Picatinny Arsenal Installation Restoration Program™

Picatinny is an Official Hawk Watch Site

PICATINNY ARSENAL
AREA D GROUNDWATER
RECORD OF DECISION

APRIL 2004

FINAL
Revision 2

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LIST OF ACRONYMS AND ABBREVIATIONS

µg/L .... micrograms per liter
1,1-DCA............... 1,1-dichloroethane
1,1-DCE............... 1,1-dichloroethene
1,1,1-TCA 1,1,1-trichloroethane
1,2-DCE............... 1,2-dichloroethene
AOC..................... Area of concern
AR .... Army Regulation
ARAR .... Applicable or Relevant and Appropriate Requirement
ARDEC................ Army Research Development and Engineering Center
ATF...................... Bureau of Alcohol Tobacco and Firearms
BERA................... Baseline Ecological Risk Assessment
bgs....................... below ground surface
BSB .... Bear Swamp Brook
CEA .... Classification Exception Area
CERCLA.............. Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CERCLIS............. Comprehensive Environmental Response, Compensation, and Liability Information System
cf.......................... cubic feet
cfs........................ cubic feet per second
cis-1,2-DCE......... cis-1,2-dichloroethene
COC .... Contaminant of Concern
COPC .... Contaminant of Potential Concern
DCE..................... dichloroethene
DERA .... Defense Environmental Restoration Account
DGI .... Data Gap Investigation
DNAPL .... Dense Non-Aqueous Phase Liquid
DO .... Dissolved Oxygen
DOC .... Dissolved Organic Carbon
EAO..................... Environmental Affairs Office
ecoCOPC .... ecological Contaminant of Potential Concern
Ertec .... Ertec Atlantic, Inc.
ESD .... Explanation of Significant Differences
ETA .... Engineering Technologies Associates, Inc.
ETI....................... Envirometal Technologies
FS........................ Feasibility Study
ft .... feet
ft/day.................... feet per day
GAC..................... Granular Activated Carbon
GIS .... Geographic Information System
GPB..................... Green Pond Brook
gpm .... gallons per minute
HEAST .... Health Effects Assessment Summary Tables
HHRA .... Human Health Risk Assessment
HI......................... Hazard Index
HRC..................... Hydrogen Release Compound
IC......................... Institutional Control
ICFKE.................. ICF Kaiser Engineers, Inc.
IRIS .... Integrated Risk Information System
IRP .... Installation Restoration Program
IT .... IT Corporation
kg/yr..................... kilograms per year
LOC .... Level of Concern
LTM .... Long-Term Monitoring

LUCIP.................. Land Use Control Implementation Plan
MCL..................... Maximum Cleanup Level
mg/kg................... milligrams per kilogram
MNA .... Monitored Natural Attenuation
msl....................... mean sea level
NCEA .... National Center for Environmental Assessment
NCP..................... National Oil and Hazardous Substances Pollution Contingency Plan
ng/L .... nanograms per liter
NJDEP................. New Jersey Department of Environmental Protection
NJMCL .... New Jersey Maximum Contaminant Level
NJPDES .... New Jersey Pollutant Discharge Elimination System
NJPQL................. New Jersey Practical Quantitation Limit
NPL .... National Priorities List
O&M .... Operation and Maintenance
ORC .... Oxygen Release Compound
ORP..................... Oxidation-Reduction Potential
OSHA .... Occupational Safety and Health Administration
PAERAB.............. Picatinny Arsenal Environmental Restoration Advisory Board
PCE .... tetrachloroethene
ppb .... parts per billion
PTA .... Picatinny Arsenal
PTW .... Permeable Treatment Wall
RAB .... Restoration Advisory Board
RAGS .... Risk Assessment Guidance for Superfund
RAO..................... Remedial Action Objective
RCRA .... Resource Conservation and Recovery Act
redox .... oxidation-reduction
RG .... Remedial Goal
RI .... Remedial Investigation
RI/FS .... Remedial Investigation/Feasibility Study
ROD .... Record of Decision
SARA................... Superfund Amendments and Reauthorization Act of 1986
SERDP................ Strategic Environmental Research and Development Program
Shaw .... Shaw Environmental, Inc.
SVE .... Soil Vapor Extraction
TCE .... trichloroethene
TCL...................... Target Compound List
TOC..................... Total Organic Compound
trans-1,2-DCE trans-1,2-dichloroethene
TRC .... Technical Review Committee
USACE................ U.S. Army Corps of Engineers
USACHPPM........ U.S. Army Center for Health Promotion and Preventive Medicine
USAEC................ U.S. Army Environmental Center
USAEHA.............. U.S. Army Environmental Hygiene Agency
USEPA .... U.S. Environmental Protection Agency
USGS .... U.S. Geological Survey
UXO..................... Unexploded Ordnance
VC .... vinyl chloride
VOC..................... Volatile Organic Compound
WWI..................... World War I
WWII.................... World War II

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Facility Name and Location:

Department of the Army
Installation Management Agency
Northeast Regional Office
Picatinny Arsenal Garrison

The facility is located as follows:

- Morris County
- Congressional District II
- EPA Region 2
- CERCLIS – EPA ID# NJ3210020704

This Record of Decision (ROD) specifically addresses groundwater at Area D at Picatinny Arsenal (PTA), Rockaway Township, New Jersey (see **Figure 1**). Area D is approximately 90 acres in size and is located in the south-central section of PTA. The southern boundary of Area D lies just to the northeast of First Street. The northern boundary is north of Farley Avenue. Green Pond Brook (GPB) runs along the southeastern boundary of Area D while Green Pond Mountain runs along the northwestern side. **Figure 2** illustrates the location of Area D within PTA. The Army has designated 14 sites in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) within Area D. Groundwater associated with 12 of these 14 sites is covered under this ROD. The Army will develop a second ROD specifically for the two remaining sites (Sites 29 and 45) in Area D. Those sites are now in the Remedial Investigation/Feasibility Study (RI/FS) process. Specific units of those sites have undergone Resource Conservation and Recovery Act (RCRA) closures, tank closures, and groundwater interim remedial actions. **Figure 3** illustrates the location of the 14 sites within Area D.

1.2 STATEMENT OF BASIS AND PURPOSE

This ROD presents the selected groundwater remedy for Area D located in PTA in Rockaway Township, New Jersey. The remedial action is selected in accordance with CERCLA, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The information supporting the decisions on the selected remedial action is contained in the administrative record, which is available at the Department of the Army, Installation Management Agency, Northeast Regional Office, Picatinny Arsenal Garrison, Installation Restoration Program (IRP) Office located in Building 319 at PTA. The Proposed Plan associated with this action is available at the information repositories listed in **Section 2.3**.

The New Jersey Department of Environmental Protection (NJDEP) concurs with the selected remedy. The U.S. Environmental Protection Agency (USEPA) has approved the feasibility study (FS) and proposed plan for the site.

1.3 ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect public health or welfare or the environment from actual or threatened releases of pollutants or contaminants from this site. Investigations at this site have determined that contaminants are present in groundwater at concentrations that exceed chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs). In addition, contaminants may be transported to surface water bodies through the discharge of groundwater to GPB.

1.4 DESCRIPTION OF THE SELECTED REMEDY: INSTALLATION OF A PERMEABLE TREATMENT WALL AND IMPLEMENTATION OF MONITORED NATURAL ATTENUATION WITH INSTITUTIONAL CONTROLS

The remediation of Area D groundwater is part of a comprehensive environmental investigation and remediation process currently being performed at PTA. Because PTA has a large number of buildings and former production operations, investigating all of the operations at one time would have been unmanageable; so the Army organized these operations into sites. Over 150 site numbers were assigned to the buildings and surrounding land that supported each operation. To ensure the investigation and cleanup of the sites was performed in an organized manner and that the sites with the greatest potential for environmental contamination were addressed first, the Army categorized all of the sites into 16 Areas named A through P. The Army anticipated that Area A had the greatest chance for environmental contamination and Area P the least. The Army further categorized the areas into three phases. The first phase of investigation included Areas A through G, the second phase H through K, and the third and last phase L through P. A site layout map for PTA, which displays each area, is presented as **Figure 2**. This ROD addresses surface water and groundwater within Area D. Area D is one of 16 Areas being addressed by the Army's IRP at PTA. The remaining areas in PTA are being considered separately and remedies for these areas are presented in separate documents. This document represents the third ROD being submitted by the Army for PTA. The Army anticipates it will submit many other RODs for PTA over the next several years.

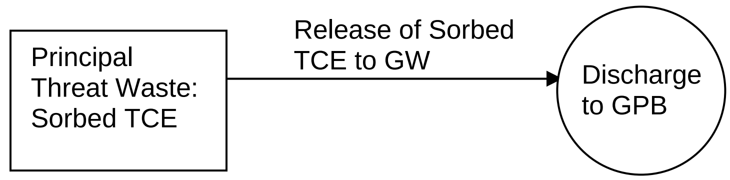
The majority of the groundwater contamination concentrations above remedial goals (RGs) at Area D are present in an approximate 27-acre area. The remedial alternative that has been selected to protect human health and the environment for Area D consists of the construction of a **Permeable Treatment Wall (PTW) that will attain the remedial goal of protecting the surface water of Green Pond Brook with Monitored Natural Attenuation (MNA) and Implementation of Institutional Controls (ICs)**.

The Army intends to conduct treatability studies to evaluate innovative technologies to replace MNA. The results of these studies will be examined within 5-year reviews. If the results indicate that a different technology can meet the performance standard at a reduced cost or greater efficiency, the Army will implement that technology within the 5-year review process.

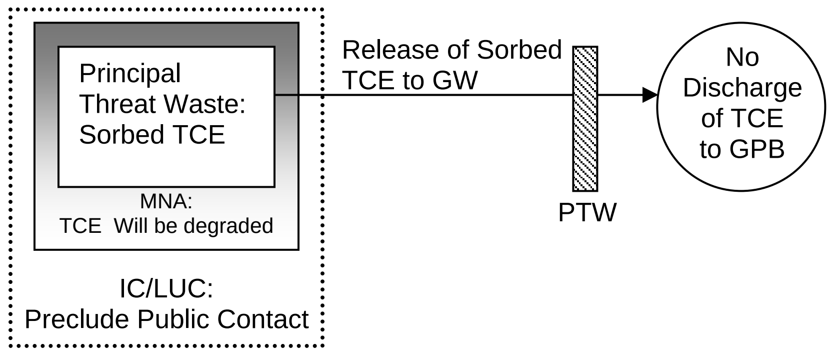
The actions described in this ROD are intended to eliminate the potential for human or ecological contact with contaminant concentrations in groundwater and surface water that could cause unacceptable risks to human health or the environment at Area D or downstream. Promulgated State and Federal criteria are being used as performance standards for this remedial action. The remedial action will be considered complete upon agreement with the USEPA Region 2, PTA, and the U.S. Army.

The principal threat waste associated with Area D groundwater is high concentrations of trichloroethene (TCE) and all associated degradation products sorbed to sediments within the base of the unconfined aquifer. The TCE and related degradation products, while shown to pose no unacceptable risk in most exposure scenarios, will be treated as a principal threat waste because contamination may be classified as subsurface soil containing high concentrations of Contaminants of Concern (COCs) that are potentially mobile due to subsurface transport. The selected remedial action addresses the source of this contamination by protecting the surface water receptor through the installation of a PTW; the remainder of the TCE will be degraded through MNA. The third part of the remedy is the use of institutional and land use controls to preclude human contact with the principal threat waste. This is summarized conceptually in the following diagram.

With no action:



With the implementation of the selected remedial action, this scenario becomes:



The major components of this remedy will include the following elements:

- **MNA**

  Elements of MNA will include:

  - Treatment of the entire plume until all ARARs are complied with
  - Oxidation-reduction (redox) zonation and full MNA study including groundwater and surface water monitoring
  - Well maintenance
  - MNA data reports
  - Closure reports
  - Closeout reports

- **ICs**

  Elements of ICs will include:

  - Exposure restrictions
  - Excavation restrictions
  - Access restrictions
  - Public education
  - Incorporation of all data into IRP office’s Geographic Information System (GIS) system
  - Emergency provisions
  - Well head treatment

  - Potable well water monitoring
  - Indoor-air sampling to monitor vapor intrusions associated with the plume

- **Implementing a PTW**

  Elements of the PTW will include:

  - Excavation/installation of the PTW
  - Installation of monitoring wells to aid in performance monitoring
  - Performance monitoring (groundwater and surface water)

1.5 STATUTORY DETERMINATIONS

The Selected Remedy is protective of human health and the environment, is compliant with Federal and State ARARs for this remedy, and is cost effective. The PTW component of this remedy satisfies the statutory preference for treatment as a principal element as the Selected Remedy. Because this remedy will result in hazardous substances, pollutants or contaminants remaining on site above levels that allow for unrestricted exposure for a period of time, statutory reviews will be conducted every five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment until such time as it may be determined that the site qualifies for unrestricted use.

1.6 ROD DATA CERTIFICATION CHECK LIST

The following information is included in the Decision Summary (**Section 2.0**) of this ROD. Additional information can be found in the Administrative Record for this site.

Criterion	Section	Page Number
Contaminants of Concern and Their Respective Concentrations	2.7.1.1	2-20
Baseline Risk Represented by the Contaminants of Concern	Table 2-2	2-24
Cleanup Levels Established for Contaminants of Concern and the Basis for These Levels	2.7.1.1	2-20
How Source Materials Constituting Principal Threats will be Addressed	1.4	1-2
Current and Reasonably Anticipated Future Land Use Assumptions Used in Baseline Risk Assessment and ROD	2.6	2-19
Potential Land and Groundwater Use Available as a Result of the Selected Remedy	2.6	2-19
Estimated Capital, Annual Operation and Maintenance (O&M) and Total Present Worth Costs, Discount Rate, and the Number of Years Over Which the Remedy Cost Estimates are Projected	2.12.3	2-48
Key Factors Leading to Selection of Selected Remedy	2.12	2-44

1.7 AUTHORIZING SIGNATURE

James M. De Paz
Colonel, U.S. Army
Commanding
U.S. Army Environmental Center

Date 4/14/04

George Pavlou, Director
Emergency and Remedial Response Division
U.S. Environmental Protection Agency, Region 2

Date 9/22/04

2.0 DECISION SUMMARY

2.1 SITE NAME, LOCATION, AND DESCRIPTION

This ROD describes the selected action to reduce human health and environmental risks associated with elevated concentrations of volatile organic compounds (VOCs). The primary VOC is TCE with limited exceedances of Tetrachloroethene (PCE) and related TCE degradation products in groundwater at PTA Area D in Rockaway Township, New Jersey. PTA is a National Priorities List (NPL) site and is registered under the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) number NJ3210020704. The Army is the lead agency for this action. The funding for this action will be provided from the Defense Environmental Restoration Account (DERA).

PTA is located approximately four miles north of the City of Dover in Rockaway Township, Morris County, New Jersey. The location of PTA is presented on **Figure 1**. Some of the nearby populous areas are Morristown, Morris Plains, Parsippany, Troy Hills, Randolph Township, and Sparta Township. The PTA land area consists of 6,491 acres of improved and unimproved land. The Arsenal is situated in an elongated classic U-shaped glacial valley, trending northeast-southwest between Green Pond Mountain and Copperas Mountain on the northwest and an unnamed hill on the southeast. Most of the buildings and other facilities at PTA are located on the narrow valley floor or on the slopes along the southeast side.

Area D occupies approximately 90 acres in the south-central section of the Arsenal and encompasses 14 study sites. The source of the groundwater contamination in Area D is primarily attributable to past activities at Sites 21 and 37. Groundwater associated with 12 of these study sites and the section of GPB receiving groundwater discharge are being addressed by this ROD. Groundwater associated with two of the sites (Sites 29 and 45) will be addressed in separate decision documents. GPB runs along the southeastern boundary of Area D, while the northwestern side is bordered by Green Pond Mountain. The entire site is located within the 100- and 500-year floodplains of GPB. A general map for Area D is presented on **Figure 3**.

The remedial alternative that is presented in this ROD was selected by the Army, in partnership with the NJDEP and the USEPA, Region 2. The remedial action is funded by the U.S. Department of the Army and was selected in accordance with CERCLA as amended by the SARA, the NCP, RCRA, and Army Regulation (AR) 200-1, Environmental Protection and Enhancement, as applicable.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.2.1 PTA Background

PTA is owned and operated by the U.S. Army. The Arsenal was a major source of munitions for World War I (WWI), World War II (WWII), the Korean War, and the Vietnam Conflict. During those periods, PTA was involved in the production of explosives, rocket and munition propellants, pyrotechnic signals and flares, fuses, and metal components. Currently, the primary mission of PTA is research, development, and engineering of munitions and weapons.

Over the years, environmental investigations into the operations and waste management procedures for PTA have indicated the potential for contamination. The facility was included on the NPL in March of 1990.

2.2.2 Area D Background

The subject of this ROD is the groundwater within Area D, one of the 16 areas discussed above. The most prominent feature of Area D groundwater is a chlorinated solvent plume. This plume was created when solvents were released to the groundwater from a metal plating operation formerly housed in Building 24. Four of the sites within Area D, Site 21/37, Site 45, Site 122, and Site 123, contain facilities where TCE was historically used. These sites were investigated as possible sources of the TCE contamination detected in the Area D aquifer. Based on the results of several investigations, it has been determined that waste handling activities at Site 21/37 were responsible for the TCE plume. Sites 21 and 37 are located in the north-central portion of Area D near Building 24 (plating facility). Site 21 includes the dry well formerly located between Building 24 and Third Avenue, and Site 37 included settling lagoons formerly located adjacent to and southwest of Building 24. Wastes generated during washing and degreasing activities operating since 1942 included waste TCE. 1,1,1-Trichloroethane (1,1,1-TCA) replaced TCE as a degreasing agent in 1983. Plating activities were discontinued in 1982; however, degreasing, aluminum cleaning with mild caustic, and aluminum anodizing using sulfuric and chromic acids continued until 1985 (ANL, 1991). According to the U.S. Geological Survey (USGS), however, the degreaser remained operational and was used sporadically until 1989 (Imbrigiotta, 1996). The dry well in Site 21, located along Third Avenue at the east side of Building 24, was determined to be a potential source of TCE contamination to the subsurface. Built in 1961, the dry well had two reported purposes: first to provide a discharge location for the TCE storage tank, and second to transport water from the TCE tank in the event a fire occurred within Building 24. In either case, there were no reported releases to the dry well. However, under normal operating conditions, the drain line from Building 24 to the dry well acted as a vent for vapors from the TCE tank. These vapors condensed within the pipeline and the dry well. When in operation, strong TCE fumes were noted to be present outside Building 24.

Both the lagoons and the dry well have been removed and are no longer a source of groundwater contamination. The dry well was excavated and disposed of in 1985. Closure of the lagoons and dry well was completed in 1991. Both of these actions were completed under the RCRA program.

Additional information regarding these topics can be found in the *Phase I Remedial Investigation (RI) Report* (Dames and Moore, 1998), *Area D Groundwater FS Data Gap Investigation Work Plan* (ICFKE, 1997), and in the *Area D Groundwater FS* (IT, 2003). Results of the studies are summarized below for groundwater and other media.

Groundwater: Studies within Area D have primarily been concerned with the extent of contamination in the shallow groundwater aquifer. However, other studies have also focused on surface water (GPB), subsurface soil, and soil gas to define the total extent of the contamination associated with the Area D groundwater plume. Studies have also been directed at the detection of potential dense non-aqueous phase liquids (DNAPLs). In addition, bioattenuation/natural attenuation studies and computer modeling have been employed to predict how the contaminant plume will behave and how long it will take the plume to degrade.

Some investigation of groundwater resources was initiated at Picatinny as early as 1958. However, the majority of investigations were conducted more recently. Over 30 environmental investigations have been conducted in various sites at Area D since 1983. On the presented timeline, these various studies are summarized by investigating agency, environmental media, and year completed. Groundwater investigations indicate that Area D groundwater was contaminated with several chlorinated VOCs, namely PCE, TCE, and their degradation products, as a result of activities at Sites 21/37. Although this contamination primarily resulted from activities at Sites 21 and 37, this proposed plan covers all groundwater in Area D except groundwater under Sites 29 and 45. Groundwater in Area D has also been impacted by activities at Sites 29 and 45 (Sites associated with Buildings 31 and 33). Groundwater contamination resulting from historic activities at Sites 29 and 45 is being addressed in a separate proposed plan and ROD being developed by the Army. These sites are now in the Remedial Investigation/Feasibility Study (RI/FS) process. Specific units of those sites have undergone Resource Conservation and Recovery Act (RCRA) closures, tank closures, and groundwater interim remedial actions.

An interim action ROD to address contaminated groundwater was signed by the Army in the fall of 1989. This ROD was concurred upon by both the USEPA and the NJDEP. In September of 1992, an interim action hydraulic barrier pump and treat system was implemented to intercept contaminated groundwater prior to discharge to GPB. The hydraulic barrier pump and treat system was installed between the plume hot spot and GPB. However, there is some TCE in the aquifer downgradient of the hydraulic barrier because the barrier was activated a number of years after the release of TCE. Consequently, TCE continues to discharge to GPB at low levels. The hydraulic barrier pump and treat system was installed primarily because the Army was concerned that the TCE concentrations in the brook would increase dramatically in the future. However, current studies and modeling predictions indicate that the plume is at steady state and concentrations in the brook are decreasing. The current studies and modeling include those performed for the Area D FS (using PEST, Mod-flow, RT3D). The Area D FS was submitted and approved by the regulators as outlined in the Timeline on the following pages.

The hydraulic barrier pump and treat system consists of six extraction wells, an air-stripping tower (with vapor phase carbon adsorption), and an aqueous phase granular activated carbon (GAC) filter. Five of the extraction wells are screened in the unconfined aquifer and linearly situated perpendicular to the centerline of the contaminant plume. A sixth extraction well, installed in 2001, will be used to increase the amount of groundwater removed from the aquifer. As part of the operation of the pump and treat system, a groundwater monitoring program has been in place since 1992. Groundwater samples were collected quarterly until 2000 and continue to be collected semiannually. Groundwater samples are collected from eighteen monitoring wells and five withdrawal wells. The system remains in operation as of the submission date of this document. Selection of a permanent remedy, as outlined in this ROD, will include the eventual shut down of the interim action pump and treat system.

TIMELINE

The Area D RI/FS process has drawn upon technical expertise from many sources including the Army, USGS, regulators, and academia. Numerous studies have been completed and many journal articles have been published. Consequently, the quantity of data generated at Area D is very extensive. A discussion of the events leading to the completion of this FS and the extent of involvement of experts from various contributing agencies is below:

5/24/96 – The first 5-year review of the interim action groundwater pump and treat was submitted by USEPA. One of the main findings of the document was that the pump and treat was not operating at a flow rate recommended by a USGS particle tracking report. The particle tracking report recommended that the pump and treat should operate at 146 gallons per minute (gpm) in order to capture 96% of the groundwater flow in the area of the plume. It should be noted that the interim action pump and treat discharge permit specifies a flow rate of 100 gpm.

9/96 – Strategic Environmental Research and Development Program (SERDP) Technical Advisory Committee met in September 1996 to discuss and review projects being completed for the Building 24 TCE plume. After a discussion of the Building 24 TCE plume data, the group decided that there was sufficient information to begin the FS process. Meeting attendants included representatives from the following organizations: University of Virginia, PTA Environmental Affairs Office (EAO), U.S. Army Environmental Center (USAEC), Dames and Moore, ICF Kaiser Engineers, Inc. (ICFKE), U.S. Army Corps of Engineers (USACE), NJDEP, USEPA, Radian, Dow, Fluor Daniel, USGS, and New Jersey Institute of Technology.

1/25/97 – The Army responded to the 5-year review in a letter. This letter explained how the Army intended to respond to the USEPA concerns regarding the effectiveness of the hydraulic barrier pump and treat.

2/97 – An Area D Groundwater FS "kick off" meeting was attended by representatives from PTA EAO, USACE, and ICFKE. During this meeting, preliminary goals of the FS were discussed and the following mission statement was adopted: “minimize migration, remediate in a cost-effective manner in the least disturbing way with acceptable risk throughout the project.” Additionally, the decision to include the USGS in the FS process was made. The USGS was included to utilize the vast institutional knowledge they had gained during their many years of studying the Area D plume.

3/97 – PTA EAO, USACE, USGS, and ICFKE met to discuss technologies that might be potentially applicable at Area D. The knowledge base of the USGS was drawn on heavily at this meeting to facilitate an accurate gross applicability assessment. Every technology discussed during this meeting is included within Section 5.0 of the FS. Additionally, data gaps were identified that could have prevented an FS assessment of several technologies that were deemed grossly applicable. ICFKE was tasked to write a work plan to fill the data gaps. The USGS provided technical support to ICFKE during this effort.

5/97 – PTA EAO, USACE, USGS, and ICFKE met to discuss specific data gaps to be incorporated into the work plan.

5/97 – PTA EAO, USACE, USAEC, USGS, ICFKE, NJDEP, and USEPA met to update regulators regarding the status of the Area D FS. Potentially applicable technologies and data gaps preventing the FS assessment of the technologies were presented. Regulators were then invited to comment.

10/97 – PTA EAO, USACE, USAEC, USGS, and ICFKE met to finalize the work plan prior to submission to regulatory agencies for comment.

10/97 – The work plan was submitted to regulators for comment.

11/97 – Regulatory comments were received and resolved to the satisfaction of all parties.

12/97 – Fieldwork to fill data gaps commenced. The collection/interpretation of field data was a cooperative effort between the USGS and ICFKE. However, the USGS and ICFKE were assigned individual tasks for which each would take the lead. Listed below is the task assignment breakdown.

USGS Tasks:

Measure sorbed concentrations of contaminants and desorption rates of VOCs (TCE) from subsurface soil.

Identify the location of the edges of the TCE plume as it intersects GPB.

Measure VOC concentrations at the groundwater/GPB interface.

Gather seepage data from GPB.

Measure surface water VOC concentrations in GPB and Bear Swamp Brook (BSB).

Compile low-permeability data.

Estimate the effect of discontinuing the current hydraulic barrier pump and treat system on GPB.

ICFKE Tasks:

Characterize depth to top of confining unit near Building 24.

Identify correlation between groundwater contaminant concentrations and sorbed contaminant concentrations.

Characterize vertical variation of VOC and metal concentrations in the area of Building 24.

Characterize subsurface redox conditions and redox couple concentrations.

Characterize current distribution of VOCs and metals within Area D groundwater.

Refine the solute transport model.

2/17/98 – The Army issued a letter to the USEPA explaining how it had responded to the initial 5-year review.

4/98 – The SERDP Technical Advisory Committee met to discuss and review the implications of the field data gathered during the Data Gap Field Investigation. Regulators were invited to discuss their interpretation of the data. Meeting attendants included representatives from the following organizations: University of Virginia, Rutgers University, PTA EAO, USAEC, IT Corporation (IT) (formerly ICFKE), USACE, NJDEP, USEPA, Fluor Daniel, USGS, and New Jersey Institute of Technology.

1/28/00 – The draft FS was submitted to the Army for review. At the request of the Army, no remedial alternative was recommended in the document. All other aspects of the FS were completed in order for the Army to perform the evaluation internally and arrive at a decision regarding the most desirable remedial alternative for the project. In this draft of the FS, the primary remedial action objective (RAO) was protection of GPB from discharge of VOCs from the groundwater plume.

3/29/00 – A meeting was held at the USGS offices in Trenton. Representatives of PTA, USAEC, USGS, Engineering Technologies Associates, Inc. (ETA) and IT attended the meeting. At this meeting, USAEC provided verbal comments on the draft FS. The USGS indicated the water-level data set that the flow model was based on were collected when the aquifer was unstressed. The calibration was done with the aquifer stressed. It was agreed that a sensitivity analysis would be performed to determine the potential impact of this finding on the predictive simulations.

5/5/00 – A memorandum detailing the results of a sensitivity analysis was submitted. This sensitivity analysis was performed to evaluate the potential effect of the stressed calibration on the ability of the model to run predictive simulations.

5/18/00 – The draft Area D Groundwater FS report was submitted to the regulators. This submission included the meeting minutes from the 3/29/00 meeting and the 5/5/00 sensitivity analysis memorandum. The FS was submitted as draft and was unchanged from the version submitted to the Army on 1/28/00. However, the Army's recommendation for MNA was stated in the cover letter. The purpose of submitting the draft document prior to making the changes recommended in Army comments was to expedite the regulatory review and provide all available information to the regulators in order to partner and open a dialog regarding the selection of a remedial alternative.

7/26/00 – A memorandum was written by Joe Marchesani to Greg Zalaskus regarding a field inspection of the Area D site. The memorandum contained general comments regarding groundwater well monitoring requirements as well as comments to the draft FS.

9/12/00 – Comments were received from the USEPA on the draft Area D Groundwater FS.

9/14/00 – A second memorandum was written from Joe Marchesani to Greg Zalaskus. This memorandum provided additional comments to the draft Area D Groundwater FS.

10/30/00 – Army responses to the USEPA comments were submitted.

12/7/00 – A meeting was held at the NJDEP Trenton office. The meeting topic was the acceptability of the Army's proposal for MNA. The Army stated at this meeting that there was no practical method of restoring the aquifer in 30-50 years. The discussions and agreements made at this meeting are documented in meeting minutes issued on 1/3/01. The primary outcomes of the meeting were that the Army would recalibrate the groundwater model and provide cost estimates for clean up of groundwater in 30, 50, and 80 years. These additional cost estimates would be used to determine if groundwater remediation in these timeframes was practical and cost-effective. It was also decided that the USEPA would respond in writing to the 10/30/00 response to comment document.

2/7/01 – The USEPA provided feed back on the response to comment document.

4/24/01 – The *Area D Groundwater FS Report of Model Re-Calibration and Cost Analysis, April 2001* (Draft) was submitted to the Army.

5/01 – Comments received and responses delivered to USGS, USACE, and USAEC on *Model Re-calibration and Cost Analysis.*

7/9/01 – *Area D groundwater FS Report of Model Re-Calibration and Cost Analysis, July 2001* (Draft Final) was submitted to the regulators. This document contained the results of the model recalibration and additional cost estimates requested at the 12/7/00 meeting.

8/01 – Comments received and responses delivered to USEPA on *Model Re-Calibration and Cost Analysis*.

9/25/01 – The NJDEP issued a memorandum regarding its concern over the potential for drinking water production well 131 to mobilize TCE contamination from the Area D TCE plume.

9/27/01 – The USEPA issued a second 5-year review. This document covered the interim action groundwater pump and treat as well as other FSs and proposed plans already in progress. The primary finding of this document was that the Army did not comply with the request in the first 5-year review. The Army disputes this point.

10/8/01 – A memorandum was issued detailing the results of a simulation of the potential for impact to well 131 from the TCE plume. The simulation indicated that the TCE in the unconfined aquifer (the location of the majority of TCE mass) would eventually slowly discharge to GPB and not be drawn through the upper semi-confined aquifer to impact the production well.

10/10/01 – A meeting was held at the IT office in Somerset, NJ. The meeting discussed the disagreement regarding the 5-year review. The attendees of the meeting also discussed the 10/8/01 memorandum regarding the effect of well 131 on the TCE plume. One primary action item of the meeting was for the Army to perform additional particle tracking experiments to further evaluate the potential effect of well 131. The first set of particle tracking experimental results were included in the groundwater model recalibration report submitted on 7/9/01.

10/15/01 – The Army responded to the second 5-year review in a letter from Colonel Newman to the Acting USEPA Regional Administrator.

10/24/01 – Additional particle tracking experiments were run and submitted via e-mail to the NJDEP. The results of these particle-tracking experiments indicate that the particles that initiate within the upper semi-confined aquifer will eventually migrate to the production well. The particles that initiate in the unconfined aquifer (hot spot) will eventually discharge to GPB. The results of these experiments are conservative because they were run with particles that only reflect advective flow. Therefore, the particle would move much farther and faster than TCE.

10/24/01 – Additional comments were received and responded to USEPA on Draft Final *Model Re-Calibration and Cost Analysis*.

11/27/01 – The USEPA issued a letter from the acting Regional Administrator to Colonel Newman. This letter responded to the 10/15/01 letter and reiterated that the USEPA wanted the pump and treat to be upgraded as suggested in the 1995 USGS particle tracking report.

12/26/01 – A memorandum was issued to discuss the results of additional modeling simulations run on the interim action pump and treat issue. The simulations utilized the updated flow and transport groundwater model to predict the effect of installing an additional withdrawal well. The transport model was used to predict plume behavior rather than the simple water budget analysis used by the USGS. This simulation indicated that the majority of the plume was captured by the current well configuration. Additionally, the supplemental well being installed between well WW-4 and WW-5 would increase the mass capture of the pump and treat.

1/15/02 – An addendum to the 12/26 memorandum was written detailing the results of a water budget analysis run to duplicate the 1995 USGS exercise with the newly calibrated groundwater model. This simulation indicated that based on the simplified water budget analysis the re-calibrated groundwater model predicted that all of the flow from within the plume was being captured in addition to water from cross gradient areas.

1/26/02 – A project-planning meeting was held at the IT office in Mt. Arlington, NJ. One topic that was addressed dealt with the remaining comments to the Area D Groundwater FS from the NJDEP. The remaining topics included wellhead protection, classification exception area, and well 131.

2/13/02 – Written comments were received from the USEPA on the flow simulation memos written on 12/26 and 1/15.

2/14/02 – An application to modify the monthly average flow rate of the pump and treat from 100 to 150 gpm on the New Jersey Pollutant Discharge Elimination System (NJPDES) permit was submitted to the NJDEP Division of Water Quality – Bureau of Point Source Permitting.

3/11/02 – Responses to the USEPA comments were delivered to the USEPA.

3/20/02 – A meeting was held at the USEPA offices in Edison, NJ. The topic of the meeting was the USEPA request that the interim action pump and treat be upgraded with a seventh well. The end result of the meeting was that the USEPA would deliver its request to the Army in a letter.

4/20/02 – The USEPA replies to the Army that it was not going to mandate a seventh well provided that the Army completed a hydraulic study demonstrating the effectiveness of the current six well system.

5/1/02 – The Army wrote to the NJDEP Bureau of Water Allocation asking that the new pumping well, WW-4A, be added to the current water allocation permit.

6/25/02 – The NJDEP Watershed Management Northeast Bureau wrote a letter requesting that a consistency determination filing be made.

8/13/02 – The Army submitted a consistency determination to the NJDEP Watershed Management Northeast Bureau.

9/18/02 – The Army received a letter from the NJDEP Watershed Management, Northeast Bureau stating that based on the information contained in the 8/13/02 submission, no consistency determination was required.

10/29/02 – The NJDEP Bureau of Water Allocation replied to the 5/1/02 letter approving the addition of WW-4A to the current water allocation permit.

5/31/03 – Final approved FS was submitted.

7/17/03 – A Public Meeting was held for the Proposed Plan for Area D Groundwater.

1/04 – Completion of PTW Pre-Design Investigation.

As of the submittal date of this document, pumping well WW-4A is still not in service because the NJDEP Division of Water Quality – Bureau of Point Source Permitting has not yet approved the application for NJPDES modification.

Other Media: Soil, sediment and surface water within Area D have been addressed in a number of investigations. These investigations have been organized by site. Nine of the 14 sites contained within Area D were addressed in the RCRA Facility Assessment and were investigated as part of the RCRA program: Sites 21/37 (combined since both were associated with Building 24 activities), 29, 39, 45, 49, 69, 182, and 183. Activities at these sites included metal plating, vehicle maintenance, waste accumulation and storage, and operation of a surveillance laboratory. The Army has performed closure cleanup and/or sampling at all of these sites. The NJDEP has approved these closure activities.

In addition to investigative activities, some sites in Area D have undergone remediation. Both the lagoons and dry well have been removed and are no longer a source of groundwater contamination. Closures of the lagoons and dry well were conducted in 1991. Both of these actions were completed under the RCRA program.

The dry well was an unmortared concrete-block pit [about 4 feet (ft) deep] that had a concrete slab top, was surrounded by about 4 inches of gravel, and drained to the subsurface. It was capped in 1985 and excavated and disposed of in 1991.

The lagoons, or surface impoundments (Site 37), were renovated in 1981, at which time approximately 315 cubic yards of soil were removed. Final closure of the Building 24 surface impoundments began in August 1991. During the removal action, the concrete surface impoundments and associated trough were dismantled. The total excavation was approximately 60 ft long, 60 ft wide, and 8 ft deep. Approximately 660 cubic yards of soil and 240 cubic yards of concrete were removed from the excavation. All excavated material was shipped offsite for ultimate disposal. Post-excavation verification sampling was conducted in October 1991 and the pit was lined with plastic, backfilled with certified-clean fill, and graded beginning October 7, 1991.

Although the lagoons and dry well, the original source of the solvents, are no longer a source of groundwater contamination, elevated levels of solvents persist in groundwater. The levels of solvents remain elevated due to an area of soils at a depth of 55 ft with high levels of TCE sorbed to the aquifer soils. Over time, solvents diffused into the soils at this depth. These soils now slowly leach these solvents back into the groundwater. This area is now referred to as the “hot spot.”

The Army is the responsible party with respect to this groundwater plume as well as the lead agency responsible for this clean up. The previous clean ups discussed above have been conducted by the Army under regulatory oversight from the USEPA and NJDEP. The closure of the dry well and lagoons was conducted and approved by the USEPA and NJDEP under the RCRA program. The installation of the hydraulic barrier pump and treat system was performed under an interim action ROD, which was approved by the USEPA and NJDEP (ERC, 1989). Prior to issuance of the interim action ROD, the public was notified through newspaper advertising. In satisfaction of the interagency agreement between the USEPA and the Army, the USEPA has performed two reviews of the interim action. These reviews are performed at five-year intervals and were performed in 1996 and 2001.

2.2.3 Enforcement Activities

No formalized enforcement activities have occurred at Area D. PTA is working in cooperation with the USEPA and NJDEP to apply appropriate remedies that will preclude the necessity of formalized enforcement actions, such as Notices of Violation.

2.3 COMMUNITY PARTICIPATION

The Army has involved the public in the CERCLA process at Area D through public notification of the interim remedy and through numerous updates and presentations to the Picatinny Arsenal Environmental Restoration Advisory Board (PAERAB). Prior to the existence of the PAERAB, the public was kept informed through the Technical Review Committee (TRC).

PAERAB members have provided comments regarding the selected remedial alternative. A courtesy copy of the Proposed Plan was given to the PAERAB’s co-chair, and a complimentary copy was offered to any PAERAB member who requested it. A final Proposed Plan for Area D was completed and released to the public in July 2003 at the information repositories listed below:

Installation Restoration Program Office
Building 319
Picatinny Arsenal, NJ 07806

Rockaway Township Library
61 Mount Hope Road

Rockaway Township, NJ 07866

Morris County Library
30 East Hanover Ave
Whippany, NJ 07981

Multiple newspaper notifications were made to inform the public of the start of the Proposed Plan comment period, solicit comments from the public, and announce the public meeting. The notification was run in the Star Ledger and the Daily Record on July 3, 2003. A public comment period was held from Thursday, July 3, 2003 to Friday, August 1, 2003, during which comments from the public were received. A public meeting was held on July 17, 2003, to inform the public about the Selected Remedy for Area D and to seek public comments. At this meeting representatives from the U.S. Army, NJDEP, USEPA, and USACE were present to answer questions about the site and the alternatives under consideration. The Army's response to comments received at this meeting as well as those submitted by other means are included in the Responsiveness Summary, **Section 3.0** of this ROD.

2.4 SCOPE AND ROLE OF RESPONSE ACTION

The remediation of Area D groundwater is part of a comprehensive environmental investigation and remediation process currently being performed at PTA. Because PTA has a large number of buildings and former production operations, investigating all of the operations at one time would have been unmanageable; so the Army organized these operations into sites. Over 150 site numbers were assigned to the buildings and surrounding land that supported each operation. To ensure the investigation and cleanup of the sites was performed in an organized manner and that the sites with the greatest potential for environmental contamination were addressed first, the Army categorized all of the sites into 16 Areas named A through P. The Army anticipated that Area A had the greatest chance for environmental contamination and Area P the least. The Army further categorized the areas into three phases. The first phase of investigation included Areas A through G, the second phase H through K, and the third and last phase L through P. A site layout map for PTA, which displays each area, is presented as **Figure 2**. This ROD addresses surface water and groundwater within Area D. Area D is one of 16 Areas being addressed by the Army's IRP at PTA. The remaining areas in PTA are being considered separately and remedies for these areas are presented in separate documents. This document represents the third ROD being submitted by the Army for PTA. The Army anticipates it will submit many other RODs for PTA over the next several years.

The selected remedy for the site consists of the construction of a PTW with MNA and implementation of ICs. The location of the proposed PTW is in Area D in the southern portion of PTA, in Morris County, New Jersey. This remedy will be designed and is intended to treat groundwater contamination in the unconfined glacial aquifer and to prevent further discharge of groundwater contaminants to the waters of GPB. Specific elements of the remedy will include:

- o Implementation of the PTW System
    - ▪ Hydrogeological/Geotechnical Investigation
    - ▪ Site Preparation
        - Establishing a decontamination area
        - Implementing erosion control measures
        - Site clearing
    - ▪ Construction of the PTW
        - Excavation and disposal
        - Injection or placement of PTW reactive media
    - ▪ Monitoring Well Installation
    - ▪ Soil Vapor Sampling (2 rounds)

- Performance Monitoring
    - Shut-off and dismantling of Pump and Treat System
- o Demonstration of MNA
    - Surface water sampling and analysis
    - Groundwater sampling and analysis
    - Well Maintenance and Repair
    - MNA data reporting
- o Implementation of Institutional and Land Use Controls
    - Excavation prohibition in accordance with soil management procedure
    - Implementation of Classification Exception Area (CEA)
    - Incorporation of all relevant data into the IRP office GIS system
    - Compliance with all NJDEP Water-Allocation regulations
    - Continuation of wellhead treatment and monitoring of potable water supply well 131.

The lead agency for this action (the Army) is selecting the aforementioned remedial action for Area D groundwater and has deemed such action necessary to prevent human and ecological contact with concentrations of 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene (cis-1,2-DCE), PCE, TCE, and vinyl chloride (VC). It is the Army's current judgment that the Selected Remedy identified in this ROD is necessary to protect public health or welfare or the environment from releases of these hazardous substances to the GPB and achieve the RGs outlined above. The action selected will be consistent with additional actions that may be applied in the future in other areas of PTA.

The interim-action hydraulic barrier pump and treat system will cease operation after the completion of the PTW (pending evaluation by the Army, PTA, USEPA, and NJDEP) and maintained on stand-by status for a period of time.

At the end of the stand-by period, upon agreement between the Army, PTA, USEPA, and NJDEP that the PTW is working acceptably (i.e., that the interim pump and treat system is no longer required in addition to the PTW, to provide sufficient protection of human health and the environment), the pump and treat system will be dismantled. This condition would be met if the concentrations of 1,1-DCE, cis-1,2-DCE, PCE, TCE, and VC found at the plume discharge point in Green Pond Brook are reduced to below RGs (ARARs) in surface water for the site at such time. During the five-year review process, newly available technologies will be evaluated and compared to the selected alternative. The basis of these evaluations will be the results of pilot studies performed within the Area D plume. In the case where the performance of a technology is favorably evaluated from a cost and risk reduction standpoint, a ROD amendment would be issued to implement that technology.

2.5 SITE CHARACTERISTICS

2.5.1 Physical Characteristics

2.5.1.1 Topography/Surface Water Hydrology

Area D is situated in the essentially flat valley region of PTA between GPB and the northwestern ridge of Green Pond Mountain. The topography in Area D ranges from approximately 695 ft mean sea level (msl) near GPB to 715 ft msl. Trending from the southwest to northeast, the elevation changes from approximately 692 to 700 ft msl. The natural topography in the area may have been altered slightly (flattened) by human development, especially in the northwestern portion of Area D.

Surface water runoff is anticipated to be minimal and controlled by a system of engineered storm drains leading away from the various buildings in the area. Expected surface water flow pathways are shown on **Figure 3**. The majority of storm drains lead into BSB, which transects Area D from the northwest to the southeast. BSB has four collection pools that were constructed to separate contaminants from the surface water before discharge to GPB. Most of the surface water from the golf course and undeveloped grassy portions of Area D is expected to infiltrate into the ground or flow overland to GPB. The entire geographic area encompassing the affected groundwater lays within the 100-year floodplains for GPB.

2.5.1.2 Surface and Subsurface Features

Area D encompasses 14 sites, each of which includes one or more building structures. Except for the golf course in the southeast, Area D is highly developed with approximately 65 buildings, and a system of roads and paved surfaces. Sites 21/37 (adjacent to building 24) and the former dry well and surface impoundments they once contained, are believed to be the source of the substantial groundwater solvent plume that underlies a large portion of Area D.

Some of the active facilities in Area D include a vehicle maintenance shop, cafeteria, bank, administrative offices, mission related facilities, residential dwellings, a portion of an 18-hole golf course, golf course maintenance facilities, and a myriad of storm and wastewater sewers, utility and communications cables (both buried and suspended), water lines, and some 140 plus monitoring wells. Within Area D is also a small apple orchard, the Army Research Development and Engineering Center (ARDEC) museum, a potable water supply well (well 131), a lumber supply facility, print shop, inactive railroad lines, a Bureau of Alcohol Tobacco and Firearms (ATF) facility, and sediment retention ponds on BSB (currently undergoing remedial excavation). Flora that covers Area D consists primarily of deciduous trees, although conifers are not uncommon. Other plants found in this portion of Picatinny are generally bushes and flowering plants intended to enhance the aesthetic appearance around the various buildings. Aside from the expanse of golf course within Area D, grassy lawns are primarily limited to the few residential structures. It is not believed that the selected remedy will adversely affect any areas of archaeological or historic importance.

2.5.1.3 Geology and Soils

The bedrock geology of Area D consists of the Silurian Green Pond Conglomerate and Cambrian Leithsville Dolomite units, which are separated by the northeast trending Picatinny Fault. The unconsolidated Pleistocene glacial sediments that fill Picatinny valley also overlie the bedrock units of Area D. The thickest section of glacial sediments occurs in the center of the valley; along the southeastern boundary of Area D, where the thickness ranges up to 250 ft. The thinnest section of glacial sediments in Area D is along the northwestern boundary where the glacial sediments pinch out along the margin of the steep valley wall where valley fill material gives way to alluvium.

The Leithsville Dolomite is a light to dark-gray and light-olive-gray, fine to medium grained, thin to medium-bedded dolomite that grades downward through medium-gray, grayish-yellow, or pinkish-gray dolomite and dolomitic sandstone, siltstone, and shale to medium-gray, medium-grained, medium bedded dolomite containing quartz sand grains as stringers and lenses near the base. Locally, the Leithsville formation has a maximum thickness of 185 ft, and weathers to a yellow silty clay and fine silt with inclusions of fine-grained sandstone and quartz (Wherry, 1909). The Green Pond Conglomerate is comprised of medium to coarse-grained quartz-pebble conglomerate, quartzitic arkose and orthoquartzite, and thin to thick-bedded reddish-brown siltstone. It grades downward into very dark red, or grayish-purple, medium to coarse-grained, thin to very thick bedded pebble to cobble-conglomerate containing clasts of red shale, siltstone, sandstone, and chert; yellowish-gray sandstone and chert; dark-gray shale and chert; and white-gray and pink milky quartz (Rogers, 1836). Locally, this unit has a maximum thickness of approximately 1000 ft and unconformably overlies the Leithsville.

The unconsolidated sediments are Late Wisconsinan Glacial deposits from glacial lake Picatinny which display a vertical sequence of sublacustrine sand and gravel, lake bottom and deltaic silty sand with overlying fluvial and deltaic sand and gravel deposited in a proglacial lake (Stanford, 1989). These sequences have a combined maximum thickness of approximately 250 ft along the southeast boundary of Area D and pinch out against the valley wall to the northwest.

The sublacustrine, lower sequence is poorly sorted and consists of a heterogeneous mix of clayey till with sand, gravel, and boulders. Occasional layers of reworked till consisting of poorly sorted sand, gravel, and silt are encountered towards the top of this unit. Thickness of this unit decreases from approximately 60 ft along the center of the valley and pinches out along the valley walls.

The lowest sequence of glacial sediments is overlain by a fine-grained sequence consisting predominantly of silt, laminated with fine sand and clay stringers. Lenses of coarse sand, cobbles, and boulders occur in the lower and middle portions of this fine-grained lake bottom/deltaic sequence. Thicknesses of the coarse-grained lenses range from approximately 12 to 20 ft. The shape of the bottom of the fine-grained sequence follows bedrock topography. The thickness increases from 20 ft in the northwestern portion of Area D to 110 ft along the linear bedrock low to the southeast. The thickest section of this sequence is to the south and ranges up to 140 ft.

The upper sequence of fluvial and deltaic sand is more horizontally stratified and has a fairly uniform thickness, ranging in thickness from 40 to 50 ft. This sequence displays an overall coarsening upward lithology, beginning with fine sand and silt at the base, to medium sand and silt with gravel, to medium sand and gravel at the top. The grain size of this sequence also decreases laterally from the northeast to the southwest. The sands exhibit variable degrees of sorting and rounding and the middle portion of the sequence shows cyclical coarsening upward sequences that vary from fine sand to fine gravel. Scattered lenses of peat occur in the upper part of this sequence along GPB and range up to 20 ft in thickness. Recent swamp deposits occur in the southern portion of Area D and are represented by organic clays and muck. Thickness of the swamp deposits range up to 9 ft. However, it is possible that the swamp deposits have a greater areal extent than presently observed, since a significant part of these deposits in the culturally developed areas of Area D may have been excavated and replaced by artificial fill material.

2.5.1.4 Hydrogeology

One of the most expansive hydrogeologic investigations of Area D was the Phase I RI conducted in 1994. During the investigation, hydrogeologic data from 54 wells was gathered. Based on the geology of Area D and aquifer slug test data collected during the Phase I RI and previous investigations, four separate aquifers were identified. The aquifers include an unconfined glacial aquifer, an upper semi-confined glacial aquifer, a lower semi-confined glacial aquifer, and a dolomitic bedrock aquifer. The unconfined glacial aquifer corresponds to the coarse-grained fluvial/deltaic upper sequence of glacial sediments that range from the surface to 45 to 62 ft below ground surface (bgs) and consist of sand and gravel with variable amounts of silt. The upper semi-confined glacial aquifer corresponds to the fine-grained lake-bottom/deltaic middle sequence and consists of silt laminated with sand and clay. Encountered at depths ranging from 45 to 62 ft bgs, the thickness of the upper semi-confined glacial aquifer ranges from 21 to 150 ft. The upper semi-confined glacial aquifer is finer grained than the underlying lower semi-confined glacial and bedrock aquifers, and retards downward groundwater flow to these aquifers. The lower semi-confined glacial aquifer corresponds to the lowest glacial, sublacustrine, sequence that consists of poorly sorted till with variable amounts of clay, sand, gravel, and boulders. Occurring at depths ranging from 76 to 198 ft bgs, the thickness of the lower semi-confined glacial aquifer ranges from 11 to 91 ft.

The results of the slug tests performed during the Phase I RI indicate that hydraulic conductivity estimates for the lower semi-confined glacial aquifer (116 feet per day [ft/day]) are higher than those of the unconfined glacial aquifer. Hydraulic conductivity estimates for the unconfined glacial aquifer ranged from 0.8 to 195 ft/day, with an average of 32 ft/day (Dames and Moore, 1998). In general, trends in the hydraulic conductivity estimates in the unconfined glacial aquifer are higher in the upland areas that correspond to a coarser grain size of the sediments. Hydraulic conductivity estimates also generally increase with decreasing depth, corresponding to the coarsening upward nature of the unconfined glacial aquifer.

Vertical gradients between the unconfined and lower semi-confined glacial aquifers are upward in the center of the valley along GPB. This upward vertical gradient indicates that groundwater in the glacial aquifers in Area D is discharging to GPB. In the portion of Area D closer to the northwestern ridge, vertical gradients were calculated to be downward. These calculations agree with the USGS groundwater model for Area D which indicates that groundwater from the northwestern portion of the valley moves downward and out into the glacial sediments before reversing and moving upward to discharge to GPB.

2.5.2 Summary and Findings of Site Investigations

In culmination of the findings of the numerous studies presented in the proceeding text, 1,1-DCE, cis-1,2-DCE, PCE, TCE, and VC were identified as COCs in groundwater and surface water. Detailed data tables and discussions of historical data can be found in the *Phase I RI Report* (Dames and Moore, 1998), *Area D Groundwater FS Data Gap Investigation Work Plan* (ICFKE, 1997), and in the *Area D Groundwater FS* (IT, 2003), all of which are available in the PTA Administrative Record. A summary of the analytical data and fate and transport information for TCE is presented in this section.

Once it was determined that Site 21/37 was the primary cause of the Area D plume, most of the numerous environmental investigations at Area D were conducted in the vicinity of Building 24 (Site 21), the associated lagoons to the southwest of Building 24 (Site 37), and areas downgradient of these two sites extending to GPB. Much of the contamination originating from Site 21/37 in Area D has migrated to the groundwater and was identified and investigated by several agencies during the 1980s and early 1990s. In the late 1990s, much of this data was used to develop a three-dimensional groundwater flow and transport model. This section provides a summary of the major investigations conducted at Area D. The investigations described in this ROD contributed to the characterization of groundwater contamination in the FS. Other media are discussed as they are impacted by the groundwater contamination (e.g., soil, surface water, and air).

Numerous investigations have been conducted to investigate the Area D groundwater plume. Studies within Area D have primarily been concerned with the extent of contamination in the overburden aquifers. However, more recent studies have also focused on the surface water (GPB), subsurface soil, and soil gas to define the total extent of the contamination due to the Area D groundwater plume. In addition, studies have been directed at the detection of potential DNAPLs. More recently, bioattenuation/natural attenuation studies and computer modeling have been employed to predict the fate of the contaminant plume.

Additional data were required in the area of the PTW to ensure optimal performance of the treatment system after it is installed. Shaw Environmental, Inc. (Shaw) performed a field investigation from January 2003 to April 2003 to acquire the additional data needed to support the PTW installation. The findings of this investigation are in preparation.

2.5.2.1 Groundwater

Reports published in the early 1980s by the U.S. Army Environmental Hygiene Agency (USAEHA)[1] and Ertec Atlantic, Inc. (Ertec, 1982) indicated that chlorinated VOCs likely originated from Site 21/37 in the vicinity of Building 24. Beginning in 1982, numerous USGS investigations were conducted to characterize water resources at Area D and investigate contamination. In addition to the TCE and PCE identified by USAEHA, additional VOCs [1,1-dichloroethane (1,1-DCA), 1,1,1-TCA, 1,1-DCE, trans-1,2-dichloroethene (trans-1,2-DCE)] were detected between 1981 and January 1985 (Sargent et al., 1986). Results of these studies indicated that VOCs were present in the aquifer at concentrations in excess of drinking water standards.

In 1986, USGS collected groundwater samples from 15 drive-point locations at 5- to 10-foot depth intervals to determine the horizontal and vertical extent of contamination. These drive point samples extended from Building 24 to GPB and spanned the width of the plume (Sargent et al., 1990). Due to the comprehensiveness of the drive-point investigation, it was one of the three primary investigations used to develop the site-specific groundwater flow and contaminant transport model.

The Phase I RI sampling performed by Dames and Moore indicated that TCE, PCE, and dichloroethene (DCE) were still the primary constituents of the groundwater plume. Minor levels of other VOCs, including VC and 1,1,1-TCA, were detected infrequently. Since some of the wells sampled overlapped with previously sampled USGS wells, this data set was also used to develop the site-specific model.

In addition to the VOC contaminants, several inorganic constituents were detected above comparison criteria. These constituents were antimony, arsenic, beryllium, cadmium, chromium, copper,

[1] Currently known as U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM).

lead, nickel, sodium, and thallium. However, no distinct plume of metals-contaminated groundwater was discovered.

ICFKE and the USGS completed a Data Gap Investigation (DGI) in late 1997 and early 1998 because the majority of past investigations did not focus on collecting data to evaluate treatment options. The DGI was specifically scoped to gather data necessary to evaluate potentially applicable remedial alternatives. In this investigation, samples of groundwater, surface water, and subsurface soil were collected and analyzed to aid in the evaluation of remedial technologies. A detailed discussion of the results from the DGI is presented in fate and transport and nature and extent sections of the Area D FS (IT, 2003).

A determination of the potential for natural attenuation to occur in the Area D unconfined aquifer was conducted as part of the DGI. The natural attenuation investigation indicated that reduction of PCE and TCE to DCE and VC is plausible within the Area D unconfined aquifer. However, the aquifer's overall lack of electron donors [minimal dissolved organic carbon (DOC)] and the high ferric oxyhydroxide concentrations will ultimately limit the attenuation process to a slow attenuation in which accumulation of DCE and VC is possible before complete mineralization of TCE.

The three most comprehensive data sets (USGS drive-point, Dames and Moore Phase I RI, and ICFKE DGI) were used to spatially evaluate changes in the PCE, TCE, and cis-1,2-DCE plumes. It is evident from the graphical depiction of the plume using these data sets and from further vertical delineation conducted during the DGI in the vicinity of the former source area, that the highest concentrations of TCE have migrated downgradient of Building 24 to the area beneath the golf course east of Building 92. Since no source was located in this area of the aquifer, it is believed that a large amount of VOCs have sorbed to the soil upgradient and are slowly supplying VOCs to groundwater.

A site-specific, three-dimensional, non-equilibrium flow and transport model was developed and used to predict the behavior of PCE, TCE, and cis-1,2-DCE in Area D groundwater. The model was calibrated using the three comprehensive data sets discussed previously. Once calibrated, the model was used to evaluate the various remedial alternatives (MNA, mass extraction pump and treat system in 70- and 80-year cleanup timeframes, aggressive in-situ treatment in 30-, 50- and 80-year cleanup timeframes). Many of the remedial alternatives scoped were based directly on the modeled results or indirectly on the clean-up goal estimated by the in-situ clean-up scenario and the natural attenuation, polishing step.

2.5.2.2 Surface Water

A USGS study of GPB from 1984 to 1987 indicated the presence of TCE [1 to 4 micrograms per liter (µg/L)] and 1,2-dichloroethene (1,2-DCE) (2 to 11 µg/L) in surface water both upstream and within the stream reach where the plume discharges. No significant concentrations of metals were detected in samples collected within the stretch of GPB that receives discharge. During a 1990-1992 investigation conducted by the USGS, samples collected from within the Area D groundwater discharge reach of GPB (GPB at Parker Road) contained TCE (2 to 4 µg/L during four sampling events) and DCE (less than or equal to 2 µg/L during two sampling events). It is important to note that during several of the aforementioned studies, samples collected from the intersection of GPB and First Street just down stream of the Area D groundwater point of discharge, were found to contain significant concentrations of TCE and DCE (Dames and Moore, 1998).

A USGS water resource investigation report (Storck et al., 1996) utilized historic GPB analytical data (samples referenced above collected prior to 1991) to examine the quality of water in GPB. The report concluded that VOCs from the Building 24 (Area D) groundwater plume were discharging to GPB.

Surface water samples collected in 1994 as part of the Dames and Moore Phase I RI (1998) indicated detectable levels of TCE and 1,2-DCE in GPB immediately downgradient of the Area D groundwater plume. Further downstream, these compounds were no longer detectable. Thus, it was concluded that these concentrations were directly related to the plume discharging to GPB (Dames and Moore, 1998).

As part of the 1997 DGI, several rounds of surface water samples were collected in GPB and BSB. All samples were analyzed for VOCs. Three samples across the width of GPB at mid-depth were collected from each sampling location. Median and low flow samples were collected on September 9 and October 9, 1997, respectively. Results of VOC analysis on these samples indicated that TCE and VC were detected above their levels of concern (LOCs) in all samples collected from within the plume discharge area as well as downstream of the plume discharge. The majority of contamination in surface water was concentrated at First Street, approximately 300 ft downstream. Samples of groundwater beneath the GPB streambed were also collected at this time. Results indicated that VOCs were discharging to GPB at levels above LOCs.

In November of 2001, a surface water-monitoring program was initiated. Surface water samples were collected and analyzed for VOCs in March 2002, October 2002, and February 2003. Concentrations of VC and TCE exceeded LOCs only in the March 2002 round of sampling. This monitoring program will continue to be performed every six months to coincide with the groundwater monitoring program associated with the hydraulic barrier pump and treat system.

2.5.2.3 Soil

Investigations conducted between 1988 and 1994 indicated there were two primary areas of subsurface soil with high TCE concentrations. The first area was in the unsaturated zone near the former dry well location adjacent to Building 24. In the area near the former dry well, TCE concentrations as high as 7.3 milligrams per kilogram (mg/kg) were detected. The second area was deep in the saturated zone of the upper semi-confined aquifer immediately east of the Ramsey Avenue and Fourth Street intersection, near well 92-3. Within the second area, TCE concentrations as high as 15.6 mg/kg were detected. As part of the 1997 DGI, four soil cores were collected near pre-existing groundwater monitoring wells. The soil core collected closest to well 92-3 exhibited TCE levels of 5.6 mg/kg. The data obtained through analysis of these soil samples enabled a more complete estimate of the mass of TCE remaining in the aquifer.

2.5.2.4 Desorption Column Studies

As part of the 1997 DGI, USGS conducted column desorption studies on intact cores collected from the Area D groundwater plume in order to estimate the desorption rate from the unconfined aquifer sediments. Cores were collected from locations near monitoring wells 92-3, 21MW-1, 41-9, and 9B. In the laboratory, the columns were purged with natural groundwater at a flow rate representative of actual flow rates. The primary goal of this exercise was to determine how long it would take to remove all of the TCE from the soil. Desorption studies were conducted for a minimum of 292 days (9B) and a maximum of 425 days (92-3).

First, a sample of soil was removed from the intact column. This sample was analyzed to determine the total concentration of TCE on the soil. After flushing the rest of the soil column with natural water, column effluent was collected, sampled, and analyzed for TCE to determine the cumulative concentration in the effluent over a given time period (or pore volume), in order to calculate the total mass desorbed by the natural water.

The desorption study results indicated that the majority of TCE desorbed in the first one thousand hours of the experiments, and desorption decreased with increasing time asymptotically. When the small soil sample was removed from the column initially, it was rigorously extracted with heated methanol. This extraction and analysis still underestimated the total mass of TCE initially sorbed to soil, suggesting that TCE is very strongly sorbed to the sediments and is impacted by the texture, organic carbon content, and amount of TCE sorbed to the sediments. This inability to recover all of the sorbed mass via the heated methanol extraction was evident in cores 41-9 and 9B. In these desorption cores, greater than 100% of the TCE appeared to have desorbed over a large time period with the natural water flush. This experiment indicates that large amounts of time are required to remove all of the TCE from this soil matrix. This estimate of the amount of time required for removal of TCE from the soils allowed the groundwater model to more accurately predict the effectiveness of the remedial alternatives evaluated in the FS.

2.5.2.5 Soil Gas

Several soil gas investigations have been completed at Area D. Most of the sampling locations associated with the investigations have been located along the centerline of the groundwater plume.

Results showed that the predominant contaminant within the gas phase is TCE. Measured TCE concentrations were as high as 7300 nanograms per liter (ng/L) (Smith, 1988). Overall, approximately 50 kilograms per year (kg/yr) of TCE gas were calculated to be exiting the subsurface to the atmosphere (Tisdale, 1995; Smith et al., 1996). The soil gas data enabled a more accurate estimate of the amount of TCE vaporizing from the groundwater plume. Analysis of indoor air collected from structures situated above the contaminant plume revealed the presence of several VOCs, including TCE, within the buildings (ICFKE, 1997).

2.5.2.6 Area D PTW Design Study

Additional data were required in the area of the PTW to ensure optimal performance of the treatment system after it is installed. Shaw performed a field investigation from January 2003 to April 2003 to acquire the additional data needed to support the PTW installation.

The field activities for acquiring these data included a temporary shutdown of the hydraulic barrier pump and treat system to obtain non-pumping water levels and flow directions, as well as aquifer characteristics by performing a pumping test.

The design study also included the installation of 22 soil borings using a Geoprobe® unit and hollow stem augers to collect soil samples for observation and groundwater samples for determining TCE, PCE, and DCE concentrations as well as field parameter information (i.e. pH, conductivity, dissolved oxygen [DO], total dissolved solids, and salinity). Two soil samples were also analyzed for target compound list (TCL) VOCs to determine the amount of sorbed TCE on the clay-silt upper semi-confining unit in Area D.

Three soil borings were also installed along the probable PTW alignment using hollow stem augers and split-spoon samplers to acquire soil penetration test data and soil samples for geotechnical analysis. The borings were also used to install temporary wells for monitoring the water table and collecting groundwater samples.

Also, several Area D wells and three temporary wells were sampled for DO content. The 1997 DGI indicated several wells had much higher DO than other wells in the area. In areas with high DO, the iron media in the PTW may react with oxygen to form mineral precipitates that could reduce the permeability of the influent portion of the reactive wall, reducing its long-term effectiveness.

The study included a bench study using site groundwater and zero-valent iron to determine the required groundwater residence time for the PTW and the potential for mineral precipitation in the treatment wall media that would affect the long-term performance of the system.

2.5.3 Conceptual Site Model

A conceptual site model has been developed for the Area D groundwater plume in order to convey the salient processes affecting the introduction, movement, and distribution of contaminant mass at the site. High concentrations of the chlorinated solvent were introduced to the subsurface in small volumes from plating activities via a dry well or the infiltration basins/lagoons associated with Building 24. Following introduction to the subsurface, the bulk of the contaminant mass was mobilized southward by groundwater flow while descending toward the base of the unconfined aquifer. Once at the base of the aquifer, the bulk of the contaminant mass becomes strongly sorbed to the silts and clays that make up in the base of the aquifer, thus establishing the hot spot.

Release of TCE from the hot spot into downgradient portions of the aquifer and, subsequently, discharge into GPB is controlled by desorption and matrix diffusion. Being driven primarily by density gradient, more TCE would have been most likely to desorb initially when the TCE concentration gradient would have been most severe. Desorption rates most likely decreased with increasing time asymptotically; that is the more TCE that desorbs, the less mass of bulk TCE remains to drive desorption.

Another factor that controls the rate of TCE release from the hot spot is the phenomenon of matrix diffusion. Matrix diffusion is mass transport, limited movement of solute (high concentration) into the natural pore or fracture networks of the environmental matrix. Systems in which transport is controlled by matrix diffusion exhibit extremely long durations of contaminant leaching. Therefore, it is likely that matrix diffusion controlled kinetics are responsible for the nature of the subsurface soil contamination at the site. Through desorption and matrix diffusion, it is possible to maintain a stable mass of TCE at depth in the unconfined aquifer while continuously releasing TCE into the downgradient aquifer at a low rate. This model also allows for contamination remaining locked into soils downgradient of the hydraulic barrier created by the pump and treat system. Under this conceptual model, TCE will continue to slowly desorb from the soils within the aquifer for an extremely long time.

Once TCE is desorbed and aqueous, it is mobilized and transported by advection towards GPB where it is discharged to the surface water. Once discharged to GPB, the contamination is potentially accessible to a number of receptors as represented in **Figure 4**.

2.5.4 Plume Characteristics

The most prominent feature of Area D groundwater is a chlorinated solvent plume. This plume was created when solvents were released to the groundwater from a metal plating operation formerly housed in Building 24. Four of the sites within Area D, Site 21/37, Site 45, Site 122, and Site 123, contain facilities where TCE was historically used.

2.5.4.1 Characterization of COCs

In culmination of the findings of the numerous studies presented in the text of this ROD, 1,1-DCE, cis-1,2-DCE, PCE, TCE, and VC have been identified as contaminants of concern. More information on the COC selection process is presented in **Section 2.7.1.1** of this text. The Army has identified these five chemicals as those which pose the greatest potential risk to human health in Area D groundwater and surface water. However, it should be noted that the majority of the Area D plume contains only TCE. The remaining COCs discussed here are found at lower levels or are not detected at all in the majority of the wells. The characteristics of the five COCs that have been identified in Area D groundwater are presented below:

- **TCE:** is a halogenated organic compound historically used as a solvent and degreaser in many industries. Exposure to this compound has been associated with deleterious health effects in humans. Based on laboratory studies, TCE is considered a probable human carcinogen.
- **1,1,-DCE:** is a halogenated organic compound formed through the degradation of TCE. Exposure to this compound has been associated with deleterious health effects in humans.
- **cis-1,2-DCE:** is a halogenated organic compound formed through the degradation of TCE by microorganisms. Exposure to this compound has been associated with deleterious health effects in humans.
- **PCE:** is a halogenated organic compound historically used as a solvent and degreaser in many industries. Exposure to this compound has been associated with deleterious health effects in humans.
- **VC:** is a halogenated organic compound formed through degradation of both cis-1,2-DCE and 1,1-DCE. Exposure to this compound has been associated with deleterious health effects in humans. VC is a known human carcinogen.

2.5.4.2 Fate and Transport of TCE and PCE

The fate and transport characteristics of the contaminants that reside in the plume are vital aspects of the chemical compounds that affect their behavior, ability to mobilize, rate of degradation, and probability of human, biotic, or ecological exposure. The important physical processes that may influence the fate of TCE and PCE include biodegradation, removal via the pump and treat system, and discharge to GPB. The important physical processes that may influence transport of TCE and PCE include dispersion/diffusion and advection, sorption, and volatilization.

The following outline provides a list of the primary components both fate and transport of TCE and PCE within the Area D groundwater plume. For a detailed elaboration of this material, see Section 3.0 of the Area D Groundwater FS (IT, 2003).

Fate Pathways of PCE and TCE in Area D groundwater are limited to:

- Natural Attenuation/Biodegradation - As controlled by:
    - Electron donor availability,
    - Redox couple concentration,
    - Thermodynamic stability of terminal electron acceptor, and
    - Hydrogen concentration.
- Capture by the Pump and Treat system
- Discharge to GPB

Transport mechanisms defined for PCE and TCE in Area D groundwater are:

- Dispersion/Diffusion and Advection within the aquifer
- Volatilization
- Sorption to aquifer sediments
- Matrix diffusion within aquifer solid material

2.5.4.3 Extent of Contamination

Between 1973 and 1983 at least 11,800 gallons of TCE was purchased for use in a vapor degreaser in the Building 24 metal plating operation. Use of this material in the degreaser led to contamination of the aquifer through leaks and disposal through a dry well and lagoons formerly located at Building 24. The primary method of introduction of the solvents is thought to be condensation of TCE vapors in an overflow pipe from the vapor degreaser to a dry well. The plume is over 1,700 ft long and approximately 800 ft wide (at a concentrations of 10 µg/L). The highest concentrations of TCE in recent sampling events have been approximately 10,000 µg/L. The highest concentrations of TCE occur in the unconfined aquifer. There are three other aquifers beneath the unconfined aquifer in Area D (upper semi-confined, lower semi-confined, and bedrock). Each of these three aquifers contains TCE but at much lower levels than the unconfined aquifer. The majority of the mass of TCE in groundwater in Area D is in the unconfined aquifer. As TCE has degraded in the groundwater TCE degradation products (i.e., DCE and VC) have been produced. Concentrations of TCE degradation products in Area D are much lower than concentrations of TCE.

2.5.4.4 Contamination Mobility and Exposure Potential

The COCs within groundwater at Area D are relatively sessile, as discussed in **Section 2.5.3** of this text, because of the compounds affinity for the silty and clayey sediments in the base of the unconfined aquifer. The resulting nominal mobility of the bulk of the mass of the contamination is attributed to gradual desorption and/or matrix diffusion of small amounts of aqueous contamination becoming mobile and traveling via advection toward GPB.

In addition to the exposure routes as outlined in **Figure 4**, potential exposure to the bulk of the contamination could be facilitated by excavation within the area of the hot spot. In such a scenario, contaminated soil could be moved to another location where it would be capable of causing potential risk to human health or the environment. Also the personnel performing the excavation could potentially be at risk of dermal contact to the contaminated soil or inhalation of volatilized vapors. Additionally, if a building were to be placed within the excavation as described in this scenario, the residents would be subject to inhalation of volatilized vapors as well. It should be noted that the potential for risk from vapors seeping into current buildings in Area D has been evaluated and found to be acceptable. It is very important to note that the Institutional Controls in place at PTA would preclude any construction near or within the footprint of the Area D groundwater plume. Any excavation near or within the footprint of the plume (such as the excavation potentially associated with the installation of the selected remedy as outlined in this ROD) would be performed with specific engineering controls and health safeguards to minimize or eradicate potential exposure to workers performing the excavation.

2.6 CURRENT AND POTENTIAL FUTURE LAND USES

Numerous industrial activities are conducted in this area of the Arsenal, including vehicle maintenance, waste accumulation and storage, surveillance laboratory operation, and photographic processing. This area also contains administrative space, the post cafeteria and several military housing units, as well as a portion of the base golf course. No VOC contamination originated from these latter activities.

Groundwater supply well 131 is located within the boundaries of Area D east of Building 34. It is screened in the lower semi-confined and bedrock aquifers, and is located below the majority of the contaminated groundwater. The water produced by well 131 contains low levels of TCE. This water is extracted and treated prior to consumption. As a part of all remedial alternatives, the current wellhead treatment will continue for this well.

The future land use of Area D is anticipated to remain unchanged from current land use. Area D will continue to be used for industrial activities by the Army. Potential exposure pathways to site contaminants include physical contact with surface water, inhalation of soil vapor should it infiltrate into site buildings, and ingestion of groundwater. It is very unlikely that the contamination associated with Area D groundwater will be ingested by Picatinny workers or residents because of the monitoring and treatment practices associated with the potable water extraction and distribution process. All of the water generated from supply wells at PTA is monitored regularly by both US Filter (the current water authority for PTA) and the PTA EAO. The water is also treated to remove VOC compounds prior to distribution.

2.7 SUMMARY OF SITE RISKS

Area D groundwater has been the subject of several investigations including risk assessments designed to evaluate the potential impact to human health and the environment. All of the risk assessments summarized below were performed at the request of the USEPA. It should be noted that currently no one ingests untreated groundwater pumped from Area D. Therefore there are no human receptors for any of the HHRA scenarios modeled for groundwater. Additionally, swimming, wading, and fishing are undesirable and routinely not performed in the section of GPB within Area D. A summary of the results from the human health and environmental risk assessments are presented in the following sections.

Chemical-specific ARARs are the basis for taking action at the site. There are several compounds that have emanated from industrial activities within Area D that also exceed chemical-specific ARARs for groundwater and/or surface water. This remedial action is being undertaken because of non-compliance with groundwater ARARs and because discharge of contaminated groundwater is causing non-compliance with surface water ARARs in a short section of GPB. The NJDEP considers any surface water with an exceedance of the State surface water criteria to be an impacted "receptor."

Additionally, in 1997, indoor air sampling was performed for 13 buildings over the Area D groundwater plume. Indoor air samples were collected and analyzed for VOCs. VOCs were detected in several of the buildings. The estimated excess cancer risk and non-cancer hazard was calculated for each building sampled and summarized in **Table 2-2**. The results of the risks estimated as a result of this indoor air sampling are also summarized **Section 2.7.1.4**.

The response action selected in this ROD is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

2.7.1 Human Health Risk Assessment (HHRA)

To determine whether remedial action is warranted, USEPA requires a baseline HHRA be conducted for each site. The baseline risk assessment estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section summarizes the results of the baseline risk assessment for Area D groundwater. As part of the baseline risk assessment, estimates of excess cancer risk and non-carcinogenic hazard are calculated. Currently, USEPA guidelines for acceptable exposures are individual lifetime carcinogenic risk in the range of $1x10^{-6}$ (one in a million) and $1x10^{-4}$ (one in ten thousand). Exceedances of this acceptable range may trigger remedial action. The hazard index (HI) is the sum of all hazard quotients for all contaminants of potential concern (COPCs) in a given exposure pathway that have a similar mechanism or pathway. Based on current USEPA guidance, an acceptable HI is not to exceed 1.

2.7.1.1 Identification of COCs

This section presents a summary of the COC selection that was performed as part of the Area D Groundwater FS (IT, 2003). There were also HHRA COCs selected during the performance of the RI (Dames and Moore, 1998). This selection was performed in accordance with Risk Assessment Guidance for Superfund (RAGS). However, it is believed that presenting the selection of COCs performed for the FS was more appropriate.

As part of the Area D groundwater FS, the contaminants detected in groundwater and surface water were screened to identify COCs. COCs were identified for groundwater and surface water. The five COCs identified in these media were 1,1,-DCE, cis-1,2-DCE, PCE, TCE, and VC.

COCs were identified in each individual aquifer (unconfined, upper semi-confined, lower semi-confined, and bedrock). The starting point for determining COCs was the entire list of constituents that were detected in Area D groundwater samples collected during the Phase I RI or the DGI. The screening criteria identified below were used to refine the COPC list to obtain COCs:

- The highest concentration detected was above the chemical-specific ARAR.
- Contaminant was detected above background concentrations as determined in the Phase I RI.[2]
- The contaminant was confirmed to be present at concentrations exceeding ARARs during the DGI.
- Contaminant distribution is indicative of a contaminant plume. Inorganic contaminants exhibiting random distribution were removed from COC consideration. Additionally, organic contaminants that were sporadically detected and not confirmed in adjacent or subsequent samples were also eliminated via this criterion.
- The contaminant was identified as a COC in the unconfined aquifer (or COC determination in the underlying aquifers).

In the unconfined aquifer, 1,1-DCE, cis-1,2-DCE, PCE, TCE, and VC were selected as COCs. TCE was identified as a COC in all three of the underlying aquifers. Additionally, PCE is identified as a COC in the lower semi-confined aquifer. **Table 2-1** summarizes the COCs, their ARARs, and associated maximum concentrations in groundwater.

Table 2-1
Maximum Concentrations of COCs

Compound	ARAR, µg/L	Maximum Groundwater Concentration, µg/L
TCE	1 [3]	13,800
PCE	1 [4]	53
cis-1,2-DCE	10 [5]	670
1,1-DCE	2 [6]	12
VC	2 [7]	9

[2] In the Phase I RI, background concentrations of naturally occurring compounds were defined by the 99% confidence interval for the true mean of the contaminants background concentration. This statistical analysis was used on data collected from wells in the unconfined aquifer.

[3] This ARAR value corresponds to the New Jersey Maximum Contaminant Level (NJMCL) for drinking water, New Jersey Groundwater Quality Criteria, and the New Jersey Practical Quantitation Limit (NJPQL).

[4] This ARAR value corresponds to the NJMCL for drinking water and the NJPQL.

[5] This ARAR value corresponds to the New Jersey Groundwater Quality Criteria.

[6] This ARAR value corresponds to the NJMCL for drinking water.

[7] This ARAR value corresponds to the Federal Drinking Water Standards Maximum Cleanup Level (MCL).

2.7.1.2 Exposure Assessment

The Phase I RI (Dames and Moore, 1998) included an HHRA for Area D groundwater, surface water, and air. Hypothetical future exposure of groundwater to workers, adult/child residents, and child residents were evaluated for ingestion, inhalation, and skin contact risks. The evaluation of the potential risk from contaminated surface water considered the risk to trespasser swimmers.

The potential pathways through which individuals may be exposed to COCs were discussed in further detail within the Phase I RI HHRA. Probable exposure pathways were then selected for quantitative evaluation in the HHRA. Using the site-specific data obtained from the field samples, chemical concentrations were computed for the points of potential exposure associated with each pathway selected for quantitative evaluation. Conservative exposure assumptions were made for the magnitude, frequency, and duration of exposure for each pathway, and potential exposures (intakes) were then quantified. Ingestion, dermal absorption, and inhalation of VOCs were evaluated for groundwater, and dermal absorption was evaluated for surface water. Detailed evaluations for the incidental ingestion and dermal absorption in sediment and ingestion for fish can also be found in the Phase I RI HHRA.

2.7.1.3 Toxicity Assessment

The potential toxicity of chemicals to humans was presented and the chemical-specific toxicity criteria were compiled for each COC within the Phase I risk assessment. Specifically, the toxicity criteria used in the quantitative assessment were obtained from USEPA's Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Tables (HEAST), and the National Center for Environmental Assessment (NCEA).

2.7.1.4 Risk Characterization

The risks were calculated for the unconfined aquifer and semi-confined aquifers separately. For the unconfined aquifer, carcinogenic risk for hypothetical Picatinny workers was $2x10^{-4}$ (70% of this risk was the result of TCE, $8x10^{-5}$, and VC, $6x10^{-5}$). For adult/child residents, the carcinogenic risk was $1x10^{-3}$ (97% of this risk was the result of TCE, $6x10^{-4}$, and VC, $3.7x10^{-4}$). For child residents, the carcinogenic risk was $4x10^{-4}$ (83% of this risk was the result of TCE, $2X10^{-4}$, and VC, $1.3x10^{-4}$). HIs associated with the unconfined aquifer were 10 for hypothetical Picatinny workers (80% as a result of thallium), 50 for adult/child residents (80% as a result of thallium, 30, and TCE, 10), and 90 for child residents (78% as a result of thallium, 50, and TCE 20).

There are new cancer slope factors and noncancer reference doses for estimating cancer risk and noncancer hazard for a number of the constituents detected in sampled environmental media. The risks and hazards estimates presented in this document were made using the most up-to-date information available at the time the 1998 Risk Assessment was produced. Although some cancer slope factors and noncancer reference doses may have changed for a number of different constituents since this time, we are discussing TCE because it is the primary contaminant in this groundwater plume.

The TCE cancer slope factors used in the risk calculation performed in 1998 were based on information first presented on USEPA's IRIS data based in 1987, based on data contained in the *Addendum to the Health Assessment Document for TCE* (EPA 600/8-82/006F, June 1987). Subsequently these data were removed from the IRIS database as a result of uncertainty associated with the accuracy of the information in the carcinogenicity file. In the absence of IRIS carcinogenicity data for TCE, the USEPA Environmental Criteria and Assessment Office (now the NCEA) released a Risk Assessment Issue Paper that presented provisional data for TCE. These data presented an oral TCE cancer slope factor of 1.1E-2 $(mg/kg\text{-}day)^{-1}$ and an inhalation TCE cancer slope factor of 6.0E-3 $(mg/kg\text{-}day)^{-1}$. These data were used in the 1998 Risk Assessment.

New cancer slope factors for TCE were issued by USEPA NCEA in 2001. These slope factors were updated to utilize the most up-to-date information with respect to the USEPA current consensus on the carcinogenicity of TCE. The cancer slope factors for both oral and inhalation exposure are now 4.0E-1 $(mg/kg\text{-}day)^{-1}$. The slope factor associated with risk from oral (and dermal) exposure to TCE thus changed by a factor of 36, meaning the portion of the estimated risk resulting from TCE exposure through these routes would increase 36 fold. The slope factor associated with risk from inhalation of TCE changed by a factor of 67, meaning the portion of the estimated risk resulting from TCE exposure through this route would increase 67 fold.

However, it is important to note that exposure to TCE is only responsible for a fraction of the total estimated cancer risk for all of these potential exposure pathways. It is also important to note that with all risk estimates there are uncertainties in the results due to a number of factors, such as uncertainties in oral and inhalation intake rates, dermal contact rates, body weight, absorption into the body, exposure time and duration, and variability in chemical concentrations in environmental media. The fact that new cancer slope factors for TCE are available since the baseline risk assessment in 1998 does not invalidate the original results. No recalculation of risk is necessary for the final selection of a remedy for Area D Groundwater.

For the semi-confined aquifers, carcinogenic risk was $3x10^{-5}$ for the PTA workers (100% as a result of arsenic, $2x10^{-5}$, and beryllium, $1x10^{-5}$), $2x10^{-4}$ for adult/child residents (80% as a result of arsenic, $8x10^{-5}$, beryllium, $6x10^{-5}$, and TCE, $2X10^{-5}$), and $7x10^{-5}$ for child residents (86% as a result of arsenic, $3x10^{-5}$, beryllium, $2x10^{-5}$, and TCE, $1x10^{-5}$). HIs were 20 for PTA workers (95% as a result of iron, 10, and thallium, 9), 90 for adult/child residents (100% from iron, 50, manganese, 10, and thallium, 30), and 200 for child residents (90% from iron, 90, manganese, 20, and thallium, 60). HHRA calculations for Area D groundwater are summarized in **Table 2-2**.

Exposure to surface water by trespassers (swimmers) in GPB was evaluated for ingestion and skin contact risk. The predicted carcinogenic risk was $8x10^{-6}$ and the HI was 0.8. In 1997, indoor air sampling was performed for 13 buildings over the Area D groundwater plume. Indoor air samples were collected and analyzed for VOCs. VOCs were detected in several of the buildings. The estimated excess cancer risk and non-cancer hazard was calculated for each building sampled. Estimated cancer risk ranged from below the USEPA risk range to 3×10^{-5}. The maximum estimated risk was calculated for Building 33, the motor pool garage. The maximum estimated hazard calculated was 0.5. This is below the USEPA threshold of 1. HHRA calculations for GPB surface water and sediment are summarized in **Table 2-2**.

The contaminants summarized in **Table 2-2** were selected from the HHRA conducted as part of the Phase I RI. The contaminants shown in **Table 2-2** are either the five COCs for the Area D groundwater plume or those chemicals that are significant contributors to the overall risk. It should also be noted that the COCs absent from these tables were not selected for consideration during the performance of the Phase I RI HHRA due to the lack of detections of these compounds or detections of very low levels for the media in question.

The risk assessment evaluations performed by the Army for media sampled in Area D indicated that groundwater is the only medium associated with unacceptable risks due to the VOC contamination. The VOCs that primarily contributed to the elevated risks for the ingestion pathway (the pathway with the greatest risks) were TCE and VC in the unconfined aquifer. There were no VOCs that contributed significantly to HIs exceeding the threshold value of 1.0 for the groundwater ingestion pathway, even though the HIs based on individual health endpoints exceeded the threshold value of 1.0. It should be noted that currently no one ingests untreated groundwater from Area D. Furthermore, no additional pumping wells could be installed at PTA without being subject to wellhead protection due to Army ICs and CEA status established with the NJDEP. Risks associated with exposures to surface water were lower than or at the low end of the target risk range. There were no chemicals that exceeded the HI threshold value of 1.0 for the surface water pathways. Calculated risks associated with exposure to air in office and residential buildings in close proximity to Area D were at the middle to high end of the target risk range. No calculated risks were found to be above the target risk range and no chemicals exceeded the HI threshold value of 1.0 for the air pathway.

2.7.2 Ecological Risk Assessment

As part of the Phase I RI (Dames and Moore, 1998), the active reach of GPB from the Picatinny Lake outfall to the Picatinny southern boundary (this includes Area D) was investigated. The investigation included the collection of additional surface water and sediment samples and a baseline ecological risk assessment (BERA). VOCs were not selected as ecological contaminants of potential concern (ecoCOPCs) in this ecological risk assessment because they are not persistent in surface water or surface soils within the vadose zone and are unlikely to bioaccumulate. Subsequent to the BERA, an FS was performed to evaluate cleanup options for GPB. All areas of GPB were examined and sections of the brook requiring cleanup were deemed areas of concern (AOCs). It was determined that the section of GPB that receives the TCE from the Area D plume was not a risk to the stream ecology and therefore not an AOC. In addition, no AOCs were selected in the reach between Farley Avenue and First Street in a study focusing on GPB and BSB, which evaluated the risks along the entire portion of GPB in Phase I areas (along with upstream portions of GPB in Phase II and Phase III areas). Since ecological risk was the main driver in the GPB and BSB studies, there does not appear to be any contaminant concerns from an ecological risk perspective in GPB where groundwater discharge of VOCs occurs.

As a result, decisions for choosing a remedial alternative in the Area D FS were not based on ecological risk.

Table 2-2
Risk Characterization Summary

Scenario Timeframe: Current
Receptor Population: Picatinny Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Surficial Aquifer Use	1,1-DCE	2 E-06	N/A	N/A	2.0 E-06
		Surficial Aquifer Use	1,2-DCE	N/A	N/A	N/A	0.0 E+00
		Surficial Aquifer Use	PCE	7 E-07	N/A	N/A	7.0 E-07
		Surficial Aquifer Use	TCE	8 E-05	N/A	N/A	8.0 E-05
		Surficial Aquifer Use	Vinyl Chloride	6 E-05	N/A	N/A	6.0 E-05
		Surficial Aquifer Use	Arsenic	3 E-05	N/A	N/A	3.0 E-05
		Surficial Aquifer Use	Beryllium	1 E-05	N/A	N/A	1.0 E-05
						Total Risk =	**2 E-04**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Semiconfined Aquifer Use	1,1-DCE	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	1,2-DCE	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	PCE	1 E-07	N/A	N/A	1.0 E-07
		Semiconfined Aquifer Use	TCE	1 E-06	N/A	N/A	1.0 E-06
		Semiconfined Aquifer Use	Vinyl Chloride	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	Arsenic	2 E-05	N/A	N/A	2.0 E-05
		Semiconfined Aquifer Use	Beryllium	1 E-05	N/A	N/A	1.0 E-05
						Total Risk =	**3 E-05**

Table 2-2
Risk Characterization Summary

Scenario Timeframe: Current
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Surficial Aquifer Use	1,1-DCE	9 E-06	4 E-06	4 E-11	1.3 E-05
		Surficial Aquifer Use	1,2-DCE	N/A	N/A	N/A	0.0 E+00
		Surficial Aquifer Use	PCE	7 E-07	2 E-07	2 E-10	9.0 E-07
		Surficial Aquifer Use	TCE	8 E-05	3 E-04	4 E-08	3.8 E-04
		Surficial Aquifer Use	Vinyl Chloride	6 E-05	7 E-05	1 E-09	1.3 E-04
		Surficial Aquifer Use	Arsenic	1 E-04	N/A	8 E-11	1.0 E-04
		Surficial Aquifer Use	Beryllium	5 E-05	N/A	2 E-09	5.0 E-05
						Total Risk =	**1 E-03**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Semiconfined Aquifer Use	1,1-DCE	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	1,2-DCE	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	PCE	5 E-07	3 E-08	4 E-11	5.3 E-07
		Semiconfined Aquifer Use	TCE	1 E-05	1 E-05	2 E-09	2.0 E-05
		Semiconfined Aquifer Use	Vinyl Chloride	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	Arsenic	8 E-05	N/A	6 E-11	8.0 E-05
		Semiconfined Aquifer Use	Beryllium	6 E-05	N/A	2 E-09	6.0 E-05
		Semiconfined Aquifer Use	Heptachlor	3 E-06	5 E-06	1 E-12	8.0 E-06
						Total Risk =	**2 E-04**

Table 2-2
Risk Characterization Summary

Scenario Timeframe: Current
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Surficial Aquifer Use	1,1-DCE	3 E-06	2 E-06	8 E-12	5.0 E-06
		Surficial Aquifer Use	1,2-DCE	N/A	N/A	N/A	0.0 E+00
		Surficial Aquifer Use	PCE	1 E-06	7 E-08	4 E-11	1.1 E-06
		Surficial Aquifer Use	TCE	1 E-04	1 E-04	7 E-09	2.0 E-04
		Surficial Aquifer Use	Vinyl Chloride	1 E-04	3 E-05	3 E-10	1.3 E-04
		Surficial Aquifer Use	Arsenic	4 E-05	N/A	3 E-11	4.0 E-05
		Surficial Aquifer Use	Beryllium	2 E-05	N/A	5 E-10	2.0 E-05
						Total Risk =	**4 E-04**

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Semiconfined Aquifer Use	1,1-DCE	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	1,2-DCE	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	PCE	2 E-07	1 E-08	6 E-12	2.1 E-07
		Semiconfined Aquifer Use	TCE	5 E-06	5 E-06	3 E-10	1.0 E-05
		Semiconfined Aquifer Use	Vinyl Chloride	N/A	N/A	N/A	0.0 E+00
		Semiconfined Aquifer Use	Arsenic	3 E-05	N/A	2 E-11	3.0 E-05
		Semiconfined Aquifer Use	Beryllium	2 E-05	N/A	6 E-10	2.0 E-05
		Semiconfined Aquifer Use	Heptachlor	1 E-06	2 E-06	6 E-11	3.0 E-06
						Total Risk =	**7 E-05**

Table 2-2
Risk Characterization Summary

Scenario Timeframe: Current
Receptor Population: Trespasser/Swimmer
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Water	Green Pond Brook	Contact While Swimming	PCE	2 E-08	N/A	6 E-07	6.2 E-07
		Contact While Swimming	TCE	5 E-11	N/A	3 E-09	3.1 E-09
Sediment	Green Pond Brook	Contact While Swimming	Total PCBs	4 E-06	N/A	2 E-07	4.2 E-06
		Contact While Swimming	Total from Dioxins	2 E-06	N/A	1 E-07	2.5 E-06
						Total Risk =	**8 E-06**

Table 2-2
Risk Characterization Summary

Scenario Timeframe: Current
Receptor Population: Picatinny Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Air	Indoor Air	Building 24	Carbon Tetrachloride	N/A	4.0 E-07	N/A	4.0 E-07
			Chloroform	N/A	9.0 E-07	N/A	9.0 E-07
						Total Risk =	**1 E-06**
Air	Indoor Air	Building 64-1	Carbon Tetrachloride	N/A	5.0 E-07	N/A	5.0 E-07
			Chloroform	N/A	1.0 E-07	N/A	1.0 E-07
						Total Risk =	**6 E-07**
Air	Indoor Air	Building 64-2	Carbon Tetrachloride	N/A	7.0 E-07	N/A	7.0 E-07
			1,1-DCE	N/A	3.0 E-07	N/A	3.0 E-07
						Total Risk =	**1 E-06**
Air	Indoor Air	Building 61/62	Benzene	N/A	7.0 E-07	N/A	7.0 E-07
			Carbon Tetrachloride	N/A	7.0 E-07	N/A	7.0 E-07
			Chloroform	N/A	1.0 E-07	N/A	1.0 E-07
			1,2-DCE	N/A	1.0 E-07	N/A	1.0 E-07
			1,1-DCE	N/A	6.0 E-07	N/A	6.0 E-07
			Methylene Chloride	N/A	3.0 E-07	N/A	3.0 E-07
						Total Risk =	**3 E-06**

Table 2-2
Risk Characterization Summary

Scenario Timeframe: Current
Receptor Population: Picatinny Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Air	Indoor Air	Building 34	Benzene	N/A	1.0 E-06	N/A	1.0 E-06
			1,1-DCE	N/A	1.0 E-06	N/A	1.0 E-06
						Total Risk =	**2 E-06**
Air	Indoor Air	Building 11	Benzene	N/A	8.0 E-07	N/A	8.0 E-07
			Carbon Tetrachloride	N/A	7.0 E-07	N/A	7.0 E-07
			1,2-DCE	N/A	1.0 E-07	N/A	1.0 E-07
			1,1-DCE	N/A	4.0 E-07	N/A	4.0 E-07
						Total Risk =	**2 E-06**
Air	Indoor Air	Building 33	Benzene	N/A	7.0 E-06	N/A	7.0 E-06
			Carbon Tetrachloride	N/A	5.0 E-06	N/A	5.0 E-06
			1,2-DCE	N/A	1.0 E-06	N/A	1.0 E-06
			1,1-DCE	N/A	9.0 E-06	N/A	9.0 E-06
			PCE	N/A	1.0 E-06	N/A	1.0 E-06
						Total Risk =	**3 E-05**
Air	Indoor Air	Building 30	Benzene	N/A	5.0 E-07	N/A	5.0 E-07
			Carbon Tetrachloride	N/A	6.0 E-07	N/A	6.0 E-07
			Chloroform	N/A	8.0 E-07	N/A	8.0 E-07
			1,2-DCE	N/A	2.0 E-07	N/A	2.0 E-07
			1,1-DCE	N/A	2.0 E-06	N/A	2.0 E-06
			Vinyl Chloride	N/A	4.0 E-07	N/A	4.0 E-07
						Total Risk =	**5 E-06**

Table 2-2
Risk Characterization Summary

Scenario Timeframe: Current
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Air	Indoor Air	Building 100	Carbon Tetrachloride	N/A	7.0 E-06	N/A	7.0 E-06
			Chloroform	N/A	2.0 E-06	N/A	2.0 E-06
			1,1-DCE	N/A	4.0 E-06	N/A	4.0 E-06
						Total Risk =	**1 E-05**
Air	Indoor Air	Building 102	Benzene	N/A	1.0 E-05	N/A	1.0 E-05
			Carbon Tetrachloride	N/A	9.0 E-06	N/A	9.0 E-06
			Chloroform	N/A	7.0 E-06	N/A	7.0 E-06
			1,2-DCE	N/A	3.0 E-06	N/A	3.0 E-06
			1,1-DCE	N/A	4.0 E-05	N/A	4.0 E-05
			PCE	N/A	3.0 E-06	N/A	3.0 E-06
						Total Risk =	**7 E-05**
Air	Indoor Air	Building 127	Benzene	N/A	2.0 E-05	N/A	2.0 E-05
			1,1-DCE	N/A	2.0 E-05	N/A	2.0 E-05
						Total Risk =	**4 E-05**

Table 2-2
Risk Characterization Summary

Scenario Timeframe: Current
Receptor Population: Resident
Receptor Age: Adult/Child

Medium	Exposure Medium	Exposure Point	Chemical of Concern	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Air	Indoor Air	Building 117	Carbon Tetrachloride	N/A	7.0 E-07	N/A	7.0 E-07
			1,2-DCE	N/A	1.0 E-06	N/A	1.0 E-06
			1,1-DCE	N/A	2.0 E-06	N/A	2.0 E-06
			Methylene Chloride	N/A	2.0 E-07	N/A	2.0 E-07
						Total Risk =	**5 E-06**
Air	Indoor Air	Building 113	Benzene	N/A	9.0 E-06	N/A	9.0 E-06
			Carbon Tetrachloride	N/A	8.0 E-06	N/A	8.0 E-06
			Chloroform	N/A	1.0 E-06	N/A	1.0 E-06
			1,2-DCE	N/A	2.0 E-06	N/A	2.0 E-06
			1,1-DCE	N/A	6.0 E-06	N/A	6.0 E-06
						Total Risk =	**3 E-05**
Air	Indoor Air	Building 112	Benzene	N/A	5.0 E-06	N/A	5.0 E-06
			Carbon Tetrachloride	N/A	7.0 E-06	N/A	7.0 E-06
			Chloroform	N/A	1.0 E-06	N/A	1.0 E-06
			1,2-DCE	N/A	1.0 E-06	N/A	1.0 E-06
			1,1-DCE	N/A	6.0 E-06	N/A	6.0 E-06
						Total Risk =	**2 E-05**

2.8 REMEDIAL ACTION OBJECTIVES

This remedial action has been triggered by the exceedance of chemical-specific ARARs, therefore, the RAOs for PTA's Area D groundwater have been developed in such a way that attainment of these goals will result in the protection of human health and the environment (although the groundwater currently poses little or no threat to human health, implementing the intended remedy will ensure that groundwater is even more protective of human health than at the present time). These objectives are specific to ground and surface water contaminated by sources originating from Building 24, but are not so limited that the choice of remedial technologies is overly restricted.

Although closure of Site 21/37 was achieved in 1991 as part of the RCRA program at Picatinny, contamination remains in the groundwater and subsequently impacts the surface water. Groundwater contamination, particularly of the unconfined aquifer, and surface water contamination of a section of GPB where the plume discharges, necessitates a remedial action.

The Army determined that concentrations of VOCs in groundwater exceeded the chemical-specific ARARs. See **Table 2-1** for the maximum concentrations of COC compared to the corresponding groundwater ARAR. In addition, the presence of TCE and VC in the unconfined aquifer could result in unacceptable risk if ingestion of groundwater from the unconfined aquifer were permitted. During the process of evaluating remedial alternatives for the treatment of Area D groundwater, the Army established the following RGs:

- Prevent exposure to contaminated groundwater;
- Establish ICs to restrict access to the contaminant plume;
- Protect uncontaminated ground and surface water for designated uses;
- Minimize migration of contaminants to adjacent ground and surface water;
- Restore contaminated ground and surface water to comply with their respective use designations;
- Comply with ground and surface water ARARs; and,
- Continue to ensure the protection of environmental receptors.

2.9 DESCRIPTION OF ALTERNATIVES

The recommended remedial alternative for Area D groundwater is Alternative 5, PTW and Limited Action with MNA. Area D has undergone an RI/FS in accordance with the CERCLA process. The RI phase is the mechanism for collecting data to characterize the site and assess potential human health and ecological risk. The RI phase is followed by the FS phase, which involves the development, screening, and detailed evaluation of remedial alternatives. Based on the findings of the *PTA Phase I RI Report* (Dames and Moore, 1998), and the DGI conducted by ICFKE in 1999, an FS was prepared to determine applicable treatment technologies and to assemble these technologies into remedial alternatives. Four general response actions were identified which included: No Action, Limited Action and MNA, Ex-Situ Active Restoration, and In-Situ Active Restoration. Numerous remedial technologies were identified for each general response action and process options of each remedial technology were screened based on effectiveness, implementability, and cost. This information is provided in detail in the *Area D Groundwater FS* (IT, 2003).

These remedial technology process options derived from the consideration of the general response actions yielded the following alternatives:

- Alternative 1: No Action
- Alternative 2: Limited Action with MNA
- Alternative 3: Mass Extraction Pump and Treat System and Limited Action with MNA
  - ➢ Alternative 3A – 80-year cleanup timeframe
  - ➢ Alternative 3B – minimum timeframe for technology (70 years)

- Alternative 4: Six Phase Heating with Soil Vapor Extraction (SVE) and Enhanced Bioremediation using Hydrogen Release Compound (HRC) and Limited Action with MNA
  - Alternative 4A – 85-year cleanup timeframe
  - Alternative 4B – 55-year cleanup timeframe
  - Alternative 4C – 35-year cleanup timeframe
- Alternative 5: PTW and Limited Action with MNA

Some remedial alternatives were designed to treat the plume passively through natural groundwater movement (Alternatives 2 and 5), while others were designed to aggressively treat groundwater near monitoring well 92-3 (termed the hot spot of the plume) while more passively treating the contamination outside of the hot spot (Alternatives 3 and 4). Detailed analysis of the more aggressive alternatives included a range in cleanup times from 35 to 85 years (e.g., Alternative 4A, 4B, and 4C), as noted above. Each timeframe is presented as its own alternative in the detailed analysis to facilitate comparisons. A description of the alternatives retained for detailed analysis with estimated costs are presented as follows. Because each alternative will leave levels of groundwater contaminants in place for a period of time, identical ICs and wellhead treatment are proposed for each remedial alternative.

2.9.1 Alternative 1: No Action

Estimated Capital Cost:	$ 0
Estimated O&M Cost:	$ 0
Present Worth:	$ 0

CERCLA and the NCP require that a No Action alternative be evaluated at every site to establish a baseline for the comparison of other remedial alternatives. Under this alternative, no remedial action would take place.

2.9.2 Alternative 2: Limited Action with MNA

Estimated Capital Cost:	$ 84,500
Estimated O&M Cost:	$ 605,700
Present Worth:	$ 690,200

(Calculated using a 7% discount rate)

Alternative 2 is a combination of MNA and ICs, which includes institutional and access restrictions, public education, emergency provisions, and the current PTA well head treatment system, as well as long-term monitoring of the groundwater and surface water. No active treatment would be implemented to remove contaminants from groundwater at the site. Rather, monitoring of groundwater and surface water for natural attenuation parameters would verify that contaminants are being attenuated. It was estimated, using the site-specific groundwater model that it may take up to 170 years to achieve compliance with groundwater ARARs. Therefore, ICs must be implemented while surface water and groundwater quality does not meet ARARs to minimize risk to potential receptors.

Alternative 2 will include:

- **MNA**
- **ICs**

Elements of MNA will include:

- Treatment of the entire plume until all ARARs are complied with
- Redox zonation and full MNA study including groundwater and surface water monitoring
- Well maintenance (including closure of unnecessary wells)

- MNA data reports
- Closure reports
- Closeout reports

The details presented here will be executed for all alternatives that include MNA. In the interest of streamlining this text, these details will not be repeated for every alternative, including MNA.

Elements of ICs will include:

- Exposure restrictions
- Excavation restrictions
- Access restrictions
- Public education
- Incorporation of all data into IRP office's GIS system
- Emergency provisions
- Well head treatment
- Potable well water monitoring
- Two rounds of indoor-air sampling to monitor vapor intrusions associated with the Area D plume

The details presented here will be implemented for all alternatives that include ICs. In the interest streamlining this text, these details will not be repeated for every alternative, including ICs.

2.9.3 Alternative 3: Mass Extraction Pump and Treat System and Limited Action with MNA

2.9.3.1 Alternative 3A: Mass Extraction Pump and Treat System and Limited Action with MNA (plume treatment within 80 years)

Estimated Capital Cost:	$ 555,470
Estimated O&M Cost:	$ 5,985,240
Present Worth:	$ 6,541,000

(Calculated using a 7% discount rate)

Alternative 3A modifies the current pump and treat hydraulic barrier to an aggressive mass extraction pump and treat system. This aggressive treatment is concentrated in the vicinity of the hot spot and is combined with simultaneous MNA in the other regions of the plume. This alternative was designed to bring Area D groundwater into compliance within 80 years and surface water in less than 3 years. Much of the plume, including the groundwater near well 92-3, will be in compliance after 50 years of pumping.

In this alternative, a total of eight extraction wells will pump contaminated groundwater to the treatment plant. Five of the eight extraction wells will be placed in the area of the hot spot. One well will be installed in the vicinity of well 92-12, and one well will be installed between WW-3 and WW-4. Current extraction well WW-3 also will be utilized. These wells will be pumped at a combined capacity of 210 gpm. Once at the treatment plant, contaminated groundwater passes through the multi-media filter before entering the air stripper, where most of the VOCs are removed. Groundwater is then passed through vapor or liquid phase carbon treatment units prior to discharge to surface water.

Alternative 3A will include:

- **MNA**
- **ICs**

- **Pump and Treat**

Elements of pump and treat system will include:

- Installation of additional pumping wells (8 Total Extraction Wells)
- Upgrading existing facility to accommodate additional pumpage
- Air stripping/carbon filtration/discharge
- Performance monitoring (groundwater and surface water)
- Operation and Maintenance (O&M)
- Progress Reports

2.9.3.2 Alternative 3B: Mass Extraction Pump and Treat System and Limited Action with MNA (plume treatment within 70 years)

Estimated Capital Cost:	**$ 731,520**
Estimated O&M Cost:	**$ 6,091,190**
Present Worth:	**$ 6,823,000**

(Calculated using a 7% discount rate)

Alternative 3B modifies the current pump and treat hydraulic barrier to a mass extraction pump and treat system designed for the most aggressive mass removal of contaminants from Area D groundwater sustainable by the aquifer. This aggressive treatment is concentrated in the vicinity of the hot spot and is combined with simultaneous MNA in the other regions of the plume to achieve the RAOs. This alternative was designed to bring Area D groundwater into compliance within 70 years and surface water in less than 3 years. Much of the plume, including the groundwater near well 92-3, will be in compliance after 45 years of pumping.

In this alternative, a total of 14 extraction wells will pump contaminated groundwater to the treatment plant. Ten of the 14 extraction wells will be placed in the area of the hot spot. One well will be installed in the vicinity of well 92-12, and one well will be installed between WW-3 and WW-4. Current extraction wells WW-2 and WW-3 also will be utilized. These wells will be pumped at a combined capacity of 275 gpm. This pumping scenario is the maximum that the site-specific model indicates the aquifer is capable of sustaining. Once at the treatment plant, contaminated groundwater passes through the multi-media filter before entering the air stripper, where most of the VOCs are removed. Groundwater is then passed through vapor or liquid phase carbon treatment units prior to discharge to surface water.

Alternative 3B will include:

- **MNA**
- **ICs**
- **Pump and Treat**

Elements of pump and treat will include:

- Installation of additional pumping wells (14 Total Extraction Wells)
- Upgrading existing facility to accommodate additional pumpage
- Air stripping/carbon filtration/discharge
- O&M
- Performance monitoring (groundwater and surface water)
- Progress Reports

2.9.4 Alternative 4: Six Phase Heating with SVE and Enhanced Bioremediation using HRC and Limited Action with MNA

2.9.4.1 Alternative 4A: Six Phase Heating with SVE and Enhanced Bioremediation using HRC and Limited Action with MNA (plume treatment within 85 years)

Estimated Capital Cost: **$ 4,182,400**

Estimated O&M Cost: **$ 1,957,500**

Present Worth: **$ 6,140,000**

(Calculated using a 7% discount rate)

Alternative 4A consists of simultaneously implementing a three-phased approach to remediate the entire Area D groundwater plume. The alternative was designed to achieve compliance with the RAOs in the groundwater and surface water in approximately 85 years. In order to achieve compliance in this timeframe, two active technologies had to be combined with MNA to treat the entire plume. The first phase of remediation consists of actively treating the majority of contamination in the core of the hot spot, confined to an area at the base of the unconfined aquifer, through the use of six phase heating. The second phase of remediation includes actively treating a larger, targeted area surrounding the hot spot core with enhanced bioremediation using HRC injections in a series of barriers. The third phase of the remediation consists of MNA in the contaminated area of the plume not treated in phase 1 and 2.

Using the site-specific model, it was determined that the process of actively treating an area of 135,000 square feet in the region of highest contamination to a TCE concentration of 70 to 100 parts per billion (ppb), could be combined with MNA to facilitate overall cleanup in the plume within the given timeframe. The most highly contaminated groundwater within the targeted area will be actively remediated with six phase heating and SVE. This hot spot measures approximately 23,400 square feet within the larger targeted area. An additional area of approximately 109,000 square feet of the plume requires aggressive treatment in order to achieve ARARs within the 85-year cleanup timeframe. The injection of HRC into the subsurface in a series of barriers will enhance bioremediation (to facilitate mass removal by reductive dechlorination) of the chlorinated VOCs. The remaining contaminated groundwater will be treated with MNA. Six phase heating with SVE will require less than one year of heating to remediate the core of the hot spot of the plume; whereas, HRC is expected to remediate the larger targeted area in less than 5 years (assuming two subsequent injections). MNA will be treating the residual contamination at the site for the remaining 80 years. The currently configured hydraulic barrier pump and treat system would be shut down upon implementation of this alternative.

The six phase heating technology is owned by Thermal Remediation Services. In six phase heating, arrays of electrodes are used to create steam by raising the temperature of groundwater using electrical current. Water vapor and VOCs are then removed from the soil through vapor extraction wells. Extracted vapor is treated with carbon and remaining vapor is condensed and discharged to the sanitary sewer. Implementation of six phase heating with SVE will require the installation of 67 electrodes in six-point arrays, co-located with vapor extraction wells and 13 temperature monitoring wells.

Due to high voltage required for the six phase heating system, a six-foot high chain link fence will be installed around the perimeter of the treatment area with signs informing the public of the hazards and high voltage involved in operation of the technology.

Alternative 4A will include:

- **MNA**
- **ICs**
- **Six Phase heating with SVE**
- **Bioremediation using HRC**

Elements of Six Phase heating with SVE will include:

- Installation of heating electrodes, temperature monitoring wells, and vapor extraction wells (treatment of 135,000 square foot area)
- Treatment of the extracted vapor with carbon
- Implementing Engineering controls to protect the public from the electrical components of the heating system
- Performance monitoring (groundwater and surface water)

Elements of enhanced bioremediation will include:

- Injection of HRC (+ 2 re-injections)
- Performance monitoring (groundwater and surface water)

2.9.4.2 Alternative 4B: Six Phase Heating with SVE and Enhanced Bioremediation using HRC and Limited Action with MNA (plume treatment within 55 years)

Estimated Capital Cost:	**$ 4,657,100**
Estimated O&M Cost:	**$ 2,095,900**
Present Worth:	**$ 6,753,000**

(Calculated using a 7% discount rate)

Alternative 4B, similar to Alternative 4A, consists of simultaneously implementing a three-phased approach to remediate the entire Area D groundwater plume. The alternative was designed to achieve compliance with the RAOs in the groundwater and surface water in approximately 55 years. In order to achieve compliance in this timeframe, two active technologies had to be combined with MNA to treat the entire plume. As in Alternative 4A, the phases consist of six phase heating, enhanced bioremediation using HRC injections in a series of barriers, and MNA.

Using the site-specific model, it was determined that the process of actively treating an area of 174,500 square feet in the region of highest contamination to a TCE concentration of 19 ppb could be combined with MNA to facilitate overall cleanup in the plume within 55 years. Note that this is an increased area and a lower cleanup goal compared to Alternative 4A. The most highly contaminated groundwater within the targeted area will be actively remediated with six phase heating and SVE. This hot spot measures approximately 23,400 square feet within the larger targeted area. An additional area of approximately 150,000 square feet of the plume requires aggressive treatment in order to achieve ARARs within the 55-year cleanup timeframe. The injection of HRC into the subsurface in a series of barriers will enhance bioremediation (to facilitate mass removal by reductive dechlorination) of the chlorinated VOCs. The remaining contaminated groundwater will be treated with MNA. Six phase heating with SVE will require less than one year of heating to remediate the core of the hot spot of the plume, whereas HRC is expected to remediate the targeted area in less than 5 years (assuming two subsequent injections). MNA will be treating the residual contamination at the site for the remaining 50 years. The currently configured hydraulic barrier pump and treat system would be shut down upon implementation of this alternative.

Implementation of six phase heating with SVE will require the installation of 67 electrodes in six-point arrays, co-located with vapor extraction wells and 13 temperature monitoring wells. Due to the high voltage required for the six phase heating system, a six-foot high chain link fence will be installed around the perimeter of the treatment area with signs informing the public of the hazards and high voltage involved in operation of the technology.

The enhanced bioremediation phase of this alternative will use a series of ten successive HRC barriers, mainly downgradient of the six phase heating treatment area. HRC injections within the designated targeted area will consist of direct-push injections and 88 re-application wells. Barriers 1 and 3 will be comprised of a combination of both direct-push and re-injection wells. Direct-push injections are split between shallow (15 to 30 ft bgs) and deep (30 to 62 ft bgs) injections. A total of 40 and 48 wells will be installed in barrier 1 and 3, respectively, in the deep interval (88 total), whereas the shallow interval will be applied using 66 direct-push injections in each. Up to ten additional direct-push injections may be required in the deeper intervals in these two barriers.

Alternative 4B will include:

- **MNA**
- **ICs**
- **Six Phase heating with SVE**
- **Bioremediation using HRC**

Elements of Six Phase heating with SVE will include:

- Installation of heating electrodes, temperature monitoring wells, and vapor extraction wells (treatment of 174,500 square foot area)
- Treatment of the extracted vapor with carbon
- Implementing engineering controls to protect the public from the electrical components of the heating system
- Performance monitoring (groundwater and surface water)

Elements of enhanced bioremediation will include:

- Injection of HRC (+ 2 re-injections)
- Performance monitoring (groundwater and surface water)

2.9.4.3 Alternative 4C: Six Phase Heating with SVE and Enhanced Bioremediation using HRC and Limited Action with MNA (plume treatment within 35 years)

Estimated Capital Cost: **$ 5,009,300**

Estimated O&M Cost: **$ 2,159,700**

Present Worth: **$ 7,169,000**

(Calculated using a 7% discount rate)

Alternative 4C, similar to Alternatives 4A and 4B, consists of simultaneously implementing a three-phased approach to remediate the entire Area D groundwater plume. The alternative was designed to achieve compliance with the RAOs in the groundwater and surface water in approximately 35 years. In order to achieve compliance in this timeframe, two active technologies had to be combined with MNA to treat the entire plume. As in Alternative 4A, the phases consist of six phase heating, enhanced bioremediation using HRC injections in a series of barriers, and MNA.

Using the site-specific model, it was determined that active treatment of an area of approximately 228,000 square feet in the region of highest contamination to a TCE concentration of 6 ppb could be combined with MNA to facilitate overall cleanup in the plume within 35 years. Note that this is an increased area and a lower cleanup goal compared to Alternatives 4A and 4B. The most highly contaminated groundwater within the targeted are will be actively remediated with six phase heating and SVE. This hot spot measures approximately 23,400 square feet within the larger targeted area. An additional area of approximately 214,000 square feet of the plume requires aggressive treatment in order to achieve ARARs within the 35-year cleanup timeframe. The injection of HRC into the subsurface in a series of barriers will enhance bioremediation (to facilitate mass removal by reductive dechlorination) of the chlorinated VOCs. The remaining contaminated groundwater will be treated with MNA. Six phase heating with SVE will require less than one year of heating to remediate the core of the hot spot of the plume; whereas, the HRC is expected to remediate the targeted area in less than 5 years (assuming two subsequent injections). MNA will be treating the residual contamination at the site for the remaining 30 years. The currently configured hydraulic barrier pump and treat system would be shut down upon implementation of this alternative.

Implementation of six phase heating with SVE will require the installation of 67 electrodes in six-point arrays, co-located with vapor extraction wells and 13 temperature monitoring wells. Due to high voltage required for the six phase heating system, a six-foot high chain link fence will be installed around the perimeter of the treatment area with signs informing the public of the hazards and high voltage involved in operation of the technology.

Operation of the six phase heating and SVE system will require continuous electricity during heating. Replacement of the vapor and liquid phase carbon for polishing will be required periodically. The enhanced bioremediation phase of this alternative will use a series of 13 HRC barriers. Ten barriers will be located mainly downgradient of the six phase heating treatment area. The additional three barriers will be located in the vicinity of well 92-12. HRC injections within the designated targeted area will consist of direct-push injections and 88 re-application wells. Barriers 1 and 3 will be comprised of a combination of both direct-push and re-injection wells. Direct-push injections are split between shallow (15 to 30 ft bgs) and deep (30 to 62 ft bgs) injections. A total of 40 and 48 wells will be installed in barriers 1 and 3, respectively, in the deep interval (88 total); whereas, the shallow interval will be applied using direct-push. Up to ten additional direct-push injections may be required in the deeper intervals in these two barriers.

Alternative 4C will include:

- **MNA**
- **ICs**
- **Six Phase heating with SVE**
- **Bioremediation using HRC**

Elements of Six Phase heating with SVE will include:

- Installation of heating electrodes, temperature monitoring wells, and vapor extraction wells (treatment of 228,000 square foot area)
- Treatment of the extracted vapor with carbon
- Implementing Engineering controls to protect the public from the electrical components of the heating system
- Performance monitoring (groundwater and surface water)

Elements of enhanced bioremediation will include:

- Injection of HRC (+ 2 re-injections)
- Performance monitoring (groundwater and surface water)

2.9.5 Alternative 5: PTW with Limited Action and MNA

Estimated Capital Cost:	**$ 2,672,621**
Estimated O&M Cost:	**$ 943,520**
Present Worth:	**$ 3,616,141**

(Calculated using a 7% discount rate)

Alternative 5 consists of Limited Action and MNA of the plume and a PTW, near the discharge point. The PTW, to be comprised of zero-valent iron filings, will prevent any contaminants from passing through the PTW at levels that would lead to surface water ARAR exceedances in Green Pond Brook. The design will ensure the reduction in concentration of contaminants as measured in the stream to an acceptable level. In place, the wall will immediately serve as a barrier and will facilitate chemical dehalogenation of the chlorinated solvents in groundwater. The TCE sorbed to aquifer sediments downgradient of the PTW may continue to affect the concentration of TCE discharging to Green Pond Brook for a period of time. However, the TCE associated with the sorbed sediments will slowly be reduced in concentration as water exiting the PTW moves through the sediments. A performance standard for the wall will be reduction of chlorinated solvents within the wall to acceptable levels. The PTW will remain in place until the requirements in the exit strategy are satisfied. The second performance standard will be based on the hydraulic performance of the wall. The wall will be tested to ensure that the flow of groundwater through the wall meets design specifications. The interim-action hydraulic barrier pump and treat system will be shut-down upon the installation of the PTW and "mothballed" until it is demonstrated that the PTW is functioning as intended.

The suggested design of the PTW will require the excavation of contaminated soil parallel to GPB to allow for the insertion of iron-filings to an estimated depth of 30 bgs in the northern section of the wall and 20 ft bgs in the southern section. The estimated volume of iron for the suggested design of the wall (estimated as being 600 ft in length) is a large portion of the capital cost of this alternative. See **Figure 5** for a depiction of the suggested location and length of the PTW.

The suggested dimensions (length, depth and thickness) were estimated based on the preliminary draft results of a 2003 PTW Pre-Design Investigation. The final dimensions of a PTW will not be determined until the design is complete.

A sufficient amount of iron is required for the wall to reduce chlorinated solvents to acceptable levels. The required iron mass is based on the residence time of the contaminant within the wall. Sand will be mixed with the iron to bring the wall thickness to a manageable construction thickness.

The groundwater flow and transport model predicts that levels of TCE in the hot spot will be above groundwater ARARs for up to 170 years. However, concentrations of COCs next to the stream are not as high as in the hot spot. Therefore, the solvents in that area will attenuate sooner than in the hot spot. The predicted TCE concentrations in surface water of GPB are predicted to be below the ARAR of 1.08 µg/L in the first year of the MNA simulation. Following the shutdown of the hydraulic barrier pump and treat, TCE concentrations in GPB are predicted to exhibit some rebound (predicted increase 0.125 µg/L to 0.32 µg/L). Therefore simulations predict that the surface water concentrations of TCE will be below the ARARs both before and after shutdown of the pump and treat.

The PTW does not require any maintenance. However, if breakthrough of the wall results in contaminant concentrations in GPB at levels above ARARs or that would result in unacceptable risk, replacement or repair of the wall may be necessary. Monitoring of upgradient and downgradient wells and wells within the PTW will ensure the wall is functioning properly. A suggested total of 22 wells will be sampled monthly during the first quarter following installation, semi-annually for 15 years, and annually for 20 years. Groundwater samples will be analyzed for VOCs and several inorganic parameters [including several metals, anions, alkalinity, total dissolved solids, total suspended solids, total organic compound (TOC), and DOC] to ensure that breakthrough does not occur.

Groundwater level measurements will be taken to monitor flow as it relates to the wall and ensure that the plume is not bypassing the wall. Measurements will be taken every two weeks for the first quarter following installation, and then every two months for 2.75 years, followed by semi-annual monitoring for 12 years, and annual monitoring for 20 years.

Alternative 5 also includes Limited Action, including the passive attenuation of the plume. The Limited Action will be a combination of MNA and ICs, which includes continued implementation of the approved CEA, access restrictions, public education, emergency provisions, and the current PTA well head treatment system. Monitoring of groundwater and surface water for natural attenuation parameters would verify that contaminants are being biodegraded. ICs would be implemented until concentrations of the chemicals of concern in groundwater meet ARARs.

Alternative 5 will include:

- **MNA**
- **ICs**
- **Implementing a PTW**

Elements of the PTW will include:

- Excavation/installation of the PTW

- Installation of monitoring wells to aid in performance monitoring
- Performance monitoring (groundwater and surface water)

2.10 COMPARITIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Section 300.430(e) of the NCP lists nine criteria against which the remedial alternatives must be assessed. The acceptability or performance of each alternative against the criteria is evaluated individually so that relative strengths and weaknesses may be identified. The criteria are as follows:

1. Protection of human health and the environment;
2. Compliance with ARARs;
3. Long-term effectiveness and permanence;
4. Reduction of toxicity, mobility, or volume through treatment;
5. Short-term effectiveness;
6. Implementability;
7. Cost;
8. Regulatory acceptance; and,
9. Community acceptance.

The NCP [Section 300.430(f)] states that the first two criteria, protection of human health and the environment and compliance with ARARs, are "threshold criteria" which must be met by the selected remedial action unless a waiver can be granted under Section 121(d)(4) of CERCLA. Criteria three through seven are "primary balancing criteria," and the trade-offs within this group must be balanced. The preferred alternative will be the alternative that is protective of human health and the environment, is ARAR-compliant, and provides the best combination of primary balancing attributes. The final two criteria, regulatory and community acceptance, are "modifying criteria" that are evaluated following the comment period on the Proposed Plan.

The following discussion provides a synopsis of the detailed evaluation of the remedial alternatives presented in the *Final Area D Groundwater FS* (IT, 2003).

2.10.1 Overall Protection of Human Health and the Environment

Alternative 1 will not meet this criterion because no actions are taken to eliminate, reduce or control exposure pathways.

Alternatives 3A and 3B, mass extraction pump and treat system, and Alternatives 4A, 4B, and 4C, six phase heating and enhanced bioremediation with HRC, are all equally protective of the environment due to their aggressive treatment of the majority of the contaminant mass in groundwater coupled with MNA polishing. Timeframes for groundwater cleanup vary from 35 to 85 years and protection from surface water contamination is less than 5 years.

Alternative 2, limited action with MNA, does not include any active treatment of the plume. Alternative 5, permeable treatment wall, relies on natural groundwater flow. Therefore, any hazards posed to human health or the environment will not be completely mitigated in groundwater for approximately 170 years under Alternatives 2 and 5. Alternative 5 immediately increases the protection of human health and the environment from exposure to the surface water contamination.

2.10.2 Compliance with ARARs

Alternative 1, No Action, does not comply with ARARs. Alternatives 3A, 3B, 4A, 4B, and 4C would equally meet chemical-specific ARARs for groundwater, with the time to achieve compliance ranging from 35 to 85 years, and surface water in less than 5 years. Similarly, Alternative 5 would meet chemical-specific ARARs in groundwater, with the time to achieve compliance in 170 years, whereas surface water ARARs would be achieved immediately. All alternatives, with the exception of Alternative

1, include ICs to assure protection of human receptors. The action- and location-specific ARARs would be met by Alternatives 3A, 3B, 4A, 4B, 4C, and 5 with the proper permit equivalents.

2.10.3 Long-term Effectiveness and Permanence

Alternative 1 provides no long-term effectiveness or permanence. Alternatives 2, 3A, 3B, 4A, 4B, 4C, and 5 would all provide permanent reduction in risk and achieve the RAOs. Alternatives 2 and 5 will achieve long-term effectiveness after 170 years. Alternatives 3, 4, and 5 remove the majority of the contaminant mass actively in combination with Alternative 2 to remediate the site more quickly than Alternative 2 alone.

Alternatives 2, 3A, 3B, 4A, 4B, 4C, and 5 will achieve the reduction of risk with the proper implementation of ICs to be outlined in the site-specific Land Use Control Implementation Plan (LUCIP).

2.10.4 Reduction in Toxicity, Mobility or Volume through Treatment

This evaluation criterion refers to a reduction in toxicity, mobility, or volume through treatment, as defined by the CERCLA guidance of the NCP. All of the remedies, except Alternatives 1 and 2, which include no active treatment, satisfy these criteria. Alternatives 4A, 4B, and 4C provide the most aggressive treatment, by desorbing and volatilizing contaminants in the area of the hot spot combined with enhanced bioremediation and MNA. Alternatives 3A and 3B remove contaminants from the groundwater and treat them using in-situ and ex-situ methods. The contaminants themselves are not actually destroyed, but are transferred from water to air to the solid phase. Alternatives 3A and 3B comply with the CERCLA guidance and the NCP, but the treatment goals are not achieved until after 70 to 80 years. Alternative 5 is a passive form of treatment that relies on the natural velocity of groundwater flow to pass through the wall. Therefore, the cleanup timeframe is equivalent to Alternative 2. The goal of Alternative 5 is achievement of all of the RAOs by destroying COCs in groundwater that flows through the wall and precluding access to contaminated groundwater as it naturally degrades.

2.10.5 Short-term Effectiveness

Alternatives 1 and 2 do not pose any hazards to workers in the short-term. Of the engineered remedial alternatives, Alternatives 4A, 4B, 4C, and 5 pose the greatest safety hazards when compared to the other technologies. Construction activities associated with Alternatives 4A, 4B, and 4C require installation of extraction wells and a high voltage power line. With adherence to a site-specific health and safety plan, the hazards will be minimized. Alternatives 4A, 4B, and 4C also involve injection of material into the aquifer, which pose risks associated with the contaminated media and the injection solution. Alternatives 3A and 3B would have limited hazards associated with them because the existing pump and treat system will be incorporated for mass removal of the contaminants from the hot spot. The only construction activities associated with those alternatives would be installation of additional wells at the source of contamination for extraction of the groundwater and the piping from the wells to the treatment plant. All hazards associated with the implementation and O&M of active remediation systems are minimal if the health and safety plan is followed correctly. Alternative 5 involves extensive excavation of soils and construction of a PTW, and would present a greater short-term risk due to the potential to generate dust. Short-term impact to the sediments and surface water of Green Pond Brook would also be a concern. This impact would be largely mitigated by engineered controls.

2.10.6 Implementability

Alternative 1 would require no resources to implement. Alternative 2 requires minimal resources and only a limited effort (due to monitoring requirements). Mass removal at the source of the contamination by Alternatives 4A, 4B, and 4C, as well as 3A and 3B require intensive labor and design to implement the alternatives effectively. Since six phase heating is a relatively new technology, it will require additional negotiations with the regulatory agencies to obtain necessary permits. Excavation of soils under Alternative 5 would be challenging since the construction would be taking place within a close proximity of GPB and on active golf course grounds. Because the excavation will take place in close proximity to GPB, controls (i.e., silt fencing) must be put in place to preclude damage to the brook. Because the action is on an active golf course, controls must be put in place (i.e. fencing) to ensure the health and safety of golfers.

2.10.7 Cost

Present worth (discount rate of 7%) for each alternative is presented. With the exception of Alternative 1, Alternative 2 results in the lowest cost, followed by Alternative 5.

Alternative 1: No Costs associated with this alternative.

Alternative 2:

Present Worth $690,200
Capital Cost $84,500

Alternative 3A:

Present Worth $ 6,541,000
Capital Cost $ 555,470

Alternative 3B:

Present Worth $ 6,823,000
Capital Cost $ 731,520

Alternative 4A:

Present Worth $ 6,140,000
Capital Cost $ 4,182,400

Alternative 4B:

Present Worth $ 6,753,000
Capital Cost $ 4,657,100

Alternative 4C:

Present Worth $ 7,169,000
Capital Cost $ 5,009,300

Alternative 5:

Present Worth $ 3,616,141
Capital Cost $ 2,672,621

2.10.8 State Acceptance

Based on NJDEP approval of the Area D Groundwater FS, it is anticipated that the NJDEP will concur with the selection of the preferred remedial alternative for Area D Groundwater.

2.10.9 Community Acceptance

Community acceptance is addressed in the **Responsiveness Summary** of this ROD.

2.11 PRINCIPAL THREAT WASTES

The NCP establishes an expectation that USEPA will use treatment to address the principal threats posed by a site wherever practicable [NCP §300.430(a)(1)(iii)(A)]. Identifying principal threat wastes combines concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, non-principal wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure.

The issue whether the contaminated groundwater present at Area D meets the USEPA's definition of mobile source material is relative; as the source of the contaminants have been removed and the media being dealt with under the scope of this ROD is the mobilized contaminants (rather than a mobile source). However, discharge of the plume to the water of GPB could potentially constitute a threat to human health. The alternatives presented in **Section 2.10** address the contaminants in Area D groundwater in the following manner:

- Alternative 1: No Action – Does not address the possible principal threat waste;
- Alternative 2: Limited Action with MNA – Addresses the possible principal threat waste through the natural degradation of the contaminant compounds;
- Alternative 3: Mass Extraction Pump and Treat System with Limited Action MNA – Addresses the possible principal threat waste by extracting the groundwater and removing the contaminants;
- Alternative 4: Six Phase Heating – Addresses the possible principal threat waste by creating a subsurface environment where contaminants are thermally and biologically destroyed; and,
- Alternative 5: PTW with Limited Action and MNA – Addresses the possible principal threat waste by creating a subsurface environment where the contaminants are chemically and biologically destroyed.

2.12 SELECTED REMEDY

This ROD represents the Selected Remedy for Area D groundwater at PTA, in Rockaway Township, New Jersey, developed in accordance with CERCLA as amended and consistent with the NCP. This decision is based on the administrative record for the site. The Selected Remedy for this site is Alternative 5: PTW that will attain the remedial goal of protecting the surface water of Green Pond Brook with Limited Action and MNA. A detailed description of the preferred remedial action is provided in this section.

The total project estimated capital cost, if approved, is $ 2,672,621, the sum total of which will be paid by the U.S. Army for the Department of Defense.

Alternative 5 is the preferred alternative for Area D groundwater because it provides the best balance between the assessed criteria while still providing overall protection of human health, ecological receptors, and the environment.

2.12.1 Summary of the Rationale for the Selected Remedy

Alternative 5, PTW with Limited Action and MNA, represents the best balance of the nine evaluation criteria considered in **Section 2.10**. Active remediation of groundwater in the Area D plume is anticipated to be very difficult due primarily to the large mass of TCE sorbed to and diffused into the aquifer sediments. The TCE has been shown to take extremely large amounts of time to desorb, rendering pumping technologies inefficient in removing the contaminant. Further, the difficulty in delivering amendments [such as HRC, Oxygen Release Compound (ORC), etc.] to the silty formation near the base of the unconfined aquifer makes biological treatment difficult. Although the HHRA for groundwater predicts there is risk, currently Army land use controls and wellhead treatment preclude the exposures modeled in the risk assessment. It is the Army's opinion that no unacceptable risk was modeled for exposure to surface water. Therefore, one of the primary factors in the selection of the preferred remedy was compliance with ARARs. Compliance with groundwater ARARs is either going to be extremely costly or take large amounts of time. Compliance with surface water ARARs can be achieved in shorter amounts of time with an initial cost that is an order of magnitude less than groundwater treatment options. Based on these considerations, Alternative 5 was selected. Alternative 5 can attain surface water compliance within a relatively short period of time for a capital cost of $2,672,621. Under this alternative, groundwater clean-up goals will be attained, but over a long period of time, through MNA. Five-year reviews will need to be completed for this remedy. Per the interagency agreement between the USEPA and the Army, these reviews are to be performed by the USEPA although the Army may provide technical information. As part of the five-year review process, new and evolving technologies will be examined to determine if an alternative to MNA exists that is more cost effective.

With the exception of Alternative 1 (No Action), each of the alternatives analyzed in detail would meet the RGs. In addition, Alternatives 3A, 3B, 4A, 4B, 4C, and 5 were found to be adequately protective of human health, ecological receptors, and the environment; to provide both short-term and long-term effectiveness; to reduce toxicity, mobility, and/or volume of contaminants; to be capable of being implemented without any significant obstacles; and to be compatible with applicable legal and institutional requirements.

The PTW will protect the surface water from discharge of contaminated groundwater in the shortest time. Although Alternative 5 relies on the natural velocity of groundwater to reach the treatment wall, receptors will be protected by wellhead protection at well 131. Degradation of contaminants by MNA will be closely monitored in accordance with the exit strategy. Therefore, the combination of MNA, ICs (including well head protection), and the PTW would likely comply with the groundwater ARARs over the long-term. PTWs have been implemented at many sites similar to Area D and do not present any significant short-term risks to the surrounding community, environment, or site workers. Therefore, Alternative 5 is recommended as the preferred alternative for Area D.

Based on information currently available, the lead agency believes the Preferred Alternative meets the threshold criteria and provides the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. The Army expects the Preferred Alternative to satisfy the following statutory requirements of CERCLA § 121(b): 1) be protective of human health and the environment; 2) comply with ARARs; 3) be cost effective; 4) utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and, 5) satisfy the preference for treatment as a principal element.

2.12.2 Detailed Description of the Selected Remedy

The selected remedy consists of treatment of contaminated groundwater using iron filing reactive wall that will attain the remedial goal of protecting the surface water of Green Pond Brook. The continuous iron wall will be installed next to the GPB to achieve surface water regulatory limits in the GPB for the VOCs present in the plume. The permeable wall of granulated iron will be installed via a method to be specified in the remedial design. The wall will likely be installed via injection or long reach excavator. The actions associated with this alternative include:

- Soil excavation;
- Installation of the permeable treatment wall;
- Erosion and sediment controls;
- Sampling/monitoring of the downgradient surface water;
- ICs;
- Excavated soil handling/ storage/disposal; and,
- Environmental Permit-Equivalents.

Figure 5 shows the proposed location for the PTW system.

2.12.2.1 Institutional Controls

ICs for this alternative include institutional restrictions, access restrictions, and public education. Most of these measures have been addressed in seven elements of the Land Use Restrictions policies for PTA. The seven elements are Site Clearance and Soil Management Procedures; Unexploded Ordnance (UXO) Clearance Procedures; Master Plan Regulations; PTA GIS Database; PTA Base Access Restrictions; PTA Safety Program; and Army Military Construction Program. These ICs have been developed with a consideration of all reasonably anticipated land uses in this area; these include administrative and industrial military operations, outdoor recreation/golf course, and residential. It should be noted that land use controls to be implemented in harmony with this remedy would prohibit any new residential land usage where there would be an exposure to unacceptable risk.

An IC Remedial Design shall be developed that includes the short and long-term actions needed to implement, report on, maintain and enforce the ICs and outline the responsibilities for those actions. The map in **Figure 6** presents a delineation of the geographic area to which the ICs will apply. The ICs will be enforced/practiced for the amount of time required for this alternative to achieve the RGs (170 years, as estimated in Section 2.9.5). The ICs will be developed in order to meet the following performance objectives: 1) Prohibit excavation without safeguards in all areas below the water table in the plume footprint through the soil management procedure; 2) Implementation of a CEA to the NJDEP specifically addressing the Area D groundwater plume; 3) Incorporation of all Area D data into the IRP Office GIS system; 4) Compliance with all NJDEP water allocation regulations; and, 5) Continuation of wellhead treatment and monitoring of potable water supply well 131. These ICs will be described in further detail and submitted in an LUCIP that will be submitted as a primary document at approximately the same time as the submission of the formal Remedial Design document. The IC remedial design will be submitted to the EPA as part of the Remedial Design for this action.

2.12.2.2 Site Preparations

Several actions must be taken to prepare the site for installation of the PTW. Since a considerable amount of soil will be excavated from the area of groundwater contamination, a temporary decontamination area will have to be established for equipment, vehicles, and personnel. Since excavation of the soil will be in close proximity to GPB, erosion control measures must be taken to protect the stream. A silt fence will be constructed along the southern boundary of the excavation/installation area and will extend 50 ft in excess on both sides of the wall, for a total length of 700 ft.

2.12.2.3 Planning, Permitting, and Reporting

The PTW system itself will require an engineering design to construct the wall to sufficiently remove the contaminants from the groundwater that passes. In order to implement the PTW alternative, a work plan, health and safety plan, and finally, a closure report will be required. Because this action will take place under CERCLA, permit equivalencies will be reached in lieu of formal permits. Permit equivalents will be reached for all required activities.

2.12.2.4 Construction of the PTW

The 600-ft length required for the wall was estimated based on the groundwater data near the brook, the piezometer study by USGS, and historic surface water concentrations in GPB and a pre-design characterization study that was completed in winter 2003. This data in conjunction with previously collected data will be used in the remedial design. Although the final length and depth of the PTW will be determined as part of the remedial design, current estimates propose a 600-foot wall length with two sections (350 feet long and 20 feet deep in its south section, and 250 feet long and 30 feet deep for the north section) with a maximum iron thickness of 1.6 feet. The thickness and thus the amount of iron required in the PTW will be based on the groundwater residence time required for the contaminants to be sufficiently reduced. Technical and construction oversight would be required prior to and during the installation of the PTW system.

It was estimated that the installation of the PTW will be completed using conventional excavation with Biopolymer shoring. Biopolymer trenching is anticipated to be the most effective mode of installation because it has been successfully implemented for walls of similar depth and in similar geologic formations. The excavation method will be determined during the remedial design phase. Contaminated soil generated during the wall excavation shall be transported off-site and disposed of at a Title D landfill.

It is anticipated that several additional monitoring wells will be required to be installed near or within the wall itself. Proposed monitoring plans were designed based on the *Design Guidance for Application of Permeable Barriers to Remediate Dissolved Chlorinated Solvents* (Gavaskar et al., 1997). In addition to the use of existing wells, it is projected that approximately five additional wells in the unconfined aquifer and two wells in the intermediate aquifer, as well as three wells in the wall itself, will be required. Monitoring will occur to ensure that contamination is not bypassing the wall.

2.12.2.5 Miscellaneous Capital Costs

Additional costs for the PTW system would include the performance of a bench scale test and modeling to determine wall thickness, iron requirements, and lifetime of the wall. Envirometal Technologies (ETI) requires payment of 12% of the capital costs as a licensing fee.

2.12.2.6 O&M of the PTW System

There are no operational costs for the PTW. The lifetime reactivity of the iron is expected to out-live the need for the wall since after 35 years, MNA will decrease groundwater discharge concentrations to a level that will not require remediation.

Groundwater level monitoring and sampling and analysis will provide information regarding the effectiveness of the PTW. Wells would be monitored and sampled for 35 years. Groundwater sampling and monitoring varies over the duration of the 35 years as recommended by the guidance (ITRC, 1997). It is assumed that post-closure sampling will occur for 15 years. Groundwater samples will be analyzed for VOCs and will also require analysis of several inorganic parameters to determine what is being leached out of the wall.

2.12.2.7 Demonstration of MNA

The demonstration of MNA will be performed through the collection of field data, input of the field data into the site conceptual model, and analysis of the groundwater fate and transport model, if necessary. One of the primary tasks to be completed in the demonstration of monitored natural attenuation is field sampling. The anticipated duration of MNA to comply with chemical-specific groundwater ARARs will take approximately 170 years for this alternative since no engineered action would be taken to reduce the mass of the hot spot. The effectiveness of the natural attenuation will be monitored during that time by implementing groundwater and surface water sampling programs.

The groundwater samples will be collected initially from 12 wells during the first eight (8) quarters, then from 10 wells twice per year for the next 30 years and from 8 wells on an annual basis for 88 years, and 5 wells for the remaining 50 years. It should be noted that the number of samples listed here are estimates. The number of wells sampled will be finalized in the long-term monitoring (LTM) plan. Additionally, the LTM plan will outline the plan by which sampling can cease. The LTM plan will contain a detailed exit strategy outlining decision logic for the reduction in the number of samples and the cessation of sampling. When the concentration of COCs falls below the chemical-specific ARAR, groundwater monitoring will be continued for an additional one to three years to ensure the reduced concentration is not the result of seasonal fluctuation. The exit strategy will utilize a statistical approach to ensure the reduction in concentration is valid.

All the samples will be analyzed for VOCs, DO, nitrate, iron (II), sulfate and methane to monitor the attenuation of COCs and the changing redox state of the aquifer. The redox state of the aquifer needs to be monitored to infer the health and activity of the microbial population. As electron donors and terminal electron donors are consumed in the aquifer, the rate of attenuation may change. These changes can be used as a predictor of actual changes to the rate of attenuation of COCs. These parameters ensure monitoring of the plume for regulatory compliance as well as monitoring for changing geochemical and redox state.

Surface water samples will be collected at a rate of eight per year for 10 years to monitor effect of the natural attenuation on surface water. Surface water will be monitored for VOCs. When the concentration of COCs falls below the chemical-specific ARAR, surface water monitoring will be continued for an additional one to three years to ensure the new reduced concentration is not the result of seasonal fluctuation.

Each groundwater monitoring well will be maintained over 170 years and replaced as necessary to provide continuous service.

Samples of indoor air will be collected two additional times from inside buildings over the plume to verify that no unacceptable risk exists in these buildings. (In 1997, indoor air was collected from buildings over the plume and tested to determine if the chlorinated solvents were a risk to building inhabitants. The analysis of these samples determined that there was no unacceptable risk to Area D building inhabitants.)

2.12.2.8 Interim Action Exit Strategy

The implementation of this remedial alternative necessitates a decision regarding the fate of the existing interim pump and treat hydraulic barrier system that, by design, alters the natural hydrogeologic flow of Area D. In addition to the financial burden associated with two concurrent remediation operations, optimal performance of the PTW may require natural flow conditions. Both factors will require an exit strategy for the interim hydraulic barrier pump and treat system currently in operation.

The interim hydraulic barrier pump and treat system will cease operation after the completion of the PTW (pending evaluation by the Army, PTA, USEPA, and NJDEP) and maintained on stand-by status for a period of time, pending Army, PTA, USEPA, and NJDEP concurrence.

At the end of the stand-by period, upon agreement between the Army, PTA, USEPA, and NJDEP that the PTW is working acceptably (i.e., that the interim pump and treat system is no longer required in addition to the PTW, to provide sufficient protection of human health and the environment), the pump and treat system will be dismantled. During the five-year review process, newly available technologies will be evaluated and compared to the selected alternative. The basis of these evaluations will be the results of pilot studies performed within the Area D plume. In the case where the performance of a technology is favorably evaluated from a cost and risk reduction standpoint, a ROD amendment would be issued to implement that technology.

2.12.3 Summary of the Estimated Costs for the Selected Remedy

The costs associated with the preferred alternative for Area D groundwater are summarized as outlined in the following list:

CAPITAL COSTS[8]

➢ **Institutional Actions**	**$115,000**
• Land Use Restrictions	$55,000
• 2 Rounds of Indoor Air Monitoring	$60,000
➢ **Plans/Licenses**	**$351,469**
• PTW Design	$55,000
• PTW Construction Work Plan	$42,480
• Health and Safety Plan	$11,617
• Quality Control Plan	$14,414
• Modify LUCAP	$11,979
• ETI Wall License	$170,978
• LTM Plan	$45,000
➢ **Site Preparation**	**$320,225**
• Mobilization/Demobilization	$51,079
• Construct Working Platform	$269,146
➢ **PTW System**	**$1,885,928**
• Mixing Plant Operation	$129,606
• Wall Excavation	$136,846
• Backfill Wall	$155,485
• Iron Filings (Connelly Iron, Inc.)	$924,161
• Platform/ Excess Slurry Disposal	$250,162
• Monitoring Well Installation	$32,512
• Site Restoration	$73,359
• Wall Administration/Support	$145,810
• Wall Completion/Final Report	$37,987
TOTAL CAPITAL COSTS	**$2,672,621**

[8] The pricing presented assumes that the wall will be constructed using conventional excavation with Biopolymer shoring.

O&M COSTS

➢ **PTW System**	**$512,220**
• PTW Monitoring Reports[†]	$40,000
• Groundwater Sampling and Analytical [‡]	$432,220
• Water Level Monitoring[†]	$40,000
➢ **Demonstration of MNA**	**$322,900**
• Surface Water Sampling	$6,000
• Surface Water Analysis	$24,000
• Groundwater Sampling[*]	$82,000
• Groundwater Analysis[*]	$128,600
• Well Maintenance/Repair	$82,300
➢ **MNA Data Reporting**	**$108,400**
• MNA Data Reports[*]	$55,400
• CERCLA 5-Year Reviews	$53,000
TOTAL PRESENT WORTH O&M COSTS (7% INT.)	**$943,520**

170-YEAR PRESENT WORTH OF ALL COSTS (AT 7% INTEREST) = $3,616,141[9]

The costing information in this section is based on the best available information regarding the anticipated scope of the remedial alternative. Details on the above cost items are presented in Appendix F of the Final FS for Area D. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences (ESD), or a ROD amendment.

2.12.4 Expected Outcomes of the Selected Remedy

It is anticipated that implementation of the PTW will reduce potential risks to human and ecological receptors to within acceptable levels. It is expected that all chlorinated solvent compounds (i.e., the COCs) will undergo degradation upon passage through the PTW. Because of the essentially sessile nature of the plume's hot spot, desorption of VOC compounds from the aquifer sediments will be the only pathway for these contaminants to leach into GPB. Over the life of this remedy, the rate of contaminant desorption is likely to decline. Thus, migration of groundwater contaminants into GPB will be prevented. However, as contaminants will remain in the aquifer sediments at levels exceeding the RGs, uncontrolled use of the site is not provided by completing this action.

2.13 STATUTORY DETERMINATIONS

Under CERCLA §121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment and permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against off-site disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

[†] Present worth through 35 years

[‡] Present Worth through 50 years

[*] Present worth through 170 years

[9] This total present worth differs from that quoted in the FS because the FS included a characterization study that is already funded and completed, also the capital costs associated with the construction of the PTW have been modified based upon more detailed information obtained from the characterization study. Further, the O&M costs shown have been modified since the FS.

2.13.1 Protection of Human Health and the Environment

Because this alternative does not remove the source of contamination and only treats the plume extending into GPB, the environment is still being exposed to TCE and DCE contamination in the groundwater plume. However, since the groundwater will be treated prior to intercepting the surface water, any threat of exposure due to contact with or ingestion of the contaminated surface water will be eliminated. Exposure to the VOCs in the air will still remain a potential threat to human health and the environment, depending on the concentrations. It should be noted that air samples were collected in buildings over the Area D plume in 1997 and measurable amounts of TCE were found in some structures; however, risks calculated using conservative assumptions were within acceptable ranges. VOC emissions, therefore, will have to be periodically measured and its effect on human and environmental receptors evaluated.

2.13.2 Compliance with ARARs

This alternative will comply with the chemical-specific ARARs for groundwater listed in Table 4-1 of the final feasibility study (IT, 2003). These ARARs include state and federal MCLs, federal MCLGs, and state groundwater quality standards. Since the hot spot is not being actively treated, the groundwater plume will be remediated primarily by MNA in 170 years. Chemical specific ARARs for surface water will be met through the installation of the iron-filing wall. These chemical specific ARARs include the New Jersey Surface Water Quality Standards and Federal Water Quality Standards. Chemical specific ARARs for surface water are listed in Table 4-3 of the final FS (IT, 2003).

Location-specific ARARs for Area D are listed in Table 4-5 of the final FS. This list of ARARs is inclusive of all remedial alternatives in the FS some of which are applicable or relevant and appropriate for the implementation of Alternative 5. These location-specific ARARs will be satisfied during construction of the wall in the vicinity of the stream, which is located within wetlands and/or stream encroachment areas, as well as the 100-year floodplain.

Action specific ARARs for all remedial alternatives in the FS are listed in Table 4-7 of the FS (IT, 2003). Action-specific ARARs applicable or relevant and appropriate to Alternative 5 will be met by obtaining appropriate permit equivalents for installation of the reactive wall. All personnel will be properly trained to handle hazardous materials in accordance with Occupational Safety and Health Administration (OSHA) Act 29 C.F.R 1910. Any contaminated excavated soil will be properly stored and disposed offsite to comply with the NJDEP Hazardous Waste Management, RCRA, USEPA, and OSHA regulations for waste storage/disposal/handling and transport.

2.13.3 Cost Effectiveness

In the lead agency's judgment, the Selected Remedy is cost-effective and represents a reasonable value in the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness." (NCP §300.430(f)(1)(ii)(D)). This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility and volume through treatment; short-term effectiveness; regulatory acceptance; and, community acceptance). Overall effectiveness was then compared to costs to determine cost-effectiveness. The relationship of the overall effectiveness of this remedial alternative was determined to be proportional to its costs and hence this alternative represents a reasonable value for the money to be spent.

The estimated present worth cost of the Selected Remedy is in excess of $2,000,000. Although Alternatives 1 and 2 are less expensive, immediate risks to human health and the environment (i.e., surface water impact) are not addressed; therefore, Alternative 5 is cost effective. The Army believes that the Selected Remedy's additional cost provides a significant increase in protection to human health and the environment and is cost-effective.

2.13.4 Utilization of Permanent Solutions and Alternative Treatment Technologies (or Resource Recovery Technologies) to the Maximum Extent Practicable

The Army has determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. The Army has determined that the Selected Remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against off-site treatment and disposal and considering regulatory and community acceptance.

The Selected Remedy employs treatment to eliminate contaminants present at the site. 1,1-DCE, cis-1,2-DCE, PCE, TCE, and VC concentrations in groundwater will be reduced over time. The Selected Remedy satisfies the criteria for long-term effectiveness by plume degradation through MNA while eliminating direct contact exposure pathways via treatment prior to groundwater discharge to GPB. In addition, further reduction of risks could be accomplished through proper enforcement of ICs. The Selected Remedy does not present short-term risks that cannot be effectively controlled through safe work practices. There are no special implementability issues that set the Selected Remedy apart from any of the other alternatives evaluated.

2.13.5 Preference for Treatment as Principal Element

The Selected Remedy addresses principal threats posed by the site through the use of PTW to eliminate the COCs from groundwater prior to its discharge to GPB. Therefore, the statutory preference for remedies that employ treatment as a principal element is satisfied.

2.13.6 Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, statutory reviews will be conducted every five years after remedial action initiation pursuant to NCP §300.430(f)(5)(iii) and CERCLA §121(c). Five-year reviews will ensure that the remedy is, or will be, protective of human health and the environment. The USEPA will be responsible for conducting reviews.

3.0 RESPONSIVENESS SUMMARY

The final component of the ROD is the Responsiveness Summary. The purpose of the Responsiveness Summary is to provide a summary of the stakeholders' comments, concerns, and questions about the Selected Remedy for Area D groundwater and the Army's responses to these concerns.

In general, the community is accepting of the Selected Remedy. Some community concern has been expressed regarding the proper design, installation, and performance monitoring of the PTW portion of the remedy. The Army, USEPA, and NJDEP have considered all comments and concerns summarized below in selecting the final remedy for Area D groundwater at PTA.

3.1 PUBLIC ISSUES AND LEAD AGENCY RESPONSES

As of the date of this ROD, the Army endorses the preferred alternative for Area D groundwater as Installation of a PTW, MNA, and Continued Implementation of Land Use and Access Restrictions. The USEPA and the NJDEP support the Army's plan. Comments received during the public comment period on the Proposed Plan (including the public meeting) are summarized below.

3.1.1 Summary of Comments Received during the Public Meeting on the Proposed Plan and Agency Responses

A public meeting was held on July 17, 2003, at which an explanation of the history of the site and remedial alternatives considered were presented. Specific comments raised during the public meeting are presented in this section (a complete transcript of the meeting is presented in **Appendix A** of this document).

Comment 1: Mr. Bob Cruthers, Denville representative to the Restoration Advisory Board (RAB), inquired if the water being discharged from the pump and treat system is cleaner and better water than that normally flows in GPB.

Reply: The reply was made by Ted Gabel, Project Manager, PTA. Mr. Gabel responded that the effluent from the pump and treat system is cleaner than the GPB surface water because it is filtered. GPB surface water, when tested, generally displays low-level contamination (Mr. Gabel added that the low levels are generally within an acceptable range). The excess risk calculated for this section of GPB was within the USEPA risk range of $1x10^{-6}$ to $1x10^{-4}$, indicating no unacceptable levels of risk. He later added that the water coming out the pump and treat system is filtered by carbon and activated filters, as well as stripped.

Comment 2: Mr. Charles Botti inquired whether contaminants were found in the water from the drinking well (well 131).

Reply: The PTA water supply is sampled in accordance with all State and Federal requirements. The water supply meets all State and Federal drinking water standards. The most recent samples collected of PTA drinking water were collected in 2003. There were no exceedances of MCLs in any of the samples collected from this sampling round. Further information on this topic can be found in the *PTA Water Treatment Facility Report on Water Quality Drinking Water Consumer Confidence Report 2003,* Prepared by US Filter Operating Services for PTA. This report can be found on the PTA website at www.pica.army.mil.gov.

Comment 3: Mr. Botti later inquired about the history of the PTW technology; he was concerned that this may be the first time a PTW will be used to prevent groundwater VOC contamination from discharging to a stream. He also inquired whether the iron-sand mixture would need to be replaced during the life of the PTW. He wanted verification that the PTW with MNA option was expected to require 170 years for degradation of the entire plume. Mr. Botti also requested an explanation as to what prevents the plume from routing around or under the wall, and asked to what depth the PTW will be installed.

Reply: Mr. Douglas Schicho, Project Manager for Shaw, responded that PTWs have been installed and used on full-scale multiple times. He also stated, regarding the iron-sand mixture's longevity, that, "In this case we feel it will be good for the life of the project." He added that because the surface water is almost at its compliance point now, it is not anticipated that the treatment wall will have to remain active for a very long period of time. He cited iron filing wall studies conducted by the patent holder that indicate PTWs of this sort are expected to last on the order of decades. Although there are no PTWs that have been in place for decades yet, the iron is not expected to require replacement or refurbishment in this case. Mr. Schicho confirmed that Mr. Botti had understood correctly that the total anticipated time required for groundwater to meet cleanup goals (NJDEP groundwater criteria) is on the order of 170 years.

In response to the final component of Mr. Botti's question regarding the plume's potential to route around the wall, Mr. Schicho explained that because the PTW will be installed in the downgradient reaches of the plume, and since the wall is more porous than the surrounding soils, the plume will not change its flow direction and would flow through the wall naturally. Mr. Schicho added that because the design hasn't been completed yet, depth of the wall's installation is not known. He explained that for the purposes of planning and the FS, a depth of 26 ft was assumed. He added that the final installation depth would be decided upon in the final design.

Comment 4: Mr. Mark Hiler, Rockaway Township representative to the PAERAB, asked what concentrations of TCE would be expected in GPB if the pump and treat system were not in operation.

Reply: Mr. Schicho responded that the concentrations of TCE in GPB would not be substantially different than what is currently observed with the pump and treat system in operation. He explained that the groundwater model predicts that the concentrations of TCE in GPB would currently be below the cleanup goals. He referred to surface water data from the previous three sampling events. The surface water TCE concentrations from two of the previous three sampling events were below the NJDEP criteria for that media. He explained that without the operation of the pump and treat system, the concentrations are not expected to change drastically and added that if the wall were to be installed and the pump and treat system shut down, the concentrations in GPB would be expected to be below detection limits and below the cleanup goals.

Comment 5: Mr. Charles Botti asked whether the contaminants from the Area D groundwater plume have impacted BSB (which is a tributary to GPB that runs through Area D).

Reply: Mr. Schicho responded that because BSB is upgradient of the TCE source, it has not been affected.

Comment: Mr. Botti inquired about a lagoon (referring to the sediment retention basins in BSB) and its hydrologic significance.

Reply: Mr. Schicho explained that the majority of the TCE came from the drywell on the opposite side of the building from the lagoon and added that the bulk of the contamination in the vicinity of the original source area (i.e., near the dry wells and the lagoons) has "cleaned itself up." The highest concentrations of TCE are now down at 55 ft bgs. Mr. Ted Gabel then added that this summer, the army would be removing contamination from other sources in the sediment, around the sediment basins near Building 61.

Comment 6: Mr. Lee Moreau of PTA who is responsible for Picatinny's Golf Course tendered the following comment: The PTA Golf Club like other golf courses in Morris County have a positive impact on the economy of the county. He also inquired as to the fate of the irrigation and drainage lines in the vicinity of the PTW.

Reply: Mr. Schicho responded, "…the next step in this [remedy implementation process] is public comments. The step after that is designing the wall. So at this point, the exact length, thickness and depth of the wall is undetermined. So, we're not exactly sure how many of the lines will be in the same place as the wall."

Comment: Mr. Moreau further commented that one of the other issues of concern to him was in regard to the project controls. He asked, "Once this is put into place and you've got your controls on it, would people be expected to be able to play on top of that surface once it's restored?"

Reply: Mr. Schicho responded that the only other physical augmentations to the area (besides the wall) that will be required are the monitoring points (wells). He assured Mr. Moreau that no above-surface structural elements would be necessary for the implementation of the PTW.

Comment: Mr. Moreau, upon the realization that Mr. Schicho was familiar with the site, added, "Then, you're familiar with the area, you know the crags we use as a bridge is kind of rickety-rackety. We have uncertain plans to replace it and I just want to make sure that that gets incorporated in the construction plan. You know that happens, so whenever we do replace it, we don't put it in the wrong place, or we put it in a place that you know would not interfere with the project, putting that in. Only last real concern, and I've talked with the folks at Picatinny about this [at length], and that would be the timing of the construction and my ability to influence the period of performance so that it would happen in what is off-peak, off-season. For the very reasons I stated at the very beginning, it does have an economic impact to our community and our ability to reinvest in our community. With that, those are my only comments. Thank you."

Reply: The Army recognizes of the recreational and economic benefits the golf course brings to PTA and the surrounding communities. It is the Army's intention that the installation of the PTW will be coordinated with Mr. Moreau to the extent possible in order to minimize impact on the golfing season and the physical playing surface. The Army intends to maintain communication with Mr. Moreau and his organization regarding the coordination of all phases of construction and implementation of the wall (including monitoring well installation) as well as the sampling events that will be part of the monitoring program.

<u>Comment 7</u>: Mr. Michael Glaab, the community Co-Chair of the PAERAB, offered several comments. In reference to a handout that was distributed to the meeting attendees, he inquired about the anticipated length of the wall (listed as 200 ft in the handout).

Reply: Mr. Doug Schicho responded that the dimensions shown in the fact sheet Mr. Glaab was referring to, were used for planning purposes in the FS. He further stated, "The Army did a study this spring, to collect more data to more carefully design the wall. That design will be done at some point in the near future. So the dimension, that are in [the handout], are conceptual and they may changed based upon the design.

Comment: Mr. Glaab then asked how whether the composition of the reactive media (3:1 sand to iron) listed in the handout was definitively decided upon.

Reply: Mr. Schicho stated that the mixture was not definite. He added that the patent holder for the iron barrier, Envirometal Technologies, ETI, completed a column study with Picatinny groundwater collected this spring as part of the design study. After the results of the column study, and the data report are available, the exact thickness of the wall will be determined along with the exact percentage of iron and sand. Mr. Schicho further stated that optimal iron-sand ratio will vary based upon the groundwater chemistry, the amount of TCE in groundwater and the groundwater flow rate through the wall.

Comment: Mr. Glaab commented further that it appears to him that the established track record for PTWs is around ten years. He commented that with a track record of ten years, he would reasonably expect that the performance of a PTW could be accurately extrapolated out through a ten-year period.

Reply: Mr. Richard Magee, NJCAT, stated that laboratory studies could provide future performance estimates as accurate and temporally further than track-record comparisons.

Mr. Glaab responded, "I'm sure that you will take all these factors into consideration. You've got an established track record of 10 years, so you can do comparisons with what you already have and I'm sure you will put in sufficient iron so that we can at least be relatively assured that there will not be a problem before 10 years have lapsed. We already have examples for 10 years, so we should at least be able to determine what percentage of iron would be desirable to minimize the likelihood of there being a problem at least within 10 years. And then after 10 years, there might be a more advanced technology available which maybe would be more cost-effective anyway."

<u>Comment 8</u>: Mr. Glaab added a final comment regarding the interim action pump and treat system, which initiated the following discussion (presented below). He inquired as to the Army's plans to "mothball" the pump and treat system.

Reply: Mr. Gabel responded that the Army intends to mothball the system (as was stated in the fact sheet handout) until it's determined that the wall is working. Once it has been established that the wall is working according to design and upon regulatory concurrence, the Army plans to remove the equipment that is not needed. He added that the equipment would be kept if there were a need for it. He further stated "…the plan is not to keep the pump and treat system around after we determine the wall is working. It will act as a backup contingency."

Comment: Mr. Glaab asked, "Do you come up with guidelines for determining how long you will keep this mothball -- you don't want to totally disassemble it."

Reply: Mr. Gabel responded, "I agree with that. We haven't determined the exact length of time. It would be a guess on my part, we would work it out with the affected community."

Comment: Mr. Glaab commented, "But I think we can all safely agree that your intent is not to too quickly disassemble it."

Reply: To which Mr. Gabel replied, "Yes. Not too quickly, no."

Comment: Mr. Glaab further commented, "Do you have any ideas as to the sample and testing schedule for the monitoring wells which would be built along either side of the barrier? You probably haven't determined that yet."

Reply: Mr. Gabel responded, "There's regulatory guidance on both MNA requirement, plus I believe there's guidance on permeable reactive barriers. It would be in our design plan."

Comment: Mr. Glaab requested the following reassurance, "Of course, that would have to conform to the DEP and EPA's requirements?

Reply: Mr. Gabel reassured him, "Yes. We'll try -- I mean we will."

Comment: Mr. Magee reminded Mr. Gabel of his legal obligation to do so, to which Mr. Glaab added, "Are you only thinking about 200 ft as your length? Because the plume is a large plume. The site is 1,700 ft. As one dimension, 1,700 was one dimension and 800 ft was the other dimension of the plume overall. I'm wondering if 200 ft would be enough."

Reply: Mr. Schicho stated that the exact shape would be determined based upon what will be protective of the brook. He reiterated that the primary goal of the PRB is to protect the brook and added that the length that will most satisfactorily protect the brook will be proposed based on the design study calculations.

Comment: Mr. Glaab inquired whether there be another public hearing when the more specific details would be presented.

Reply: Mr. Gabel responded, "No, we're not planning to. There will be restoration advisory board meetings and meetings with the technical staff of both the DEP and EPA. But there's no requirement to have a meeting, public meeting, as this one. And any members of the public who care to attend our restoration advisory board meetings, that's also open, to discuss the remedial design when we get to it."

Comment: Mr. Glaab expressed his gratitude for the answers he was given.

<u>Comment 9</u>: Mr. Charles Botti inquired as to what the annual cost to run the pump and treat system in 'hard dollars' per month.

Reply: Mr. Gabel explained to him that the cost was $300,000 per year including the costs associated with the required monitoring.

A group discussion then ensued from which it was established that Army would be realizing a substantial savings by implementing the PTW and ceasing operation of the pump and treat. It was explained that in present worth dollars, a sum of money on the order of $13,000 per year will be required to 'operate' and monitor the PTW as opposed to an approximate minimum of $300,000 to operate and monitor the pump and treat system. The component expenses for both the PTW and the pump and treat system were also outlined as part of the discussion. The estimates were provided and explained by Ms. Nancy Flaherty of the USACE, Mr. Doug Schicho, Mr. Gabel and Mr. Richard Isaacs.

Comment: Mr. Botti followed up by commenting, "You'll have more money in your environmental budget to work in other areas as needed, and this will be paying for itself in three and-a-half years."

Response: The Army would like to point out that the cost estimates for the selected remedy is presented in **Section 2.0** of this ROD and in the Area D FS and Proposed Plan.

3.1.2 Summary of Comments Received during the Public Comment Period and Agency Responses

Written Comments were submitted by one source: Subsurface Solutions LLC, on behalf of the PAERAB.

Comments Regarding the PTW Design Specifications:

Comment 1: At the time of the public meeting, the results of the laboratory and field investigation to collect data for PTW design had not yet been compiled. General dimensions (length, width, and depth) and wall composition (percent sand, percent iron) were available from the FS. The RAB understands that these general specifications may not accurately reflect the wall as it is to be designed. The actual PTW specifications will be formulated from a review of the laboratory and field data.

The RAB requests that appropriate safety factors be built into the design parameters such that the PTW will be constructed to account for all foreseeable contingencies. For example, groundwater flow data should be evaluated to account for seasonal changes in flow and the wall length and depth planned accordingly. In addition, the wall thickness and composition should be appropriately sized to treat the maximum concentration of VOCs expected to reach the barrier.

Response: During the design of the PTW, the historical groundwater level data will be reviewed to estimate the variation in groundwater levels, hydraulic gradients and groundwater velocities that can be expected to occur at the site. The groundwater analytical data will also be reviewed to estimate the current horizontal and vertical extent of VOCs in the groundwater, and the VOC concentrations expected to reach the barrier. These parameters will be used to determine the PTW dimensions and the required zero-valent iron flow through thickness with appropriate safety factors for the site as described in the Design Guidance for Application of Permeable Reactive Barriers for Groundwater Remediation (Interstate Technology Regulatory Cooperation, 1999).

Comments Regarding Performance Monitoring

Comment 2: Numerous data has been collected on existing installations of zero-valent iron PTWs. However, the oldest of these PTWs is only about 10 years in age and thus, reliable PTW design and performance data are presumably currently available for analysis of a PTW use interval of only 10 years. Therefore, PTW design parameters (PTW dimensions, percentage of iron in the PTW, sampling and monitoring schedules, sampling parameters, and number/placement of monitoring wells) should be conservatively estimated to assure the functional efficacy of the PTW for a minimum of at least 10 years.

Response: Long-term (five- to ten-year) performance data from iron PTW installations indicate no significant decline in VOC degradation by the barriers over time, minimal porosity loss in the reactive media due to mineral precipitation, and expectations that the PTWs will continue to perform satisfactorily for at least another ten to fifteen years. Based on these performance data, current expectations are that iron PTWs will function for at least 30 years, with the possibility of a much greater lifetime depending on site conditions. The “PTW Design Parameters” listed above will be estimated to assure functional efficacy for significantly greater than ten years. The PTW design will include appropriate safety factors to allow for long-term performance of the barrier, and will include a monitoring well network and groundwater sampling and analysis program specifically designed to evaluate the PTW performance.

Comment 3: A great uncertainty with the iron-bearing PTWs is the longevity of the reactive media. A number of processes can act simultaneously to deplete the iron and/or cause a loss of reactivity. Precipitation of various minerals can cause a loss of reactivity of the iron particles. In addition, not only can the functioning of the reactive media be impaired but [also] the hydraulic integrity of the wall itself can be affected. Hydraulic impairment may be caused by several means as follows: through bypass of groundwater under or around the wall instead of through it, by creation of preferential flow pathways through the wall (such zones may not provide adequate residence time for treatment), or by creation of low permeability areas (such as might result from inadequate breakdown of construction additives or creation of smear zones on excavation walls).

Response: Long-term (five- to ten-year) performance data from iron PTW installations indicate no significant decline in VOC degradation by the barriers over time, minimal porosity loss in the reactive media due to mineral precipitation, and expectations that the PTWs will continue to perform satisfactorily for at least another ten to fifteen years. Careful design and construction of the PTW will safeguard against hydraulic performance issues listed in the comment. The PTW design will include a monitoring well network and groundwater sampling and analysis program that will be designed to monitor groundwater flow within and adjacent to the PTW, and to evaluate the performance of the reactive media over time.

Comment 4: Given all the potential impairments to proper functioning of the wall, a comprehensive hydraulic and geochemical monitoring program is essential. The RAB is especially concerned about monitoring during the first few years after PTW installation. During this early stage a decision will be made about permanent dismantling of the existing pump and treat system. Prior to dismantling the pump and treat system, the RAB would like to be assured that the PTW is performing satisfactorily. The pump and treat system should not be permanently dismantled until hydraulic and geochemical indicators have reached equilibrium and have continued to exhibit such conditions for at least a year and perhaps two years depending on the frequency of sampling.

PTA representatives have repeatedly stated that the costs for “mothballing” the pump and treat system may be excessive. Although the RAB is aware of this cost factor, it is also acutely aware of the potential future costs to the environment, to PTA itself, and to its neighboring communities should the pump and treat system be prematurely dismantled and the PTW prove to be ineffective due to an inadequacy in design or due to improper construction. However, the RAB is concerned that should the PTW fail, that a proven, reliable means of preventing the plume from entering Green Pond Brook be readily and immediately available. Without having the pump and treat system as a readily available fail-safe measure, the plume would discharge to GPB. The timeframe between detection of failure of the PTW and a means to prevent the discharge (in the absence of the pump and treat system on standby) could be many months, if not years, given design and regulatory requirements.

Response: The Army intends to mothball the pump and treat until the PTW has been proven to be working. As discussed in this ROD, the interim pump and treat system will remain in operation for a period of one-year after installation of the PTW, at which time it will be shut down and maintained on stand-by status for a period of time, pending Army, PTA, USEPA, and NJDEP concurrence.

At the end of the stand-by period, upon agreement by the Army, PTA, USEPA, and NJDEP that the PTW is working acceptably (i.e., that the interim pump and treat system is no longer required in addition to the PTW, to provide sufficient protection of human health and the environment), the pump and treat system will be dismantled. This condition would be met if the concentrations of 1,1-DCE, cis-1,2-DCE, PCE, TCE, and VC in the groundwater discharging from the wall are reduced to below RGs (ARARs) by the PTW. Hydraulic performance will also be monitored to ensure the plume is not circumventing the PTW. During the five-year review process, newly available technologies will be evaluated and compared to the selected alternative. The basis of these evaluations will be the results of pilot studies performed within the Area D plume. In the case where the performance of a technology is favorably evaluated from a cost and risk reduction standpoint, a ROD amendment would be issued to implement that technology.

Comment 5: The monitoring program should be formulated to ensure that the wall is operating as designed. Once an equilibrium has been established, then the monitoring program objective should shift to detect changes in performance.

Both physical and geochemical parameters should be incorporated in the monitoring program. Groundwater sampling upgradient, within, and downgradient of the PTW should be included to evaluate contaminant degradation and byproduct formation. Similarly, water level monitoring should be conducted upgradient, within, and downgradient of the PTW to evaluate flow conditions and determine whether hydraulic capture is adequate. Monitoring parameters should be selected such that the potential for precipitate formation and loss of reactivity can be evaluated.

Routine parameters might be sampled on a quarterly frequency during the first few years of PTW operation. Once satisfactory performance is demonstrated, the sampling frequency could be reduced. However, a contingency monitoring program should be developed for unexpected conditions. In this case, sampling may be more frequent and involve the use of specialized techniques or non-routine parameters.

Response: The PTW design will include a monitoring well network and groundwater sampling program that will be specifically designed to monitor groundwater flow within and adjacent to the PTW, and to evaluate the effectiveness and long-term performance of the reactive media. The monitoring network will include upgradient and downgradient monitoring wells. Monitoring wells may also be installed within the reactive media depending on the construction method used to install the PTW. The performance monitoring will include measurement of groundwater levels, field parameters (oxidation-reduction potential [ORP], pH, DO and specific conductance), VOC target compounds (1,1-DCE, cis-1,2-DCE, PCE, TCE, and VC) and inorganic constituents (Na, K, Mg, Ca, alkalinity, Cl, nitrate and sulfate). The details of the proposed monitoring well network design and sampling plan, including the sampling frequency, analytical parameters and analytical methods for the post-installation monitoring phase of the PTW will be presented in the Remedial Design.

Comment 6: The RAB would appreciate the opportunity to learn the details of the PTW design and the monitoring program in the preliminary planning stages. A future RAB meeting would be an appropriate forum for disseminating such details.

Response: The Army is amenable to conducting a future RAB meeting to present the proposed PTW design, construction methods and performance-monitoring program.

Comment 7: In addition, the RAB respectfully suggests consideration be given to contractual stipulation that the contractor tasked with the construction of the PTW be required to guarantee its product for at least 10 years with a suitable long-term performance bond.

Response: The Army has a wide variety of contracts that can be utilized for remedial construction. As part of the procurement process consideration is given to which type of contract would provide the government with the best value.

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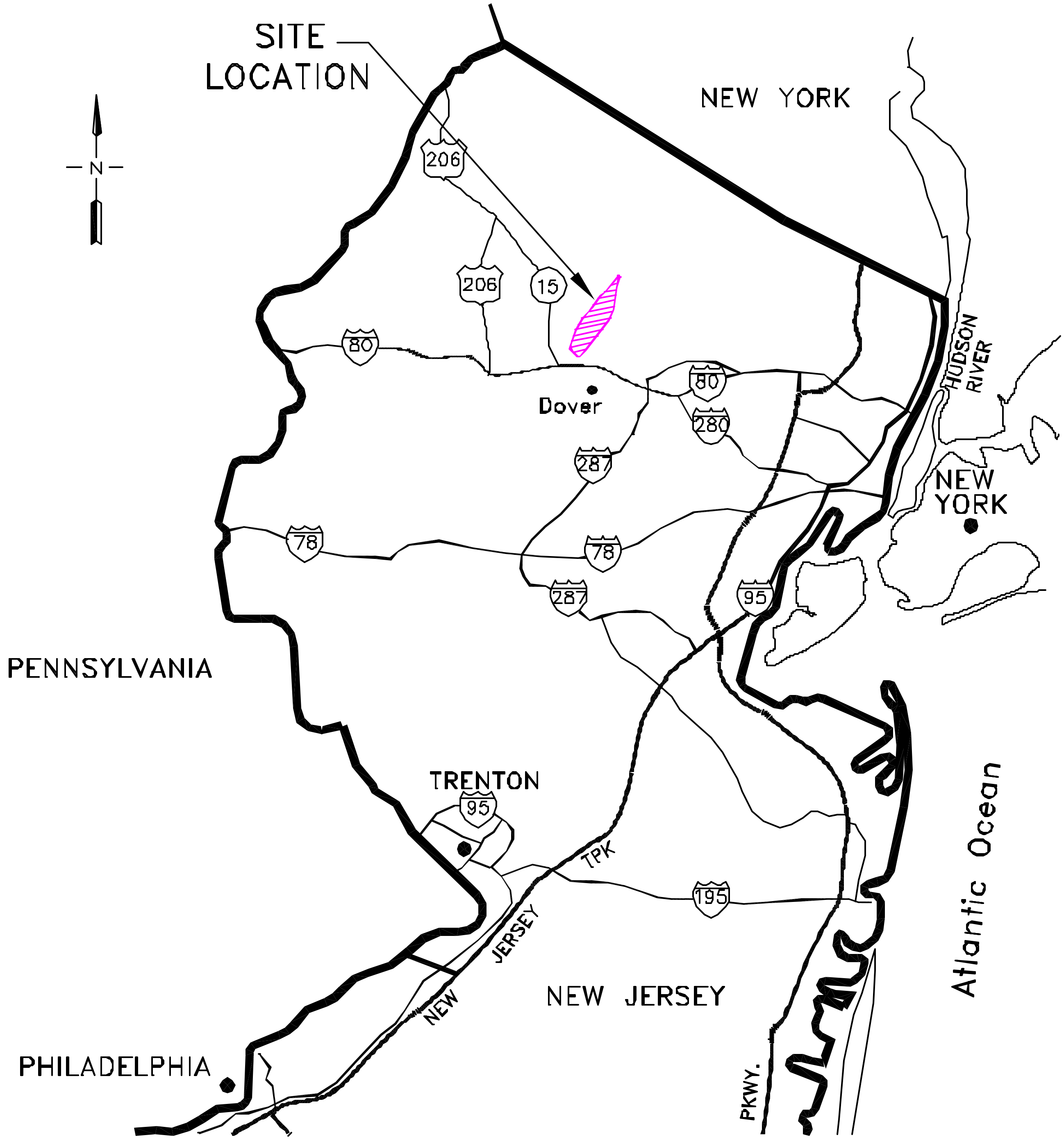

Picatinny Installation Restoration Program

U.S. Army Corps of Engineers

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FIGURE 1

**PICATINNY ARSENAL
SITE LOCATION MAP**

**AREA D GROUNDWATER ROD, FINAL, Revision 1
PICATINNY, DOVER, NJ**

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
C. KONTOS	K. RUSCZYK	E. MAJOR	Figure1.dwg
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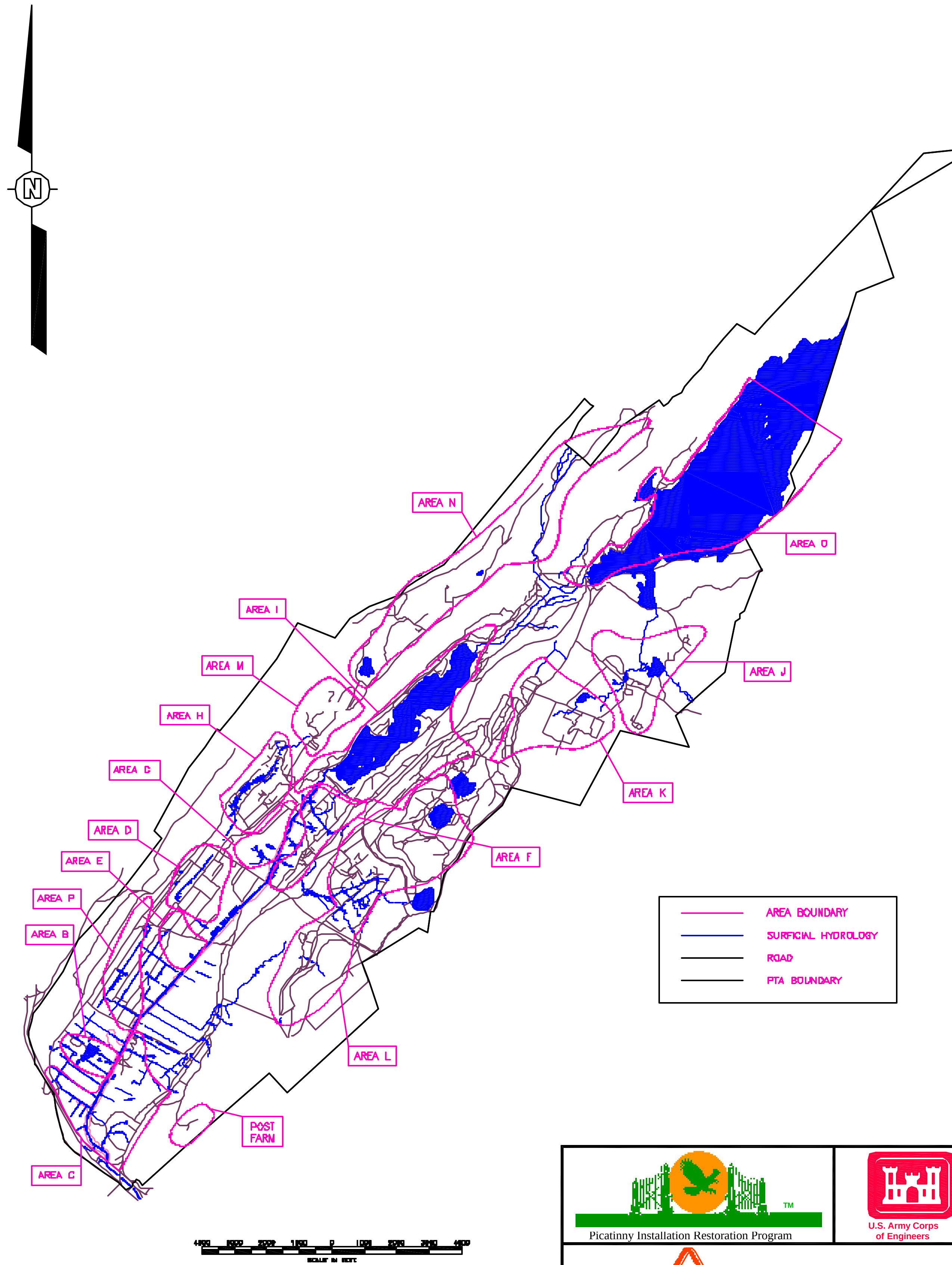

Picatinny Installation Restoration Program

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FIGURE 2

PICATINNY AREA BOUNDARIES

AREA D GROUNDWATER ROD, FINAL, Revision 1
PICATINNY, DOVER, NJ

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
A. Smith 10/01/03	M. Jacob 10/01/03	D. Schicho 10/01/03	Figure2.dwg

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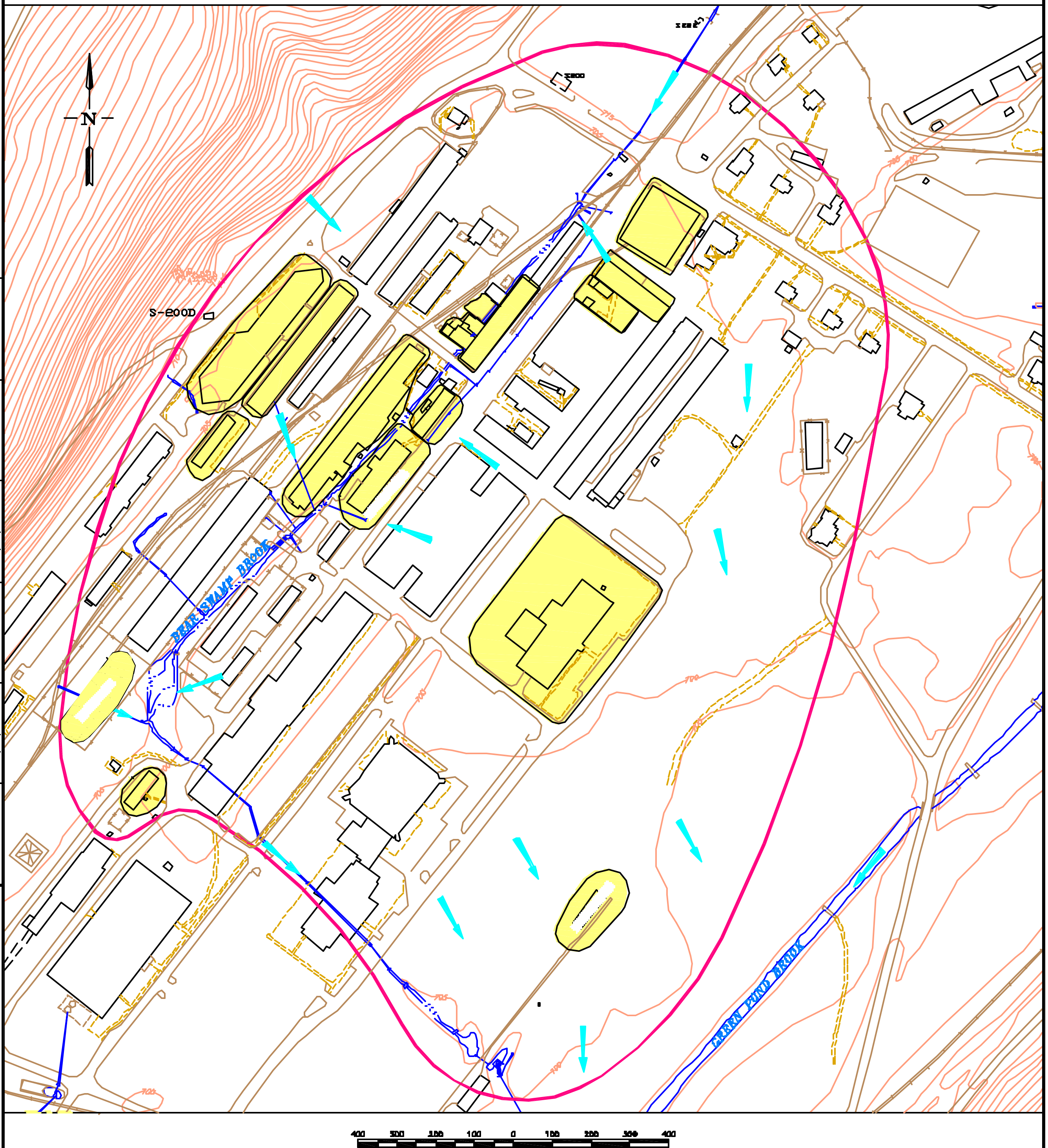

LEGEND

RAILROAD		BLDG. NO.	BUILDING
FENCE		BLDG. NO.	FORMER BUILDING
TR-732	TRANSFORMER		COVERED WALKWAY
BLAST WALL			SWAMP
STS OR STS	STORM SEWER		WATER
SS OR SS	SANITARY SEWER		SITE BOUNDARY
	EARTH MOUND		AREA D BOUNDARY
			SURFACE WATER FLOW

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FIGURE 3

AREA D LOCATION, TOPOGRAPHY, AND SURFACE WATER HYDROLOGY

AREA D GROUNDWATER ROD, FINAL, Revision 1

PICATINNY, DOVER, NJ

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
R. Gross 9/4/03	M. Jacob 9/4/03	-- --	Figure3.dwg

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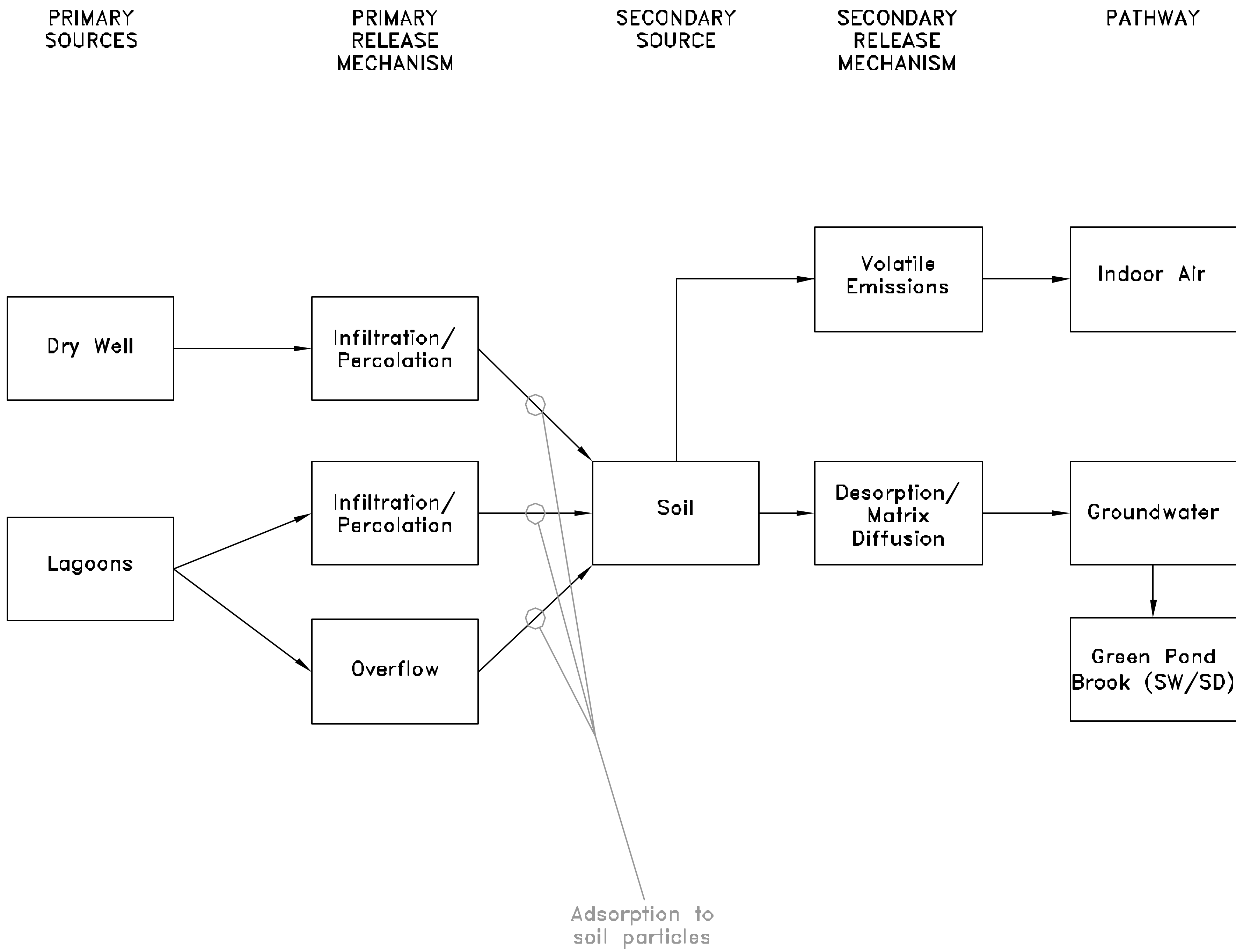

RECEPTOR

Pathway	EXPOSURE ROUTES	Resident	Worker	Tresspasser
Indoor Air	Ingestion			
	Inhalation	●	●	
	Dermal			
Groundwater	Ingestion	●	●	
	Inhalation	●		
	Dermal	●		
Green Pond Brook (SW/SD)	Ingestion			●
	Inhalation			
	Dermal			●

Exposure routes shown in this model demonstrate possible exposure scenarios, and do not represent the expectation that receptors will be exposed to contaminant. It should also be noted that the Institutional Controls in place would preclude many of the possible exposure scenarios shown herein.

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FIGURE 4

CONCEPTUAL SITE MODEL FOR AREA D GROUNDWATER

AREA D GROUNDWATER ROD, FINAL, Revision 1
PICATINNY, DOVER, NEW JERSEY

DRAWING NUMBER FIGURE4.dwg
APPROVED BY --
D. Schicho
CHECKED BY --
D. Schicho
DRAWN BY --
A. Smith

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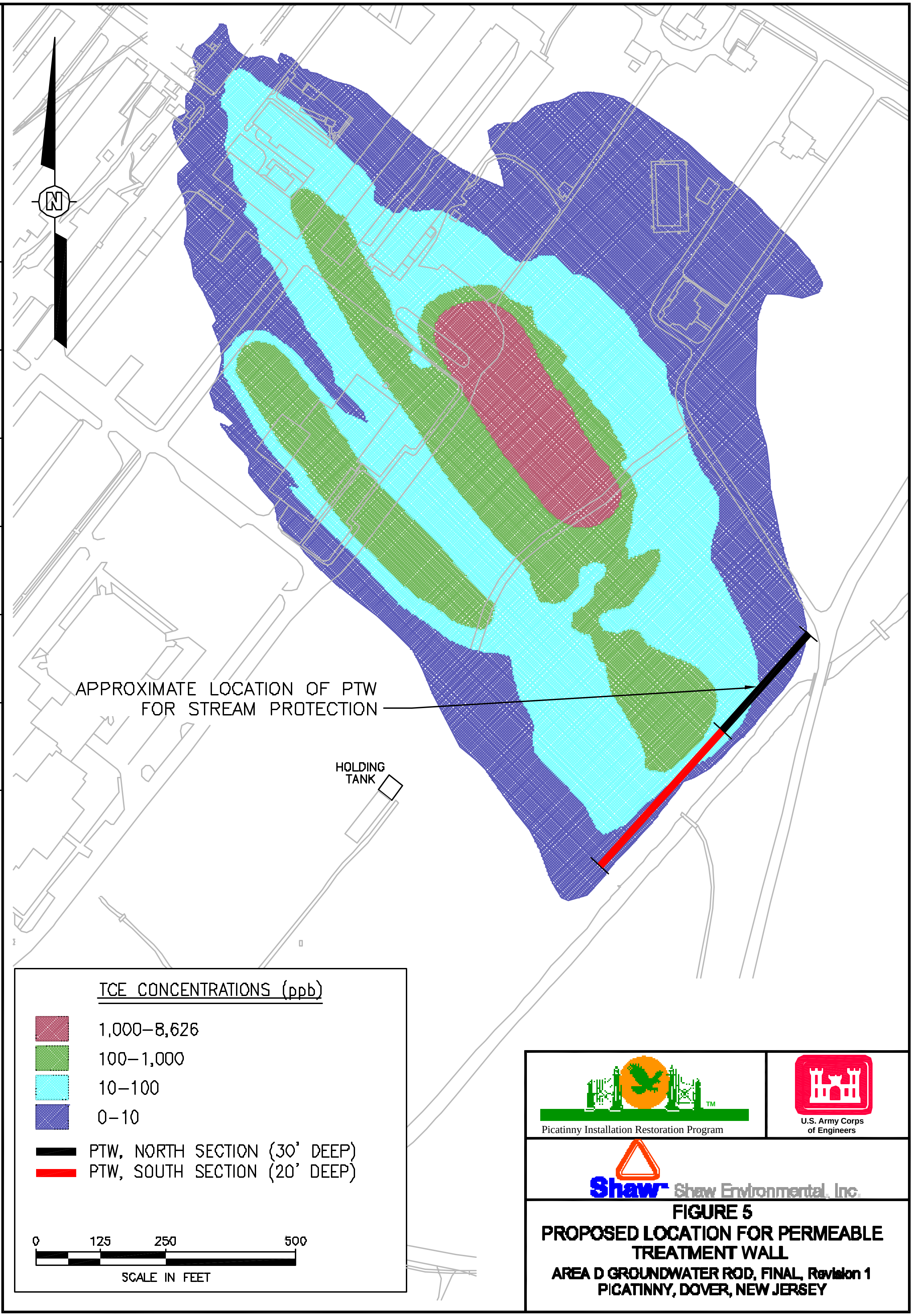

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FIGURE 5
PROPOSED LOCATION FOR PERMEABLE TREATMENT WALL
AREA D GROUNDWATER ROD, FINAL, Revision 1
PICATINNY, DOVER, NEW JERSEY

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
--	--	--	Figure5.dwg
A. Smith	A.Smith	D. Schicho	

File: N:\cad\CAD drawings\Picatinny\Area-D\Area D ROD\FINAL\Revision1\FIGURE5.dwg
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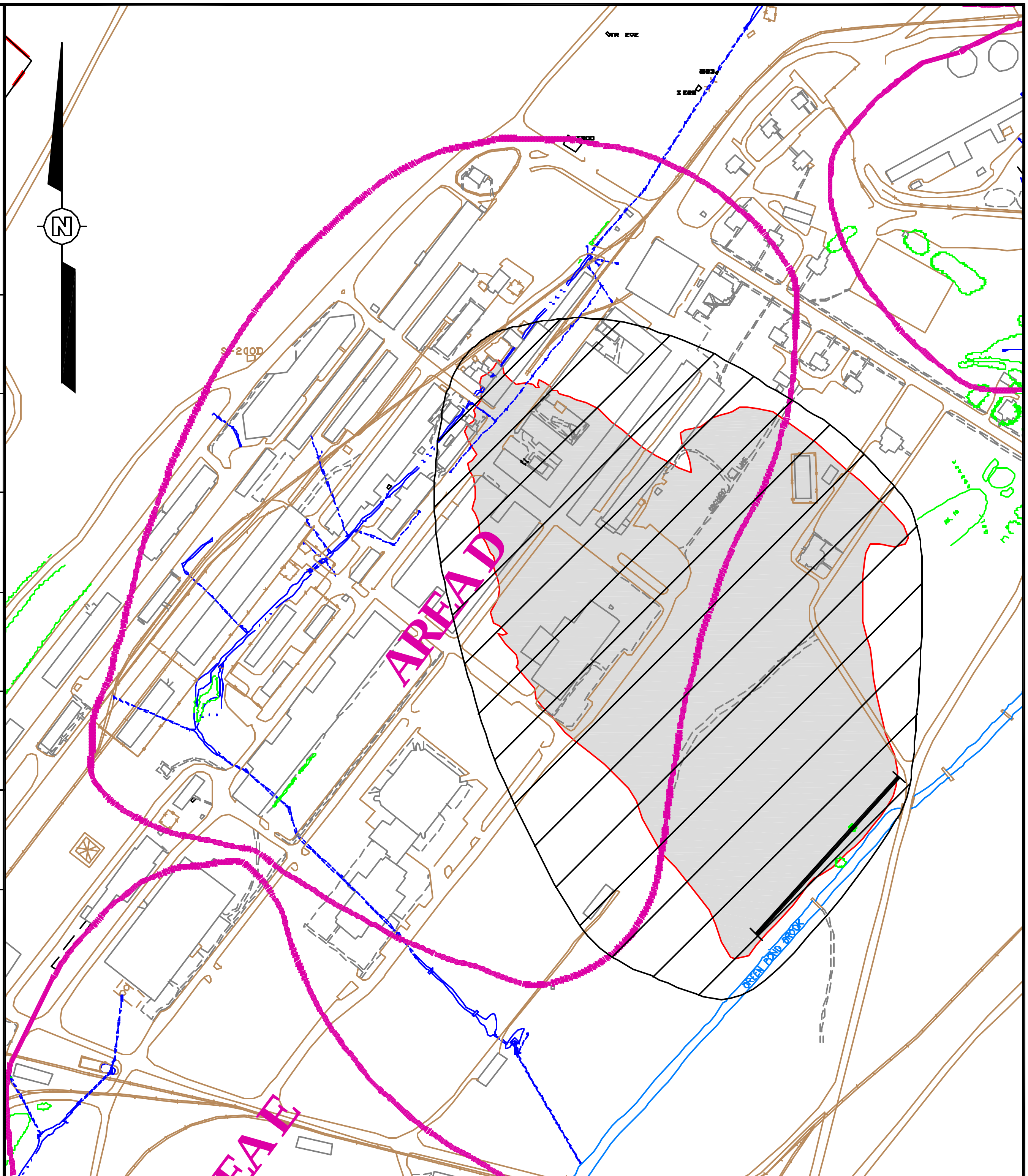

SCALE

0 500 1000 FEET

Footprint of Groundwater TCE Plume

Area of Applicability for Institutional Controls to Implemented as Part of this Decision

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
A. Smith --	D. Schicho --	D. Schicho --	Figure6.dwg

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Picatinny Installation Restoration Program

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FIGURE 6

INSTITUTIONAL CONTROLS AREA OF APPLICIBILITY

AREA D GROUNDWATER ROD, FINAL, Revision 1
PICATINNY, DOVER, NJ