluctuations. Although the contaminant plume at this site was adequately delineated during the 2000 SI (E & E October 2000), the data was obtained from temporary Geoprobe points. Therefore, three wells (WSA-MW18, -MW19, and -MW20) would be installed and sampled in the long-term monitoring program (see Figure 6-1) in addition to the sampling of four existing permanent wells (WSA-MW8, -MW9, -MW11, and LAWMW-9). Although two monitoring wells were included in the original design of this alternative, a third was added to provide additional monitoring for the culverted section of Six Mile Creek. Minor costs are anticipated with the installation/monitoring of this well. Therefore, the cost estimate was not changed. New programs at the base may result in the installation of new wells at this site. Therefore, monitoring wells proposed for the long-term monitoring program at this site may be impacted and the numbering/locations of the proposed wells may be modified during the design stage. To monitor the potential discharge of site groundwater to Six Mile Creek, one surface water sample will be collected from the nearest downgradient manhole in the culverted section of Six Mile Creek in the projected pathway of the plume and one sample each of surface water and sediment from the culvert effluent.

Two of these new wells (WSA-MW19 and -MW20) would be installed south of WSA-GP33 because there is only one well along the downgradient edge of the plume (WSA-MW9). Similar to WSA-MW9, these new wells would monitor downgradient migration of the plume. Finally, a well (WSA-MW18) would be installed in the vicinity of WSA-GP32 to determine and monitor any side-gradient migration occurring toward the intermittent tributary to the southeast due to the abrupt change in topography (i.e., the deep gully to the southeast). Although the 2000 SI determined groundwater flow was predominantly to the southwest, the inferred contours bend slightly from southwest to south/southeast. Because these contours were based on a limited amount of data collected from permanent wells that are all in the same linear plane from northeast to southwest, an additional sidegradient well is needed.

The seven wells (four existing and three new), surface water, and sediment would be sampled and analyzed for the contaminants of concern (PCE/TCE) and breakdown products (chloroethane, dichloroethanes, dichloroethenes, and vinyl chloride) through analysis of a suite of VOCs using a low-level method of SW8260B. This low-level method could produce detection limits that are five times less than

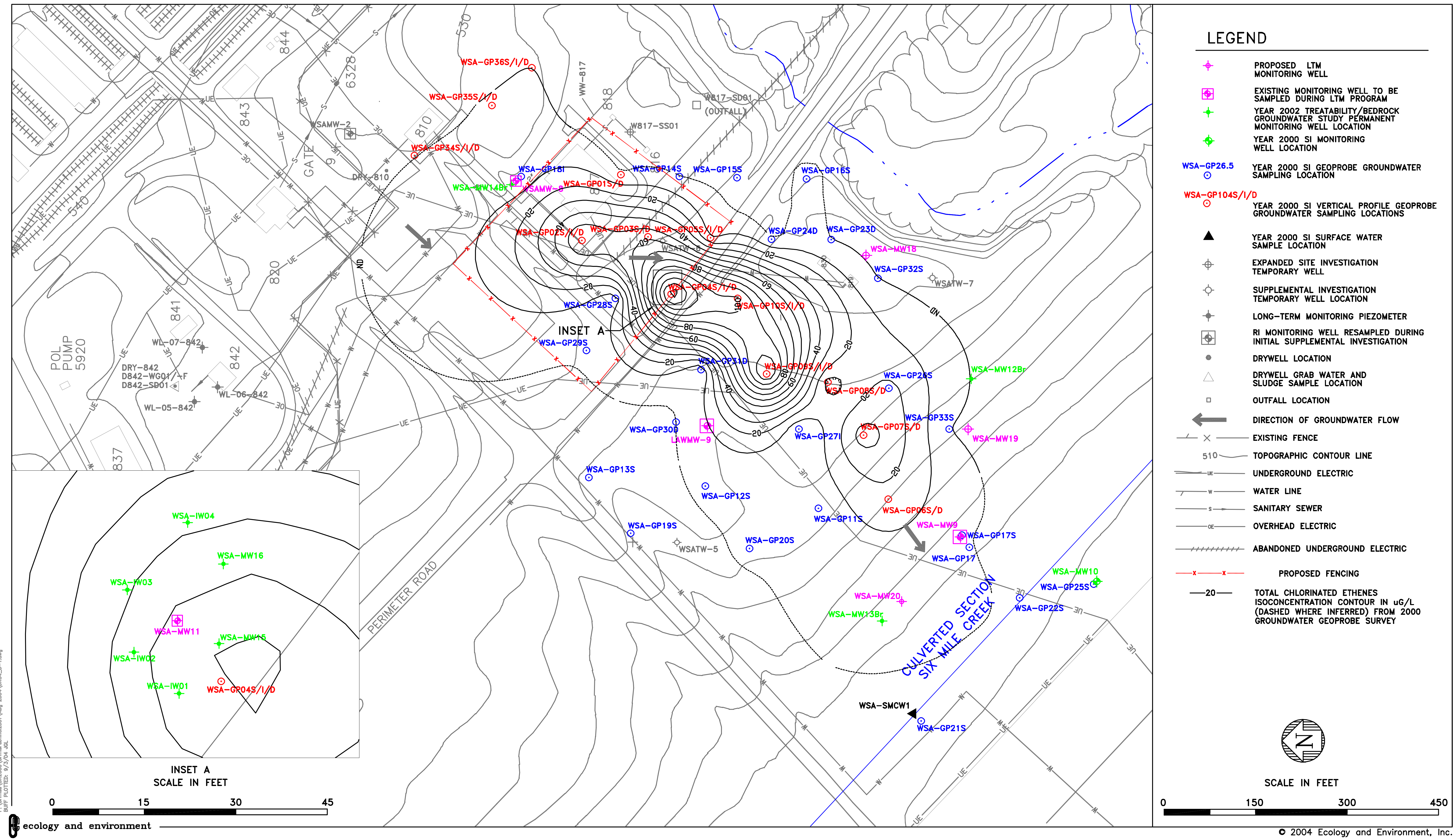





FIGURE 6-1 B817/WSA ALTERNATIVE 2
INSTITUTIONAL ACTIONS
FORMER GRIFFISS AFB
ROME, NEW YORK

the standard method, enabling earlier detection of contaminants migrating down-gradient into wells that are currently clean.

Because contaminants would remain above groundwater standards for the fore-seeable future, a deed restriction would need to be applied to the area where con-tamination above ARARs is present to minimize the potential for future uses of groundwater in this area.

For purposes of this FS, it is assumed that on-site contaminant concentrations would remain above ARARs for the 30-year alternative duration and that remedial actions at the site may require a re-evaluation at that time (i.e., incorporation of passive technology such as phytoremediation). However, if concentrations ob-served on-site achieve ARARs, this alternative would no longer be needed, moni-toring would be reduced or eliminated, and a report written requesting site clo-sure.

### 6.1.3 Alternative 3: In situ Oxidation

This alternative involves the delivery of a strong oxidizing agent into the subsur-face through temporary injection points (i.e., direct push points) to oxidize con-taminants 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 cleanup goals were achieved. During this action there would be continued monitoring of the extent of migration or natural attenuation of the plume.

Between February 2002 and March 2004, bench-scale and pilot studies were per-formed 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 con-taminated soil/groundwater in June 2002, $KMnO_4$ was selected as the most effec-tive oxidizing agent. The use of $KMnO_4$ produces $MnO_2$ particles as a by-product, which are not a concern as they are naturally present in the soils. How-ever, the formation of $MnO_2$ from the oxidation reaction may result in reduction of permeability and clogging, thus reducing the treatment efficiency (observations made during the pilot study indicated that elevated levels of metals in groundwa-ter were detected between pre- and post-injection sampling rounds; however, these levels are expected to be localized to the treatment area). Based on the re-sults of the bench-scale study, a pilot study was conducted at the site in November 2002 that targeted an area in the vicinity of WSA-MW11, where one of the high-est total VOC concentrations (TCE at 83 µg/L and PCE at 56.9 µg/L) has been detected. The results of the bench scale and pilot study were presented in the *Fi-nal Groundwater Treatability Pilot Study Report* (E & E June 2004) and are summarized below.

Bench-scale tests using potassium permanganate were performed for groundwater at Building 817/WSA by ENVIROX LLC in June 2002 (E & E June 2004). Re-sults from the tests on the groundwater indicated that TCE/PCE was effectively destroyed by $KMnO_4$. It should be noted that soil and groundwater samples used in the bench-scale study were obtained from the WSA-MW11 borehole and well, respectively, where the highest TCE/PCE concentrations were detected.

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, four injection wells were advanced at the site perpendicular to the groundwater flow direction in the vicinity of WSA-MW11. At this location, the total saturated thickness is approximately 20 feet. The wells were screened to target the highest zone of contamination between 10 and 20 feet below ground surface and spaced approximately 15 feet apart. Injection activities occurred in November 2002 and consisted of delivering 8,000 gallons of 0.6% by weight of $KMnO_4$ by gravity. A second injection event was not performed at this site due to observations made during the first injection event; this is discussed further below.

One existing monitoring well (WSA-MW11) and two new monitoring wells (WSA-MW15 and WSA-MW16) downgradient of the injection location were selected to monitor VOCs, DOC, and TAL metals levels during the baseline and one or more of the three subsequent sampling rounds. Baseline groundwater sampling was conducted in October 2002 prior to injection activities, while the three rounds of post-injection sampling were conducted two weeks, six weeks, and 72 weeks after treatment.

The results of the pilot study generally indicated a general decrease in VOC concentrations from the study area. The comparison between pre- and post-treatment analytical results in the injection wells indicated a reduction of TCE and PCE of up to 54% and 21%, respectively, after six weeks and further reduction up to 25% and 5%, respectively, after 72 weeks in a different injection well. The monitoring wells showed no initial reduction of TCE and PCE after six weeks; however, the largest reduction of these contaminants was estimated at 47% and 36% respectively in the three monitoring wells (WSA-MW15) 72 weeks after the injection (E & E June 2004). Based on the bench-scale testing, more significant contaminant reduction was anticipated. There are two possible primary reasons for the lack of significant reduction: 1) more oxidant was consumed by the NOD than was estimated by the bench-scale testing and 2) the presence of preferential pathways (both vertically and horizontally) would allow the oxidant to move away from the monitored treatment area before sufficient treatment could occur. The pilot study and additional subsurface work suggest that an underground utility is located in the downgradient part of the treatment area. This utility could have provided a preferential pathway for oxidant during the pilot study. The presence of a gravelly till layer between the silty fine sands and shale bedrock may also be serving as a preferential pathway. This layer is present at a depth of approximately 20 feet below ground surface, at the base of the injection and monitoring wells. To further evaluate these potential limitations, costs have been included to explore the existence/extent of underground utilities at the site. These observations would be taken into consideration during the design stage if this alternative is selected. Based on the investigation findings, modification to the design may be needed to address preferential pathways. This could include removal or relocation of existing utilities (if identified as the preferential pathway). Preferential pathway corrective measures could include measures such as backfilling the excavated area with less permeable material or grouting the less permeable area. Since the gravelly till layer is also a preferential pathway, will placement in that deeper zone will be avoided. The need and/or the effectiveness of pressure injecting should be evaluated during design after the evaluation of the preferential pathways is resolved.

This alternative assumes a 15-foot radius of influence in areas with total VOC concentrations greater than 10 µg/L. Permanent injection wells were advanced during the pilot study. However, for costing purposes it was assumed that temporary injection wells would be advanced using the Geoprobe method at this site. One-inch PVC casing with a 10-foot screen spanning the saturated depth exhibiting the highest levels of contamination would be left in place as the Geoprobe rod is pulled out. By installing these temporary wells, the drilling crew, can work independently of the injection crew, allowing more flexibility with scheduling than if the Geoprobe unit were used to directly inject the oxidant as the rod is pulled out. In addition, pressure injection up to 10 gpm of the oxidant is proposed to further reduce time spent in the field. This approach would result in significant cost savings, considering the size and depth of the plume, compared to installing well clusters. Since the plume exhibits localized areas of high contamination and because the cost of implementing in-situ type technologies is proportional to the area, a more cost-effective approach would involve targeting the areas with high levels of VOC contamination.

This FS assumes full-scale remediation using this technology for the area contained within the 10-µg/L total VOC concentrations contour line (see Figure 6-2). Remediating this area would remove about 90% of the contaminant mass and approximately 58% (or 4.7 acres) of the plume area (see Table 6-1). Although biological activity would be reduced in those areas directly affected by the oxidant, contaminant concentrations remaining on-site above cleanup levels after injection event(s) have occurred are expected to continue to attenuate naturally (by biological and other processes).

**Table 6-1 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at Building 817/WSA**

| Contour Interval (µg/L) | Lower Bound Concentration of Contour Interval (µg/L) | Area of Contour Interval ($ft^2$) | Cumulative Percentage 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 (%) |
|---|---|---|---|---|---|
| >130 | 130 | 78 | 0 | 0.00 | 0 |
| 120-130 | 120 | 837 | 0 | 0.01 | 2 |

**Table 6-1 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at Building 817/WSA**

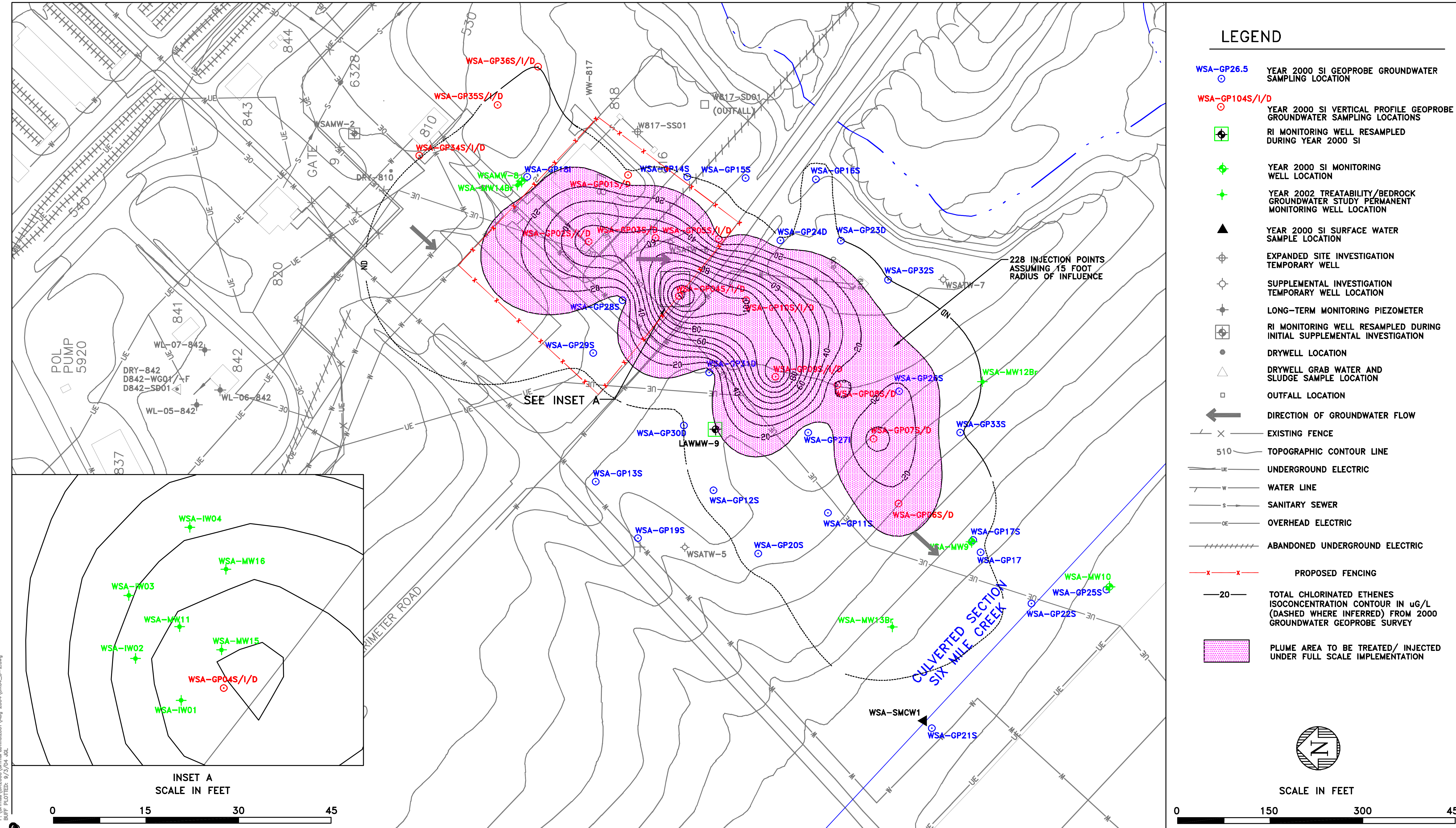
| Contour Interval (µg/L) | Lower Bound Concentration of Contour Interval (µg/L) | Area of Contour Interval ($ft^2$) | Cumulative Percentage Area of Contour Interval Compared to Entire Plume Area (%) | Mass of Contaminants per Foot Within Interval (lb/ft) (lower bound concentration multiplied by incremental contour interval area) | Cumulative Percentage of Total Mass of Contaminants Per Depth (%) |
|---|---|---|---|---|---|
| 110-120 | 110 | 1,506 | 1 | 0.01 | 4 |
| 100-110 | 100 | 3,881 | 2 | 0.02 | 9 |
| 90-100 | 90 | 10,118 | 5 | 0.06 | 22 |
| 80-90 | 80 | 7,703 | 7 | 0.04 | 30 |
| 70-80 | 70 | 7,680 | 9 | 0.03 | 37 |
| 60-70 | 60 | 8,731 | 11 | 0.03 | 45 |
| 50-60 | 50 | 14,061 | 15 | 0.04 | 54 |
| 40-50 | 40 | 15,301 | 20 | 0.04 | 63 |
| 30-40 | 30 | 18,542 | 25 | 0.03 | 70 |
| 20-30 | 20 | 26,031 | 32 | 0.03 | 77 |
| 10-20 | 10 | 89,969 | 58 | 0.06 | 90 |
| 5-10 | 5 | 148,104 | 100 | 0.05 | 100 |
| **Total** | | **352,542** | | | |

Note: Contour interval areas determined by E & E and AutoCAD file associated with Figure 2-4 of this report.

Temporary injection wells required to effectively cover this area number approximately 228 wells, which will be installed to target one interval containing the highest VOC concentration intervals, similar to the pilot study. Consideration will be given during the well installation to avoiding suspected preferential pathways, as previously discussed. For costing purposes, maximum well depths were assumed for well installations. The injection well configuration and target intervals will be refined during the design stage. Field parameters such as ORP, conductivity, and water levels will be collected during the injection activities to assess oxidant distribution in the subsurface.

For purposes of costing this alternative, one primary injection event was assumed and one secondary event. The secondary injection event is intended as a polishing step to target areas where contaminant concentrations and mass were not reduced to acceptable levels (approximated at 50% of the treatment area). The primary and secondary injection events are assumed to occur within one year.

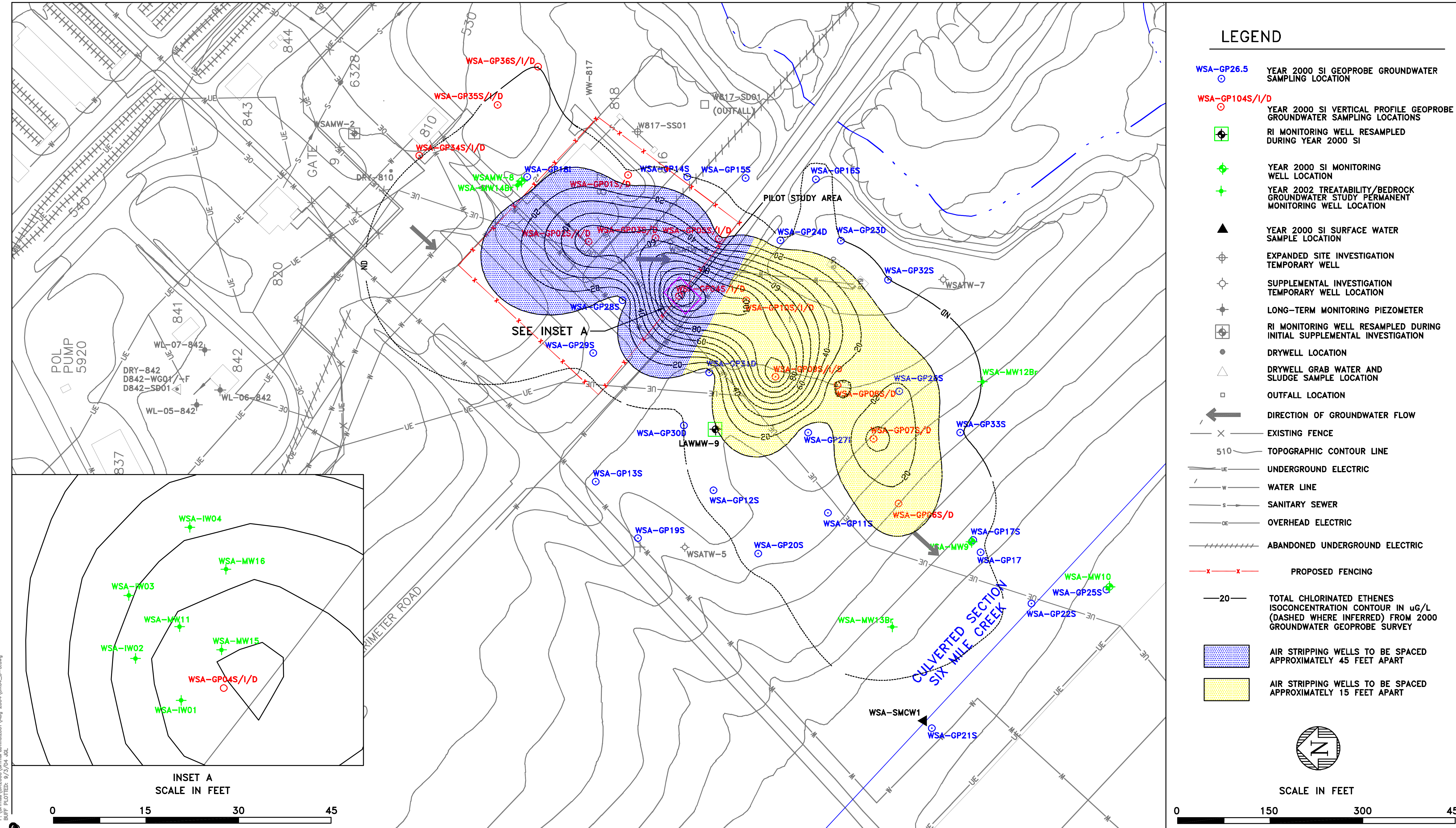
Monitoring the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2. Two additional sampling rounds will be collected during the first year (for a total of four) to adequately monitor the plume during treatment. Metals are not expected to mobilize within the plume. Therefore, metals analysis is not included in the long-term monitoring program. Since this alternative involves active treatment of and destruction of contaminants of concern, maintenance of institutional controls and the long-term monitoring program was assumed for 10 years. If contaminants




ecology and environment

© 2004 Ecology and Environment, Inc.

FIGURE 6-2 B817/WSA ALTERNATIVE 3
IN-SITU OXIDATION
FORMER GRIFFISS AFB
ROME, NEW YORK




ecology and environment



FIGURE 6-3 B817/WSA ALTERNATIVE 4
IN-WELL AIR STRIPPING
FORMER GRIFFISS AFB
ROME, NEW YORK

of concern remain above proposed cleanup goal concentrations after the assumed 10-year long-term monitoring period, based on data evaluation, additional monitoring may be needed.

### 6.1.4 Alternative 4: In-well Air Stripping

This alternative involves the installation of groundwater-circulating/air-stripping wells to strip the contaminated groundwater of contaminants. The contaminated vapors can be drawn off and treated above ground, discharged directly into the atmosphere, or discharged into the vadose zone to be degraded in situ via bioremediation. The treated groundwater is not removed from the subsurface, but is cycled through a groundwater circulation cell that is created around the well. This circulation cell is a result of the continuous extraction of contaminated groundwater at the bottom of the aquifer or polluted portion thereof and reintroduction of the treated/stripped groundwater into the top of the aquifer or above into the vadose zone.

At Building 817/WSA, the depth to groundwater is about 7 feet. Based on the results of the spring 2000 SI conducted by E & E, the geologic conditions correspond with the design and operating parameters for optimum performance of this technology. The average hydraulic conductivity (K) and hydraulic gradient at the Building 817/WSA site are $10^{-3}$cm/sec and 0.04 ft/ft respectively. The site also consists of uniform mixtures of silty sands and sand/silt mixtures with no adverse stratigraphy such as the presence of low permeability layers continuous over large areas. The hydraulic conductivity, which is within the desired operating limit of $K > 10^{-5}$cm/sec (see the Federal Remediation Technologies Roundtable, which can be accessed at http://www.frtr.gov/matrix2/section4/4-40.html), and the low hydraulic gradient would enable the wells to capture and sufficiently treat the water several times, via recirculation, before it flows out of the treatment zone.

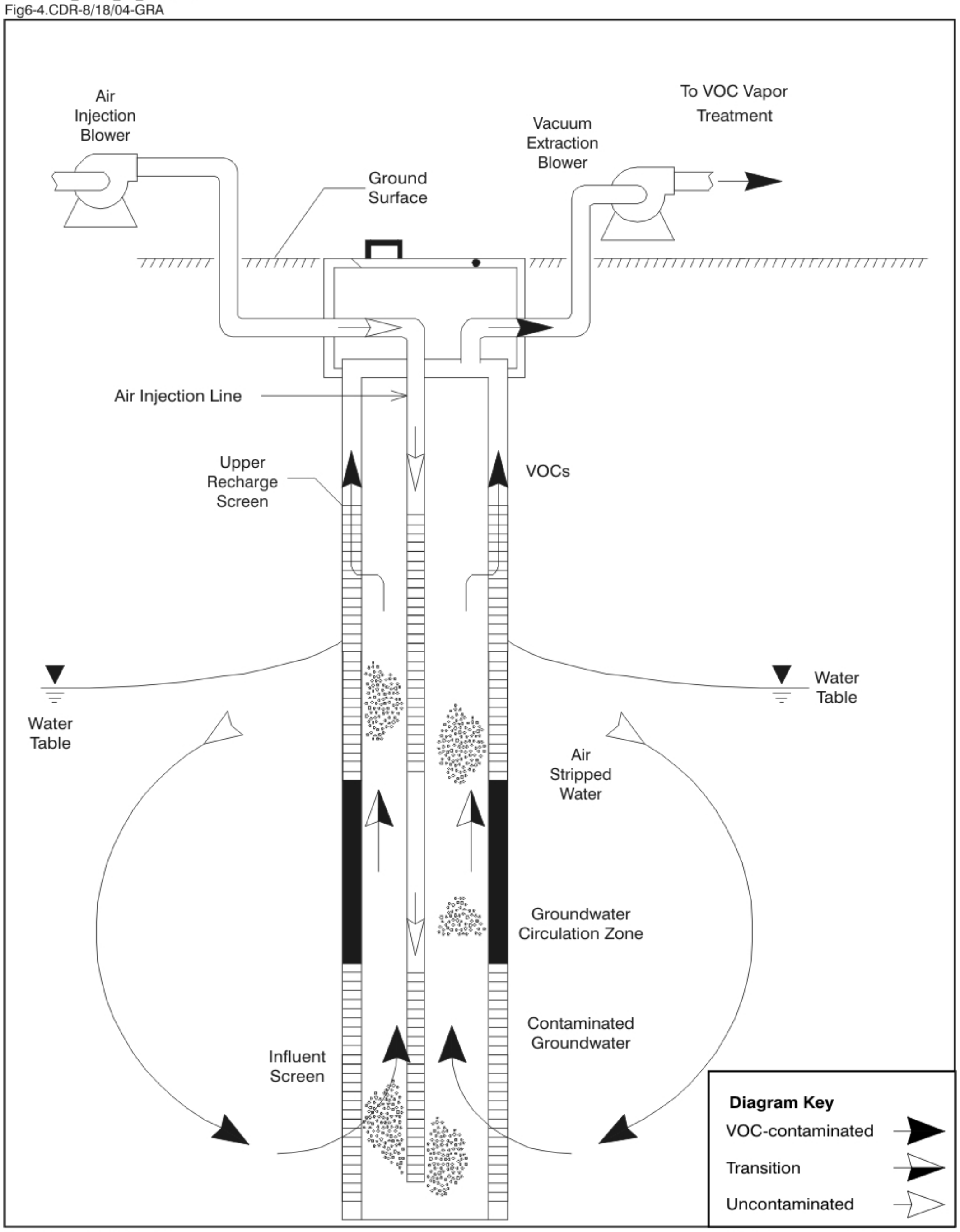
Geochemical characteristics of the site can affect the performance of the system if not properly controlled. The high dissolved oxygen concentrations caused by air stripping can cause precipitates to develop in the air stripping well and in the aquifer at locations away from the well. This is caused by the oxidation of iron and manganese that can clog the recharge zone and well screens. Iron was detected at 7,750 µg/L, manganese was detected at 1,050 µg/L (obtained from the averages of all positive analytical results from the 1996 RI for the Building 817 area), and ferrous iron was detected at an average of 5.1 mg/L (determined from all Building 817/WSA wells sampled during the spring 2000 SI). Also, air stripping removes dissolved carbon dioxide from the water, increasing the pH. Increased pH levels can cause the precipitation of calcium carbonates, especially if the alkalinity is high. Heavy metal concentrations have also been shown to decrease as a result of scavenging by calcium carbonate precipitation. Therefore, the stripping of carbon dioxide from groundwater may also lead to the precipitation of larger amounts of metals than would normally occur from the oxygenation of the aquifer. It is relatively safe to assume that there will be minimal calcium carbonate precipitation when the alkalinity is 200 mg/L $CaCO_3$ or less. The average alkalinity of the

Building 817/WSA wells sampled during the spring 2000 SI was 6.43 mg/L. Therefore, metals precipitation is not expected to be a concern at this site. However, for costing purposes, the process of discharging carbon dioxide into the air stripping wells was included in this alternative.

There are three patented in-well air stripping technologies available, with slight variations in design. However, these technologies all employ the same principle of air-lift pumping to create a groundwater-circulation pattern and simultaneous aeration within the stripping well to volatize VOCs from the groundwater. The DDC system (see Figure 6-4) is developed and patented and is currently available from Wasatch Environmental, Inc. The contaminated vapors can be drawn out of the well and treated aboveground. The NoVOCs system (see Figure 6-5), patented by Stanford University and available from Metcalf & Eddy, is very similar to the DDC system. The NoVOCs system uses a vacuum to draw off contaminated vapors for treatment. The NoVOCs system can be retrofitted to allow for the removal of metals from groundwater through in situ fixation (adsorption and/or precipitation) using common water treatment chemicals. The UVB or vacuum vaporizer well system (see Figure 6-6) was developed by IEG Technologies Corp. and is available from Legette, Brashers and Graham, Inc. The UVB system supplements air-lift pumping with a submersible pump and employs a stripper reactor that increases contact between the two phases, which facilitates the transfer of volatiles from the aqueous to gas phase before the water is returned to the aquifer. The technologies directly considered for the implementation of in-well air stripping at the Building 817/WSA site were the NoVOCs and DDC systems. The UVB well system was not considered further in this FS because it is more complex and expected to have a higher overall cost. The ranges for all parameters considered during the assessment for both of these technologies are presented in the following discussion.

Based on discussions with vendors of the DDC and NoVOCs technologies, there are multiple well configurations that are expected to effectively treat contaminated groundwater at this site, including installation of horizontal and vertical wells. For costing purposes, the more proven, traditional approach using vertical stripping wells was assumed. However, during the design stage alternative well configurations may be explored/implemented if this alternative is selected. Because the aquifer is relatively shallow at this site and the observed hydraulic gradient/conductivity are greater, the expected radius of influence is significantly less when compared to the radius of influence at Landfill 6 and Building 775. The groundwater circulation zone (as shown on Figure 6-4 or 6-5) would be radially reduced, as the required screened intervals would be installed at minimum lengths (2 feet to 5 feet) to account for the existing saturated depth at this site. Further, two treatment zones are proposed, based on areas exhibiting steeper versus flatter localized hydraulic gradients. A smaller radius of influence is assumed in the

02:001515_UK01_02_01-B1466
Fig6-4.CDR-8/18/04-GRA

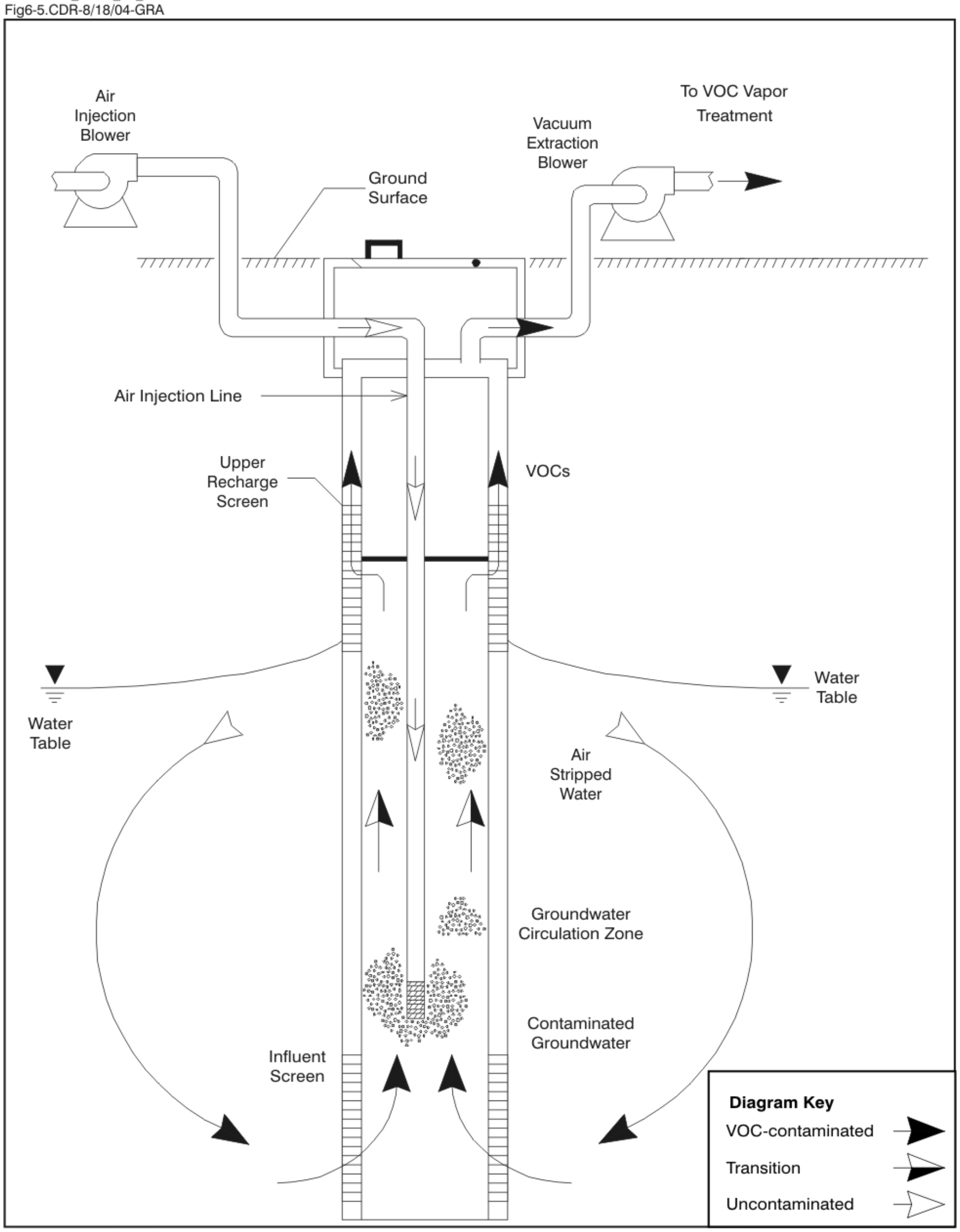



SOURCE: GWRTAC, 2001



**Figure 6-4 Typical Density-Driven Convection (DDC) Well Construction**

02:001515_UK01_02_01-B1466
Fig6-5.CDR-8/18/04-GRA

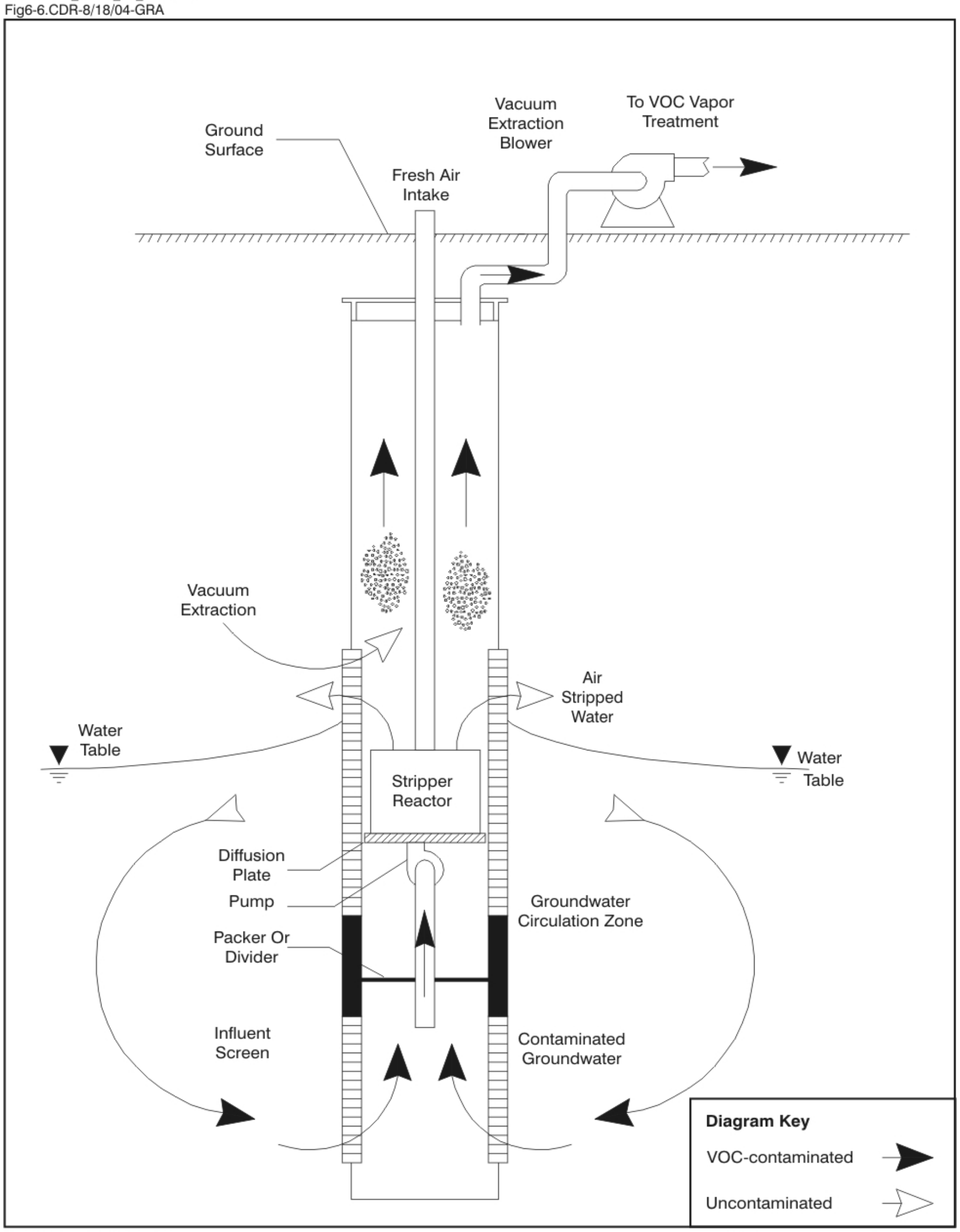



SOURCE: GWRTAC, 2001



**Figure 6-5 Typical NoVOCs Well Construction**

02:001515_UK01_02_01-B1466
Fig6-6.CDR-8/18/04-GRA




SOURCE: GWRTAC, 2001



**Figure 6-6 Typical Unterdruck-Verdampfer Brunner (UVB) Well Construction**

steeper areas to effectively capture the contaminated groundwater. Based on implementation assumptions using geological and geotechnical data collected during the spring 2000 SI and design assumptions developed through communication with vendors, the estimated effective treatment radius for an air-stripping well at the Building 817/WSA plume is approximately 45 feet in the flat gradient portion of the plume (approximate area of 85,000 $ft^2$) and 15 feet in the steep gradient portion of the plume (approximate area of 120,000 $ft^2$) (see Figure 6-3). These radius of influences will be refined during the pilot study. Full-scale implementation of this technology was assumed for the area contained within the 10 µg/L total VOC concentration contour line. Remediation of this area could potentially remove 90% of the contaminant mass but would address only approximately 58% of the area or 4.7 acres (see Table 6-1). Treating this area would require the installation of about 144 wells. The well system (i.e., spacing, placement, construction) presented in this FS should be refined accordingly during the design stage to address the leading edge of the plume and reduce the potential for contaminating uncontaminated groundwater within the aquifer. Furthermore, a polishing step such as enhanced biodegradation should be considered upon completion of the full-scale implementation of this technology to address residual contamination, as necessary. Costs for such a treatment are not included in this FS.

Stripping efficiencies of about 85% to 99% are anticipated in a single well for the chlorinated compounds but require field test verification. In order to eliminate emissions to the atmosphere, the system would be closed-loop in design. Contaminated vapors would be collected at each well head and routed back to two 1,800-pound carbon vessels connected in series. The clean air discharged from the carbon vessels would then be routed to the air intake of the air injection blower. In order to counteract the formation of calcium carbonate and metal precipitates, a compressed-gas cylinder would be used to bleed small quantities of carbon dioxide into the recirculated air. This will prevent the stripping of carbon dioxide from the groundwater. If oxidized metals precipitate due to the oxygenation of the aquifer, it will be addressed by in-well sequestering and/or acid treatment of the aquifer water. The final design criteria will be established through the implementation of a single-well pilot study centrally located in the Building 817/WSA contamination plume with consideration given to the location of the chemical oxidation pilot study performed at this site in 2002-2003. Residual oxidant and any precipitate from the 2002-2003 pilot study injections is not expected to have an effect on the in-well air stripping pilot study. During the pilot study, the following should be addressed: estimation of the vertical hydraulic conductivity of the aquifer (circulating wells operate efficiently when the ratio of horizontal to vertical hydraulic conductivity is between 3 and 10; the circulation time may be too long if the ratio is greater than 10), determination of the optimum well screen design (e.g., slot size, filter pack, etc.); and identification of the presence of preferential pathways within the stratified drift should be ascertained, particularly in the deep portions of the plume near the gravelly till layer (where applicable).

The system components outside the stripping wells such as the air injector, carbon vessels, carbon dioxide cylinder, etc. would be housed in a dedicated, insulated, temperature-controlled structure in order to prevent freezing and to facilitate operations and maintenance activities. Source and return air piping lines would be trenched underground. Based on contaminant concentrations and site geological and geochemical conditions, it is assumed that the air-stripping wells will need to be in service for approximately four to six years before the contaminant concentrations satisfy cleanup goals. Annual operational costs include energy and possible chemical (precipitate) control, and maintenance activities are assumed to included two changeouts of the carbon vessels and one changeout of the carbon dioxide cylinder, as well as air sample acquisition. For costing purposes, it is assumed that treatment would be required for approximately five years.

Monitoring of the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2. Metals are not expected to mobilize within the plume, therefore metals analysis is not included in the long-term monitoring program. Monitoring is assumed to be required for 15 years (5 years during operation of the air stripping system and 10 years into the future). If contaminants of concern remain above proposed cleanup goal concentrations after the assumed 15-year long-term monitoring period, based on data evaluation, additional monitoring may be needed.

### 6.1.5 Alternative 5: Zero-valent Iron Wall

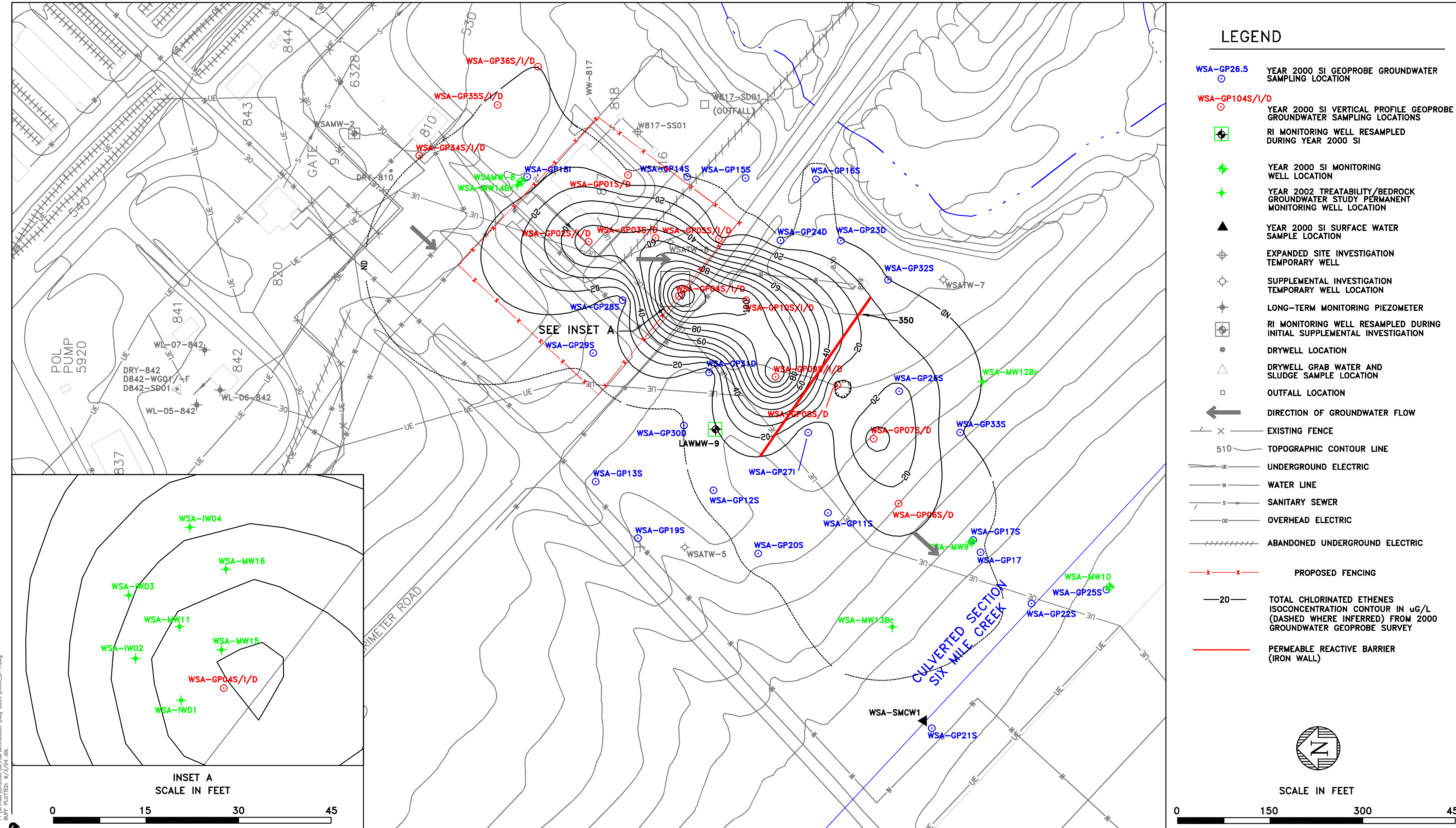
This alternative involves the installation of an in situ permeable reactive barrier (PRB) containing commercially available granular iron. The groundwater flows through the iron wall barrier where metal-enhanced reductive dehalogenation reactions occur. These reductive dehalogenation reactions reduce the chlorinated ethenes present in the groundwater to ethene and chloride.

Zero-valent iron walls used as a PRB to remediate VOCs is patented by the University of Waterloo. The patent holder has granted the exclusive rights for the commercialization of this technology to Environmental Technologies, Inc. (ETI). Although ETI retains the right to have on-site representation during the installation phase of the project, engineering or contracting firms normally handles construction management.

There are two basic designs for a PRB: a continuous PRB and a funnel and gate. A continuous PRB configuration involves distributing the granular iron across the entire path of the contaminated groundwater. The granular iron has a hydraulic conductivity greater than many aquifers and thus does not significantly alter the groundwater flow path or velocity. A funnel and gate configuration uses low permeability materials, the funnel, to direct groundwater towards a permeable treatment zone, the gate. The natural groundwater flow velocity may be increased significantly by funneling the groundwater toward a treatment gate. Therefore, for a funnel and gate system, groundwater flow modeling is required to estimate the velocity through the gate to determine the required flow-through thickness. Also, funnel and gate designs need to extend beyond the extent of the plume to ensure that all of the contaminated groundwater is captured and treated. The length of the funnel and gate system may be on the order of 1.2 to 2.5 times the plume width, depending on the number of gates and the funnel-to-gate ratio. To ensure that flow beneath the system does not occur, funnel and gate systems must be keyed into a competent underlying low permeable zone. The mass of iron required is generally the same regardless of the configuration, continuous or funnel and gate, because the same contaminant flux must be treated. To facilitate the evaluation of this remedial technology, ETI provided estimates of preliminary design criteria and costs for the construction of a continuous PRB.

ETI estimated the residence time required for sufficient contaminant degradation of PCE and TCE to be about 0.5 days. This residence time was calculated by ETI using degradation rates and VOC concentrations in the plume and would need to be confirmed and refined based on a more complete review of groundwater chemistry and, possibly, a bench-scale test. The recommended installation location is between WSA-GP8 and WSA-GP9 in an east-west orientation. The closest location of the iron PRB to the culverted section of Six Mile Creek would be approximately 375 feet and would include the easternmost edge of the iron PRB (see Figure 6-7). The groundwater flow velocity of 0.04 ft/day was obtained using a hydraulic conductivity of $10^{-4}$ cm/sec, a hydraulic gradient of 0.04 ft/ft, and an aquifer porosity of 0.3. The groundwater flow velocity, in conjunction with the residence time, requires a granular iron PRB thickness of 0.02 foot. Based on excavation and installation, the likely minimum trench construction width would be about 2.5 feet. In order to minimize iron costs, the iron can be mixed with sand to no less than 20% by volume. Therefore, the effective iron wall thickness would be 0.5 foot. Based on a saturation thickness of 17 feet, the recommended length of the PRB of 350 feet and the iron flow-through thickness of 0.5 foot, the required volume of granular iron is 2,975 cubic feet. The most cost-effective construction method will be excavation using biodegradable slurry for trench support. The total depth, 27 feet, and required width, 2.5 feet, are within the range that can be excavated with this method. The biodegradable slurry used is typically guar-based and the granular iron is placed into the trench through the slurry. After some time the slurry breaks down and becomes less viscous, allowing groundwater to flow through the iron PRB.

Operations and maintenance may include the possible need for periodic rejuvenation of iron sections affected by mineral precipitates. The iron material is expected to last for decades, but the formation of precipitates on the iron can reduce permeability and reactivity. The precipitates, if significant, will likely form in a zone on the upgradient face of the PRB. Rejuvenation techniques include jetting the upgradient face of the PRB with water under high pressure, using solid-stem augers to agitate the upgradient face of the PRB, using ultrasound to break up the precipitate on the upgradient face, and using a pressure-wave hydraulic pulse to break up the precipitate. It is important to note that such cleaning reportedly has not been needed on the 60 pilot- or full-scale implementations of this technology.




ecology and environment



FIGURE 6-7 B817/WSA ALTERNATIVE 5
ZERO-VALENT IRON WALL
FORMER GRIFFISS AFB
ROME, NEW YORK

For costing purposes, however, it is assumed that a rejuvenation procedure may be required once after 10 to 15 years of operation. According to the preliminary evaluations conducted by ETI, the rejuvenation of a PRB with one of the these methods is anticipated to be less than 50% of the cost of replacement of the PRB.

Monitoring the plume and treatment performance during full-scale implementation would consist of a program similar to that described for Alternative 2. However, some of the wells may be repositioned closer to the PRB (specifically on each end of the iron wall) to evaluate the performance of the PRB. Because the treatment mechanism relies on the plume migrating through the PRB, a portion of the plume upgradient of the PRB will remain that will still be contaminated during the treatment process. For this reason, a deed restriction would have to be placed over the area that defines the plume.

### 6.1.6 Alternative 6: Extraction, Treatment, and Disposal

This alternative involves the collection of contaminated groundwater using an intercepting trench, followed by treatment with a carbon-adsorption system. Treated groundwater would then be discharged to the culverted section of Six Mile Creek. Based on the topography of the site and the groundwater flow direction, the trench would be located north of the Six Mile Creek culvert, as shown in Figure 6-8. This location may be modified in the design stage. The trench would extend 275 feet along the whole width of the plume and would have a maximum depth of 11 feet to bedrock. A 6-inch perforated PVC pipe would be installed near the trench bottom to increase the available pore space and water flow. The collection trench would be backfilled with 7 feet of highly permeable granular material such as gravel and sand. The upper 4 feet of the trench would be backfilled with 3.5-feet general fill (low permeability) and 6-inch topsoil for establishing vegetation. Geotextile filter fabric would be placed around the permeable backfill to minimize fine particles clogging the trench drain system. The trench would be slightly sloped toward a collection point, where a submersible-type pump would be used to pump the contaminated water through the carbon treatment system. Using a trench length of 275 feet and depth of 11 feet, and given a hydraulic conductivity and gradient of 0.002 ft/min ($10^{-3}$ cm/s) and 0.04 ft/ft respectively, (E & E October 2000), the required pumping rate from the trench was estimated at 2 gpm.

The extracted groundwater would be pumped through a carbon adsorption system consisting of two prefiltered 55-gallon drums in series. The second in-series carbon drum would provide redundancy in the system if breakthrough occurs in the first unit. The treatment system would be housed in a prefabricated protective and insulated enclosure, as shown in Figure 6-8. A sufficient power source is assumed to be available from the existing underground electric lines to feed the treatment building. Temperature control would be provided inside the enclosure to prevent freezing of system components.

The maximum total VOC concentration expected in the extracted groundwater was assumed to be half the maximum total VOC concentration detected in the plume (140 µg/L), or 70 µg/L. Given this concentration and a pumping rate of 1 gpm, the carbon usage per treatment train per day is 0.13 lb. This amounts to a carbon lifetime of approximately 7.5 years. Spent carbon drums would be removed, properly disposed of, and replaced with new carbon drums. Long-term maintenance of the system would require replacing the filters on a weekly basis and monthly sampling of the influent and effluent VOC concentrations.

Treated groundwater will be discharged to Six Mile Creek via a new underground 3-inch PVC pipe. The discharge pipe will extend through the existing surface grate that drains surface water into the culvert, as shown in Figure 6-8. Requirements of the SPDES permit would need to be achieved before discharge of treated water to the creek. Sampling may be increased, based on permit requirements.

Monitoring the plume and treatment performance during full-scale implementation would consist of a program similar to that described in Alternative 2.

For purposes of this FS, it is assumed that on-site contaminant concentrations would remain above ARARs for the 30-year alternative duration and that remedial actions at the site may require a re-evaluation at that time. However, if concentrations observed on-site achieve ARARs, this alternative would be terminated, monitoring would be reduced or eliminated, and a report written requesting site closure.

## 6.2 Detailed Analysis of Alternatives

### 6.2.1 Alternative 1: No Action

#### Overall Protection of Human Health and the Environment

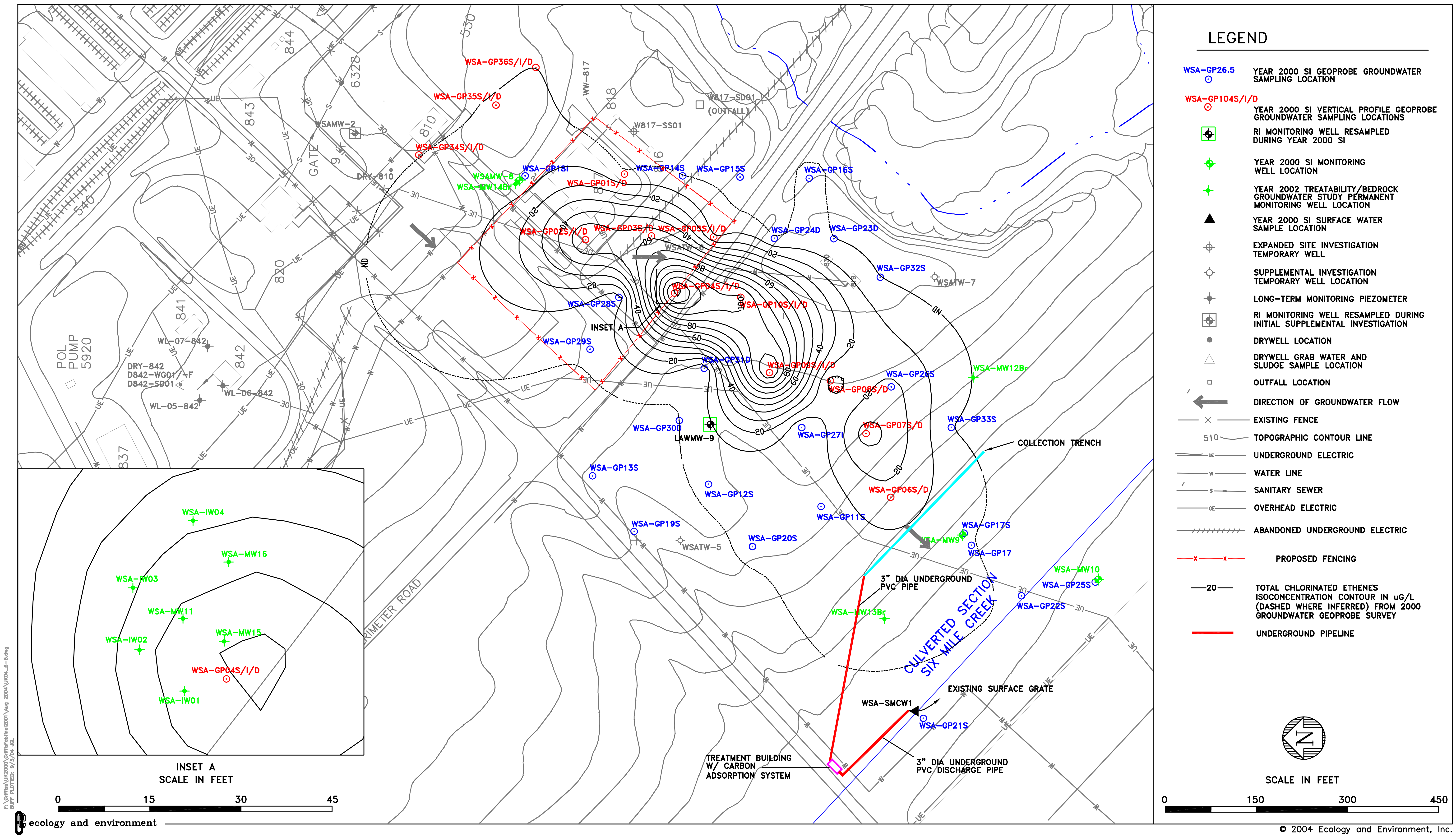
This alternative is not protective of human health and the environment. Although there are no current receptors of contamination at the Building 817/WSA plume, this alternative does not prevent future exposures through installation of groundwater wells or construction in soils above the plume. Although the plume would be expected to eventually discharge into the culverted section of Six Mile Creek, environmental receptors would not be exposed until the creek leaves the culvert approximately 1.2 miles downstream. By this time, it is expected that low levels of solvents would continue to decrease by natural processes.

#### Compliance with ARARs

This alternative does not comply with groundwater standards and thus does not comply with chemical-specific ARARs. Because no action would be taken, no action-specific ARARs would apply.

#### Long-term Effectiveness

Because no action is taken by this alternative, it is not effective in the long-term.






ecology and environment

FIGURE 6-8 B817/WSA ALTERNATIVE 6
EXTRACTION TREATMENT
AND DISPOSAL
FORMER GRIFFISS AFB
ROME, NEW YORK

### Reduction of Toxicity, Mobility, or Volume through Treatment
This alternative employs no treatment techniques and thus does not reduce toxicity, mobility, or volume.

### Short-term Effectiveness
Property transfer may be impacted until RAOs have been achieved. There are no additional short-term impacts posed from the implementation of this alternative.

### Implementability
There are no technical barriers to implementing this alternative.

### Cost
Because this alternative calls for no action, no costs are incurred.

## 6.2.2 Alternative 2: Institutional Actions

### Overall Protection of Human Health and the Environment
Because this alternative would prevent future uses of contaminated groundwater, it is protective of human health. There are currently no human or environmental receptors impacted by this plume. No environmental receptors are anticipated in the foreseeable future. Although the plume would be expected to eventually discharge into the culverted section of Six Mile Creek, environmental receptors would not be exposed until the creek flows out of the culvert approximately 1.2 miles downstream. At that point, it is expected that low levels of solvents would have dissipated by natural processes.

### Compliance with ARARs
This alternative does not comply with groundwater standards and thus does not comply with chemical-specific ARARs. Although a deed restriction would be placed and monitoring would be conducted, no action-specific ARARs would apply.

### Long-term Effectiveness
Deed restrictions are an effective mechanism limiting the potential for future exposures to contaminated groundwater. Because municipal water is available in this area and there are no plans for development at this time, this alternative would be effective in the long term.

### Reduction of Toxicity, Mobility, or Volume through Treatment
This alternative employs no treatment techniques and thus does not reduce toxicity, mobility, or volume.

### Short-term Effectiveness
Property transfer may be impacted until RAOs have been achieved. There are no additional short-term impacts posed from the implementation of this alternative. Monitoring would be required to be continued for the foreseeable future.

### Implementability

This alternative is readily implemented.

### Cost

The 2004 total present-worth cost of this alternative of $478,600 was based on the calculated 2001 total present-worth cost of $450,100 using RS Means Historical Cost Index (see Table 6-2). The capital cost of $64,200 includes the drilling, installation, and development of two standard monitoring wells, along with characterization and disposal of associated investigation-derived waste. The O & M cost of $20,200 includes two events of groundwater sampling of four existing wells, two new wells, two surface water samples, and one sediment sample per year. The 30-year present worth of the annual sampling is $385,900.

## 6.2.3 Alternative 3: In situ Oxidation

### Overall Protection of Human Health and the Environment

There are currently no human or environmental receptors impacted by this plume. This alternative would destroy contaminants in the plume through chemical oxidation, resulting in removal of contaminants from the subsurface and thus eliminating future potential exposure threats.

### Compliance with ARARs

Through destruction of contaminants via oxidation, concentrations in the aquifer would be reduced to levels below groundwater standards, thus meeting chemical-specific ARARs. By focusing on treatment of the plume defined by the 10 μg/L contaminant contour interval, this alternative would remove approximately 90% of the contaminant mass. Some areas with contamination concentrations between 5 and 10 μg/L would remain; however, these would represent less than 10% of the original contaminant mass and would likely naturally attenuate to within ARARs over time.

### Long-term Effectiveness

Because the majority of the contaminants would be permanently destroyed, this alternative is effective in the long-term.

### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative employs reductive dechlorination via chemical oxidation to destroy the contaminants, thus resulting in toxicity reduction through treatment.

**TABLE 6-2**
**COST ESTIMATE**
**Former Griffiss AFB - Building 817/WSA**
**Alternative 2 - Institutional Actions**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Work Plan | Includes submittals, reporting, meetin | 1 | LS | NA | $8,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 1,300 | LF | $14 | $18,800 |
| **Well Installations** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 2 | EA | $3,200 | $6,400 |
| Well Development | | 2 | EA | $750 | $1,500 |
| IDW Sampling and Disposal | | 1 | LS | NA | $6,600 |
| Subtotal | | | | | $46,300 |
| | | | | Capital Cost Subtotal: | $46,300 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $42,781 |
| | | | | 25% Legal, administrative, engineering fees, construction management: | $10,700 |
| | | | | 20% Contingencies: | $10,700 |
| | | | | **Capital Cost Total:** | **$64,200** |
| **Annual Costs** | | | | | |
| Bi-Annual Sampling | Total 6 wells; assume 3 wells/day, add 4 hrs for surface water and sediment sampling, 2-persons @ $65/hr, 10hr/day | 2 | Events | $3,200 | $6,400 |
| Analytical Costs (Groundwater - VOCs) | VOC samples from 6 wells | 2 | Events | $600 | $1,200 |
| Analytical Costs (Surface Water - VOCs) | VOC samples from 2 locations | 2 | Events | $200 | $400 |
| Analytical Costs (Sediment - VOCs) | VOC sample from 1 location | 2 | Events | $200 | $400 |
| Data Evaluation and Reporting | | 70 | HR | $85 | $6,000 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 65 | LF | $14 | $1,000 |
| Subtotal | | | | | $16,400 |
| | | | | Annual Cost Subtotal: | $16,400 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $15,154 |
| | | | | 10% Legal, administrative, engineering fees: | $1,600 |
| | | | | 20% Contingencies: | $3,400 |
| | | | | **Annual Cost Total:** | **$20,200** |
| | | | | **30-year Present Worth of Annual Costs:** | **$385,900** |
| | | | | **2001 Total Present Worth Cost:** | **$450,100** |
| | | | | **2004 Total Present Worth Cost:** | **$478,600** |

**Notes:**
1. Six monitoring wells will be sampled during the long-term monitoring program (2 new + 4 existing).
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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
3. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

4. Costs presented are based on conventional contracting methods.

### Short-term Effectiveness

Implementation of this alternative would require the installation of 228 wells over the plume during the primary injection event and 50% of that amount during the second injection event. However, the area above the plume is relatively open, and the oxidant-injections are expected to be completed within one year, resulting in only minor short-term impacts. Monitoring is assumed for approximately 10 years (including the assumed one year for oxidant injections at the site). Property transfer may be impacted until RAOs have been achieved.

### 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 oxidant) requirements necessary to treat the contaminants of concern at this site.

### Cost

The 2004 total present-worth cost of this alternative of $2,267,700 was based on the calculated 2001 total present-worth cost of $2,133,000 using RS Means Historical Cost Index (see Table 6-3). The capital cost of $1,962,400 includes the full-scale implementation of the technology. For purposes of this FS, it was assumed that the injection wells during full-scale implementation would be temporary-type wells installed using the direct-push method. The O & M cost of $170,600 includes 10 years of monitoring and sampling.

## 6.2.4 Alternative 4: In-well Air Stripping

### Overall Protection of Human Health and the Environment

There are currently no human or environmental receptors impacted by this plume. This alternative would remove contaminants from the subsurface as a vapor, limiting future potential exposure threats.

### Compliance with ARARs

Through removal of contaminants as vapors, concentrations in the aquifer would be reduced to levels below groundwater standards, thus meeting chemical-specific ARARs. By focusing on treatment of the plume defined by the 10 µg/L contaminant-contour interval, this alternative would remove 90% of the contaminant mass. Some areas with contamination between 5 and 10 µg/L would remain; however, these would represent less than 10% of the original contaminant mass and would likely naturally attenuate to within ARARs over time.

Although the system would recirculate air and remove VOCs with gas-phase carbon, some discharge of VOCs into the air would occur and application for an air permit would be required. This action-specific ARAR would be met.

**TABLE 6-3**
**COST ESTIMATE**
**Former Griffiss AFB - Building 817/WSA**
**Alternative 3 - In situ Oxidation**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Subsurface Investigation | Investigate underground utilities at site | 1 | LS | NA | $5,000 |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $50,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 1,300 | LF | $14 | $18,800 |
| Subtotal | | | | | $78,800 |
| **Health and Safety** | | | | | |
| Construct Decontamination Pad & Containment | For equipment & personnel | 2 | Setups | $1,900 | $3,800 |
| Air Monitoring | Organic Vapor Analyzer (4 units) | 9 | months | $3,800 | $34,200 |
| Health and Safety Plan and Management | Includes development of plan and medical surveillance of on-site personnel | 1 | LS | NA | $9,500 |
| Site Safety Officer | 10 hrs/day, 5days/wk, $65/hr | 36 | manweeks | $3,250 | $117,000 |
| Personal Protective Equipment | Includes coveralls, hard hats, safety glasses, reusable boots, gloves | 1 | LS | NA | $7,100 |
| Subtotal | | | | | $171,600 |
| **Full-scale Implementation** | | | | | |
| *Geoprobe Installation* | | | | | |
| Mobilization/Demobilization (Geoprobes) | | 1 | LS | NA | $25,000 |
| Installation of Injection Points, Primary Injection | Assumes Geoprobe depth to 25', 2 drill rigs, vendor oversight, see Notes | 23 | day | $4,000 | $92,000 |
| Installation of Injection Points, Secondary Injection | Assumes Geoprobe depth to 25', 2 drill rigs, vendor oversight, see Notes | 12 | day | $4,000 | $48,000 |
| PVC Piping for Injection Points | 1" PVC pipe to depth of each injection point | 342 | Each | $11 | $3,700 |
| Injection Point Caps | 1" locking cap | 342 | Each | $9 | $3,300 |
| *Chemical Oxidation Injection* | | | | | |
| Reagent Injection, Pump (Equipment) | Assume pressure inject around 10gpm | 2 | Each | $5,000 | $10,000 |
| Reagent Injection, Primary Injection | Includes vendor oversight | 105 | days | $3,500 | $365,800 |
| Reagent Injection, Secondary Injection | Includes vendor oversight | 52 | days | $3,500 | $182,900 |
| Reagent Material incl. Transportation | $KMnO_4$, see Notes | 102,600 | lb | $2.60 | $266,800 |
| Electrical Fee | Provided by generator | 157 | day | $100 | $15,700 |
| Oversight | Duration of injection point installation and reagent injection; Assume 1-person @ $65/hr, 5days/week, 8hr/day | 192 | day | $520 | $99,800 |
| Injection Point Abandonment | Abandon injection points in place | 342 | Each | $50 | $17,100 |
| Subtotal | | | | | $1,130,100 |
| **Full-scale Monitoring** | | | | | |
| *Well Installation* | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 2 | EA | $3,200 | $6,400 |
| Well Development | | 2 | EA | $750 | $1,500 |
| IDW Sampling and Disposal | | 1 | LS | NA | $6,600 |
| *Treatment Monitoring* | | | | | |
| Groundwater Sampling (Labor) | 2-person @ $65/hr, 10hr/day; 5 total wells - assume 3 wells per day, 2 additional sampling rounds | 2 | Events | $3,200.00 | $6,400 |
| Groundwater Sampling (Equipment) | Groundwater level indicator, multi-parameter instrument, low-flow pump | 2 | Events | $400.00 | $800 |
| Parameter Analyses (VOC) | Includes TCL VOCs (Method SW8260B); assume 1 groundwater sample per well for 5 wells for 2 additional sampling rounds | 2 | Events | $600.00 | $1,200 |
| Parameter Analyses (Metals and DOC) | Includes TAL Metals and DOC; assume 1 groundwater sample per well for 5 wells for 2 additional sampling rounds | 2 | Events | $3,600.00 | $7,200 |
| Data Evaluation and Reporting | | 60 | HR | $85.00 | $5,100 |
| Subtotal | | | | | $35,200 |
| | | | | Capital Cost Subtotal: | $1,415,700 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $1,308,107 |
| | | | | 25% Legal, administrative, engineering fees, construction management: | $327,100 |
| | | | | 20% Contingencies: | $327,100 |
| | | | | **Capital Cost Total:** | **$1,962,400** |

**TABLE 6-3**
**COST ESTIMATE**
**Former Griffiss AFB - Building 817/WSA**
**Alternative 3 - In situ Oxidation**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Annual Costs (For First 10 Years)** | | | | | |
| Bi-Annual Sampling | Total 6 wells; assume 3 wells/day, add 4 hrs for surface water and sediment sampling, 2-persons @ $65/hr, 10hr/day | 2 | Events | $3,200 | $6,400 |
| Analytical Costs (Groundwater - VOCs) | VOC samples from 6 wells | 2 | Events | $600 | $1,200 |
| Analytical Costs (Surface Water - VOCs) | VOC samples from 2 locations | 2 | Events | $200 | $400 |
| Analytical Costs (Sediment - VOCs) | VOC sample from 1 location | 2 | Events | $200 | $400 |
| Data Evaluation and Reporting | | 70 | HR | $85 | $6,000 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 65 | LF | $14 | $1,000 |
| Subtotal | | | | | $16,400 |
| | | | | Annual Cost Subtotal: | $16,400 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $15,154 |
| | | | | 10% Legal, administrative, engineering fees: | $1,600 |
| | | | | 20% Contingencies: | $3,400 |
| | | | | **Annual Cost Total:** | **$20,200** |
| | | | | **10-year Present Worth of Annual Costs:** | **$170,600** |
| | | | | **2001 Total Present Worth Cost:** | **$2,133,000** |
| | | | | **2004 Total Present Worth Cost:** | **$2,267,700** |

**Notes:**

1. Assume radius of influence (ft) = 15
2. Assume treatment area (acre) = 4.7
   Assume treatment area (ft2) = 204,438
3. Assume number injection points for Primary Injection based on treatment area = 228
4. Assume percentage of this area would require a second injection = 50%
5. Assume installation of Geoprobes per day at this site = 10
6. Assume downtime during Geoprobe installation due to refusal, maneuvering around site = 25%
7. Based on pilot study, quantity of $KMnO_4$ in 1.5% solution required per injection point = 300 lb
8. Assume water will be provided by nearby hydrant at no cost.
9. Six monitoring wells will be sampled during the long-term monitoring program (2 new + 4 existing).
10. 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).
11. 10-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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
12. Total present worth costs presented were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

13. Costs presented are based on conventional contracting methods.

### Long-term Effectiveness

Because the vast majority of the contaminants would be removed from the aquifer and be permanently destroyed, this alternative is effective in the long-term.

### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative removes contaminants from the aquifer through in-well stripping, reducing the volume of contaminated media through treatment. It also employs carbon adsorption of the stripped air, and during carbon regeneration contaminants would be destroyed, resulting in toxicity reduction through treatment.

### Short-term Effectiveness

Implementation of this alternative would require installing 144 wells over the plume. O & M of the air stripping system is expected to be five years. Long-term monitoring would be required for an assumed 15 years (includes five years during the O & M of the air stripping system). Property transfer may be impacted until RAOs have been achieved.

### Implementability

This alternative would require pilot-scale testing to demonstrate its effectiveness prior to implementation. There is a possibility that this testing would reveal technical problems that may limit the ability to implement this technology or require changes in the assumptions that have been made regarding, for example, radius of influence, that may then increase or decrease costs of implementation.

### Cost

The 2004 total present-worth cost of this alternative of $2,912,900 was based on the calculated 2001 total present-worth cost of $2,739,800 using the RS Means Historical Cost Index (see Table 6-4). The capital cost of $1,436,900 includes the installation of in-well air stripping wells, long-term monitoring wells, the carbon adsorption system, compressors/blowers, trenching, electrical drops, pilot study, and full-scale implementation costs. The annual cost of $218,400 for the first five years is for the O & M of the in-well stripping system. Annual monitoring costs of $26,200 were assumed for the first 15 years. The present-worth value of the O & M and monitoring annual costs is $1,302,900.

## 6.2.5 Alternative 5: Zero-valent Iron Wall

### Overall Protection of Human Health and the Environment

Currently no human or environmental receptors are impacted by this plume. This alternative would treat the contaminants in situ, preventing the migration to potential receptors and eliminating future potential exposure threats. For the portion of the plume that remains upgradient of the PRB during treatment, deed restrictions would limit potential exposures to potential receptors who otherwise could conceivably install drinking water wells in the aquifer. However, this area is served

**TABLE 6-4**
**COST ESTIMATE**
**Former Griffiss AFB - Building 817/WSA**
**Alternative 4 - In-well Air Stripping**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Pilot Study Program | | 1 | LS | NA | $90,000 |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $50,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 1,300 | LF | $14 | $18,800 |
| Subtotal | | | | | $163,800 |
| **Well Installation** | | | | | |
| Mobilization/Demobilization | | 1 | LS | NA | $15,000 |
| Well Install/Developed | | 144 | Each | $2,000 | $288,000 |
| Surface Completion /Well Heads | | 144 | Each | $650 | $93,600 |
| Waste Disposal | | 144 | Each | $376 | $54,200 |
| **Aboveground In-Well Stripping System** | | | | | |
| Trenching/Piping | | 4,400 | LF | $40 | $176,000 |
| Carbon Vapor Adsorption System | 1800lb. Carbon Units | 8 | Each | $7,500 | $60,000 |
| Blower/Compressor | | 4 | Each | $6,500 | $26,000 |
| Vacuum | | 4 | Each | $6,500 | $26,000 |
| Carbon Dioxide/pH Control | | 4 | Each | $4,000 | $16,000 |
| Knock Outs | | 13 | Each | $1,500 | $19,500 |
| Pre-Fabricated Enclosure | | 4 | Each | $10,000 | $40,000 |
| Electrical Panel | | 4 | Each | $6,000 | $24,000 |
| Electrical Service Connection | | 4 | Each | $5,000 | $20,000 |
| Subtotal | | | | | $858,300 |
| **Monitoring** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 2 | Each | $3,200 | $6,400 |
| Well Development | | 2 | Each | $750 | $1,500 |
| IDW Sampling and Disposal | | 1 | LS | NA | $6,600 |
| Subtotal | | | | | $14,500 |
| | | | | Capital Cost Subtotal: | $1,036,600 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $957,818 |
| | 25% Legal, administrative, engineering fees, construction management: | | | | $239,500 |
| | | | | 20% Contingencies: | $239,500 |
| | | | | **Capital Cost Total:** | **$1,436,900** |
| **Annual Costs** | | | | | |
| **Operation (For First 5 Years)** | | | | | |
| Energy Consumption (Electric) | | 224,000 | KWH | $0.09 | $20,200 |
| Carbon Drum Replacement (Biannual) | | 16 | Each | $2,070 | $33,200 |
| Carbon Disposal (Biannual) | | 16 | Each | $1,900 | $30,400 |
| Carbon Dioxide Replacement/pH Control | | 12 | Mo | $1,920 | $23,040 |
| General O & M | | 12 | Mo | $6,000 | $72,000 |
| Subtotal | | | | | $178,840 |
| | | | | Annual Cost Subtotal: | $178,900 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $165,304 |
| | 10% Legal, administrative, engineering fees: | | | | $16,600 |
| | | | | 20% Contingencies: | $36,400 |
| | | | | **Annual Cost Total:** | **$218,400** |
| | **5-year Present Worth of Annual Costs:** | | | | **$994,600** |

**TABLE 6-4**
**COST ESTIMATE**
**Former Griffiss AFB - Building 817/WSA**
**Alternative 4 - In-well Air Stripping**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Monitoring (For First 15 Years)** | | | | | |
| Bi-Annual Sampling | Total 6 wells; assume 3 wells/day, add 4 hrs for surface water and sediment sampling, 2-persons @ $65/hr, 10hr/day | 2 | Events | $3,200 | $6,400 |
| Analytical Costs (Groundwater - VOCs) | VOC samples from 6 wells | 2 | Events | $600 | $1,200 |
| Analytical Costs (Surface Water - VOCs) | VOC samples from 2 locations | 2 | Events | $200 | $400 |
| Analytical Costs (Sediment - VOCs) | VOC sample from 1 location | 2 | Events | $200 | $400 |
| Air Samples Analysis (VOCs) | | 4 | Events | $1,250 | $5,000 |
| Data Evaluation and Reporting | | 70 | HR | $85 | $6,000 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 65 | LF | $14 | $1,000 |
| Subtotal | | | | | $21,400 |
| | | | | Annual Cost Subtotal: | $21,400 |
| | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | | | | $19,774 |
| | | | | 10% Legal, administrative, engineering fees: | $2,000 |
| | | | | 20% Contingencies: | $4,400 |
| | | | | **Annual Cost Total:** | **$26,200** |
| | | | | **15-year Present Worth of Annual Costs:** | **$308,300** |
| | | | | **2001 Total Present Worth Cost:** | **$2,739,800** |
| | | | | **2004 Total Present Worth Cost:** | **$2,912,900** |

**Notes:**

| | |
|---|---|
| 1. Assume radius of influence for steep gradient portion of plume (ft) = | 15 |
| Assume radius of influence for flat gradient portion of plume (ft) = | 45 |
| 2. Assume treatment area for steep gradient portion (acre) = | 2.7 |
| Assume treatment area for steep gradient portion (ft2) = | 119,001 |
| Assume treatment area for flat gradient portion (acre) = | 2.0 |
| Assume treatment area for flat gradient portion (ft2) = | 85,437 |
| Total treatment area (acre) = | 4.7 |
| Total treatment area (ft2) = | 204,438 |
| 3. Assume number of wells in steep gradient portion = | 133 |
| Assume number of wells in flat gradient portion = | 11 |
| Total number wells based on treatment area = | 144 |

4. Six monitoring wells will be sampled during the long-term monitoring program (2 new + 4 existing).

5. 5 and 15-year present worth of costs assume 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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).

6. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

7. Costs presented are based on conventional contracting methods.

by public water supplies and thus installation of new wells in this area would be unlikely.

### Compliance with ARARs

This alternative treats all groundwater passing through the PRB to levels below groundwater standards and thus meets chemical-specific ARARs. While groundwater upgradient of the PRB would remain above standards during treatment, it is expected that the majority of contaminated groundwater would pass through the PRB, resulting in compliance with ARARs.

### Long-term Effectiveness

Because this treatment mechanism is passive and provides ongoing treatment effectiveness, this alternative is effective in the long term.

### Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative treats the contaminants, rendering them non-toxic and thus resulting in toxicity reduction through treatment.

### Short-term Effectiveness

Implementation of this alternative would require installing an iron wall. Because the area is already developed and relatively open, this would have no short-term impacts. Treatment is assumed to be 20 to 30 years (see Appendix B) and monitoring is expected to be required for 30 years. Property transfer may be impacted until RAOs have been achieved.

### Implementability

This alternative may require bench-pilot-scale testing to demonstrate its effectiveness prior to implementation. However, this technology has been used successfully at similar sites and should be effective on this plume. There are no anticipated technical barriers to implementation.

### Cost

The 2004 total present-worth cost of this alternative of $1,201,900 was based on the calculated 2001 total present-worth cost of $1,130,500, using RS Means Historical Cost Index (see Table 6-5). The capital cost of $744,600 includes the site license fee for the use of this patented technology, ETI consulting fees, bench-scale testing, cost of excavation, the required amount of granular iron, PRB installation, and iron rejuvenation, if required. The 30-year present worth O & M cost of $385,900 includes the costs for long-term monitoring only.

## 6.2.6 Alternative 6: Extraction, Treatment, and Disposal

### Overall Protection of Human Health and the Environment

There are currently no human or environmental receptors impacted by this plume. This alternative would remove contaminants from the subsurface through direct extraction of contaminated groundwater, eliminating future potential exposure

**TABLE 6-5**
**COST ESTIMATE**
**Former Griffiss AFB - Building 817/WSA**
**Alternative 5 - Zero-valent Iron Wall**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Bench-scale Testing | Includes vendor data review and site visit | 1 | LS | NA | $20,000 |
| Work Plan / Final Report | Includes submittals, reporting, meeti | 1 | LS | NA | $50,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 1,300 | LF | $14 | $18,800 |
| Subtotal | | | | | $93,800 |
| **Iron Wall Installation** | | | | | |
| Mob/demob | | 1 | LS | NA | $60,000 |
| Bioslurry Excavation | Approximately 112 CY | 1 | LS | NA | $142,000 |
| Iron Supply and Delivery | | 224 | Ton | $425 | $95,200 |
| Subtotal (Charges Applicable to Site License Fee) | | | | | $297,200 |
| **Miscellaneous Costs Associated with the Iron Wall Installation** | | | | | |
| Site License Fee | 13% of Iron Wall Installation Costs | 1 | LS | 13% | $38,700 |
| ETI Assistance with Field Design and Implementation | | 1 | LS | NA | $10,000 |
| Subtotal | | | | | $48,700 |
| **Monitoring** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 2 | EA | $3,200 | $6,400 |
| Well Development | | 2 | EA | $750 | $1,500 |
| IDW Sampling and Disposal | | 1 | LS | NA | $6,600 |
| Subtotal | | | | | $14,500 |
| **Other Costs** | | | | | |
| Iron Rejuvenation present-worth cost | One time occurrence: 10 years following installation completion | 1 | LS | NA | $83,000 |
| Subtotal | | | | | $83,000 |
| | | | | Capital Cost Subtotal: | $537,200 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $496,373 |
| | | | | 25% Legal, administrative, engineering fees, construction management: | $124,100 |
| | | | | 20% Contingencies: | $124,100 |
| | | | | **Capital Cost Total:** | **$744,600** |
| **Annual Costs** | | | | | |
| Bi-Annual Sampling | Total 6 wells; assume 3 wells/day, add 4 hrs for surface water and sediment sampling, 2-persons @ $65/hr, 10hr/day | 2 | Events | $3,200 | $6,400 |
| Analytical Costs (Groundwater - VOCs) | VOC samples from 6 wells | 2 | Events | $600 | $1,200 |
| Analytical Costs (Surface Water - VOCs) | VOC samples from 2 locations | 2 | Events | $200 | $400 |
| Analytical Costs (Sediment - VOCs) | VOC sample from 1 location | 2 | Events | $200 | $400 |
| Data Evaluation and Reporting | | 70 | HR | $85 | $6,000 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 65 | LF | $14 | $1,000 |
| Subtotal | | | | | $16,400 |
| | | | | Annual Cost Subtotal: | $16,400 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $15,154 |
| | | | | 10% Legal, administrative, engineering fees: | $1,600 |
| | | | | 20% Contingencies: | $3,400 |
| | | | | **Annual Cost Total:** | **$20,200** |
| | | | | **30-year Present Worth of Annual Costs:** | **$385,900** |
| | | | | **2001 Total Present Worth Cost:** | **$1,130,500** |
| | | | | **2004 Total Present Worth Cost:** | **$1,201,900** |

**Notes:**
1. Six monitoring wells will be sampled during the long-term monitoring program (2 new + 4 existing).
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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
3. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

4. Costs presented are based on conventional contracting methods.

threats. However, complete removal of the contaminants would require many years. To prevent exposures during cleanup, deed restrictions would be required in the interim on the property where the contamination observed is above ARARs.

### Compliance with ARARs
Through removal of contaminants via extraction, concentrations in the aquifer would be reduced to levels below groundwater standards, thus meeting chemical-specific ARARs.

To discharge the treated water into the Six Mile Creek culvert, the requirements of a SPDES permit would have to be met. This action-specific ARAR would be complied with.

### Long-term Effectiveness
Because contaminants would be removed from the aquifer, this alternative is effective in the long-term.

### Reduction of Toxicity, Mobility, or Volume through Treatment
This alternative removes contaminants from the aquifer and concentrates them onto activated carbon, thus reducing volume through treatment. When the carbon is spent, it is sent off-site for regeneration, where the contaminants are destroyed, thus reducing toxicity through treatment.

### Short-term Effectiveness
Implementation of this alternative would require installing a collection trench to recover the groundwater and a small treatment building and discharge pipeline. This would require clearing some vegetation and associated well drilling activities. However, these impacts would be minor. Property transfer may be impacted until RAOs have been achieved.

### Implementability
Fouling issues must be considered upon implementation of this alternative. Otherwise, this alternative is readily implemented.

### Cost
The 2004 total present-worth cost of this alternative of $1,155,700 was based on the calculated 2001 total present-worth cost of $1,087,000, using RS Means Historical Cost Index (see Table 6-6). The capital cost of $319,000 includes the carbon adsorption system, interceptor trench construction, underground piping, and electrical distribution. The 30-year present-worth O & M cost of $768,000 includes the carbon treatment system maintenance, carbon drum replacement and disposal, and long-term monitoring.

**TABLE 6-6**
**COST ESTIMATE**
**Former Griffiss AFB - Building 817/WSA**
**Alternative 6 - Extraction, Treatment and Disposal**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Capital Costs** | | | | | |
| Pre-Design Investigation | Numerical modeling or aquifer test | 1 | LS | NA | $45,000 |
| Work Plan / Final Report | Includes submittals, reporting, meetings | 1 | LS | NA | $65,000 |
| Institutional Controls | Includes deed restrictions | 1 | Each | $5,000 | $5,000 |
| Fence Installation | Includes labor and materials | 1,300 | LF | $14 | $18,800 |
| **Site Preparation** | | | | | |
| Mob/demob | | 1 | LS | $15,000 | $15,000 |
| Subtotal | | | | | $148,800 |
| **Trench Construction** | | | | | |
| Excavation | Assume 4' W x 275' L x 11' D | 450 | CY | $1.17 | $600 |
| Backfill w/ excavated material | | 145 | CY | $1.26 | $200 |
| Compaction | | 145 | CY | $4.50 | $700 |
| Gravel Backfill | Includes delivery and spreading | 285 | CY | $36.18 | $10,400 |
| Topsoil from on-site stripping and stockpile | Includes spreading and compaction | 20 | CY | $9.14 | $200 |
| Filter Fabric (80 mil) | | 675 | SY | $1.42 | $1,000 |
| 6" perforated plastic tubing | | 275 | LF | $2.45 | $700 |
| 4 " Submersible Pump | | 1 | EA | $1,075 | $1,100 |
| Seeding, Vegetative cover | | 0.25 | AC | $2,660 | $700 |
| Manhole section for pump installation | | 1 | EA | $935 | $1,000 |
| Subtotal | | | | | $16,600 |
| **Carbon Treatment System** | | | | | |
| Carbon Adsorption System | Assumes (2) 55-gal drums and installation | 2 | LS | $818 | $1,700 |
| Pre-filter and Internal Piping Kit | | 1 | EA | $1,740 | $1,800 |
| Delivery of Carbon Drums to Site | | 1 | LS | $1,500 | $1,500 |
| Pre-Fabricated Enclosure (200 sf) | For Carbon System-includes installation, insulation, piping etc. | 1 | LS | $30,000 | $30,000 |
| Subtotal | | | | | $35,000 |
| **Piping Installation** | | | | | |
| Pipe Trenching (Influent) | Influent piping from trench to enclosure- Assume 2' wide, 4' deep -includes backfill and compaction | 200 | LF | $10 | $2,100 |
| Pipe bedding- Influent Piping | | 200 | LF | $6 | $1,200 |
| 3" PVC Pipe -Influent Piping | | 200 | LF | $7 | $1,400 |
| Pipe Trenching (Discharge) | Discharge pipe to surface grate. Assume 2' wide, 4'deep -includes backfill and compaction | 200 | LF | $10 | $2,100 |
| Pipe bedding- Discharge Piping | | 200 | LF | $6 | $1,200 |
| 3" PVC Pipe -Discharge Piping | | 200 | LF | $7 | $1,400 |
| Subtotal | | | | | $9,400 |
| **Electrical Distribution- to building and extraction wells** | | | | | |
| Underground Electrical Distribution | Trenching includes backfill and compaction 2' wide x 3' deep | 45 | CY | $7 | $300 |
| 3" PVC conduit | | 200 | LF | $7 | $1,400 |
| Feed Cable | | 200 | LF | $5 | $1,100 |
| Panel Board | | 1 | EA | $1,325 | $1,400 |
| Electrical connection fee and meter | Assume source of power is overhead electric from southeast corner of the site | 1 | LS | NA | $1,500 |
| Subtotal | | | | | $5,700 |
| **Monitoring Wells** | | | | | |
| Drilling/Installation of Standard Monitoring Wells | | 2 | EA | $3,200 | $6,400 |
| Well Development | | 2 | EA | $750 | $1,500 |
| IDW Sampling and Disposal | | 1 | LS | NA | $6,600 |
| Subtotal | | | | | $14,500 |
| | | | | Capital Cost Subtotal: | $230,000 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $212,520 |
| | | | | 25% Legal, administrative, engineering fees, construction management: | $53,200 |
| | | | | 20% Contingencies: | $53,200 |
| | | | | **Capital Cost Total:** | **$319,000** |

**TABLE 6-6**
**COST ESTIMATE**
**Former Griffiss AFB - Building 817/WSA**
**Alternative 6 - Extraction, Treatment and Disposal**

| Description | Comments | Quantity | Units | Unit Cost | Cost |
|---|---|---|---|---|---|
| **Annual Costs** | | | | | |
| **Operation** | | | | | |
| Filter Replacement | Assume 1-person @ $65/hr; 2.5 hr/week (130 hr/yr) | 130 | HR | $65 | $8,500 |
| Pump & Motor Maintenance | Assume 6 events/year; 1-person @$65/hr; 8hr/event, $100 for materials | 6 | EA | $620 | $3,800 |
| Monthly System Sampling | Influent & effluent for VOCs | 12 | Events | $200 | $2,400 |
| Electric Charge | | 20,000 | KWH | $0.06 | $1,200 |
| Carbon Drum Replacement | Assume every 7.5 years; assume 2 drums | 0.13 | Ea | $2,000 | $300 |
| Carbon Drum Sampling and Disposal | Assume every 7.5 years; assume 2 drums | 0.13 | Ea | $1,500 | $200 |
| Institutional Controls | | 1 | LS | NA | $1,000 |
| Fence Replacement | Assume 5% each year | 65 | LF | $14 | $1,000 |
| Subtotal | | | | | $18,400 |
| **Monitoring** | | | | | |
| Bi-Annual Sampling | Total 6 wells; assume 3 wells/day, add 4 hrs for surface water and sediment sampling, 2-persons @ $65/hr, 10hr/day | 2 | Events | $3,200 | $6,400 |
| Analytical Costs (Groundwater - VOCs) | VOC samples from 6 wells | 2 | Events | $600 | $1,200 |
| Analytical Costs (Surface Water - VOCs) | VOC samples from 2 locations | 2 | Events | $200 | $400 |
| Analytical Costs (Sediment - VOCs) | VOC sample from 1 location | 2 | Events | $200 | $400 |
| Data Evaluation and Reporting | | 70 | HR | $85 | $6,000 |
| Subtotal | | | | | $14,400 |
| | | | | Annual Cost Subtotal: | $32,800 |
| | | | | Adjusted Capital Cost Subtotal for Utica, New York Location Factor (0.924): | $30,307 |
| | | | | 10% Legal, administrative, engineering fees: | $3,100 |
| | | | | 20% Contingencies: | $6,700 |
| | | | | **Annual Cost Total:** | **$40,200** |
| | | | | **30-year Present Worth of Annual Costs:** | **$768,000** |
| | | | | **2001 Total Present Worth Cost:** | **$1,087,000** |
| | | | | **2004 Total Present Worth Cost:** | **$1,155,700** |

**Notes:**

1. Six monitoring wells will be sampled during the long-term monitoring program (2 new + 4 existing).
2. Carbon drum replacement unit costs based on life cycle of activated carbon. Here, carbon drums assumed to be replaced once every
   7.5 years
   90 months
   Therefore, carbon replacement adjusted to account for these costs annually.
3. 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 for the year 2001 (http://www.whitehouse.gov/omb/circulars/a094/a94_appx-c.html).
4. Total present worth costs presented in referenced documents were adjusted to 2004 costs using RS Means Historical Cost Index.

| | |
|---|---|
| RS Means Historical Cost Index (2004) | 133 |
| RS Means Historical Cost Index (2001) | 125.1 |
| (2004) / (2001)= | 1.063 |

5. Costs presented are based on conventional contracting methods.

## 6.3 Comparison of Alternatives

### 6.3.1 Overall Protection of Human Health and the Environment

There are currently no human or environmental receptors impacted by this plume. Although there are no current receptors of contamination at the Building 817/WSA plume, Alternative 1 does not prevent future exposures through installation of drinking water wells or construction in soils above the plume. Alternative 2 includes deed restrictions and a monitoring program to ensure that there are no future exposures to contaminants. Because the future use of the area above the plume is used for open space and other nonresidential purposes at this time, this approach would be protective. Alternatives 3 through 6 employ active treatment mechanisms to destroy contaminants, thus providing the highest level of protection of human health and the environment.

### 6.3.2 Compliance with ARARs

Groundwater standards comprise the chemical-specific ARARs for this plume. Alternatives 3 through 6 provide active treatment mechanisms for removing contaminants from the groundwater, thus accelerating compliance with these ARARs. Alternatives 3 and 4 employ active in situ treatment technologies to meet ARARs in the shortest period. Alternative 5 provides in situ treatment but relies on a passive technique, requiring the plume to flow through the reactive wall to provide contaminant destruction. Although this technique is effective, groundwater upgradient of the PRB would remain above ARARs until it passes through the wall, which would take many years due to the rate of groundwater flow in the area of the plume (expected to be approximately 20 to 30 years). Alternative 6 uses extraction and treatment that would require still longer treatment periods before ARARs are met. ARARs would not be achieved with Alternatives 1 and 2.

Alternatives 3 and 4 apply in situ treatment approaches over an area that covers about 90% of the contamination on a mass basis. Increasing the extent of coverage of these technologies to the entire plume area defined by groundwater standards would increase area and, thus, costs by approximately 50%. While there would be some area in the 5 to 10 µg/L concentration range initially remaining above ARARs, this area would represent only a small fraction of the plume and would likely reduce to levels below ARARs over time after treatment of the plume was complete.

### 6.3.3 Long-term Effectiveness

Alternatives 3, 4, and 5 use active in situ treatment technologies. The chemical oxidation pilot study at this site was effective in reducing contaminant mass and thus is effective in the long-term. As with any in situ technology, effectiveness can not be well predicted until after pilot studies and/or initial implementations of the technology. However, the in-well air stripping technology used in Alternative 4 and the zero-valent iron technology used in Alternative 5 has been applied at a number of sites and are therefore expected to be reasonably effective. However, pending successful use of these technologies, both would represent effective long-term solutions.

Alternative 6 employs a more established, proven technology and thus its effectiveness is more predictable. Extraction and treatment is a well-established technology known to control plume migration. It would, over the long term, provide effective protection. However, its ability to completely reduce concentrations to groundwater standards throughout the aquifer is somewhat limited by the long period required to reduce concentrations.

The use of deed restrictions combined with ongoing monitoring as called for by Alternative 2 provides an effective long-term mechanism to protect human health and the environment. However, in the absence of treatment mechanisms, protection is less compared with Alternatives 3 through 6.

### 6.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 through 6 employ treatment mechanisms to reduce toxicity of contaminants in the plume. Alternative 3 treats the contaminants in situ, providing the most effective and most rapid toxicity reduction. Alternatives 4, 5, and 6 rely on migration of contaminants to either air stripping wells, a PRB, or extraction wells, respectively. Contaminants will be treated and disposed accordingly, thus reducing toxicity.

### 6.3.5 Short-term Effectiveness

None of the alternatives considered would have significant short-term impacts. Until RAOs have been achieved for any of the alternatives, property transfers may be impacted. In addition, the active in situ treatment of Alternative 3 would require surface access throughout the area of the plume, but this area is currently relatively open. Alternative 3 would also provide the shortest duration of implementation (assumed to be one year). Monitoring for this alternative would span an assumed 10-year period.

Alternative 4 would provide the next shortest duration of implementation/operation, estimated at five years with monitoring events performed during operation activities and extending 10 years beyond. Alternative 5 assumes ARARs will be achieved in approximately 20 to 30 years. However, monitoring is assumed to be performed for a total of 30 years. Alternative 2 requires essentially continuous ongoing monitoring that would likely extend for decades. The duration of the extraction called for by Alternative 6 is assumed to require decades before standards are met.

### 6.3.6 Implementability

Alternatives 4 and 5 employ in situ treatment technologies, which would require pilot- (and possibly bench-) scale testing to demonstrate effectiveness prior to implementation. There is a possibility that testing would reveal technical problems that may limit the ability to implement the technology or require changes from the assumptions that have been made regarding, for example, radius of influence or amount of zero-valent iron required, that may increase or decrease costs of implementation. There are no actions to implement for Alternative 1. Alternatives 2, 3, and 6 are readily implementable.

### 6.3.7 Cost

Alternative 1 calls for no action and thus incurs no costs. Alternative 2, which comprises long-term monitoring, is the least expensive of the remaining alternatives at a 2004 present-worth cost of $478,600.

Alternatives 3, 4, and 5 call for in situ treatment. Since the chemical oxidation pilot study has been performed at this site, the implementation methodology for Alternative 3 has been evaluated to the point where the cost estimate presented in this FS is expected to have less potential to vary. On the other hand, the cost estimates for full-scale implementation of Alternatives 4 and 5 obtained from the in-well air stripping and iron wall vendors are conceptual and may not fully represent site-specific conditions. Additionally, the cost estimate for in situ treatment could vary based on the bench- and/or pilot-scale testing.

Considering these issues, the 2004 present-worth cost of Alternative 4 is $2,912,900, which is the most expensive alternative primarily due to the cost associated with the installation of the number of in-well air stripping wells and associated equipment needed to effectively treat the plume. Alternative 5 (zero-valent iron wall) is the least expensive of the active treatment alternatives with a 2004 present-worth cost of $1,201,900. The 2004 present-worth cost of Alternative 3 (in situ chemical oxidation) is between Alternatives 4 and 5 with a value of $2,267,700.

Alternative 6 employs extraction and treatment to treat the plume. Its present worth cost is estimated to be slightly greater than Alternative 5 but less than Alternatives 3 and 4. Most of its $1,155,700 estimated 2004 present-worth cost is due to 30 years of operation of the treatment system.

Cost estimates for Building 817/WSA groundwater remediation alternatives are summarized in Table 6-7.

## 6.4 Recommendation

Considering the RAOs for Building 817/WSA and the remedial alternative evaluation completed in this section, the recommended remedy for the Building 817/WSA plume is in situ oxidation (Alternative 3). It was determined that the long-term site goals included the need for cleanup of the site (i.e., meeting RAOs) in less than 30 years. Additionally, considering the potential for contaminated groundwater at the site to impact Six Mile Creek in the future, alternatives with shorter remediation durations are more desirable (i.e., Alternative 3).

## Table 6-7 Summary of Total Present Values of Alternatives at Building 817/WSA Former Griffiss AFB, Rome, New York

| Description | Alternative 1 No Action | Alternative 2 Institutional Actions | Alternative 3 In Situ Oxidation | Alternative 4 In Well Air Stripping | Alternative 5 Zero Valent Iron Wall | Alternative 6 Extraction, Treatment, and Disposal |
|---|---|---|---|---|---|---|
| Total Project Duration (Years) | 0 | 30 | 10 | 15 | 30 | 30 |
| Capital Cost | $0 | $64,200 | $1,962,400 | $1,436,900 | $744,600 | $319,000 |
| Annual O&M Cost | $0 | $20,200 | $20,200 | $218,400 (for first 5 years) $26,200 (for first 15 years) | $20,200 | $40,200 |
| **2001 Total Present Value of Alternative** | **$0** | **$450,100** | **$2,133,000** | **$2,739,800** | **$1,130,500** | **$1,087,000** |
| **2004 Total Present Value of Alternative** | **$0** | **$478,600** | **$2,267,700** | **$2,912,900** | **$1,201,900** | **$1,155,700** |

In situ oxidation of contaminated groundwater represents an active remedial approach to permanently reduce the toxicity, mobility, and volume of site contaminants of concern, which is the preferred approach, when practical. This alternative also provides for protection of human health and the environment and has the ability to have the shortest treatment durations of the alternatives presented. However, it should be noted that during the remediation process, deed restrictions would be required that could impact property transfer. Although in situ oxidation was not the least expensive alternative, a pilot study performed at this site proved successful in reducing contaminant mass and is a proven technology.

Taking into consideration the possible impact on property transfer until RAOs have been achieved, an active treatment approach (which has shorter cleanup duration than non-active approaches) appears most desirable. Several active treatment technologies have been presented, including Alternatives 3, 4, 5, and 6. Of the active alternatives, chemical oxidation (Alternative 3) is the second most expensive alternative presented and this technology assumes the shortest treatment duration at approximately one year to achieve RAOs and 10 years of long-term monitoring. In addition, the chemical oxidation pilot study performed at this site illustrated that contaminant mass can effectively be reduced and indicated that this innovative technology is viable at this site. Unlike Alternative 3, Alternatives 4, 5, and 6 require some form of preliminary testing before full-scale implementation. Alternative 4, in-well air stripping, is estimated as the most expensive alternative. RAOs are expected to be achieved within five years of operation for Alternative 4, with long-term monitoring continuing into the future for 10 years. However, uncertainties associated with effectiveness must be determined with a pilot-scale study before full-scale implementation. Present value costs of Alternatives 5 and 6 are on the same order of magnitude (least expensive of the active treatment alternatives). Rejuvenation of the iron wall in Alternative 5 is assumed to occur once, with RAOs estimated to be achieved in approximately 20 to 30 years; long-term monitoring was assumed to continue for 30 years. For Alternative 6 (Extraction, Treatment, and Disposal), which is expected to meet RAOs some time after the 30-year evaluation period assumed for this FS, continuous operation and maintenance of a treatment system would be required.

Alternatives 1 and 2 represent the least expensive alternatives. However, treatment technologies would not be implemented and RAOs are not expected to be achieved within the assumed 30-year period used for evaluation purposes for this FS.

# 7 References


Ecology & Environment, Inc. (E & E). 1998. *Final Report for Supplemental Investigations of Areas of Concern*, Volume I., Lancaster, New York.

__________. August 2000. *Landfill 6 and Building 775 Areas of Concern Groundwater Study, Technical Memorandum No. 1: Field Investigation Conducted in Spring 2000*. Lancaster, New York.

__________. October 2000. *Addendum to the July 1998 Supplemental Investigations of Areas of Concern, Technical Memorandum No. 1: On-Base Groundwater (Area South of the WSA)*. Lancaster, New York.

__________. 2002. *Final Landfill 6, Building 775, AOC 9, and Building 817/WSA, Technical Memorandum No. 1: Bedrock Groundwater Study*. December 2002, Lancaster, New York.

__________. December 2003. *Final Records of Decision for Areas of Concern, Three Mile Creek and Six Mile Creek, Former Griffiss Air Force Base.* Lancaster New York: Ecology and Environment, Inc

__________. June 2004. *Final Groundwater Treatability Pilot Study Report.* Lancaster, New York.

Federal Remediation Technologies Roundtable (FRTR), Remediation Technologies Screening Matrix and Reference Guide, Version 4.0. Accessed at http://www.frtr.gov/matrix2/section4/4-40.html

Law Engineering and Environmental Services, Inc. (LAW). 1996. *United States Air Force, Griffiss Air Force Base, New York, Remedial Investigation Draft Final Primary Report – Building 775 (Pumphouse 3) Trichloroethylene Contamination Area of Concern*, Volume 27. Law Environmental Inc., Kennesaw, Georgia, December 1996.

__________. 1996. *United States Air Force, Griffiss Air Force Base, New York, Remedial Investigation Draft Final Primary Report – Landfill 6 Area of*

*Concern*, Volume 10. Law Environmental Inc., Kennesaw, Georgia, December 1996.

__________. 1996. *United States Air Force, Griffiss Air Force Base, New York, Remedial Investigation Draft Final Primary Report –On-Base Groundwater Area of Concern*, Volume 31. Law Environmental Inc., Kennesaw, Georgia, December 1996.

Puls, R.W., and Powell, R.M. 1992. Acquisition of representative ground water quality samples for metals: Ground Water Monitoring Review, v. 12, no. 3, p.167–176.

RS Means. Site Work and Landscape Cost Data. 2004. 23rd Annual Edition..

Sposito, G., ed. 1989. Aqueous equilibrium data for a mononuclear aluminum species, *The environmental chemistry of aluminum*: Boca Raton, Fla., CRC Press, p. 27-53.

Wiedemeier et al. 1995. *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater*.

Wiedemeier, T.H., M. A. Swanson, D. E. Moutoux, J. T. Wilson, D. H. Kampbell, J. E. Hansen, and P. Haas. 1996. *Overview of the Technical Protocol for Natural Attenuation of Chlorinated Aliphatic Hydrocarbons in Ground Water Under Development for the U. S. Air Force Center for Environmental Excellence*, Proceedings of the Symposium on Natural Attenuation of Chlorinated Organics in Ground Water, Dallas, Texas, September 11-13, 1996, EPA/540/R-97/504 (http://www.afcee.brooks.af.mil/products/techtrans/monitorednaturalattenuation/OverviewMNA.pdf).

# A Contaminated Groundwater Volume Calculations

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

ecology and environment

**Computation Sheet**

| | | | |
|---|---|---|---|
| Project No. | | | |
| Preliminary | ☐ | | |
| Final | ☐ | | |
| Void | ☐ | | |
| Sheet 1 of 1 | | | |
| Rev. | Completed By: CMH | Checked By: KMP | |
| | Initials: 7/30/04 | Initials: 8/13/04 | |
| | Initials: / / | Initials: / / | |

Project Name Griffiss AFB - LF 6

Subject Estimation of Contaminated Groundwater

Objective: To determine the volume of contaminated groundwater at Landfill 6.

Assumptions:

1. Surface Area defined by 5 µg/L contour for total VOCs developed as Figure 3-2 of the Technical Memorandum No. 1: Field Investigation Conducted in Spring 2000 (E&E 2000).

2. Average Depth to groundwater 19' BGS (see cross-section Figure 3-3a of the 2000 Field Investigation [E&E 2000]).

3. Depth to bedrock approximately 50' below the water table (see cross-section Figure 3-3a of the 2000 Field Investigation [E&E 2000]).

4. Attached is a table of contour interval areas of total VOCs as shown in Table 4-2 of this Report.

5. Assume porosity (n) of 0.35 for silty-sand and sand (2000 Field Investigation [E&E 2000]).

Calculations: Total Area = $A_T$ = (635 + 365 + 1000 + 1384 + 2174 + 2684 + 5919 + 15,154 + 29,837 + 16,975 + 15,470 + 18,717 + 28,282 + 68,926 + 154,181) ft²

$A_T = 361{,}703\ ft^2$

Contaminated groundwater Depth = D = 50 feet

Plume Volume = $\forall = A_T D n = (361{,}703\ ft^2)(50\ ft)(0.35)$

$\forall = 6329802.5 = \boxed{47350214 \text{ gallons}}$

**Table 4-2 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at the Landfill 6 Plume**

| Contour Interval (ug/L) | Lower Bound Concentration of Contour Interval (ug/L) | Area of Contour Interval ($ft^2$) | Cumulative Percentage 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 (%) |
|---|---|---|---|---|---|
| >2500 | 2500 | 635 | 0.2 | 0.10 | 2.7 |
| 2000-2500 | 2000 | 365 | 0.3 | 0.05 | 3.9 |
| 1500-2000 | 1500 | 1,000 | 0.6 | 0.09 | 6.4 |
| 1000-1500 | 1000 | 1,384 | 0.9 | 0.09 | 8.7 |
| 900-1000 | 900 | 2,174 | 1.5 | 0.12 | 12.0 |
| 800-900 | 800 | 2,684 | 2.3 | 0.13 | 15.6 |
| 700-800 | 700 | 5,919 | 3.9 | 0.26 | 22.5 |
| 600-700 | 600 | 15,154 | 8.1 | 0.57 | 37.8 |
| 500-600 | 500 | 29,837 | 16.4 | 0.93 | 62.8 |
| 400-500 | 400 | 16,975 | 21.0 | 0.42 | 74.1 |
| 300-400 | 300 | 15,470 | 25.3 | 0.29 | 81.9 |
| 200-300 | 200 | 18,717 | 30.5 | 0.23 | 88.2 |
| 100-200 | 100 | 28,282 | 38.3 | 0.18 | 92.9 |
| 50-100 | 50 | 68,926 | 57.4 | 0.22 | 98.7 |
| 5-50 | 5 | 154,181 | 100.0 | 0.05 | 100.0 |
| **Total** | | **361,703** | | | |

Note:

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

ecology and environment

**Computation Sheet**

| | | |
|---|---|---|
| Project No. | | |
| Preliminary ☐ | | |
| Final ☐ | | |
| Void ☐ | | |
| Sheet 1 of 1 | | |
| Rev. | Completed By: CMH | Checked By: KMP |
| | Initials: 7/30/04 | Initials: 8/13/04 |
| | Initials: / / | Initials: / / |

Project Name Griffiss AFB - B775

Subject Estimation of Contaminated GW

Objective: To determine the volume of contaminated groundwater at Building 775

Assumptions:

1. Surface area defined by the 5 ug/L contour for total VOCs developed as Figure 3-2 of the Technical Memorandum No. 1: Field Investigation Conducted in Spring 2000 (E&E 2000).

2. Depth to groundwater 60' BGS (see cross-section, Figure 3-3a of the 2000 Field Investigation [E&E 2000]).

3. Depth to bedrock approximately 60' below the water table (see cross-section Figure 3-3a of the 2000 Field Investigation [E&E 2000]).

4. Attached is a table of contour interval areas for total VOCs as shown in Table 5-1 of this Report.

5. Assume porosity (n) of 0.35 for silty-sand and sand (2000 Field Investigation [E&E 2000]).

Calculations:

Total Area $= A_T = (301 + 539 + 1674 + 17{,}155 + 37{,}394 + 82{,}936 + 141{,}534 + 324{,}455)\ ft^2$

$A_T = 605{,}988\ ft^2$

Contaminated Groundwater Depth: $D = 60'$

Plume Volume $= \forall = A_T D n = (605{,}988\ ft^2)(60\ ft)(0.35)$

$\forall = 12{,}725{,}748\ ft^3 = \boxed{95{,}195{,}212 \text{ gallons}}$

**Table 5-1 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at Building 775**

| Contour Interval (ug/L) | Lower Bound Concentration of Contour Interval (ug/L) | Area of Contour Interval ($ft^2$) | Cumulative Percentage 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 (%) |
|---|---|---|---|---|---|
| >600 | 600 | 301 | 0.0 | 0.01 | 0.6 |
| 500-600 | 500 | 539 | 0.1 | 0.02 | 1.5 |
| 400-500 | 400 | 1,674 | 0.4 | 0.04 | 3.6 |
| 300-400 | 300 | 17,155 | 3.2 | 0.32 | 20.4 |
| 200-300 | 200 | 37,394 | 9.4 | 0.47 | 44.7 |
| 100-200 | 100 | 82,936 | 23.1 | 0.52 | 71.7 |
| 50-100 | 50 | 141,534 | 46.5 | 0.44 | 94.7 |
| 5-50 | 5 | 324,455 | 100.0 | 0.10 | 100.0 |
| **Total** | | **605,988** | | | |

Note:

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

ecology and environment

**Computation Sheet**

| | |
|---|---|
| Project No. | |
| Preliminary | ☐ |
| Final | ☐ |
| Void | ☐ |
| Sheet 1 of 1 | |

Project Name: Griffiss AFB - B817/WSA

Subject: Estimation of Contaminated GW

| Rev. | Completed By: CHH | Checked By: KMP |
|---|---|---|
| X | Initials: 7/30/04 | Initials: 8/3/04 |
| | Initials: / / | Initials: / / |

Objective: To determine the volume of contaminated groundwater at Building 817/WSA

Assumptions:

1. Surface area defined by the 5 ug/L contour for total VOCs developed as Figure 3-1 of the Addendum to the July 1998 Supplemental Investigations of Areas of Concern, Technical Memorandum No. 1: On-Base Groundwater (E&E 2000)

2. Depth to groundwater 7' BGS (see Section 3-1 & Table 3-1 of 2000 Tech. Memo. [E&E 2000]).

3. Depth to bedrock approximately 15' below the water table (see section 3-1 of 2000 Tech. Memo [E&E 2000]).

4. Attached is a table of contour interval areas for total VOCs as shown in Table 6-1 of this Report.

5. Assume porosity (n) of 0.35 for silty-sand & sand (2000 Technical Memorandum [E&E 2000]).

Calculations:

Total Area = $A_T$ = (78 + 837 + 1506 + 3881 + 10,118 + 7703 + 7680 + 8731 + 14,061 + 15,301 + 18,542 + 26,051 + 89,969 + 148,104) ft²

$A_T$ = 352,542 ft²

Contaminated Groundwater Depth = D = 15'

Plume Volume = $\forall = A_T D n$ = (352,542 ft²)(15 ft)(0.35)

$\forall$ = 1,850,845.5 ft³ = $\boxed{13,845,286 \text{ gallons}}$

Table 6-1 Comparison of Contaminant Mass per Depth to Areas Described by Different Intervals of Contaminant Concentration at Building 817/WSA

| Contour Interval (ug/L) | Lower Bound Concentration of Contour Interval (ug/L) | Area of Contour Interval ($ft^2$) | Cumulative Percentage 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 (%) |
|---|---|---|---|---|---|
| >130 | 130 | 78 | 0.0 | 0.00 | 0.1 |
| 120-130 | 120 | 837 | 0.3 | 0.01 | 1.5 |
| 110-120 | 110 | 1,506 | 0.7 | 0.01 | 3.8 |
| 100-110 | 100 | 3,881 | 1.8 | 0.02 | 9.1 |
| 90-100 | 90 | 10,118 | 4.7 | 0.06 | 21.6 |
| 80-90 | 80 | 7,703 | 6.8 | 0.04 | 30.1 |
| 70-80 | 70 | 7,680 | 9.0 | 0.03 | 37.5 |
| 60-70 | 60 | 8,731 | 11.5 | 0.03 | 44.6 |
| 50-60 | 50 | 14,061 | 15.5 | 0.04 | 54.3 |
| 40-50 | 40 | 15,301 | 19.8 | 0.04 | 62.7 |
| 30-40 | 30 | 18,542 | 25.1 | 0.03 | 70.3 |
| 20-30 | 20 | 26,031 | 32.5 | 0.03 | 77.5 |
| 10-20 | 10 | 89,969 | 58.0 | 0.06 | 89.8 |
| 5-10 | 5 | 148,104 | 100.0 | 0.05 | 100.0 |
| **Total** | | **352,542** | | | |

Note:

1. Contour interval areas determined by E&E and AutoCAD file associated with Figure 2-4 of this report.

# B Remediation Duration Estimate – Zero-Valent Iron Wall

**ecology and environment**

**Computation Sheet**

| | | |
|---|---|---|
| Project No. | | |
| Preliminary ☐ | | |
| Final ☐ | | |
| Void ☐ | | |
| Sheet 1 of 3 | | |
| Rev. | Completed By: KMP | Checked By: GJK |
| ☒ | Initials: 8/17/04 | Initials: 9/9/04 |
| | Initials: / / | Initials: / / |

Project Name GRIFFISS AFB OBGW FS

Subject B817 - PRB time to remediate GW

OBJECTIVE: Estimate time required to treat groundwater at Building 817 using iron wall (PRB) technology.

REFERENCES: E&E SI 2000

ASSUMPTIONS:

1. Assume porosity of 0.3 (n)

CALCULATIONS:

Given:

$K = 1 \times 10^{-3}$ cm/s

$i = 0.04$ ft/ft

Collection trench dimensions

$L = 350'$

$W = 2.5'$

$h = 17'$

(i) Determine flow through iron wall

$$Q = VA$$
$$= KiA$$
$$= (1\times10^{-3}\ \text{cm/s})(0.04\ \text{ft/ft})(350')(17')\left(\frac{1\ \text{ft}}{30.48\ \text{cm}}\right)\left(\frac{60\ \text{s}}{1\ \text{min}}\right)$$

$= 0.47\ \text{ft}^3/\text{min}$ ✓

or

3.5 gpm ✓

**ecology and environment**

**Computation Sheet**

| | |
|---|---|
| Project No. | |
| Preliminary | ☐ |
| Final | ☐ |
| Void | ☐ |
| Sheet 2 of 3 | |

Project Name Griffiss AFB OBGW FS

Subject

| Rev. | Completed By: KMP | Checked By: GJN |
|---|---|---|
| | Initials: 8/17/04 | Initials: 9/9/04 |
| | Initials: / / | Initials: / / |

(ii) Determine porevolume (PV)

A = Plume Area = 8 acres ~ 348,480 ft$^2$ ✓
b = Avg Plume thickness = 17'
Avg VOC Conc = 100 µg/L

$$PV = b n A$$

$$= (17')(0.3)(348{,}480\,ft^2)$$

$$= 1{,}777{,}248\,ft^3$$ ✓

(iii) Determine number of PVs to remediate groundwater to cleanup goals:

$$\#PVs = -R \ln\left(\frac{C_{wt}}{C_{wo}}\right)$$

where R = retardation factor
$C_{wt}$ = cleanup Conc (5 µg/L)
$C_{wo}$ = initial Conc (100 µg/L)

Assume R = 1.08, based on silty sands and VOCs ✓

$$\#PVs = -1.08 \ln\left(\frac{5}{100}\right)$$

$$= 3.2\ PV$$ ✓ ⇒ range between 3 and 4 PVs

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

**ecology and environment**

**Computation Sheet**

| | | | |
|---|---|---|---|
| Project No. | | | |
| Preliminary ☐ | | | |
| Final ☐ | | | |
| Void ☐ | | | |
| Sheet 3 of 3 | | | |
| Rev. | Completed By: KMP | Checked By: GJH | |
| ☒ | Initials: 8/17/04 | Initials: 9/19/04 | |
| | Initials: / / | Initials: / / | |

Project Name GRIFFISS AFB OBGW FS

Subject

(iv) using $Q = 0.69\ ft/min$

Time to flush 3 PVs

$$= \frac{3(1,777,248\ ft^3)}{0.47\ ft^3/min}$$

$= 11,344,136\ min$ ✓

$= 21.6\ yrs$ ✓

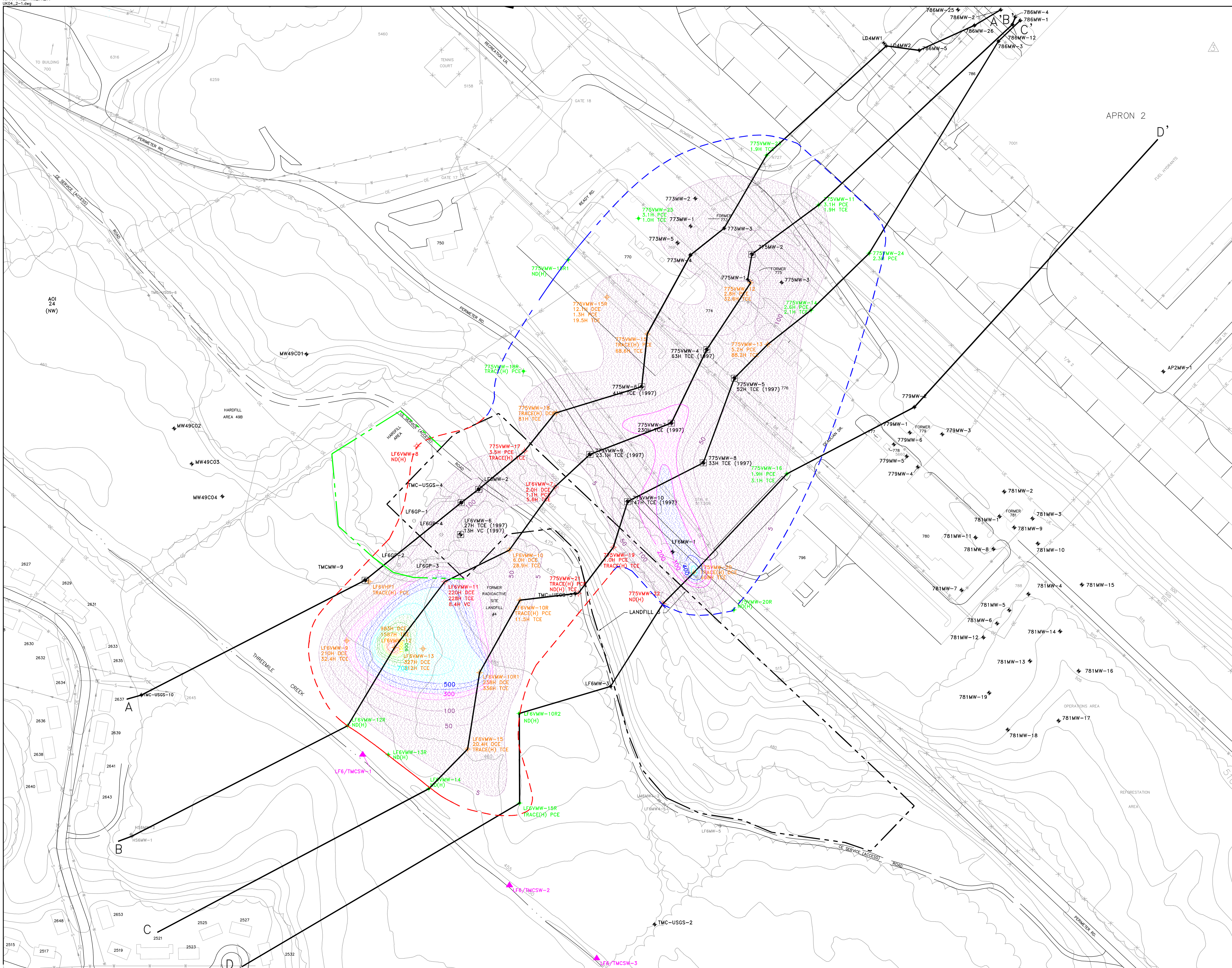
Time to flush 4 PVs

$$= \frac{4(1,777,248\ ft^3)}{0.47\ ft^3/min}$$

$= 15,125,514\ min$ ✓

$= 28.8\ yrs$ ✓

⟹ Duration expected to remediate contaminated groundwater is between about 20 and 30 yrs using zero-valent iron wall technology.




## LEGEND

- LANDFILL 6/BUILDING 775 GROUNDWATER STUDY PERMANENT MONITORING WELL LOCATION
- LANDFILL 6/BUILDING 775 GROUNDWATER STUDY TEMPORARY MONITORING WELL LOCATION
- LANDFILL 6/BUILDING 775 VERTICAL PROFILE HYDROPUNCH SAMPLING LOCATION (WELL NOT INSTALLED)
- EXISTING MONITORING WELL
- MONITORING WELL RESAMPLED DURING ROUND 1 GROUNDWATER STUDY (MAY 2000)
- DECOMMISSIONED MONITORING WELL
- SUPPLEMENTAL INVESTIGATION GEOPROBE GROUNDWATER SCREENING SAMPLE LOCATION
- LANDFILL 6/BUILDING 775 GROUNDWATER STUDY SURFACE WATER SAMPLE LOCATION
- HARDFILL AREA
- LANDFILL BOUNDARY
- APPROXIMATE BOUNDARY OF B775 PLUME (DASHED WHERE INFERRED)
- APPROXIMATE BOUNDARY OF LF6 PLUME (DASHED WHERE INFERRED)
- A — A' CROSS SECTION LINE
- TOTAL CHLORINATED VOC CONCENTRATION CONTOUR LINE FROM HYDROPUNCH DATA (CONTOUR INTERVAL [in PPB] IS VARIABLE: 5,50, EVERY 100 TO 1000, THEN EVERY 500 TO 2500)
- 775MW-23 1.9H PCE — H= HIGHEST LEVEL OF HYDROPUNCH CONTAINMENTS OF CONCERN (i.e. CHLORINATED SOLVENTS) IN PARTS PER BILLION (PPB). SAMPLE RESULTS ARE FROM SPRING 2000, UNLESS INDICATED OTHERWISE.

| | |
|---|---|
| DCE | cis-DICHLOROETHENE |
| ND | NOT DETECTED |
| PCE | TETRACHLOROETHENE |
| TCA | 1,1,1 TRICHLOROETHANE |
| TCE | TRICHLOROETHENE |
| VC | VINYL CHLORIDE |

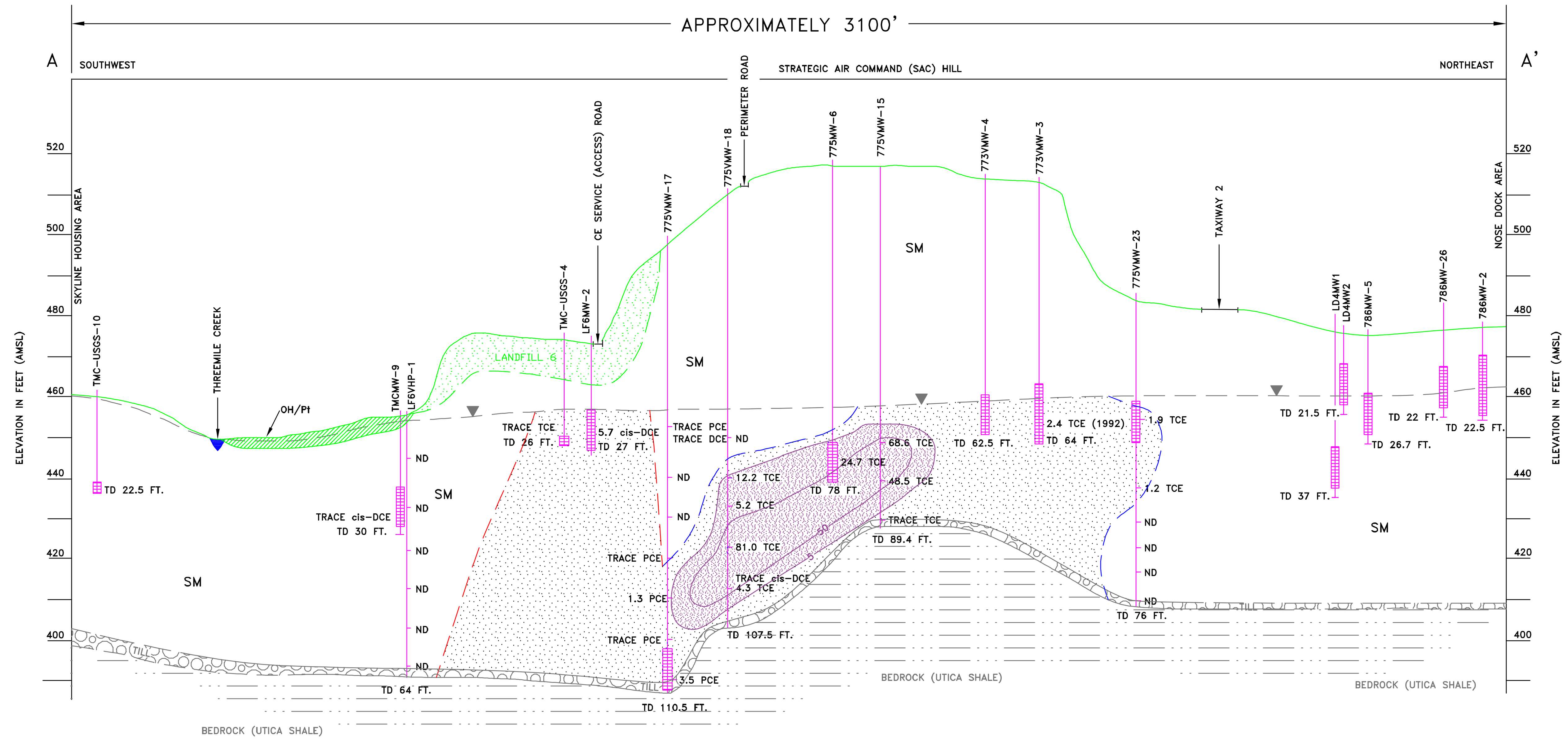
- 0-5 PPB
- 5-200 PPB
- 200-400 PPB
- 400-600 PPB
- 600-800 PPB
- 800-1000 PPB
- 1000-1500 PPB
- 1500-2000 PPB
- 2000-2500 PPB
- 2500-3000 PPB

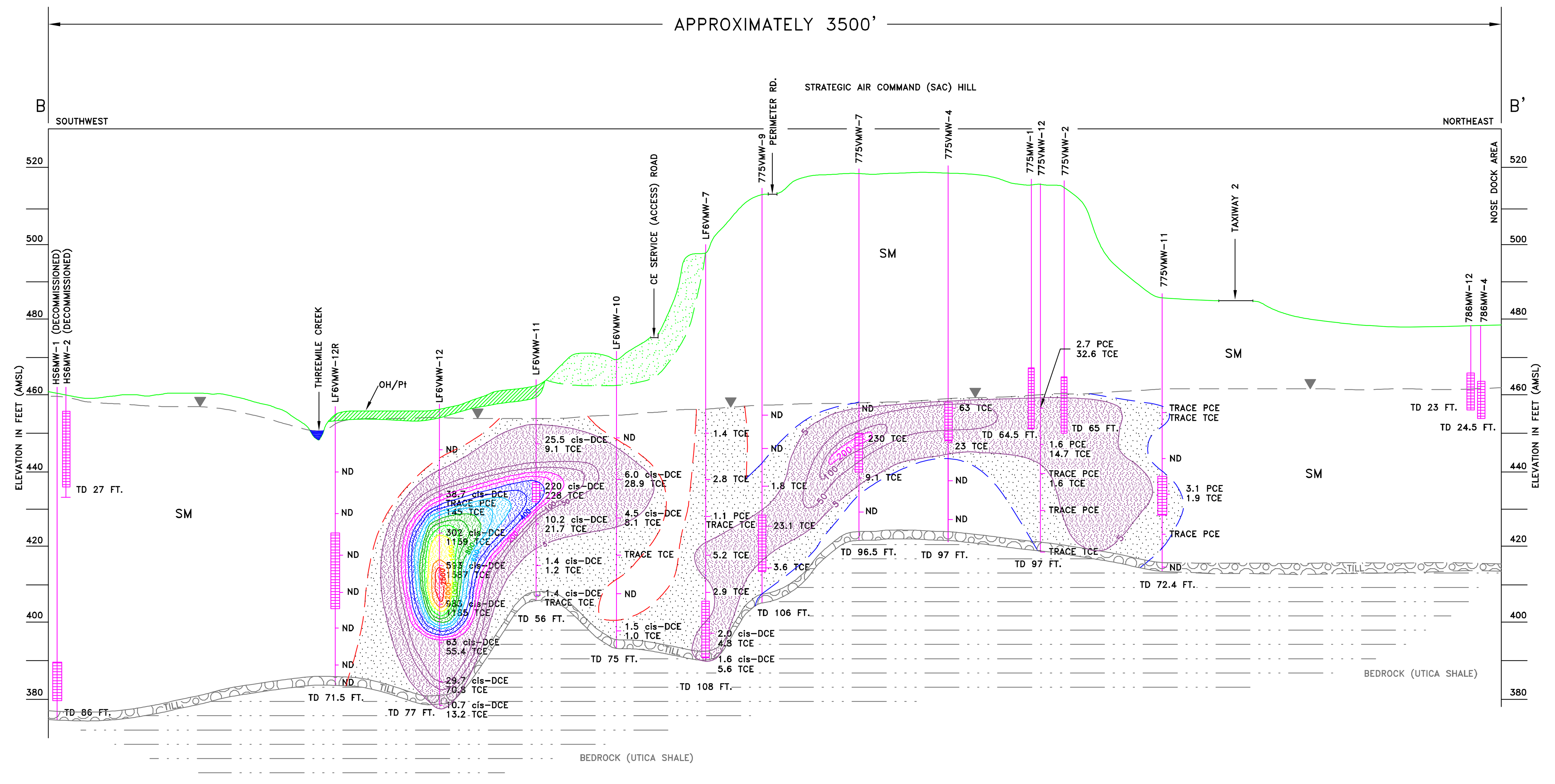
SCALE IN FEET: 0 100 200 300

UNITED STATES AIR FORCE
GRIFFISS AIR FORCE BASE
ROME, NEW YORK

Figure 2-1: LANDFILL 6 AND AND BUILDING 775 GROUNDWATER CONTAMINATION CONCENTRATION MAP BASED ON HYDROPUNCH DATA

001002UK020900 JUNE 2000




LEGEND

- WATER TABLE
- TOP OF BEDROCK (DASHED WHEN INFERRED)
- WELL SCREEN INTERVAL
- LF6 AOC PLUME
- B775 AOC PLUME

| | | | |
|---|---|---|---|
| 0-5 PPB | 400-600 PPB | 1000-1500 PPB | |
| 5-200 PPB | 600-800 PPB | 1500-2000 PPB | 2500->2500 PPB |
| 200-400 PPB | 800-1000 PPB | 2000-2500 PPB | |

AMSL ABOVE MEAN SEA LEVEL
AOC AREA OF CONCERN
DCE DICHLOROETHENE (cis-, or trans-)
ND NOT DETECTED
OH ORGANIC CLAYS, ORGANIC SILTY CLAYS, ORGANIC SILTS
PCE TETRACHLOROETHENE
Pt PEAT AND OTHER HIGHLY ORGANIC SOILS
SM SILTY SANDS, SAND-SILT MIXTURES
TCE TRICHLOROETHENE
VC VINYL CHLORIDE

NOTE:
CONTAMINANT CONCENTRATIONS ARE IN PARTS PER BILLION (micrograms/Liter) FROM SPRING 2000 SAMPLING, UNLESS OTHERWISE INDICATED.

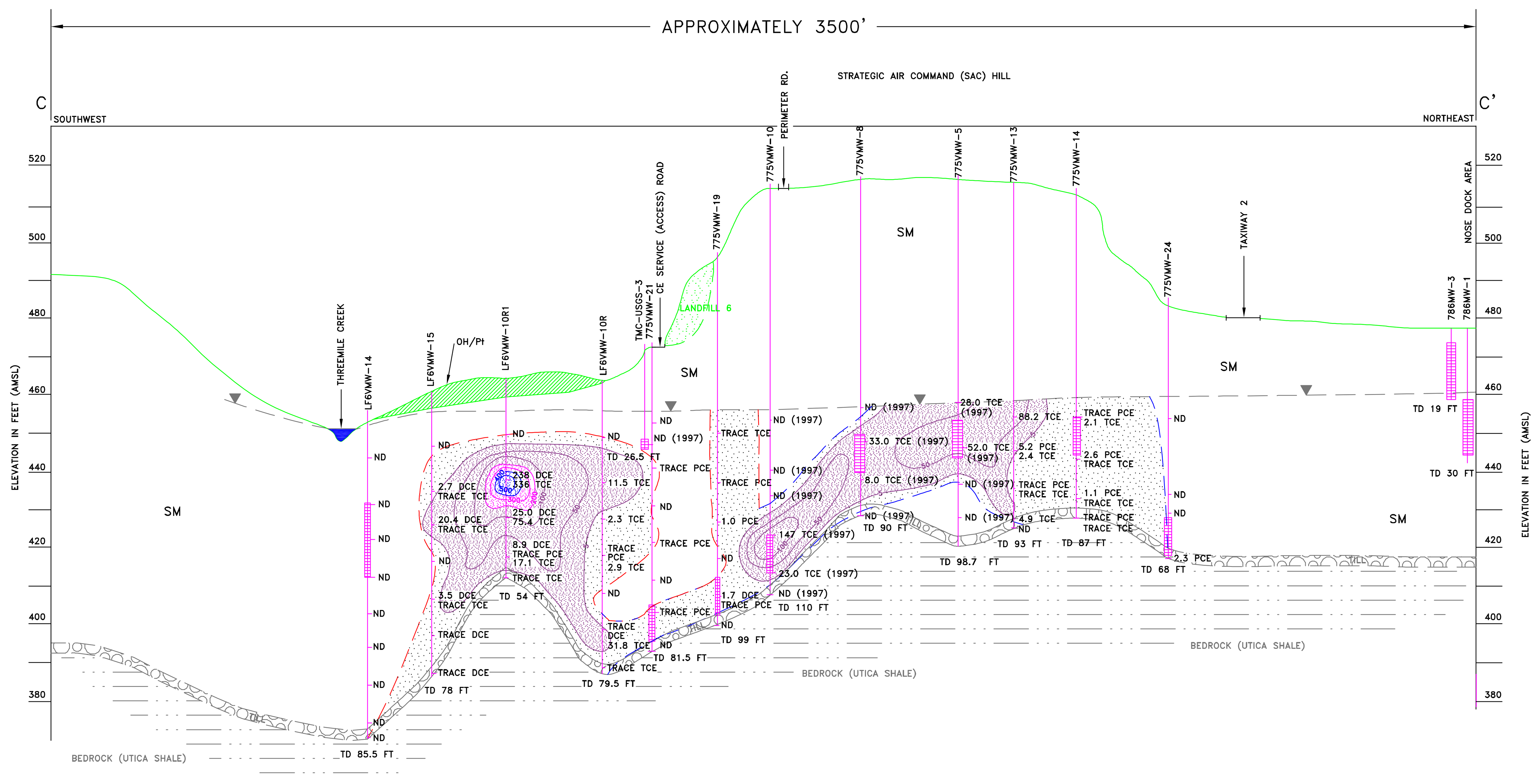
| NO. | DATE | DWN | APP'D | DESCRIPTION |
|---|---|---|---|---|
| REVISIONS | | | | |

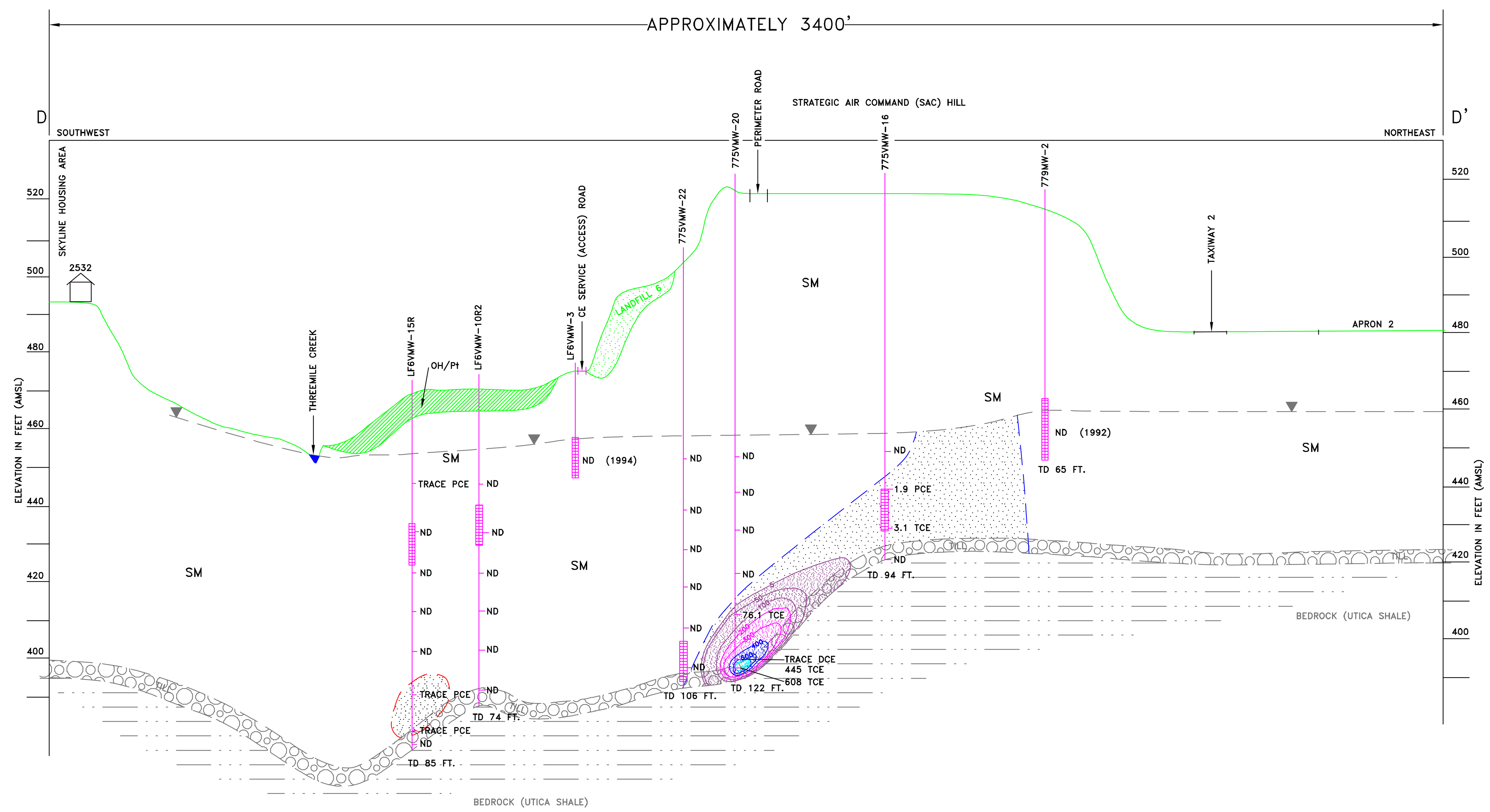
ecology and environment, inc.
International Specialists in the Environment

| | |
|---|---|
| DESIGNED BY: G. FLORENTINO | CHECKED BY: G. FLORENTINO |
| DRAWN BY: K. KRAJEWSKI | APPROVED BY: D. MILLER |

FIGURE 2-2
LANDFILL 6 AND BUILDING 775
GROUNDWATER CONTAMINATION
CROSS SECTIONS

| SCALE | DATE ISSUED | C.A.D. FILE NO. | DRAWING NO. | REV. |
|---|---|---|---|---|
| NTS | 6/00 | UK04_2-2.dwg | FIG - 2-2 | |




LEGEND

- WATER TABLE
- TOP OF BEDROCK (DASHED WHEN INFERRED)
- WELL SCREEN INTERVAL
- LF6 AOC PLUME
- B775 AOC PLUME

0–5 PPB
5–200 PPB
200–400 PPB
400–600 PPB
600–800 PPB
800–1000 PPB
1000–1500 PPB
1500–2000 PPB
2000–2500 PPB
2500–>2500 PPB

| | |
|---|---|
| AMSL | ABOVE MEAN SEA LEVEL |
| AOC | AREA OF CONCERN |
| DCE | DICHLOROETHENE (cis–, or trans–) |
| ND | NOT DETECTED |
| OH | ORGANIC CLAYS, ORGANIC SILTY CLAYS, ORGANIC SILTS |
| PCE | TETRACHLOROETHENE |
| Pt | PEAT AND OTHER HIGHLY ORGANIC SOILS |
| SM | SILTY SANDS, SAND-SILT MIXTURES |
| TCE | TRICHLOROETHENE |
| VC | VINYL CHLORIDE |

NOTE:
CONTAMINANT CONCENTRATIONS ARE IN PARTS PER BILLION (micrograms/Liter) FROM SPRING 2000 SAMPLING, UNLESS OTHERWISE INDICATED.

| NO. | DATE | DWN | APP'D | DESCRIPTION |
|---|---|---|---|---|
| REVISIONS | | | | |

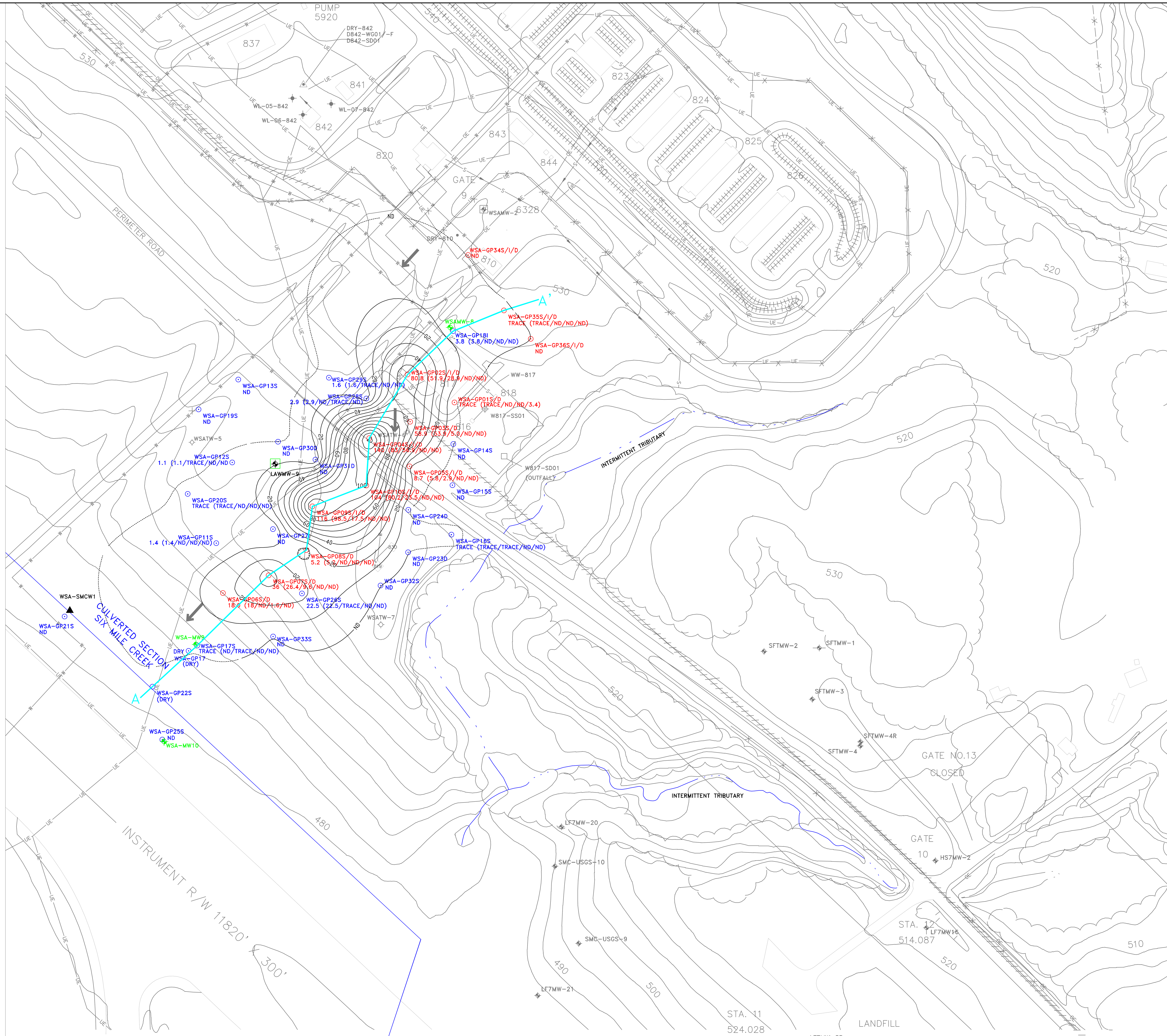
ecology and environment, inc.
International Specialists in the Environment

| | |
|---|---|
| DESIGNED BY: G. FLORENTINO | CHECKED BY: G. FLORENTINO |
| DRAWN BY: K. KRAJEWSKI | APPROVED BY: D. MILLER |

FIGURE 2–3
LANDFILL 6 AND BUILDING 775
GROUNDWATER CONTAMINATION
CROSS SECTIONS

| SCALE | DATE ISSUED | C.A.D. FILE NO. | DRAWING NO. | REV. |
|---|---|---|---|---|
| NTS | 6/00 | UK04_2-3.dwg | FIG 2–3 | |

BUFF PLOTTED 9/3/04 JGL
F:\GRIFFISS\UK2000\GRIFFISSFEBfinal2001\Aug 2004\UK04_2-3.dwg




LEGEND

| | |
|---|---|
| WSA-GP26.5 22.5 (22.5/TRACE/ND/ND) | YEAR 2000 SI GEOPROBE GROUNDWATER SAMPLING LOCATION WITH TOTAL CHLORINATED ETHENES CONCENTRATION IN uG/L. VALUES IN ( ) REPRESENT TCE/PCE/cis-1,2 DCE/VC, RESPECTIVELY. |
| WSA-GP104S/I/D 140 (83/56.9/ND/ND) | YEAR 2000 SI VERTICAL PROFILE GEOPROBE GROUNDWATER SAMPLING LOCATIONS WITH TOTAL OF HIGHEST CHLORINATED ETHENES IN µG/L. VALUES IN ( ) REPRESENT HIGHEST CONCENTRATION OF TCE/PCE/cis-1,2 DCE/VC, RESPECTIVELY, FROM EITHER THE SHALLOW, INTERMEDIATE, OR DEEP SAMPLE AT THE LOCATION INDICATED. |
| | YEAR 2000 SI MONITORING WELL LOCATION |
| | RI MONITORING WELL RESAMPLED DURING YEAR 2000 SI |
| | YEAR 2000 SI SURFACE WATER SAMPLE LOCATION |
| | EXPANDED SITE INVESTIGATION TEMPORARY WELL |
| | SUPPLEMENTAL INVESTIGATION TEMPORARY WELL LOCATION |
| | LONG-TERM MONITORING PIEZOMETER |
| | RI MONITORING WELL RESAMPLED DURING INITIAL SUPPLEMENTAL INVESTIGATION |
| | DRYWELL LOCATION |
| | DRYWELL GRAB WATER AND SLUDGE SAMPLE LOCATION |
| | OUTFALL LOCATION |
| | DIRECTION OF GROUNDWATER FLOW |
| | FENCE |
| 510 | TOPOGRAPHIC CONTOUR LINE |
| | UNDERGROUND ELECTRIC |
| | WATER LINE |
| | SANITARY SEWER |
| | OVERHEAD ELECTRIC |
| | ABANDONED UNDERGROUND ELECTRIC |
| ND | NOT DETECTED |
| TRACE | DETECTED BELOW PRACTICAL QUANTITATION LIMIT OF 1 uG/L |
| 20 | TOTAL CHLORINATED ETHENES ISOCONCENTRATION CONTOUR IN uG/L (DASHED WHERE INFERRED) |
| A—A' | CROSS-SECTION LINE |
| TCE | TRICHLOROETHENE |
| PCE | TETRACHLOROETHENE |
| DCE | DICHLOROETHENE |
| VC | VINYL CHLORIDE |

NOTE: ISO CONCENTRATION CONTOURS REPRESENT TOTAL CHLORINATED ETHENES (TCE,PCE,cis-1,2 DCE, AND VC). THE TOTAL CHLORINATED ETHENES AT VERTICALLY PROFILED LOCATIONS (S/I/D) REPRESENT THE HIGHEST CONCENTRATION OF EACH OF THE INDIVIDUAL CONTAMINANTS AT THAT LOCATION (FROM EITHER THE SHALLOW, INTERMEDIATE, OR DEEP INTERVALS), NOT THE TOTAL FROM ONE DEPTH INTERVAL.

(e.g. AT WSA-GP10, THE TOTAL CHLORINATED ETHENES ARE 104 µg/L:
80.2 µg/L TCE FROM GP-10I;
23.5 µg/L PCE FROM GP-10S;
ND OF cis-1,2-DCE;
AND ND VC).

N

SCALE IN FEET

0 100 200 300

CONTOUR INTERVAL=10 ug/L

| NO. | DATE | DWN | APP'D | DESCRIPTION |
|---|---|---|---|---|
| REVISIONS | | | | |

ecology and environment,inc.
International Specialists in the Environment

| | |
|---|---|
| DESIGNED BY R.MEYERS | CHECKED BY R.WATT |
| DRAWN BY K.KRAJEWSKI | APPROVED BY R.MEYERS |

FIGURE 2-4

B817/WSA TOTAL CHLORINATED ETHENES CONCENTRATION MAP BASED ON GEOPROBE SAMPLING

| SCALE | DATE ISSUED | C.A.D. FILE NO. | DRAWING NO. | REV. |
|---|---|---|---|---|
| 1"=100' | 7/00 | UK04_2-4.dwg | FIG - 2-4 | |

BUFFPLOT: 10/11/00 JJK