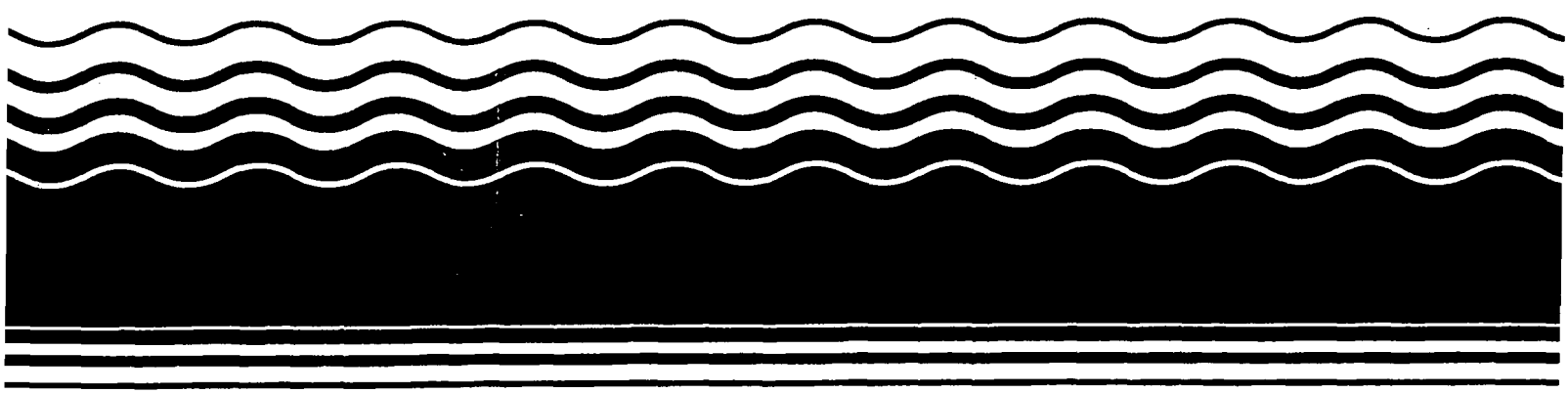
PB95-963917
EPA/ROD/R03-95/207
March 1996

EPA Superfund Record of Decision:

Dover Air Force Base, Target Area 1 of Area 6, DE 9/26/1995



RECORD OF DECISION
DECLARATION OF THE SELECTED INTERIM REMEDY

Site Name and Location

Target Area 1 of Area 6, West Management Unit, Dover Air Force Base, Kent County, Delaware.

Statement of Basis and Purpose

This Record of Decision (ROD) presents the selected interim remedial action for Target Area 1, which was chosen in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CFR Part 300. This decision prepared by the U.S. Air Force, the lead agency, as the owner/operator of the Base is based on the Administrative Record for the Site. Support was provided by the U.S. Environmental Protection Agency (EPA) Region III and the Delaware Department of Natural Resources and Environmental Control (DNREC).

The State of Delaware and the U.S. Environmental Protection Agency concur with the selected interim remedy. The information supporting this interim remedial action decision is contained in the information repository for the Administrative Record located at the Dover Public Library, Dover, Delaware.

Assessment of the Site

Four regions were identified in Area 6 where shallow groundwater contained combined concentrations of the chlorinated solvents trichloroethene, perchloroethene, and 1,2-dichloroethene in excess of 1,000 μg/L. These regions were inferred to be in the vicinity of the source areas for the chlorinated solvent plumes present in Area 6, and were incorporated into areas for remediation termed Target Areas. This ROD addresses the interim remedy for Target Area 1. The maximum concentration of total chlorinated volatile organic compounds in Target Area 1 groundwater was 16,042 μg/L. While a Risk Assessment was not performed specifically for Target Area 1, the risk associated with exposure to Area 6 groundwater under a hypothetical future commercial/industrial land use scenario was 9×10^{-4}.

Actual or threatened releases of hazardous substances from this Site, if not addressed by implementing the interim response action selected in this ROD, may present a current or potential threat to public health, welfare, or the environment.

Description of the Selected Interim Remedy

The selected interim remedy consists of *in situ* bioremediation of groundwater utilizing intrinsic bioremediation. Intrinsic bioremediation is one of the bioremediation technologies being applied to the Target Areas to promote the development of alternate and innovative treatment technologies as encouraged under CERCLA. Performance of the interim remedy and compliance with applicable or relevant and appropriate requirements will be evaluated in the Final Basewide ROD.

Statutory Determinations

The selected interim remedial action satisfies the remedial selection process requirements of CERCLA and the NCP. The selected interim remedy provides the best balance of trade-offs among the nine criteria required to be evaluated under CERCLA. The selected interim action provides protection of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the action, and is cost effective. This interim remedy utilizes permanent solutions and alternative treatment technology to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. The Air Force understands that although this interim remedy may not achieve MCLs for certain contaminants, this interim action is only part of a total remedial action for the Base that will be protective of the public health and welfare and of the environment when completed (CERCLA 121d, 42 U.S.C. 9621.d).

19 SEP 1995

CHARLES T. ROBERTSON, JR. Date
Lieutenant General, USAF
Air Mobility Command
Chairperson, Environmental
Protection Committee

SEP 2 6 1995

THOMAS C. VOLTAGGIO Date
Hazardous Waste Management
Division Director
Environmental Protection Agency
Region III

RECORD OF DECISION
FOR THE INTERIM REMEDY OF
TARGET AREA 1 OF AREA 6
WEST MANAGEMENT UNIT
DOVER AIR FORCE BASE, DOVER, DELAWARE

August 3, 1995

DECISION SUMMARY FOR THE RECORD OF DECISION
TARGET AREA 1 OF AREA 6
WEST MANAGEMENT UNIT
DOVER AIR FORCE BASE

INTRODUCTION

Dover Air Force Base (DAFB) recently completed a Focused Feasibility Study (FFS) conducted to address chlorinated solvent and pesticide source area contamination in Area 6 of Dover Air Force Base (DAFB), Delaware as an interim response. The FFS was undertaken as part of the U.S. Air Force's Installation Restoration Program (IRP). The basis for the FFS was the Area 6 Remedial Investigation (RI) report dated July 1994, which characterized contamination and evaluated potential risks to public health and the environment. The interim FFS was performed as the first phase of Feasibility Studies to be conducted on sites in the West Management Unit, the management unit to which Area 6 belongs. The scope of the FFS was limited to the evaluation of alternatives for remediation of primary chlorinated solvent and pesticide source areas originating in the northern, upgradient portion of the Area 6 region of investigation. The final remediation of source areas, if necessary, and non-source area contamination in Area 6 posing human health or environmental risks will be addressed in the final Base-wide Feasibility Study.

This Record of Decision (ROD) addresses Target Area 1, which is one of the chlorinated solvent source areas evaluated in the FFS. This ROD summarizes the FFS, describes the remedial alternatives that were evaluated, identifies the remedial alternative selected by DAFB, and explains the reasons for this selection. The U.S. Environmental Protection Agency (EPA) and the State of Delaware concur with the interim remedy selected in this ROD.

As an aid to the reader, a glossary of the technical terms used in this ROD is provided at the end of the summary.

PUBLIC PARTICIPATION

The Proposed Plan for this site was issued on June 16, 1995. The public comment period on the Plan was open through July 31, 1995. Documents comprising the Administrative Record for the site were available at the Dover Public Library. The only comments received during the public comment period were from the Remediation Technologies Development Forum expressing support for the proposed interim remedy.

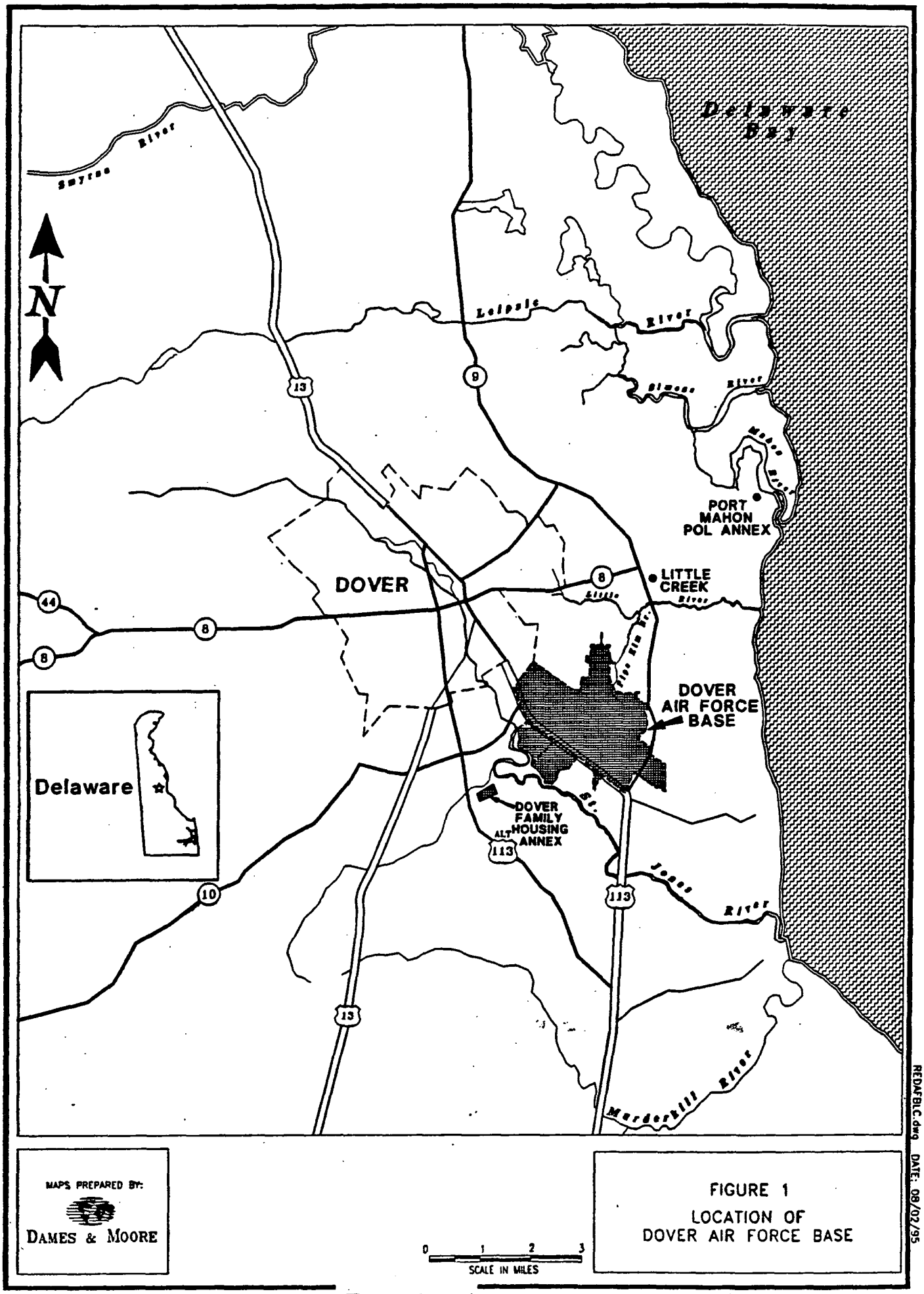
SITE BACKGROUND

DAFB is located in Kent County, Delaware, 3.5 miles southeast of the city of Dover (Figure 1) and is bounded to the southwest by the St. Jones River. DAFB comprises approximately 4,000 acres of land, including annexes, easements, and leased property (Figure 2). The surrounding area is primarily cropland and wetlands.

DAFB began operation in December 1941. Since then, various military services have operated out of DAFB. The present host organization is the 436th Airlift Wing. Its mission is to provide global airlift capability, including transport of cargo, troops, equipment, and relief supplies.

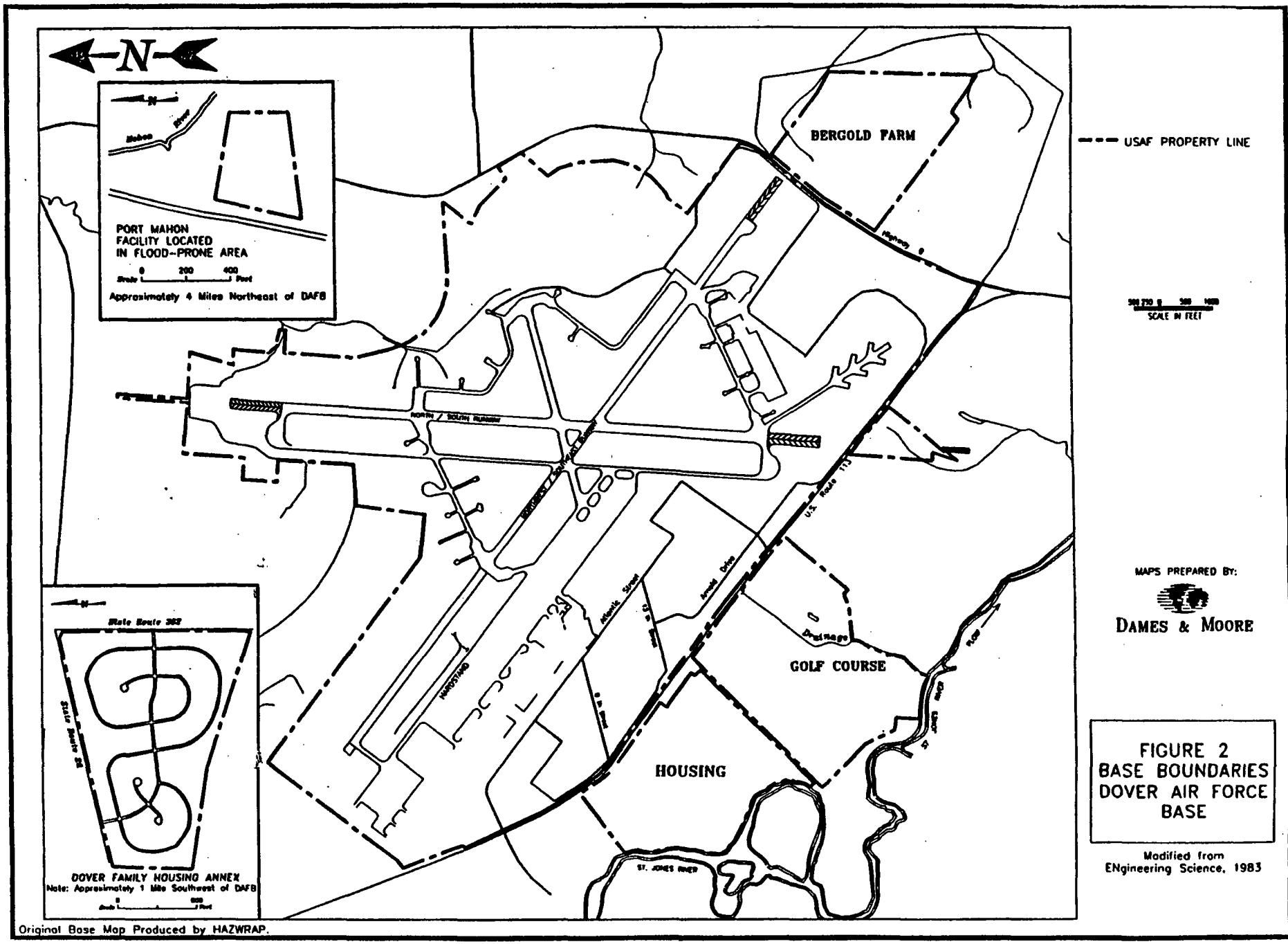
DAFB is the U.S. East Coast home terminal for the C-5 Galaxy aircraft. The Base also serves as the joint services port mortuary, designed to accept casualties in the event of war. The C-5 Galaxy, a cargo transport plane, is the largest aircraft in the USAF, and DAFB is one of a few military bases at which hangars and runways are designed to accommodate these planes.

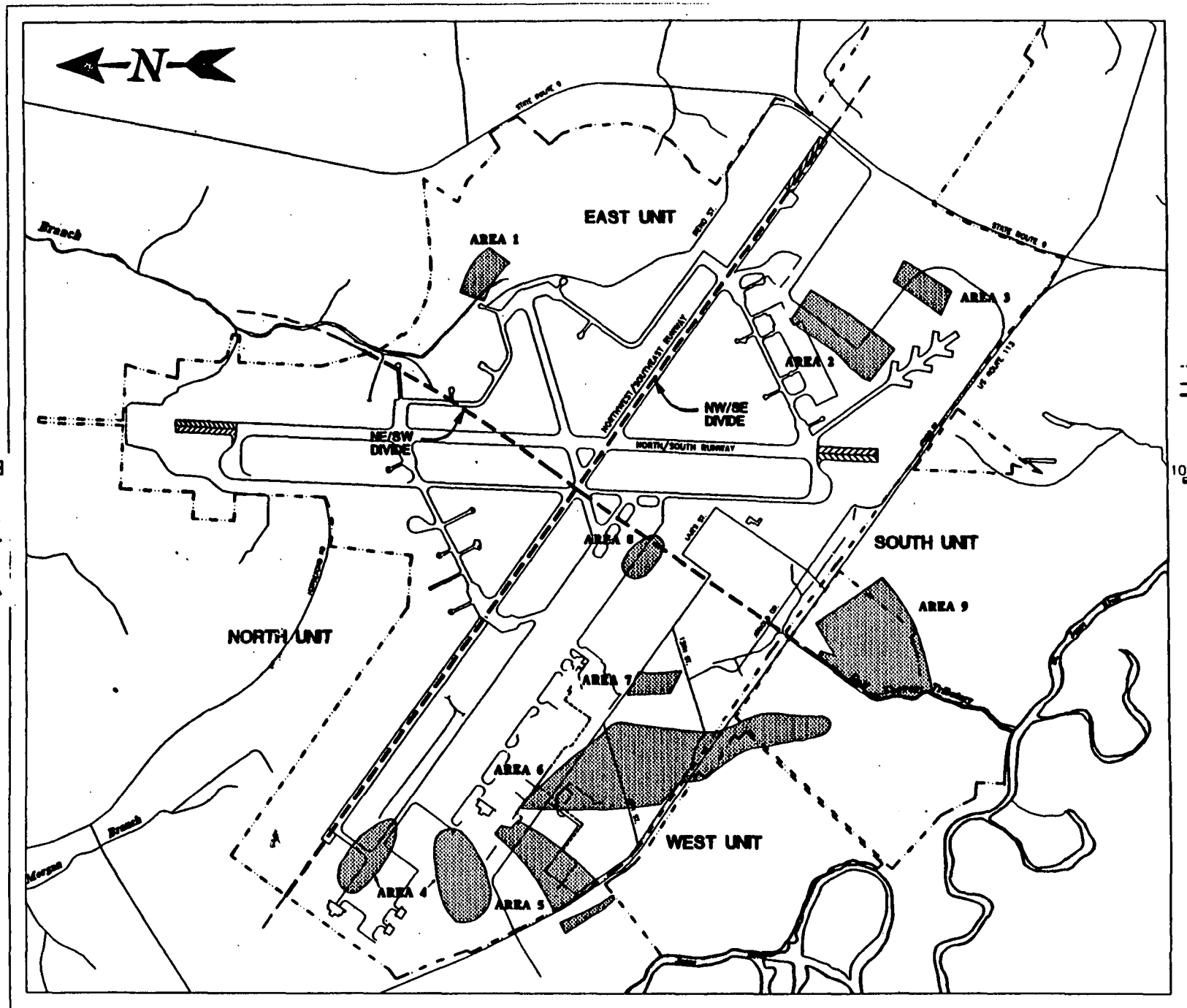
The portion of DAFB addressed in this ROD is located within Area 6 of the West Management Unit. The West Management Unit is one of four Management Units into which the Base has been divided (Figure 3). Area 6 is the largest of five associated areas identified in the West Management Unit. The Area 6 region of investigation extends approximately 8,400 feet from its northern most point near the hardstand and Building 723 to its southern most point near the St. Jones River (Figure 4). The area north of U.S. Highway 113 contains the industrialized portion



Target Area 1
ROD-3

Target Area 1
ROD-4





Target Area 1
ROD-5

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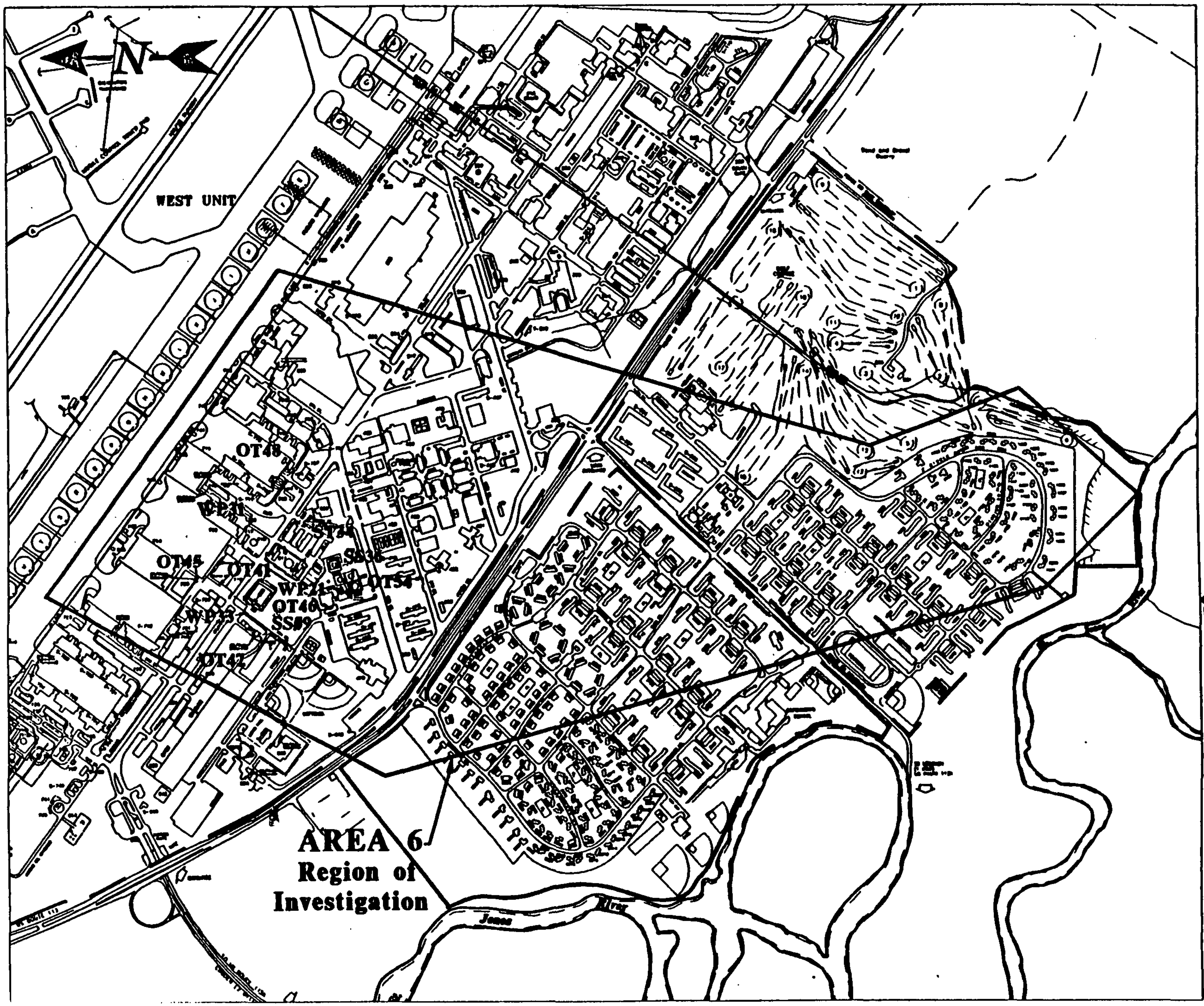
Target Area 1
ROD-6



SS59 IRP SITES

SCALE: 1 INCH = 1100 FEET

MAPS PRODUCED BY:
DAMES & MOORE

FIGURE 4
AREA 6
REGION OF
INVESTIGATION

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of the Area 6 region of investigation. The location addressed in this ROD falls within this industrialized portion of Area 6.

DAFB is relatively flat, with elevations ranging from approximately 10 to 30 feet above mean sea level (MSL). The ground surface is covered almost entirely by buildings, concrete, and asphalt. Surface water runoff throughout the industrialized portion of Area 6 is controlled by an extensive storm drainage system. The storm drains direct most runoff to either Pipe Elm Branch or the golf course tributary to the St. Jones River.

The Columbia Formation is the shallowest water-bearing unit and holds the water table aquifer. The Columbia Formation typically consists of fine to coarse grained sand with varying amounts of silt, clay, and gravel. Discontinuous lenses of gravel, silt and clay are also common. Generally, the upper portion of the Columbia Formation is finer grained and contains more silt and clay lenses than the deeper portion. The water table is generally encountered at a depth of 10 to 12 feet below ground surface (bgs) in the northern portion of Area 6 and shallows to within a few feet of the surface in the Base housing area near the St. Jones River. The groundwater elevation or potentiometric surface of both the shallow and deep zones of the Columbia Aquifer range from approximately 13.5 feet MSL in the northern portion to less than 3 feet MSL near the St. Jones River. The thickness of the Columbia Formation in Area 6 ranges from 28 to 64 feet.

Unconformably underlying the Columbia Formation is the upper unit of the Calvert Formation, which generally consists of gray to dark gray firm, dense silt and clay, with thin laminations of silt and fine sand. This upper silt and clay unit ranges in thickness from 15 to 21 feet in the northern portion of Area 6. The hydraulic conductivity of this unit range from 6.83×10^{-3} to 1.53×10^{-3} ft/day (2.41×10^{-6} to 5.39×10^{-7} cm/sec), which are three to five orders of magnitude lower than the overlying Columbia Formation. These significantly lower hydraulic conductivities form a barrier to the vertical migration of constituents identified in the Columbia Aquifer. Underlying this confining unit is the upper sand unit of the Calvert Formation or the

Frederica Aquifer. This aquifer averages 22 feet in thickness in the vicinity of DAFB. No constituents of concern were identified in the three Frederica monitoring wells installed in Area 6. Additionally, no production wells are installed the Frederica Aquifer in the vicinity of DAFB.

Area 6 is defined by the association of chlorinated solvents in groundwater forming a plume in the Columbia Aquifer. Several separate potential sources were identified in the Area 6 RI that may have contributed to the chlorinated solvent contamination. These potential sources include some of the twelve IRP sites within the Area 6 groundwater flow regime shown in Figure 4. Additionally, various shops and hangars where solvents are used may also be sources. The shop activities where solvent use is common include painting or paint stripping, aircraft and vehicle maintenance, and plating or welding. The northern most point of chlorinated solvent contamination is the aircraft maintenance area located north of Atlantic Street. The chlorinated solvent plumes extend approximately 4,600 feet south into Base Housing.

The Area 6 RI identified four regions where shallow groundwater (i.e., the top ten feet of the Columbia Aquifer) contained combined concentrations of the chlorinated solvents trichloroethene (TCE), perchloroethene (PCE), and 1,2-dichloroethene (DCE) in excess of 1,000 μg/L. These regions were inferred to be in the vicinity of the source areas for the chlorinated solvent plumes that are present in Area 6. The groundwater data suggested that primary source areas reside in the vicinity of the following reference points, which were incorporated into areas for remediation termed Target Areas:

- Paint Washout Area (Site SS59) located along the eastern portion of the open storage yard. **(Target Area 1)**
- Civil Engineering (CE) Shops Area including Building 607 (Carpentry Shop), Buildings 608 and 609 (Material Control/Supply Offices), Building 615 (Interior and Exterior Electrical Shop, Power Production, Paint Shop, and Sheet Metal Shop), and Building 650 (Sign Shop). **(Target Area 2)**
- Building 719 housing the Jet Engine Repair Shop. **(Target Area 3)**

- Buildings 715 and 716 housing the ISO-Dock and an engine storage facility, respectively. **(Target Area 4)**

The four Target Areas that have been identified are shown in Figure 5. Each Target Area incorporates one of the primary suspected source areas and the significantly impacted portions of the shallow and deep groundwater plumes associated with the respective source area. Plume maps of total chlorinated VOCs in shallow and deep groundwater are shown in Figures 6 and 7, respectively. The Target Areas are the regions of chlorinated solvent groundwater contamination that were evaluated in the FFS.

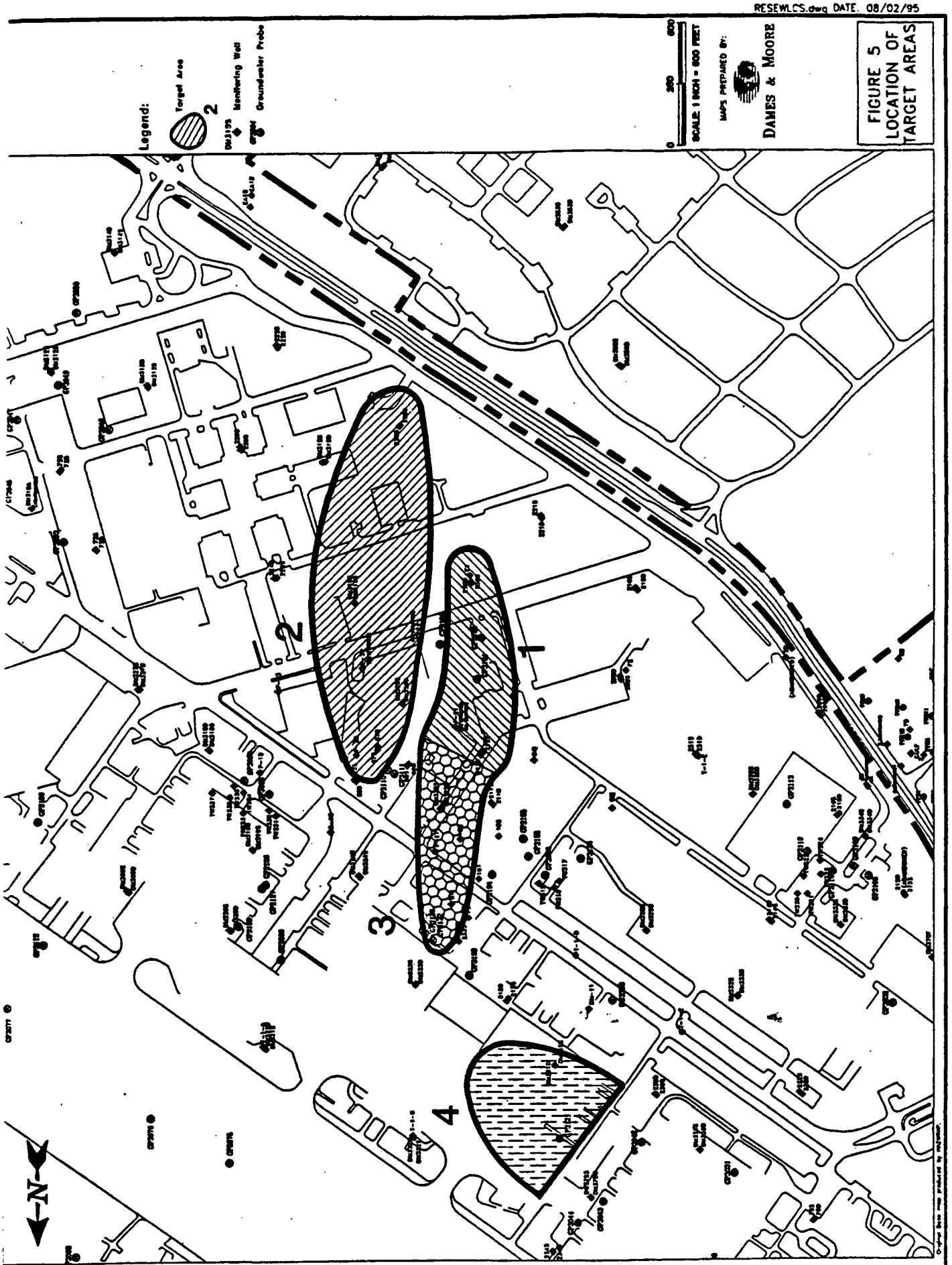
TARGET AREA/SOURCE AREA CHARACTERISTICS

The following section describes the physical and chemical characteristics of Target Area 1, which is addressed in this Record of Decision.

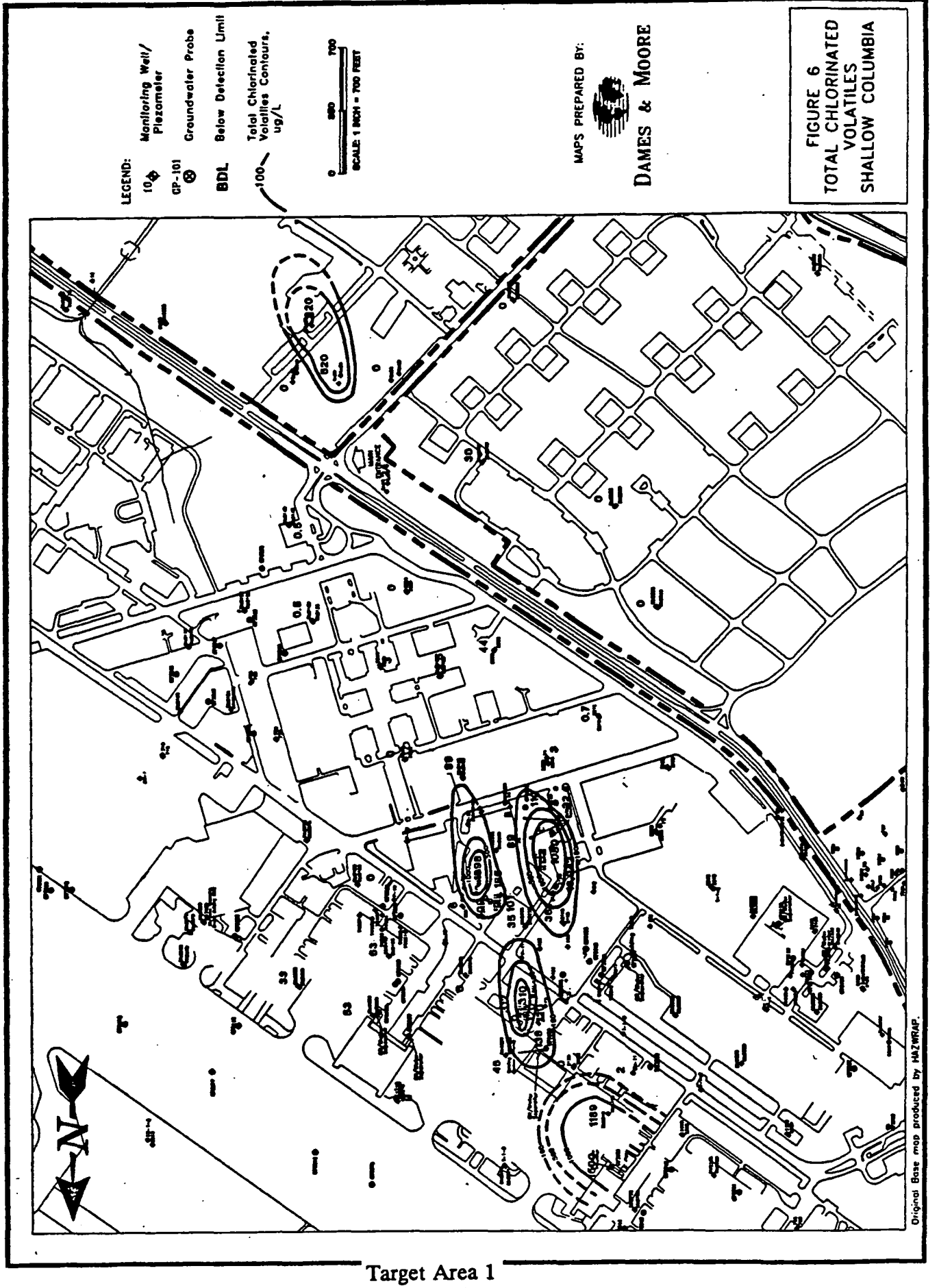
Target Area 1 originates at the Paint Washout Area (Site SS59) and extends south approximately 800 feet between 8th and 9th Streets. Target Area 1 is elliptically shaped and is approximately 5.2 acres in size. Target Area 1 adjoins Target Area 3 on its northern boundary. Expanded scale maps of the chlorinated solvent plumes residing in the shallow and deep portions of the aquifer within Target Area 1 are shown in Figures 8 and 9, respectively. The maximum concentration of total chlorinated VOCs in Target Area 1 groundwater was found in the shallow Columbia at a concentration of 16,042 μg/L in the presumed source location. Comparing the concentrations of chlorinated VOCs in the shallow and deep portions of the Columbia Aquifer, it is apparent that the constituents migrated downward through the Columbia Aquifer where most of the plume expansion occurred.

SUMMARY OF SITE RISKS

The full Risk Assessment (RA) for Area 6 can be found in the final Area 6 RI report dated July 1994. The purpose of the RA is to determine whether exposure to site-related contaminants could adversely affect human health and the environment. The focus of the baseline RA is on the possible human health and environmental



Target Area 1
ROD-10



Target Area 1
ROD-11

Target Area 1
ROD-12

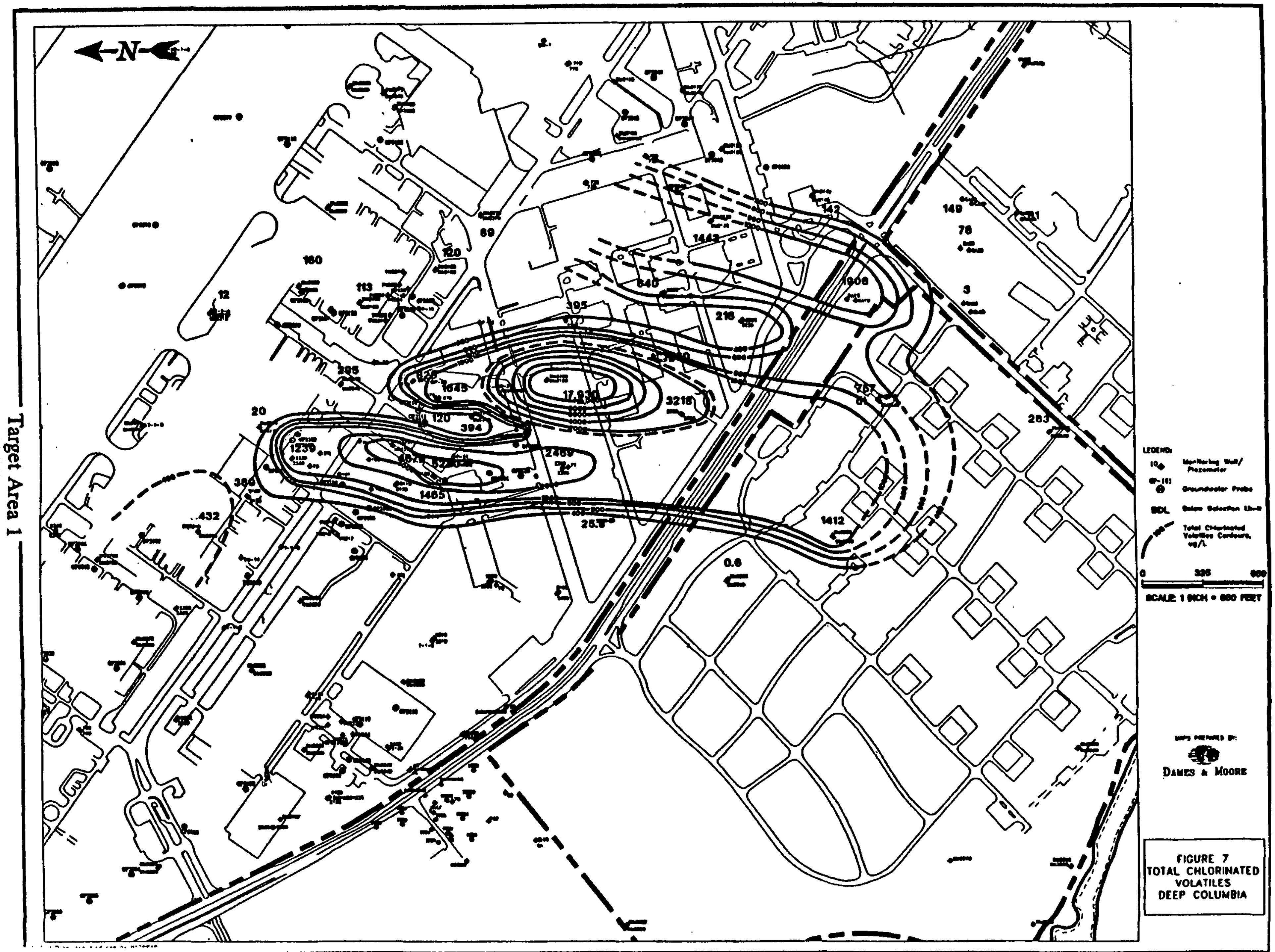
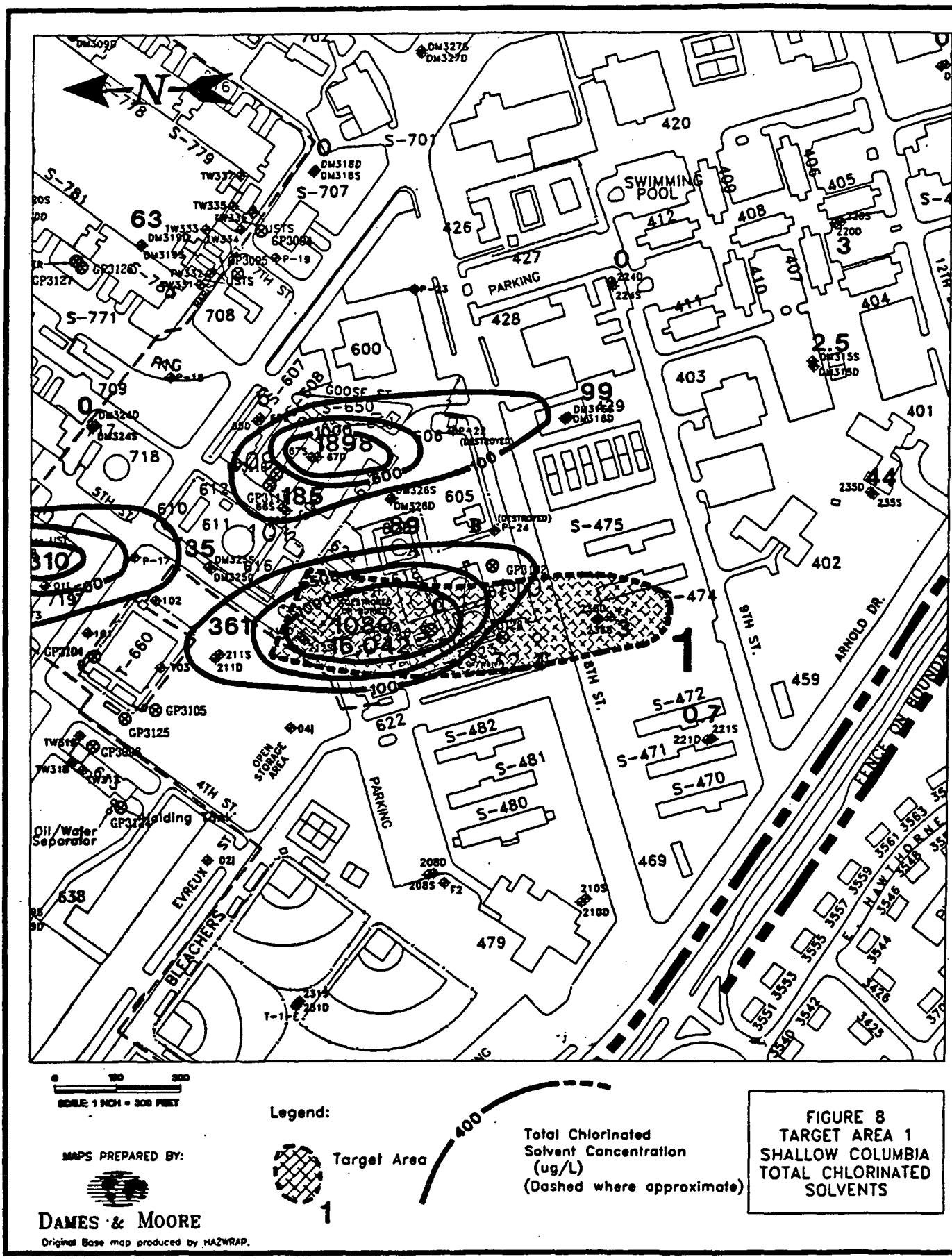
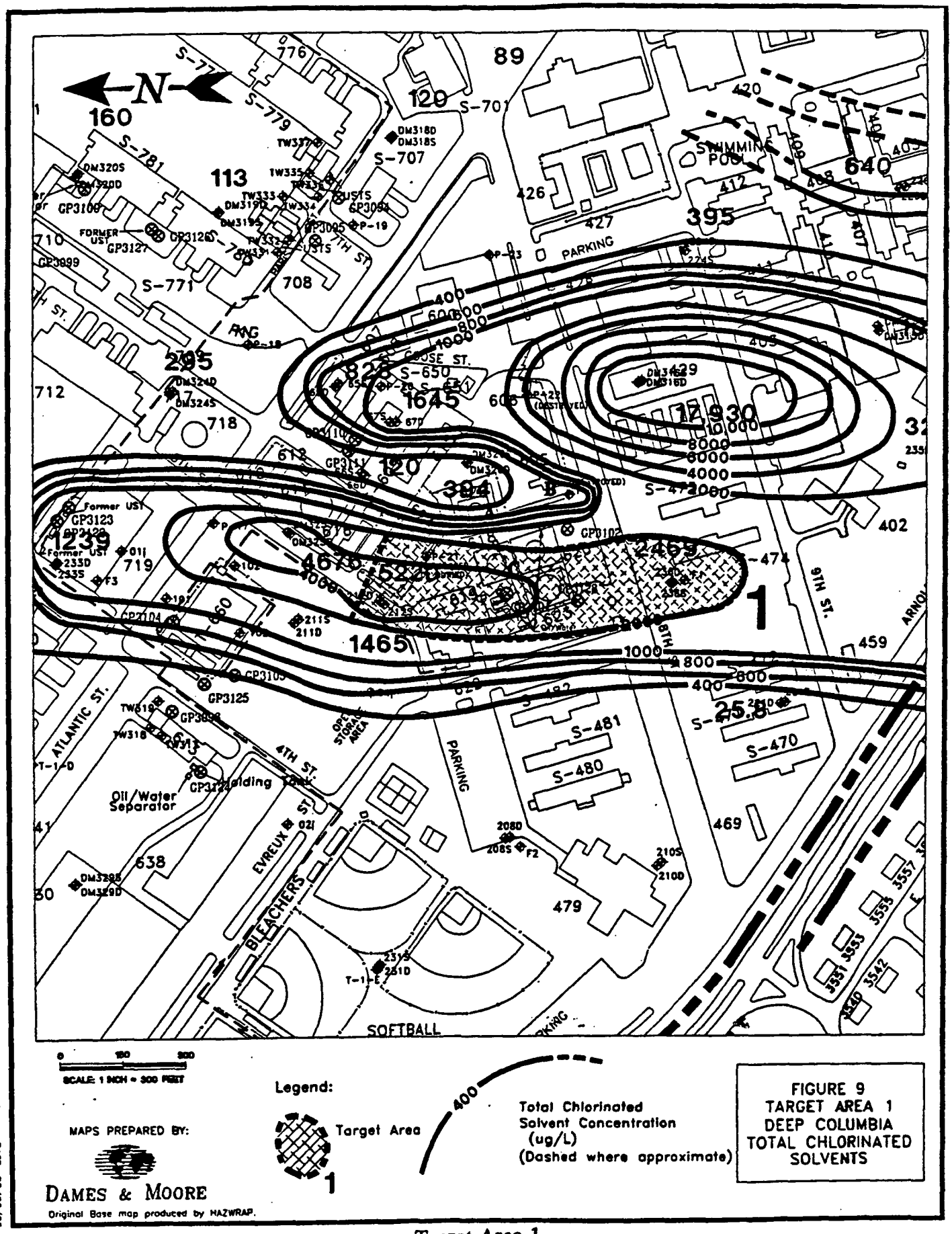


FIGURE 7
TOTAL CHLORINATED VOLATILES
DEEP COLUMBIA



Target Area 1
ROD-13



Target Area 1
ROD-14

effects that could occur under current or potential future use conditions in the event that the contamination is not remediated. The risk is expressed as lifetime excess cancer risk (LECR) for carcinogens, and hazard quotient (HQ) for noncarcinogens. For example, an LECR of 1×10^{-6} represents one additional case of cancer in one million exposed population, whereas a hazard quotient above one presents a likelihood of noncarcinogenic health effects in exposed populations.

The baseline RA focused on potential pathways by which maintenance and construction workers could be exposed to contaminated materials in Area 6. The workers' exposure to groundwater and soil have been evaluated under a regular maintenance scenario; a future construction scenario; and a hypothetical future groundwater use from the Columbia Aquifer under a commercial/industrial scenario. Although a specific Target Area 1 RA has not been performed, the risk calculated in the Area 6 Remedial Investigation from the hypothetical future exposure to groundwater within Area 6 had an LECR of 9×10^{-4}, which exceeds the 1×10^{-4} to 1×10^{-6} risk range used to evaluate the need for remediation. In addition to the overall Area 6 risk, the Target Area 1 constituents of concern have been compared to the risk-based screening concentrations (RBSCs) developed for the commercial/industrial scenario at DAFB to identify the chlorinated solvents that present a risk-based concern.

The possibility exists for exposure of workers to hazardous substances in soil during excavation activities. Source areas identified during excavation will require worker protection as per health and safety protocols. All the workers performing excavation work at DAFB will be health and safety trained for work at CERCLA sites.

Based on the direction of groundwater flow, the Area 6 plume extends in a southerly direction towards the St. Jones River. There are no surface water discharge points within Area 6 between the Target Area and the river. Presently, the Area 6 plume is confined within the Base property and has not reached the St. Jones River.

The future use of groundwater from the Columbia Aquifer by Base personnel is quite unlikely and hypothetical. This hypothetical future groundwater use assumes that groundwater from the Columbia Aquifer will be used for drinking and showering purposes by Base personnel under a commercial/industrial scenario. The RBSCs were compared

with the maximum detected concentrations of chlorinated solvents in Target Area 1 (Table 1). Concentrations of seven of the eight detected chlorinated solvents--1,2-dichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, perchloroethene, 1,1,1-trichloroethane, trichloroethene, and vinyl chloride--in Target Area 1 exceeded their corresponding RBSCs in groundwater. The concentration of the other detected compound, 1,1-dichloroethane, was below its RBSC.

Actual or threatened releases of hazardous substances from this Site, if not addressed by the selected alternative or one of the other active measures considered, may present a current or potential threat to public health, welfare, or the environment.

REMEDIAL ACTION OBJECTIVE

Within the groundwater in Target Area 1, the interim Remedial Action Objective (RAO) is to reduce the concentration of each ethyl-based chlorinated volatile organic compound (VOC) by 90 percent. The ethyl-based chlorinated VOCs include PCE, TCE, 1,1-DCE, 1,2-DCE, vinyl chloride, 1,1,1-trichloroethane, 1,1-dichloroethane, and 1,2-dichloroethane. These VOCs are considered to be the most toxic and therefore the 90 percent reduction interim RAO is applied to each of these compounds individually rather than to the aggregate concentration of all the chlorinated VOCs. For reasons of consistency, the 90-percent reduction model was based upon the RCRA Post-Closure Permit (Reference No. DE8570024010, Permit No. HW05A05) for Site WP21 of DAFB, which is a unit that adjoins Target Area 3 to the west.

The maximum concentrations of the detected chlorinated solvent compounds in Target Area 1 are summarized in Table 2, along with the compound and Target Area specific interim RAO. Table 2 also includes interim RAO concentrations for some select compounds that have not yet been detected in the Target Area. These select compounds are chemical degradation products of some of the currently detected chlorinated solvent constituents. Thus, reducing the concentration of detected compounds at the expense of producing other chlorinated VOC degradation products will not itself be sufficient to satisfy the interim RAO. Note that if a ten-fold reduction from the maximum

TABLE 1

Maximum Concentration Detected of Ethyl-Based Chlorinated Volatiles
in Target Area 1, and Corresponding Risk-Based Screening Concentrations

Compound	Target Area 1	
	Maximum Detected	RBSC
1,1-Dichloroethane	540	1,300
1,2-Dichloroethane	70	0.29
1,1-Dichloroethene	1,500	0.12
1,2-Dichloroethene	7,300	84
Perchloroethene	710	4
1,1,1-Trichloroethane	5,700	2,200
Trichloroethene	1,600	4
Vinyl chloride	180	0.058

Concentrations reported in units of μg/L.

RBSC - Risk-Based Screening Concentration for Commercial/Industrial scenario at Dover Air Force Base. The RBSCs are based on a lifetime cancer risk of 1×10^{-6} or a hazard quotient of one, whichever is lower.

TABLE 2

Maximum Concentration Detected of Ethyl-Based Chlorinated Volatiles in Target Area 1, and Corresponding Compound and Target Area Specific Interim Remedial Action Objectives

Compound	Target Area 1	
	Maximum Detected	Interim RAO
1,1-Dichloroethane	540	54
1,2-Dichloroethane	70	7
1,1-Dichloroethene	1,500	150
1,2-Dichloroethene	7,300	730
Perchloroethene	710	71
1,1,1-Trichloroethane	5,700	570
Trichloroethene	1,600	160
Vinyl chloride	180	18

Concentrations reported in units of $\mu g/L$.
RAO - Remedial Action Objective

concentration detected of a compound is below that compound's MCL, the MCL is used as the interim RAO.

The issues of final cleanup levels and attainment of ARARs will be addressed in the Final Basewide Record of Decision. The remedial action selected for this ROD is only part of the remedial action which will be selected in a Final Basewide ROD.

SUMMARY OF ALTERNATIVES

Engineering technologies applicable to remediating the contaminated media were screened according to their effectiveness and implementability. Those technologies that were determined to be most applicable were then developed into remedial alternatives. The following remedial alternatives are numbered to correspond to the alternatives described in the FFS report.

- Alternative 1--No Action.
- Alternative 2--Collection, *Ex Situ* Treatment, and Surface Water Discharge of Groundwater; and Performance of Soil Vapor Extraction in Chlorinated Solvent Source Areas if Necessary.
- Alternative 3--*In Situ* Groundwater Treatment Using Air Sparging and Density-Driven Convection Technologies Combined With Soil Vapor Extraction.
- Alternative 4--*In Situ* Bioremediation of Groundwater Utilizing Intrinsic Bioremediation.

The four remedial alternatives that were evaluated in detail are described below. In addition, the capital, annual operation and maintenance (O&M), and present worth costs of each alternative are provided.

Alternative 1

	Target Area 1
Capital Cost	$000
Annual O&M Cost	$000
Present Worth	$000

The no action alternative is evaluated in order to establish a baseline for comparison against other alternatives. Under this alternative, no efforts are undertaken to reduce the groundwater concentrations of chlorinated solvents in Target Area 1.

Alternative 2

	Target Area 1
Capital Cost	$170,000
Annual O&M Cost	$32,000[a]
Present Worth	$330,000[b]

[a]First year O&M cost. Refer to text
[b]Assumes 10 years of operation.

Alternative 2 consists of groundwater extraction, groundwater pretreatment for metals, groundwater treatment using air stripping for removal of chlorinated solvents and carbon adsorption for removal of residual contaminants, and surface water discharge of treated groundwater; performance of soil vapor extraction (SVE) in the shallow chlorinated solvent source areas if determined to be necessary during remedial design; and treatment of the offgases from the air stripper and, if implemented, the SVE system.

A total of one extraction well is estimated to be installed in Target Area 1, for cost estimating purposes only, to extract contaminated groundwater at a pumping rate of approximately 10 gallons per minute. If this alternative is ultimately selected for this interim response, then the exact number of wells and their placement will be determined during the remedial design. Extracted groundwater will be pretreated for metals to reduce the concentrations of iron and manganese. Metals pretreatment reduces the possibility of iron and manganese fouling subsequent treatment systems as well as ensuring compliance with surface water discharge standards for metals.

Pretreated groundwater will then be pumped to the top of a low profile, three-tray air stripper that will transfer over 95 percent of the VOCs dissolved in the groundwater to the air stream. The air stream containing the VOCs will then exit the air stripper unit where it will be treated using carbon adsorption prior to release to the atmosphere.

Routine air sampling at a frequency determined during remedial design will be performed to ensure compliance with air emission standards.

Treated groundwater exiting the air stripper will be pumped to a liquid phase carbon adsorption unit to reduce the concentration of residual contaminants to levels that comply with the surface water discharge standards prior to release to the golf course tributary of the St. Jones River. Semi-annual water samples, assumed for cost estimating purposes only, will be collected to ensure compliance with discharge standards. Actual sampling frequency will be determined during the remedial design.

Vadose zone chlorinated solvent contamination is present in Target Area 1 in the location where significant shallow groundwater contamination has been identified. To address this potential source, performance of SVE in a limited sized area has been included with this area. A total of two SVE wells are estimated to be sufficient to remediate the source areas presumed to be present. Soil sources would be expected to be remediated in less than 2 years with SVE treatment; 2 years of operation is assumed for costing purposes. If SVE is implemented, vapor collected by the SVE system would be treated for organic constituents by vapor phase carbon units prior to being released to the atmosphere. The necessity of performing SVE will be determined during the remedial design.

Groundwater monitoring will be performed to monitor the progress of groundwater remediation. In addition, existing land use restrictions associated with the military operation of DAFB will be enforced throughout the course of remediation to prevent unauthorized extraction and use of the contaminated groundwater from the Columbia Aquifer.

The time required to achieve the interim RAO is estimated to be in the range of 5 to 10 years, provided no free phase solvents are present in the aquifer. If free phase solvents are present, the time required to achieve the interim RAO may be extended to 30 years or more. The present worth cost of this alternative ($330,000) is calculated based on an assumed 10 year operation.

Alternative 3

	Target Area 1
Capital Cost	$440,000
Annual O&M Cost	$50,000[a]
Present Worth+	$730,000[b]

[a]First year O&M cost. Refer to text.
[b]Assumes 6 years of operation.

Alternative 3 consists of the *in situ* treatment of groundwater using a combination of air sparging (AS) and density-driven convection (DDC) technologies, combined with SVE over the entire areas where *in situ* groundwater treatment is performed; and carbon adsorption treatment of the offgases from the SVE system.

For *in situ* treatment at Target Area 1, 31 SVE wells and 28 AS/DDC wells are estimated to be required for cost estimating purposes only. If this alternative is ultimately selected for this interim response, then the exact number of wells and their placement will be determined during the remedial design. AS will be used in areas where soil is highly permeable and free of clay. DDC will be used in areas where significant clay layers are present. The SVE system operates in tandem with the AS/DDC system to capture volatile contaminants stripped from the saturated zone. Vapor phase carbon adsorption treatment units will be used to remove extracted VOCs from the air stream prior to release to atmosphere. Entrained water will be separated by knockout pots and sent to liquid phase carbon adsorption units to reduce contaminant concentration to levels acceptable for discharge.

Groundwater monitoring will be performed to monitor the groundwater remediation progress and plume migration. In addition, existing land use restrictions associated with the military operation of DAFB will be enforced throughout the course of remediation to prevent unauthorized extraction and use of the contaminated groundwater from the Columbia Aquifer.

The time required to achieve the interim RAO is estimated to be between 4 and 13 years, with 6 years being the estimate used for costing purposes. The present worth cost is estimated to be $730,000. The remediation time estimates are based on removal rate data from the AS/SVE pilot study performed at Site WP-21.

Alternative 4

	Target Area 1
Capital Cost	$000
Annual O&M Cost	$30,000[a]
Present Worth	$50,000[b]

[a] Groundwater monitoring cost expended by government in years 3 through 5 only.
[b] Net cost to government. Refer to text.

Alternative 4 consists of *in situ* bioremediation of groundwater utilizing intrinsic bioremediation in Target Area 1. Intrinsic bioremediation is one of the bioremediation technologies being applied to the Target Areas to promote the development of alternate and innovative treatment technologies as encouraged under CERCLA.

The distribution of chlorinated solvent constituents in groundwater in and downgradient of Target Area 1 indicates that intrinsic bioremediation processes are active. The degradation rates and reaction mechanisms associated with the intrinsic bioremediation processes occurring in Target Area 1 will be studied over a multi-year period by the Remediation Technologies Development Forum (RTDF), which is a consortium of partners from industry, government, and academia working to develop more effective and less costly remedial treatment technologies. Intrinsic bioremediation is a passive remediation technology; that is, it does not involve the installation of any extraction or physical/chemical treatment systems to effect the remediation of the aquifer. Instead, this technology relies on the indigenous microorganisms to biologically degrade organic contaminants. Although this technology is passive, it should not be confused with the no action alternative. Establishing the efficacy of intrinsic bioremediation requires that an extensive site characterization be made, which includes sampling, testing, modeling, and

evaluating microbial activity and biotransformation rates. The RTDF study will determine whether intrinsic bioremediation holds promise as a long-term remedy for the contaminants present. Monitoring of the Target Area 1 groundwater plume will be conducted from an estimated six monitoring wells for cost estimating purposes to allow the study and rate measurement of the intrinsic bioremediation processes. The monitoring period will extend until the final FS and ROD is completed, which is estimated to be within a period of 5 years for costing purposes.

The bioremediation process utilized is not expected to generate degradation products that can migrate beyond the Base boundary. Groundwater monitoring will be performed to monitor the groundwater remediation progress and downgradient water quality to ensure that offbase plume migration does not occur. In addition, existing land use restrictions associated with the military operation of DAFB will be enforced throughout the course of remediation to prevent unauthorized extraction and use of the contaminated groundwater from the Columbia Aquifer.

The time required to achieve the interim RAO will be evaluated during the RTDF study. It is anticipated that this interim remedy will remain active until the final remedy is selected, which for costing purposes is estimated to be 5 years.

EVALUATION OF ALTERNATIVES

The selected alternative for remediating the contamination in the Target Area is Alternative 4 (bioremediation). Based on current information, this alternative provides the best balance of trade-offs among the alternatives with respect to the nine criteria that are required to be evaluated under CERCLA. This section profiles the performance of the selected alternative against the nine criteria and explains how it compares to the other alternatives under consideration.

Overall Protection of Human Health and the Environment

The overall protectiveness criterion is a composite of other evaluation criteria, especially short-term effectiveness, long-term effectiveness, and compliance with ARARs. Alternatives 1, 2, 3, and 4 are all considered to be protective of human health during their

period of implementation because of the existence of land use restrictions that prohibit the unauthorized extraction or use of contaminated groundwater in the Target Areas, thereby preventing human exposure.

Alternative 1 (no action) is not considered effective because no provisions are made to monitor the Target Area plume to evaluate compliance with the interim RAO. Alternatives 2 (pump and treat), 3 (air sparging), and 4 (bioremediation) will all meet the interim RAOs and are considered effective.

Compliance With ARARs

The interim RAOs that have been set for chlorinated solvent constituents in groundwater will allow for the resultant concentration of several of these constituents to exceed their federal Maximum Contaminant Levels (MCLs). MCLs, as provided for in CERCLA § 121 (d)(2)(A)(ii), are relevant and appropriate requirements for any final actions expected to be taken as a result of the Base-wide investigation.

Offsite contaminant migration, even for interim actions, requires that a number of other ARARs be considered. The principal ARARs that pertain to the offsite movement of contaminants are the Delaware regulations implementing the Federal Clean Air Act and Clean Water Act. These regulations are the Delaware Regulations Governing the Control of Air Pollution (DRGCAP 1 through 3, 21 and 24), the Delaware Water Pollution Control Regulations (DWPCR1 through 6), the Delaware Industrial Waste Effluent Limitations (DWPCR 8), and the Delaware Surface Water Quality Standard (DSWQS 1 through 9, 11 and 12). The above referenced regulations regarding emissions of volatile organic compounds to the atmosphere will be complied with in Alternatives 2 and 3 to ensure that acceptable levels of emissions are met. Alternative 2 will require discharge to surface water. The above referenced regulations regarding surface water discharge define limits of acceptable chemical concentrations for wastewater, and attainment of these limits will be a requirement for this alternative. For Alternative 4, there will be no offsite migration or releases of contaminants. Alternatives 2 and 3 both meet all previously identified regulations that pertain to the offsite movement of contaminants.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence criterion primarily considers the magnitude of residual risk that would remain after the implementation of an alternative, and the adequacy and reliability of the controls instituted. All of the alternatives provide for the long-term protection of human health through the existing land use restrictions. However, reliance upon land use restrictions is not considered a permanent remedy.

Under Alternative 1 (no action), the chlorinated solvent contamination in groundwater will not be monitored. Therefore, the adequacy and reliability of this alternative cannot be established.

Alternatives 2 (pump and treat), 3 (air sparging), and 4 (bioremediation) will all result in significant reductions of chlorinated solvent concentrations in the Target Area. If any one of these treatment alternatives is selected, that system will be operated until the interim RAO is achieved. Hence, no more than 10 percent of the maximum observed concentration of each ethyl-based chlorinated solvent will remain in the Target Area. The magnitude of residual contamination remaining in the Target Area is a function of the time the treatment alternative is operated or allowed to continue. Continued operation of the treatment system beyond the point at which the interim RAO is reached may allow further reductions in contaminant levels to be achieved. Performance of the interim remedy and compliance with ARARs will be evaluated in the final Base-wide FS and ROD.

Reduction of Toxicity, Mobility, and Volume

No reduction of toxicity, mobility, or volume will be achieved by implementation of Alternative 1. The three action alternatives include components which are capable of significantly reducing the toxicity of groundwater in the Target Area.

The groundwater extraction system proposed under Alternative 2 will establish hydraulic control over the plume, thereby limiting the mobility of contaminants away from the Target Area. The air sparging *in situ* treatment technology included in Alternative 3 operates by increasing the mobility of contaminants. This increased mobility may result

in some spreading of contamination beyond the effective zones of these alternatives during the course of contaminant removal, however, the overall volume of the contaminants will be reduced. The bioremediation technology proposed under Alternative 4 will have no impact on contaminant mobility. The toxicity profile of the groundwater may shift somewhat during the biodegradation process, as vinyl chloride is generated during the degradation of the more chlorinated ethyl-based compounds. However, because little vinyl chloride has been detected in the groundwater thus far, the evidence suggests that vinyl chloride is rapidly degraded to carbon dioxide, water, and chloride ion under the aerobic conditions found downgradient of the Target Areas.

Short-Term Effectiveness

Alternative 1 (no action) includes no remedial actions. Therefore, there will be no short-term impacts on community or worker health or the environment from construction activities. However, because Alternative 1 will not monitor compliance with the interim RAOs established for this project, it is considered to be ineffective.

Alternatives 2 (pump and treat), 3 (air sparging), and 4 (bioremediation) will all be effective in reducing groundwater contaminant concentrations in the Target Area. None of these alternatives are expected to have significant impacts on worker or public health or the environment. Alternative 2 is estimated to be capable of meeting the interim RAO within a 5 to 10 year time frame. However, although not believed present, isolated pockets of DNAPLs in the aquifer could cause this time frame to increase to 30 years or more.

The presence of DNAPLs will also affect the length of time required to achieve the interim RAO under Alternative 3, though to a lesser extent than will their presence on Alternative 2. There are two reasons for this. First, there would be many more air sparging/density-driven convection wells under Alternative 3 than there would be extraction wells under Alternative 2. Thus, the chance of locating a remediation well near a pocket of free product is much greater under Alternative 3. Secondly, the *in situ* remediation is a more aggressive remediation process than pump and treat. High mass transfer rates from water to air would be achieved with the physical *in situ* treatment

technologies lowering the concentration of solvents within the plume. Lowered groundwater concentrations would increase the driving force for solubilization of free product in order to maintain equilibrium. The time required to meet the interim RAO under Alternative 3 is estimated to be between 4 and 13 years.

Alternative 4 is estimated to be capable of achieving the interim RAO in Target Area 1, though 50 years or more may be required. As with the other action alternatives, these time frames may be extended if DNAPLs are present. A DNAPL would present a continuing source of contaminants to the aquifer as the DNAPL constituents were solubilized in the groundwater. This transfer of constituents from free phase to dissolved phase would occur through the physical processes of desorption and liquid-liquid partitioning. These equilibrium-driven processes typically occur slowly because of the relatively low surface area of DNAPL in contact with the groundwater in comparison to DNAPL volume. The solubilization rate of DNAPLs would likely be slower than the rate of degradation of the dissolved constituents. Thus, the solubilization of DNAPLs would likely be the rate-limiting step.

Implementability

Three main factors are considered under this criterion: technical feasibility, administrative feasibility, and availability of services and materials. All four alternatives are administratively feasible and the required services and materials are readily available. Hence, the comparison will focus on the technical feasibility of the alternatives.

Alternative 1 (no action) and Alternative 4 (bioremediation) have no technical feasibility considerations. Alternatives 2 (pump and treat) and 3 (air sparging) have technical feasibility concerns associated with them. These concerns are related to the highly developed character of the Target Area and the numerous space constraints that are present. The Alternative 2 system includes only 5 groundwater extraction and SVE wells and a limited piping network. Alternative 3 consists of 59 air sparge, DDC, SVE wells, plus expansive piping and numerous treatment stations. Overall, Alternative 4 is judged to be the most easily implemented action alternative.

Cost

No direct costs are associated with the implementation of Alternative 1 (no action) nor with Alternative 4 (bioremediation). The capital cost of Alternative 2 (pump and treat) is $170,000 and the capital cost of Alternative 3 (air sparging) is $440,000.

The O&M cost of Alternative 2 will initially be $32,000 per year, but will drop to $20,000 per year after 2 years of operation when SVE operations are discontinued. The O&M cost of Alternative 3 will be almost $50,000 the first year, but will drop several thousand dollars per year thereafter as the carbon consumption rate associated with the SVE system's offgas treatment units decreases. The O&M costs of Alternative 4 will be approximately $30,000 per year for monitoring intrinsic bioremediation in Target Area 1. However, the first 2 years of monitoring will be performed by the RTDF as part of their intrinsic bioremediation pilot study at no cost to the government.

The present worth cost of the alternatives will depend upon the time they are operated. The present worth costs of Alternative 2 under operating scenarios of 5, 10, and 30 years are $270,000, $330,000, and $440,000, respectively. The present worth costs of Alternative 3 under operating scenarios of 4, 6, and 13 years, respectively are $690,000, $730,000, and $940,000. The present worth net cost to the government of Alternative 4 assuming 3 years of monitoring in Target Area 1 following 2 years of assumed monitoring by the RTDF is $50,000. Thus, Alternative 4 has the lowest present worth cost.

State Acceptance

The State of Delaware concurs with the selected interim remedy for Target Area 1.

Community Acceptance

The only comments received during the public comment period were from the RTDF expressing support for the proposed remedy. No community opposition to the proposed remedy was noted.

CONCLUSION

Based on the evaluation of the alternatives using the nine criteria, Alternative 4 (bioremediation) is preferred. Alternative 4 is protective of human health and the environment, complies with all ARARs, represents a permanent remedy that reduces groundwater toxicity, provides the greatest ease of implementation, and is the most cost effective action alternative.

The selected alternative utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. This interim action will not negatively impact the ability to implement a final action, if it is required. The final remedy will be selected in the final Base-wide ROD.

Actual or threatened releases of hazardous substances from this Site, if not addressed by the selected alternative, may present a current or potential threat to public health, welfare, or the environment.

GLOSSARY AND ACRONYMS

Air Sparging - Underground injection of air into saturated soil and groundwater, resulting in the *in situ* air stripping of volatile constituents.

Air Stripping - Transfer of volatile constituents from water to air by induced contact between air and water streams.

Aquifer - A geologic formation capable of yielding water to wells and springs.

ARARs - Applicable or Relevant and Appropriate Requirements. Criteria set forth by federal and state statute and regulations that must be considered in the evaluation of remedial alternatives.

Biodegradation - The breakdown of organic constituents by microorganisms into less complex compounds.

Capital Cost - Cost incurred for the construction and startup of a facility.

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act. Federal law creating the Superfund program.

Dense Non-Aqueous Phase Liquid (DNAPL) - An organic liquid with a low water solubility and a density greater than that of water. DNAPLs retain their physical and chemical properties when in contact with water and tend to sink in an aquifer when released to groundwater.

Density-Driven Convection - Modified in-ground air sparging system which induces a flow pattern in the vicinity of the sparging well.

EPA - U.S. Environmental Protection Agency.

Ex Situ - Performed above ground.

FS - Feasibility Study. Study undertaken to evaluate remedial alternatives.

FFS - Focused Feasibility Study.

Groundwater - Subsurface water residing in a zone of saturation.

HQ - Hazard Quotient. An indicator of the noncarcinogenic health risk associated with exposure to a chemical.

In Situ - In the original location (in the ground for this report).

IRP - The U.S. Air Force Installation Restoration Program.

Leach - The solubilization and transport of constituents in soil through the percolation of surface water to groundwater.

LECR - Lifetime Excess Cancer Risk. The probability of the carcinogenic health risk associated with exposure to the chemicals of concern.

O&M Cost - Annual cost incurred for operation and maintenance of a facility.

Maximum Contaminant Levels (MCLs) - Federal drinking water standards.

Plume - A recognizable distribution of constituents in groundwater.

Potentiometric Surface - An imaginary surface that represents the static head of groundwater and is defined by the level to which water will rise.

RBSC - Risk Based Screening Concentration. A chemical-specific concentration used to preliminarily assess whether exposure to a chemical poses a potential health risk.

RAO - Remedial Action Objective. Cleanup goal established for the remediation.

RCRA - Resource Conservation and Recovery Act.

ROD - Record of Decision. A legal document issued by the lead governmental agency selecting the remedy to be implemented at a CERCLA site.

RTDF - Remediation Technologies Development Forum.

Soil Vapor Extraction (SVE) - An *in situ* physical treatment process to volatilize and withdraw VOCs from subsurface soil residing above the groundwater table.

Vadose Zone - Soil zone above the water table.

VOCs - Volatile organic compounds.