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FINAL FEASIBILITY STUDY AT OPERABLE UNIT 7 (OU 7) SITE 16 NAS CECIL FIELD FL
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ABB ENVIRONMENTAL SERVICES INC

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FEASIBILITY STUDY
OPERABLE UNIT 7

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

UNIT IDENTIFICATION CODE: N60200
CONTRACT NO. N62467-89-D-0317/090

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SOUTHERN DIVISION
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FEASIBILITY STUDY
OPERABLE UNIT 7

NAVAL AIR STATION CECIL FIELD
JACKSONVILLE, FLORIDA

Unit Identification Code: N60200

Contract No. N62467-89-D-0317/090

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August 1995

The engineering evaluations and professional opinions rendered in this planning document that describes the Feasibility Study for Operable Unit 7, Naval Air Station Cecil Field, Jacksonville, Florida, were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice. This document is not intended to be used for construction of the selected alternative.

Robert C Lunardini Jr
30 Aug 95

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Expires February 28, 1997

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CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

The Contractor, ABB Environmental Services, Inc., hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/090 are complete and accurate and comply with all requirements of this contract.

DATE: August 28, 1995

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FOREWORD

The Department of the Navy developed the Installation Restoration (IR) program to locate, identify, and remediate environmental contamination from the past disposal of hazardous materials at Navy and Marine Corps installations. The Navy's IR program follows the Department of Defense's environmental restoration program mandated by the Superfund Amendments and Reauthorization Act of 1986 to address waste sites that may pose a threat to human health or the environment.

The Navy's IR program consists of Preliminary Assessment and Site Inspection, Remedial Investigation and Feasibility Study (RI/FS), and Remedial Design and Remedial Action at sites where disposal of hazardous materials allegedly occurred. The Preliminary Assessment and Site Inspection identify the presence of pollutants. The RI/FS analyzes the nature and extent of contamination and determines the optimum remedial solution. The Remedial Design and Remedial Action complete the implementation of the solution.

Previous investigations have determined that Naval Air Station (NAS) Cecil Field has 18 sites that may pose a threat to human health or the environment. Therefore, an RI/FS will be performed at each site to address the extent and magnitude of contamination at these sites.

This report presents the FS for Operable Unit 7, consisting of Site 16 (the Aircraft Intermediate Maintenance Department Seepage Pit Area). This report includes a discussion of remedial action objectives (RAOs), applicable and/or relevant and appropriate requirements, the identification and screening of applicable technologies to address the RAOs, the identification and description of remedial alternatives, and a detailed analysis of the identified alternatives against nine criteria.

Questions regarding this report should be addressed to the Commanding Officer, Code OOB, P.O. Box 111, NAS Cecil Field, Jacksonville, Florida 32215-0111.

EXECUTIVE SUMMARY

ABB Environmental Services, Inc. (ABB-ES) has been contracted by the Department of the Navy, Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) to complete a Remedial Investigation and Feasibility Study (RI/FS) for Operable Unit (OU) 7, located at Naval Air Station (NAS) Cecil Field in Jacksonville, Florida. The Navy is preparing the RI, the baseline Risk Assessment (RA), and the FS as separate documents. This report documents the FS for OU 7, which consists of Site 16, the Aircraft Intermediate Maintenance Department Seepage Pit, and the adjacent area where approximately 26 million gallons of groundwater are contaminated with trichloroethene.

The purpose of this FS is to identify remedial action objectives (RAOs), identify remedial action alternatives that will achieve those objectives, and evaluate the alternatives to provide the basis for selection of a preferred remedial action alternative. This FS contains an overview of the RI and the RA for OU 7 and contains the identification and discussion of applicable or relevant and appropriate requirements (ARARs) to develop RAOs. Next, remedial technologies that address site-specific considerations established in the RAOs are identified and screened; those technologies that pass the screening phase are developed into remedial alternatives. Remedial alternatives are then developed and analyzed in detail for comparison in the comparative analysis.

The RI/RA completed for OU 7 identified an unacceptable human health risk for surficial aquifer groundwater based on the future residential land use scenario for exposure to groundwater. No ecological risks were identified for any media at OU 7. Therefore, one RAO was developed to prevent humans from consuming surficial aquifer groundwater in the future. Location-, chemical-, and action-specific ARARs identified for the OU were examined to assess the need to develop RAOs to comply with ARARs. One RAO was developed to address chemicals in groundwater that exceed chemical-specific ARARs. These RAOs are summarized below.

RAO 1: Protect humans from unacceptable risk by preventing potable water use of surficial aquifer groundwater that exceeds site-specific health-based risk criteria.

RAO 2: Prevent the use of surficial aquifer groundwater that exceeds chemical-specific ARARs and to be considered (TBCs).

Both RAOs developed for OU 7 relate to the groundwater medium. Five remedial alternatives were developed to address management of migration (i.e., surficial aquifer groundwater) at OU 7.

Alternative 1: No Action

Alternative 2: Enhanced Bioremediation

Alternative 3: Groundwater Extraction, Treatment via Ultraviolet Radiation with Hydrogen Peroxide, and Discharge to Surface Water

Alternative 4: *In situ* Air Sparging

Alternative 5: Groundwater Extraction, Treatment via Air Stripping, and Discharge to Federally Owned Treatment Work

The evaluation of alternatives was completed based on seven of the nine criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The eighth and ninth criteria, State and public acceptance, will be addressed for OU 7 once review comments on the FS are received from the State and once a public comment period for the proposed plan for OU 7 has occurred.

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
AIMD	Aircraft Intermediate Maintenance Department
AQUIRE	Aquatic Information Retrieval
ARARs	applicable or relevant and appropriate requirements
AST	aboveground storage tank
AWQC	Ambient Water Quality Criteria
AWWA	American Water Well Association
bls	below land surface
BOD	biological oxygen demand
BRAC	base realignment and closure
CBOD	carbonaceous biological oxygen demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
COC	chemical of concern
COD	chemical oxygen demand
CPC	chemical of potential concern
CSF	cancer slope factor
°C	degrees Celsius
DCA	dichloroethane
DCE	dichloroethene
DNAPL	dense nonaqueous phase liquid
DO	dissolved oxygen
DOT	Department of Transportation
EBS	Environmental Baseline Survey
ECPC	ecological chemical of potential concern
ELCR	excess lifetime cancer risk
EM	electromagnetic
FAC	Florida Administrative Code
FATE	Fate and Treatability Estimator
FDEP	Florida Department of Environmental Protection
FDER	Florida Department of Environmental Regulation
FDNR	Florida Department of Natural Resources
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FFA	Federal Facility Agreement
FFS	Focused Feasibility Study
FGS	Florida Geological Survey
FOTW	Federally Owned Treatment Work
FS	Feasibility Study
ft/day	feet per day
ft/ft	feet per foot
ft^2/day	square feet per day
ft/yr	feet per year

GLOSSARY (Continued)

g/ml	grams per milliliter
GAC	granular activated carbon
gpm	gallons per minute
GPR	ground-penetrating radar
GW	groundwater
H	Henry's law constant
HHCPC	human health chemical of potential concern
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
HOCl	hypochlorous acid
IAS	Initial Assessment Study
ID	identification
IR	Installation Restoration
IRA	Interim Remedial Action
IROD	Interim Record of Decision
IZS	intermediate zone of the surficial aquifer
K_{ow}	octanol-water partition coefficient
K_{oc}	soil-sediment partition coefficient
LDR	Land Disposal Regulation
LZS	lower zone of the surficial aquifer
MAG	magnetometer
MCL	maximum contaminant level
MEK	methyl ethyl ketone
mℓ	milliliter
mm	millimeter
MM	management of groundwater migration
mg/kg	milligrams per kilogram
mg/kg · day	milligrams per kilogram per day
mg/ℓ	milligrams per liter
$\mu g/m^3$	micrograms per cubic meter
μg/kg	micrograms per kilogram
μg/ℓ	micrograms per liter
mgd	millions of gallons per day
NAAQS	National Ambient Air Quality Standards
NAAS	Naval Auxiliary Air Station
NACIP	Navy Assessment and Control of Installation Pollutants
NAPL	nonaqueous phase liquid
NAS	Naval Air Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDI	Nondestructive Inspection
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant and Discharge Elimination System
NPL	National Priority List
NSPS	New Source Performance Standards

GLOSSARY (Continued)

O&M	operation and maintenance
OLF	Outlying Landing Field
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PAC	powdered activated carbon
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PDE	potential dietary exposure
PEL	permissible exposure limit
PID	photoionization detector
PPE	personal protection equipment
ppb	part per billion
ppm	part per million
PSC	potential source of contamination
RA	Risk Assessment
RAO	remedial action objective
RBC	rotating biological contactor
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RfD	reference dose
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
RTV	reference toxicity value
SARA	Superfund Amendments and Reauthorization Act
SOUTHNAV-FACENGCOM	Southern Division, Naval Facilities Engineering Command
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TAL	target analyte list
TBC	to be considered
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
THM	trihalomethanes
TKN	total Kjeldahl nitrogen
TMSS	Technical Memorandum for Supplemental Sampling
TOC	total organic carbon
TOH	total organic halogen
TOX	toxicity
TPH	total petroleum hydrocarbons
TSD	treatment, storage, and disposal
TSS	total suspended solids

GLOSSARY (Continued)

USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UV/OX	ultraviolet radiation with oxidation
UZH	upper zone of the Hawthorne
UZS	upper zone of the surficial aquifer
VOC	volatile organic compound

1.0 INTRODUCTION

ABB Environmental Services, Inc. (ABB-ES) has been contracted by the Department of the Navy, Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM) to complete a Remedial Investigation and Feasibility Study (RI/FS) for Operable Units (OUs) 1, 2, and 7 at Naval Air Station (NAS) Cecil Field, Jacksonville, Florida (Figure 1-1). The RI/FSs are being conducted under contract number N62467-89-D-0317-90. This report presents the results of the FS for OU 7 that include the development, screening, and evaluation of potential remedial alternatives that address contaminated media at OU 7. OU 7 consists of Site 16, the Aircraft Intermediate Maintenance Department (AIMD) Seepage Pit Area.

This report was prepared in accordance with the following guidance documents and regulations: the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) (references made to CERCLA in this report should be interpreted as "CERCLA, as amended by SARA"); the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (U.S. Environmental Protection Agency [USEPA], 1990b); and Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (RI/FS Guidance) (USEPA, 1988).

Section 1.1 presents the purpose of the FS report. The remainder of this chapter provides an overview of the CERCLA FS process (Section 1.2) and discusses how this process will be implemented for OU 7 at NAS Cecil Field (Section 1.3). A site description and history of NAS Cecil Field and OU 7 are included in Sections 1.4 and 1.5, respectively.

1.1 PURPOSE OF THE FEASIBILITY STUDY (FS) REPORT. The purpose of this FS report is to document the results of a study that develops, screens, and evaluates potential remedial alternatives to address contaminated media at OU 7. The FS was based on the results and conclusions of the RI and the Risk Assessment (RA) completed for OU 7 as well as the interim remedial action (IRA) that has been implemented (described in Chapter 4.0). The RI and RA are submitted under separate cover (ABB-ES, 1995c; 1995a). The IRA, which included the removal of contaminated soil and an underground storage tank system, is documented in a Focused Feasibility Study (FFS) and a Nondestructive Inspection (NDI) Holding Tank Closure Certification and Report (ABB-ES, 1993 and 1994b).

The goals of the RI/FS for OU 7 are to assess the extent, magnitude, and impact of contamination at the waste disposal site (i.e., the seepage pit and adjacent area); to qualitatively and quantitatively assess the risk posed to human health and the environment; and to develop remedial alternatives to address threats to human health and/or the environment.

The RI process serves as the mechanism for collecting data to identify the source of contamination and migration pathway characteristics, for conducting the RA, and for collecting physical measurements and chemical analytical data necessary for remedial alternative evaluation in the FS.

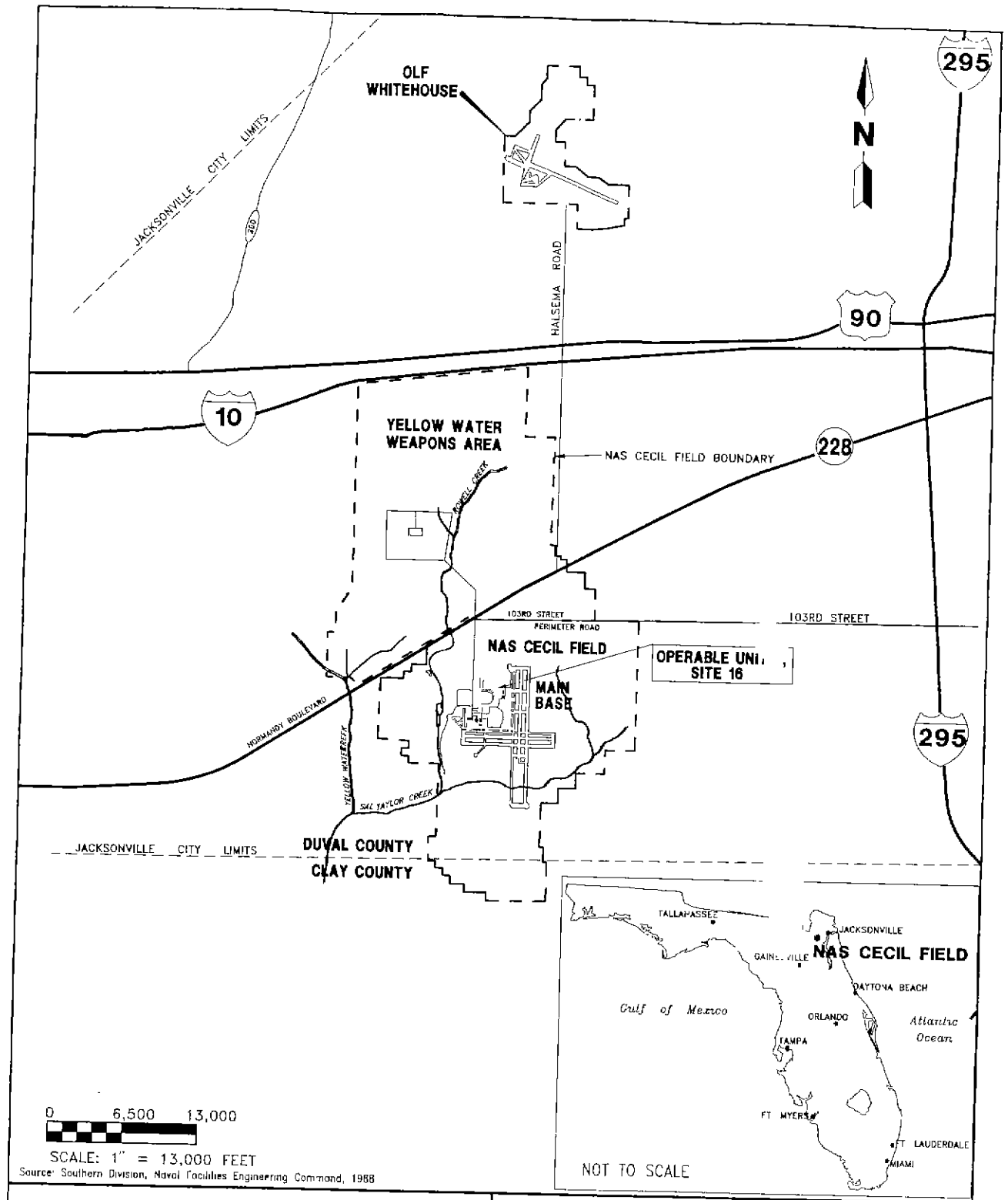


FIGURE 1-1
GENERAL LOCATION MAP

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

CECIL/CE-BRAC/WEM-NP/03-29-95

The RA provides an evaluation of the potential threat of the waste site to human health and the environment in the absence of any remedial action. The RI and RA provide the basis for determining whether remedial action is necessary.

The FS process uses the results of the RI and RA along with other available data to identify remedial action objectives (RAOs) and to develop, screen, and evaluate potential remedial alternatives. The recommended alternative will be presented in a separate document known as a proposed plan. The FS process is described in more detail in Section 1.2.

1.2 THE COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA) FS PROCESS. The development of remedial alternatives for CERCLA sites consists of identifying applicable technologies and developing those technologies into remedial alternatives. SARA emphasizes the use of treatment technologies that reduce toxicity, mobility, or volume as a principal element rather than alternatives that prevent exposure to contaminants. Also, permanent remedies are preferred. The NCP requires that a range of alternatives be presented in the FS to the maximum practicable extent.

The first step in the FS process is to develop RAOs that specify the contaminants, media of interest, exposure pathways, and preliminary remedial goals that permit a range of alternatives to be developed. The preliminary remedial goals are developed based on chemical-specific applicable or relevant and appropriate requirements (ARARs), when available; site-specific risk-based factors; or other available information (e.g., leachability of contaminants in soil to groundwater).

Once RAOs are identified, general response actions for each medium of interest are developed. General response actions typically fall into the following categories: no action, containment, excavation, extraction, treatment, disposal, or other actions, singular or in combination, that may be taken to satisfy the RAOs for the site.

Next, the volumes or areas to which general response actions might be applied are identified. The volumes or areas are determined by taking into account the requirements for protectiveness as identified in the RAOs and the chemical and physical characterization of the site (i.e., the results and conclusions of the RI).

The fourth step in the FS process is to identify and screen applicable technologies for each general response action. This step eliminates those technologies that cannot be implemented technically. Those technologies that pass the screening phase are then assembled into remedial alternatives.

Remedial alternatives are then screened based on effectiveness, implementability, and cost. The purpose of the alternative screening phase is to select a range of appropriate remedial alternatives to undergo detailed analyses. Selected remedial alternatives are described and analyzed in detail using several criteria described in the NCP, including:

- overall protection of human health and the environment;
- reduction of toxicity, mobility, or volume of contaminants through treatment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- short-term effectiveness;
- implementability; and
- economics (i.e., cost).

Alternatives are evaluated against two additional factors after State participation and the public comment period for the FS:

- State acceptance and
- community acceptance.

The results of the detailed analyses (for the first seven criteria) are summarized and compared in a comparative analysis. The alternatives are compared with each other against several criteria, including:

- protection of human health and the environment;
- attainment of Federal and State human health and environmental requirements identified for the site;
- cost effectiveness;
- use of permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable; and
- preference for treatment that reduces toxicity, mobility, or volume of contaminants as a principal element.

These criteria are used because SARA requires them to be considered during remedy selection.

State acceptance is evaluated when the State reviews and comments on the draft FS report. Community acceptance is evaluated based on comments received on the FS and proposed plan during a public comment period. This evaluation is described in a responsiveness summary in the Record of Decision (ROD). This entire process provides the information and analyses that form the basis for a proposed remedial action plan (proposed plan) and subsequent ROD that documents the identification and selection of the remedy.

1.3 IMPLEMENTATION OF THE FS FOR OU 7. The FS completed for OU 7 was conducted according to the process described in Section 1.2.

The RI for OU 7 was prepared based on the site conditions through July 1994. An IRA that included the signing of an Interim ROD (IROD) was completed at OU 7. This FS takes into account site conditions after the completion of the RI, RA, and the IRA. Consequently, this FS takes into account alternatives for additional measures beyond the IRA.

Chapter 4.0 presents an overview of the IRA. ARARs, RAOs, and general response actions for OU 7 are presented in Chapter 5.0. Chapter 6.0 presents the identification and screening of technologies chosen to meet the response objectives and develops and screens remedial alternatives. Chapter 7.0 presents a detailed analysis of selected alternatives. Chapter 8.0 provides a summary and comparative analysis of the alternatives described in Chapter 7.0.

1.4 FACILITY BACKGROUND.

The mission of NAS Cecil Field and available background information for the facility and OU 7 are presented in this section. A general description of NAS Cecil Field is given in Subsection 1.4.1. Subsection 1.4.2 summarizes available historical information for the facility.

1.4.1 Facility Description

The official mission of NAS Cecil Field is to provide facilities, services, and material support for the operation and maintenance of naval weapons, aircraft, and other units of the operating forces as designated by the Chief of Naval Operations. Some of the tasks required to accomplish this mission include: (1) operation of fuel storage facilities, (2) provision of facilities and performance of organizational-level aircraft maintenance, (3) provision of facilities and performance of intermediate-level aircraft maintenance, and (4) maintenance and operation of an engine repair facility and test cells for designated turbo-jet engines.

NAS Cecil Field comprises 11 departments, each with special assistants and staff offices. The facility also hosts more than 40 tenant commands, approximately 11,000 civilian and military personnel, and can accommodate approximately 3,500 residents in base quarters and housing.

1.4.1.1 Facility Land Use NAS Cecil Field occupies more than 31,000 acres and can be divided into four distinct areas: the main base (NAS Cecil Field), which occupies 9,516 acres; the Yellow Water Weapons Department, which occupies 8,091 acres; Outlying Landing Field (OLF) Whitehouse, which occupies 2,587 acres; and the 11,072-acre Land Target Complex Detachment Astor. The main facility, the Yellow Water Weapons Department, and OLF Whitehouse are shown on Figure 1-1. Land Target Complex Detachment Astor is located 120 miles south of the main base.

OU 7 is located on the main base. The main facility of NAS Cecil Field is located in southwestern Duval County, Florida, and is within the Jacksonville, Florida, city limits. Land west and north of the base is characterized as rural and is predominantly forested. The main facility consists of intersecting north-south and east-west runways bracketing the flightline and support facilities. These facilities occupy approximately 1,000 acres in the southeast quadrant of NAS Cecil Field. The remaining acreage of the main base is mostly undeveloped (SOUTHNAVFACENGCOM, 1989) (Figure 1-2).

1.4.1.2 Adjacent Land Use The only major city near the main base is Jacksonville, Florida, the center of which is approximately 14 miles to the northeast.

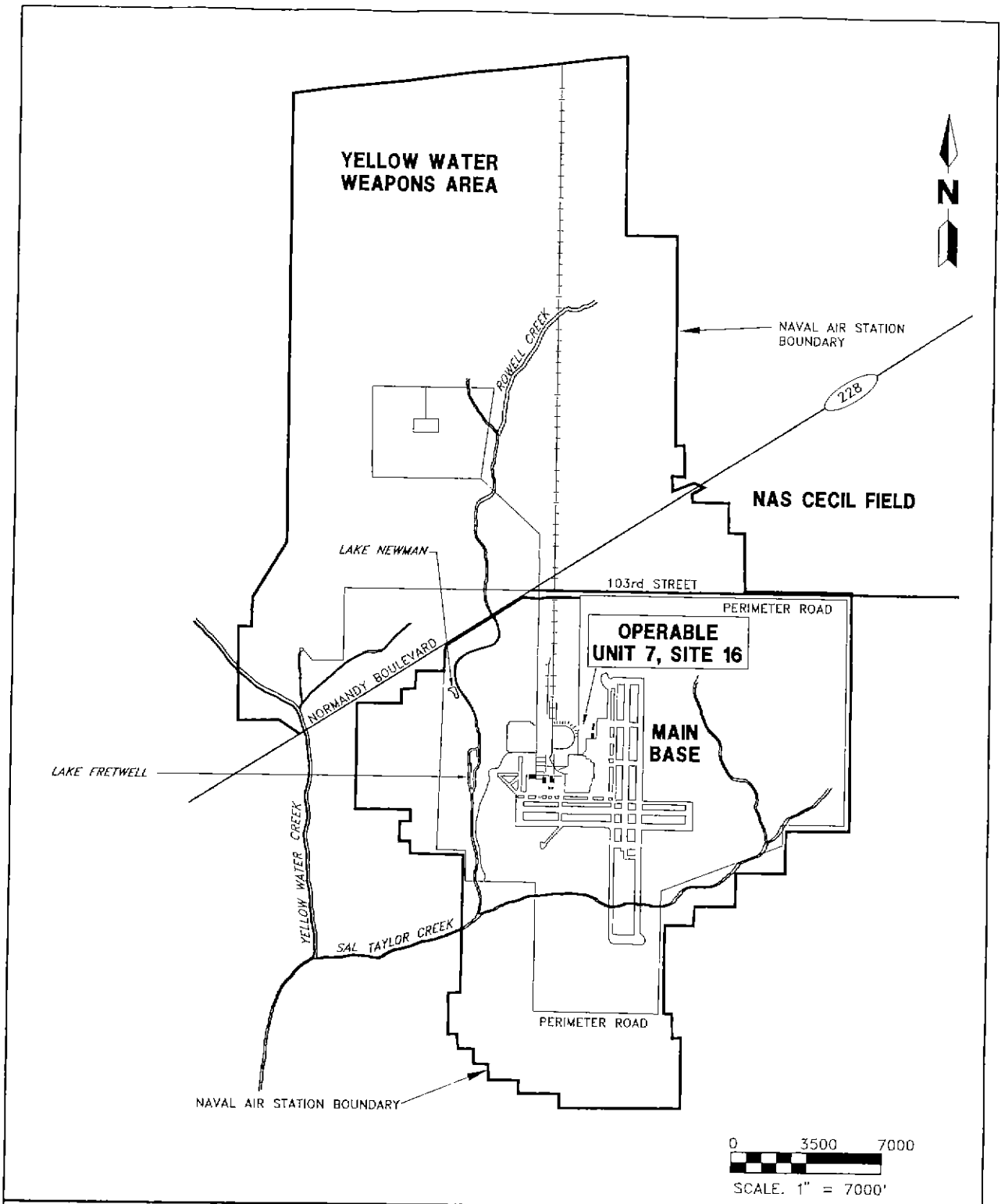


FIGURE 1-2
FACILITY AND SITE LOCATION MAP

CECIL/FT3FACIL/WDW-NP/03-20-95

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Land surrounding NAS Cecil Field is used primarily for forestry with some light agriculture and ranching. Small communities and scattered dwellings associated with these activities are located in the vicinity. The closest incorporated municipality is the town of Baldwin, which is centered approximately 6.4 miles to the northwest of the main facility entrance.

To the east, the rural surroundings grade into a suburban fringe bordering the major east-west roadways. Low intensity commercial use, such as convenience stores and low density residential areas, characterize the use of land in this eastern area. Herlong Airport lies approximately 4.5 miles east of NAS Cecil Field along State Road 228. The region becomes more urbanized as one approaches the city of Jacksonville (SOUTHNAVFACENGCOM, 1989).

1.4.2 Facility History The first environmental study for the investigation of waste handling and/or disposal sites at NAS Cecil Field was completed between 1983 and 1985 by Geraghty & Miller. This study was followed by an Initial Assessment Study (IAS) by Envirodyne Engineers in 1985. The IAS was completed under the Navy Assessment and Control of Installation Pollutants (NACIP) program, which was the precursor to the Navy's present Installation Restoration (IR) program. In 1988, a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) (Harding Lawson Associates, 1988) was completed. The RFI acted on the recommendations of the IAS. OU 7 was included in the IAS and the RFI.

NAS Cecil Field was placed on the National Priority List (NPL) by the U.S. Environmental Protection Agency (USEPA) and the Office of Management and Budget in December 1989. A Federal Facility Agreement (FFA) for NAS Cecil Field was signed by the Florida Department of Environmental Protection (FDEP, formerly the Florida Department of Environmental Regulation [FDER]), USEPA, and the Navy in 1990. Following the listing of NAS Cecil Field on the NPL and the signing of the FFA, remedial response activities at the facility have been completed under CERCLA authority.

NAS Cecil Field has several sites where hazardous wastes may have been handled, spilled, or buried. The individual sites are currently referred to as potential sources of contamination (PSCs). The name "site" is applied to PSCs that are currently under investigation at NAS Cecil Field as part of the IR program. At the time of the facility's listing on the NPL, 18 sites had been identified. A study completed by 1988 (by Harding Lawson Associates) identified another site (Site 19). Remedial response activities are currently underway at Sites 1, 2, 3, 5, 7, 8, 10, 11, 14, 15, 16, and 17. Sampling and analysis outlines are currently being prepared for the investigation of PSCs 4, 6, 9, 12, 18, and 19.

In 1993, NAS Cecil Field was selected for closure by the Base Realignment and Closure (BRAC) Commission. An Environmental Baseline Survey (EBS) was completed as the first step in the closure process. The EBS identifies parcels of land for sale, lease, or investigation depending on the condition of the parcel. OU 7 was designated in the November 1994 EBS as yellow (release of hazardous substances has occurred, and remedial actions are underway, but all required remedial actions have not yet been taken).

1.5 OU 7 SITE DESCRIPTION AND HISTORY. This section presents a description and history of OU 7.

1.5.1 Site Location OU 7 consists of Site 16, the AIMD Seepage Pit and the affected area (Figure 1-3). OU 7 is located west of the north-south jet runways at NAS Cecil Field. The AIMD seepage pit and affected area are located 60 feet north of Building 313. Currently, the Jet Engine Maintenance Shop and NDI Laboratory are located in Building 313.

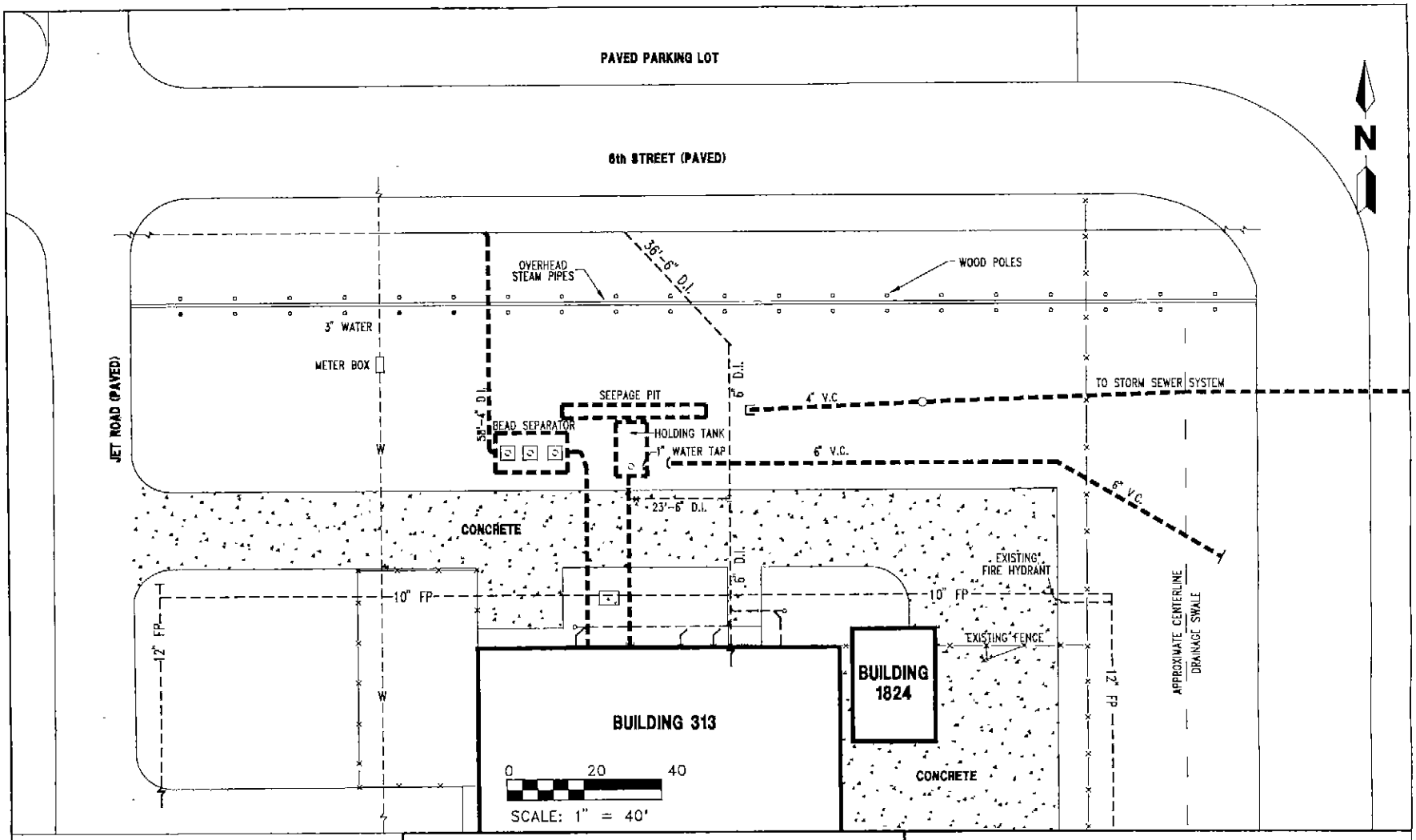
1.5.2 Site Description OU 7 is vegetated with grass that is mowed regularly. The general area adjacent to OU 7 is relatively flat and covered with asphalt and concrete. The immediate vicinity is crisscrossed with several utilities, including a water line, overhead steam line, fire water main, a sanitary sewer main, and storm drain lines (both active and abandoned, Figure 1-4). There are no inlets to the storm sewer system in the immediate vicinity of OU 7 (ABB-ES, 1992). The ground surface exhibited no evidence (staining or absence of vegetation) of adverse effects from previous waste activities at the site in 1988 or during site visits conducted by ABB-ES since 1993.

Runoff flows toward the paved roads around OU 7. However, a drainage swale that may carry some runoff to the south of the site is located east of the fence between Buildings 313 and Hangar 815. The swale is covered with grass and drains to the storm water system. Runoff from the paved roads in the vicinity of OU 7 ultimately flows to the NAS Cecil Field stormwater sewer system (Harding Lawson Associates, 1988).

1.5.3 History of OU 7 From 1959 until 1980, grease, rust, scale, solvent, and paint wastes generated during a machine and engine parts cleaning process, along with glass beads and blasting grit from the airframes blasting shop, were disposed of at OU 7. Based on operations occurring within Building 313 at this time, waste components disposed of may have included: sodium cyanide, trichloroethylene (TCE), creosol, phenol, methylene chloride, and oil (Harding Lawson Associates, 1988).

Liquid waste generated from operations conducted within Building 313 was allowed to drain toward a floor sump located at the north end of the building (Figure 1-3). This sump was connected via vitrified clay piping to a 4,100-gallon underground concrete holding tank, located north of the building. The holding tank (now identified as the NDI Holding Tank) acted as a surge tank for the adjacent seepage pit. The holding tank contained a sump equipped with a sump pump, and was constructed so that waste could be pumped from the sump into either the seepage pit or the NAS Cecil Field stormwater sewer system. The seepage pit was constructed with cinder blocks on top of a concrete slab and measured approximately 40 feet long by 3 feet wide by 10 feet deep. One-half-inch gaps were left between the vertical intersections of the cinder blocks, and no mortar was used within these gaps. The construction of the seepage pit allowed for seepage of waste directly into the subsurface material. The date of the installation of this drainage and seepage system is unknown; however, the tank is believed to have been installed concurrently with the seepage pit (C. Vargas & Associates, LTD., 1981).

Glass beads and blasting grit from sandblasting operations within Building 313 were allowed to enter the tank and seepage pit through the sump in the building. Subsequently, glass beads accumulating within the tank and seepage pit caused the system to malfunction. In the late 1960s, a 12-inch asbestos-cement discharge pipe was installed in the seepage pit to allow drainage to the NAS Cecil Field



LEGEND

- D.I. — Ductile iron
- V.C. — Vilrified clay
- W — Water main
- SS — Sanitary sewer
- FP — Fire main pipe

NOTE: Bold dashed lines include structures associated with OU7 waste disposal.

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FIGURE 1-3
AIRCRAFT INTERMEDIATE MAINTENANCE DEPARTMENT SEEPAGE PIT AREA (BEFORE REMOVAL)

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

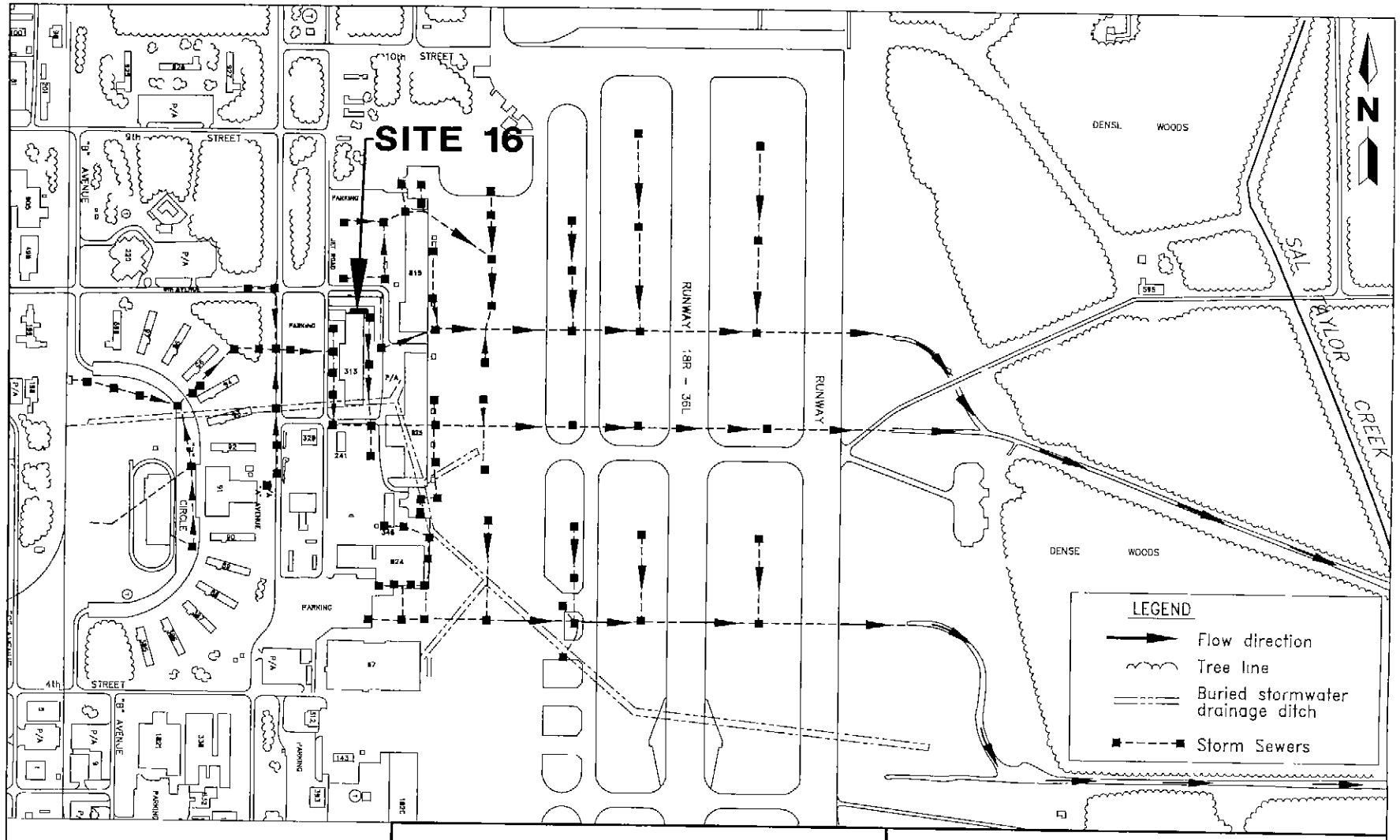

FIGURE 1-4
STORM SEWER SYSTEM

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

stormwater sewer system. The discharge pipe was installed approximately 3 feet above the base of the seepage pit. This pipe was installed so that when the level of wastewater within the seepage pit reached the level of the discharge pipe, the wastewater would overflow to the stormwater sewer system. The stormwater drainage system eventually discharges to the series of open ditches that empty into Sal Taylor Creek (Harding Lawson Associates, 1988). The distance from OU 7 to the discharge point of the stormwater system is 2,600 feet; the distance from this stormwater sewer discharge point to Sal Taylor Creek is approximately 2,400 feet.

Use of the seepage pit was discontinued in 1980. At that time, piping leading from the tank to the seepage pit was removed, and the tank's outlet to the seepage pit was plugged. As shown on Figure 1-3, piping from the seepage pit to the storm sewer system was partially removed and plugged, and the piping leading from the holding tank to the stormwater sewer system was also plugged. The length of pipe removed before plugging is unknown; soil was left in place during pipe removal and plugging activities. Also, the top 4 feet of the seepage pit was removed, and the area was backfilled with clean sand.

Because wastewater discharge from Building 313 continued after the abandonment of the drainage and seepage system, a bead separator, for gravity settling of glass beads from wastewater, was installed to the west of this system. This separator was connected to another sump located within Building 313 via ductile iron piping. Discharge from the bead separator was connected to the NAS Cecil Field sanitary sewer system via 4-inch ductile iron piping (C. Vargas & Associates, Ltd., 1988).

From 1980 until 1989, the holding tank was used for 90-day storage of hazardous waste, reportedly wash water from the first floor of the NDI Laboratory's metal cleaning area. This activity was permitted under the facility's RCRA hazardous waste storage permit number 8016-122017. This permit was granted in 1987 by the USEPA and the FDEP (SOUTHNAVFACENGCOM, 1993).

Renovation of the north end of Building 313 in 1989 included the abandonment of the bead separator and holding tank. Piping leading from the building to the bead separator and from the building to the 4,100-gallon holding tank was disconnected and plugged from within the building. In addition, all liquid in the holding tank was pumped out and transported to an offsite treatment, storage, and disposal (TSD) facility.

In March 1993, NAS Cecil Field obtained a modification to permit number 8016-122017. This modification (permit number 8016-211406) stipulated that the 4,100-gallon holding tank must be closed in accordance with RCRA by June 4, 1994. The NDI holding tank was excavated on May 11, 1994, and removed from the site on May 17, 1994. In addition, the seepage pit and glass bead separator were also removed at this time. Associated piping was either removed entirely or partially removed, cut at appropriate locations, and plugged with grout. Approximately 1,580 tons of vadose zone (above the water table) soil contaminated with TCE at concentrations above an action level of 1 mg/kg were excavated and disposed of offsite. The area was backfilled with clean fill and restored to original topographic conditions (ABB-ES, 1994b).

2.0 SUMMARY OF THE REMEDIAL INVESTIGATION

This chapter summarizes the results of the field investigation at OU 7, including the RI field investigation completed in 1994 (ABB-ES, 1995c). As discussed in Chapter 1.0, OU 7, the AIMD Seepage Pit, received waste materials from Building 313. These waste materials were discharged to the seepage pit that was in direct contact with the groundwater table. Therefore, these waste activities have resulted in the contamination of environmental media via contaminant migration. Past and recent (1994) field investigations have been completed to assess the nature, extent, and magnitude of contamination at OU 7 attributable to the seepage pit and affected area.

2.1 SUMMARY OF PREVIOUS INVESTIGATIONS. Investigation of the AIMD Seepage Pit and adjacent area at OU 7 began in 1985. Investigations completed before the RI are discussed in this section in chronological order. Findings, conclusions, and recommendations from these investigations are presented and summarized in Table 2-1.

2.1.1 Initial Assessment Study (IAS) The IAS (Envirodyne Engineers, 1985) identified hazardous waste sites at NAS Cecil Field that warranted further investigation. The investigation included the following tasks:

- records search of historical data and aerial photographs,
- field inspections, and
- personnel interviews.

No intrusive field investigations were conducted. Eighteen sites were identified during the IAS, including Site 16 (OU 7), the AIMD Seepage Pit. The information collected during the IAS led to the initiation of RFI field activities at OU 7 (Envirodyne Engineers, 1985).

2.1.2 Resource Conservation and Recovery Act (RCRA) Facility Investigation The RCRA Facility Investigation (RFI) included the following tasks (Harding Lawson Associates, 1987):

- a magnetometer survey,
- installation of three monitoring wells,
- sampling and analysis of groundwater,
- sampling and analysis of one sediment sample, and
- measurement of water levels in all monitoring wells.

When the magnetometer survey results for OU 7 were evaluated, most magnetic anomalies corresponded with the locations of buried tanks and utilities. One anomaly, east of the seepage pit, did not correspond with the location of

Table 2-1
Findings and Conclusions from Previous Investigations

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Previous Study	Tasks Completed	Results of Sampling	Recommendations
Initial Assessment Study (IAS) (Envirodyne, 1985)	1. Records search 2. Onsite survey 3 Confirmation study ranking 4. Site ranking 5. Confirmation study recommendations	No sampling conducted	1. Install three surficial monitoring wells to detect contaminant migration from the seepage pit. 2. Collect samples from the three groundwater monitoring wells on a quarterly basis for one year. 3. Collect a sediment sample from the drainageway that received discharge from the seepage pit. 4. Analyze the groundwater and sediment samples by GC/FID scan with capillary column for MEK, TCE, toluene, phenol, methylene chloride and cresol; COD; TOC; TOX; cadmium, chromium, silver, lead, cyanide; oil and grease; specific conductance; pH.
RCRA Facility Investigation (RFI) (Harding Lawson Associates, 1988)	1. Site reconnaissance 2. Geophysical survey 3. Installed three new groundwater monitoring wells 4. Collected three groundwater samples 5. Collected one surface sediment sample	Groundwater results. a. trichloroethene (TCE): 400 $\mu g/\ell$ b. 1,2-trans-DCE: 380 $\mu g/\ell$ c. chromium: 74 $\mu g/\ell$ d. lead· 175 $\mu g/\ell$	Corrective Action Study to further investigate the lateral and vertical extent and concentrations of the hazardous constituents found at the site.
Remedial Investigation and Feasibility Study for OUs 1, 2, and 7 (ABB-ES, 1991)	1. Ground penetrating radar (GPR) survey 2. Piezocone survey 3. Groundwater headspace screening 4. Surface soil sampling 5. Subsurface soil sampling and monitoring well installation 6. Groundwater sampling 7. Hydraulic conductivity testing and water level elevation measurement	1. The GPR survey was not successful in delineating the seepage pit, underground piping, and underground utility network. 2. Low concentrations of TCE, TCA, and PCE were detected in the four groundwater headspace screening samples collected. 3 The one piezocone probe installed to 48 feet, indicated fine to silty fine sand with lenses of cemented sand to hardpan. 4. Analysis of five surface soil samples indicated the presence of toluene, xylene, and PAHs.	1. Conduct EM and MAG geophysical survey to determine the location of buried piping and utility networks. 2. Collect and analyze four surface soil samples to support RA and FS. 3. Collect and screen soil and groundwater samples from a minimum of 15 locations to determine the horizontal and vertical extent of contamination at the site. 4. Install three borings with continuous split-spoon sampling to a depth of approximately 120 feet bls to determine site-specific lithology. Install four borings to identify the presence of NAPL based on the results of the screening (see 3).

Table 2-1 (Continued)
Findings and Conclusions from Previous Investigations

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Previous Study	Tasks Completed	Results of Sampling	Recommendations
Remedial Investigation and Feasibility Study for OUs 1, 2, and 7 (ABB-ES, 1991) (continued)		5. Analysis of 16 subsurface soil samples from five borings detected the presence of acetone, 1,2-DCE, TCE, naphthalene, 2-methylnaphthalene, 2-methylphenol, 4-methylphenol, and bis(2-ethylhexyl)phthalate. 6. Analysis of groundwater samples from seven new monitoring wells detected 1,1-DCE, 1,1-DCA, 1,2-DCE, 1,1,1-TCA, TCE, naphthalene, 2-methylphenol, and 2,4-dimethylphenol. 7. The hydraulic conductivity estimated from the slug tests were: 2.7 to 4.6 ft/d for three LZS wells 1.0 ft/d for one LZS well 28 ft/d for one UZH well 8. Results of water level measurements indicate a groundwater flow direction to the southeast in the UZS	5 Install eight borings to characterize and delineate soil contamination at the site. Collect two soil samples from each boring for laboratory analysis. Also collect soil samples from select borings for geotechnical analysis. 6. Install a total of ten monitoring wells to complete characterization and delineation of site contamination

Notes: GC = gas chromatograph.
FID = flame ionization detector.
MEK = methyl ethyl ketone.
TCE = trichloroethene
COD = chemical oxygen demand.
TOC = total organic carbon.
TOX = toxicity.
RCRA = Resource Conservation and Recovery Act.
$\mu g/\ell$ = micrograms per liter.
DCE = dichloroethane.
OU = Operable Unit.
TCA = trichloroethane
PCE = tetrachloroethene.
ABB-ES = ABB Environmental Services, Inc.
PAH = polynuclear aromatic hydrocarbon.
EM = electromagnetic.
MAG = magnetometer.
RA = risk assessment.
FS = Feasibility Study.
bls = below land surface.
NAPL = nonaqueous phase liquid.
DCA = dichloroethane.
ft/d = foot per day.
LZS = lower zone of the surficial aquifer.
UZH = upper zone of the Hawthorn Group.
UZS = upper zone of the surficial aquifer.

utilities and was reported as possibly representing contaminant migration from the seepage pit into the soil. Harding Lawson indicates in their report that this anomaly most likely represents disturbed soil.

1,2 Trans-dichloroethene (380 micrograms per liter [$\mu g/\ell$]), TCE (400 $\mu g/\ell$), chromium (74 $\mu g/\ell$), and lead (175 $\mu g/\ell$) were detected in unfiltered groundwater samples collected during the RFI. Lead (19 milligrams per kilogram [mg/kg]) was detected in the sediment sample collected from the ground surface above the underground discharge pipe connecting the seepage pit to the stormwater sewer system. The direction of groundwater flow, estimated from the three groundwater-level measurements, was to the south.

Based on the results of the RFI, a Corrective Action Study Plan was recommended to further investigate the lateral and vertical extent of the hazardous constituents found at the site.

2.1.3 1991-92 Remedial Investigation Activities The investigation conducted by ABB-ES during the fall of 1991 and spring of 1992 included the following tasks:

- a ground-penetrating radar (GPR) survey to identify areas of excavation, utilities, and other subsurface features;
- a piezocone (direct push technology) survey to investigate subsurface lithology and to collect subsurface soil and groundwater samples;
- headspace screening of groundwater samples for volatile organic compounds (VOCs);
- sampling and analysis of surface soil;
- sampling and analysis of subsurface soil;
- installation of monitoring wells;
- sampling and analysis of groundwater samples;
- hydraulic conductivity testing; and
- measurement of water levels in monitoring wells.

The results of these investigations are presented in the *Technical Memorandum for Supplemental Sampling (TMSS) at Operable Units 1, 2, and 7* (ABB-ES, 1992), and summarized below.

GPR Survey. The GPR survey was conducted on October 10, 1991, to locate areas of disturbed soil and underground piping and/or utility networks. An area of disturbed soil was identified in the vicinity of the holding tank, seepage pit, and bead separator. Delineation of the seepage pit, underground piping, and underground utility network was not successful.

Piezocone Survey. A piezocone survey was conducted on October 18, 1991, to collect lithologic information about subsurface soil in the vicinity of OU 7. Fine-grained to silty sand with occasional lenses of cemented sand were detected at OU 7 to a depth of approximately 48 feet below land surface (bls), when the survey was terminated.

Groundwater Headspace Screening. Onsite groundwater screening was conducted on October 18, 1991. Gas chromatographs equipped with electron capture detectors and flame ionization detectors were used to identify chlorinated aliphatics and aromatic organics in the air above groundwater samples in closed containers. TCE and 1,1,1,-trichloroethane (TCA) were detected, but their concentrations in groundwater were not quantified.

Surface Soil Sampling. Surface soil samples were collected for analysis of target compound list (TCL) organics and target analyte list (TAL) inorganics on April 29, 1992 (Figure 2-1). VOCs and several semivolatile organic compounds (SVOCs) characteristic of solvents, plasticizers, and petroleum were detected.

Subsurface Soil Sampling and Monitoring Well Installation. Subsurface soil samples were collected for analysis of TCL organics on December 3, 1991 (Figure 2-1). A total of seven borings were drilled and monitoring wells were installed in each boring. Three soil samples were selected for analysis from two borings, and two soil samples were selected for analysis from each of the remaining five borings. Analysis of the soil samples detected inorganics typical of natural soil, solvents, and petroleum-related SVOCs. Chromium and lead were detected at concentrations approximately two times higher than background subsurface soil.

Groundwater Sampling. Groundwater samples were collected for analysis of TCL organics, TAL inorganics, and total petroleum hydrocarbons (TPH) on November 11, 1991 (Figure 2-1). VOCs, particularly 1,1,1-TCA and TCE-related degradation products, were detected.

Hydraulic Conductivity Testing and Water Level Elevation Determination. Slug tests were conducted in all new monitoring wells installed at the site on December 16, 1991. The hydraulic conductivity for monitoring wells screened in the upper part of the surficial aquifer ranged from 2.68 feet per day (ft/day) to 4.6 ft/day compared to 1.01 ft/day for the lower part of the surficial aquifer. The hydraulic conductivity for the intermediate aquifer averaged 28 ft/day. Water level measurements were taken on November 19, 1991, and again on April 29, 1992. The depth to water averaged 6.81 feet bls (72.02 feet above mean sea level). The depth to groundwater varies seasonally.

Several data needs were identified after completion of the 1991 OU 7 investigation. These consisted primarily of data needed to further assess the nature and extent of soil and groundwater contamination at OU 7. Recommendations to fill the data needs were presented in the TMSS.

2.2 SUMMARY OF REMEDIAL INVESTIGATION.

2.2.1 Hydrogeology In the area of this investigation, there are three water-bearing systems. According to the Florida hydrostratographic nomenclature (Florida Geological Survey [FGS], 1986) these units, from most shallow to deepest, are the surficial aquifer system, the intermediate aquifer system and confining unit, and the carbonate-rich Floridan aquifer system. At OU 7, the surficial aquifer system is present in undifferentiated sediments. The intermediate aquifer system and confining unit are present as dolomite underlying a layer of clay with dolomite fragments. Wells designated as "rock" or "secondary" wells are screened within the intermediate "artesian" aquifer. The Floridan aquifer system was not encountered during the investigation at OU 7.

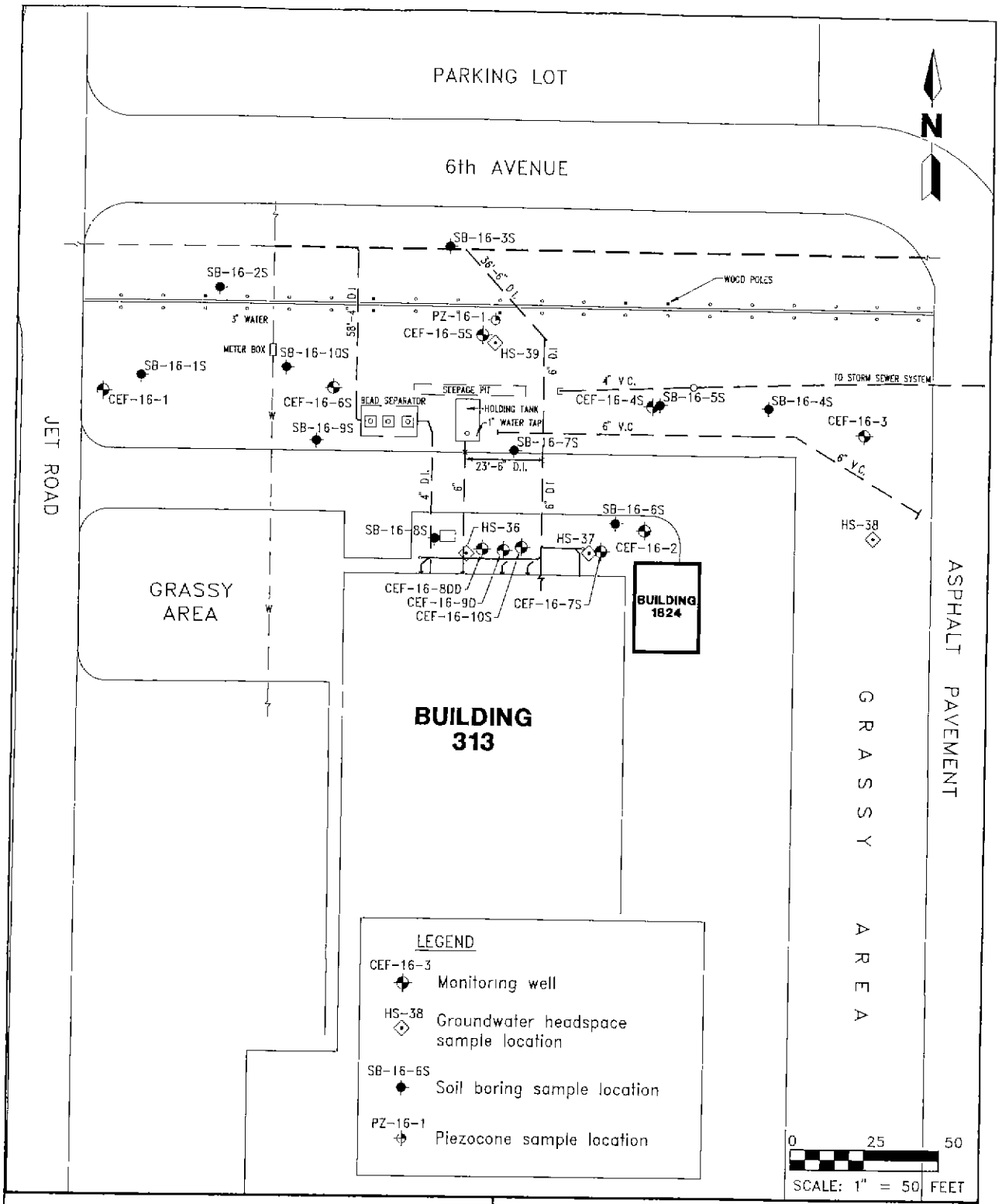

FIGURE 2-1
MONITORING WELL, SOIL BORING, PIEZOCONE, AND GROUNDWATER HEADSPACE SCREENING LOCATIONS, 1991

CECIL\CE-FSL\NP\03-23-95

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

2.2.1.1 Surficial Aquifer System The undifferentiated sediment in the surficial aquifer system in the area of OU 7 consists mostly of quartz sand with some clayey sand and clay. The Pliocene-Pleistocene Nashua Formation and the thick clay layer separating the Nashua from the differentiated sediments at other OUs on Cecil Field were not encountered at OU 7. As a result, the surficial aquifer at OU 7 is not separated into an upper and lower zone based on geology, but rather is considered as one unit. Still, well screens were placed to investigate conditions in the upper (UZS), intermediate (IZS), and lower (LZS) parts of the surficial aquifer system.

The surficial aquifer system is under water table conditions (unconfined) and is a very fine-grained quartz sand with up to 10 percent silt and clay. The unconsolidated sediments extend downward to the top of the clay unit, which separates the surficial aquifer system from the intermediate aquifer (Figure 2-2).

The general groundwater flow direction in the surficial aquifer is to the southeast. This general flow direction indicates that the groundwater discharges to the wetland area and Sal Taylor Creek east of the runways. However, there is a dramatic upward vertical gradient in the surficial aquifer before groundwater reaches the west side of the runways 2,400 feet southeast of the seepage pit. The groundwater appears to be upwelling from the intermediate aquifer to the surficial aquifer beginning southeast of well cluster CEF 16-21S, 22I, and 23D. The surficial aquifer, in turn, drains to an area south-southeast of well cluster CEF 16-38S, 39I, and 40D. The upwelling is interpreted to be caused by increased hydraulic conductivity of the clay layer on top of the dolomite.

The horizontal gradient in the surficial aquifer measured along the flowpath from the seepage pit area (CEF-16-5S) to the furthest downgradient monitoring well (CEF-16-32S) in which TCE was detected (i.e, the leading edge of the TCE plume) is approximately 0.0029 feet per foot (ft/ft), based on water level data collected in August 1994. Water levels were also collected from all wells in July, September, and October 1994. Changes in water level were observed between months, but the differences between wells within each of the four data sets were consistent.

Hydraulic conductivity values were estimated for each well in the surficial aquifer at OU 7. The mean K values for the UZS wells, IZS wells, and LZS wells are 2.5 feet per day (ft/day), 19 ft/day, and 18 ft/day, respectively. Based on the results of an aquifer test conducted by the USGS at Cecil Field, the hydraulic conductivity of the surficial aquifer ranges from 3.0 to 5.0 ft/day (Personal Communication, 1995).

A seepage velocity of 0.058 ft/day or 21 feet per year (ft/yr) was calculated for the surficial aquifer using a hydraulic conductivity of 4.0 ft/day, a horizontal gradient of 0.0029 ft/ft (based on August 1994 water levels), and an effective porosity (pore volume through which water flows as a fraction of the total volume of soil) of 0.20 (USGS, 1995).

2.2.1.2 Intermediate Aquifer System In the NAS Cecil Field area, the intermediate aquifer system or confining unit consists of sediment assigned to the Miocene Hawthorn Group. In addition to its clay-rich sediment, the Hawthorn includes near its top a locally continuous carbonate-rich unit of dolomite with

TIME (million years ago)	Stratigraphic Units	Approximate Elevation (feet, mean sea level)
		50
1.8	Undifferentiated Pleistocene and Recent Sediments	
	Nashua Formation	
5		
	Hawthorn Group	
	Coosawatchie Formation	20
	(Charlton Member)	(20 to -10)
	Marks Head Formation	-110
	Penny Farms Formation	-200
24		
	Ocala Limestone	-350
	Avon Park Formation	-700
	Oldsmar Formation	< -1,000
55		
	Cedar Key	< -1,200
62		-1,700

Sources:
Scott, 1988; and **Scott and others,** 1991.

FIGURE 2-2

GEOLOGIC COLUMN

FEASIBILITY STUDY,
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

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significant secondary (e.g., fractures) porosity, possibly including shell hash, or sand bodies. This carbonate-rich unit forms the historical "rock aquifer" or "secondary artesian aquifer," a water-bearing unit widely used in this region as a private drinking water source. For this report, this unit will be referred to as the UZH. The unit is approximately 20 to 25 feet thick and occurs at a depth of 60 to 120 feet bls. The top of this unit is irregular and may represent an erosional unconformity. The total thickness of the entire Hawthorn Group (including the underlying clayey confining beds) exceeds 300 feet in this area (Florida Geological Survey [FGS], 1991). At OU 7, all of the "DD" monitoring wells are screened in the UZH.

Regional groundwater flow in the UZH is to the east (Fairchild, 1972), although the top part of the UZH encountered in the OU 7 investigation shows flow to the south-southeast. The potentiometric surface in this unit is generally higher than the potentiometric surface in the lower zone of the surficial aquifer. As a result, the potential exists for upward leakage of water from this unit to the surficial aquifer system. This is particularly true near creeks, where topographic relief and lowering of surficial heads due to gaining streams accentuates this head difference. At OU 7, the groundwater flow direction in the intermediate aquifer is to the southeast, toward the wetlands. The horizontal hydraulic gradient in the intermediate aquifer is approximately 0.0018 ft/ft, based on water level data collected in August 1994. Water levels were also collected from all wells in July, September, and October 1994. Changes in water levels were observed between months, but the differences between wells within each of the four data sets were consistent.

A vertical upward gradient from the intermediate aquifer to the surficial aquifer is present, as documented by the higher head in the "DD" wells compared to the surficial wells. The groundwater appears to be upwelling from the intermediate aquifer to the surficial aquifer beginning southeast of well cluster CEF 16-21S, 22I, and 23D.

Hydraulic conductivity values were estimated for each well in the intermediate aquifer at OU 7. The mean hydraulic conductivity for the intermediate aquifer (UZH wells) is 15 ft/day. Based on the results of the USGS aquifer test at Cecil Field, the hydraulic conductivity of the upper portion of the intermediate aquifer is estimated at 40 ft/day.

For the intermediate aquifer, a seepage velocity of 0.36 ft/day or 131 ft/yr was calculated. This was based on a hydraulic conductivity of 40 ft/day (USGS, 1995) a horizontal gradient of 0.0018 ft/ft (based on August 1994 water levels), and an effective porosity of 0.20 (USGS, 1995).

2.2.1.3 **Floridan Aquifer System** The Floridan aquifer system is the principal source of groundwater-derived public drinking water in most of northern peninsular Florida. At NAS Cecil Field at least five Navy potable water supply wells (Navy wells that service NAS Cecil Field only) and an irrigation well are producing water from this aquifer system. In the NAS Cecil Field area, the aquifer is composed of (from oldest to youngest) the Oldsmar Formation, the Avon Park Formation, and the Ocala Limestone. The Hawthorn Group, which forms a confining zone, unconformably overlies the Floridan aquifer. Geraghty & Miller (1983) report that the transmissivity of the Floridan aquifer a few miles east of the base is 25,400 square feet per day (ft^2/day). Leve (1966) and Geraghty

& Miller (1983) report that groundwater within the Floridan aquifer flows east to northeast in the vicinity of NAS Cecil Field.

2.2.2 Nature and Extent of Contamination The OU 7 RI was completed in 1994. Surface soil, subsurface soil, groundwater, sediment, and surface water were investigated. Sampling locations are shown on Figures 2-3 through 2-8 The evaluation of investigation results indicates that contaminants were found in samples from all media.

TCE was introduced to the soil and groundwater by discharging wastewater from Building 313 to the former Seepage Pit. Other contaminants may have also been introduced to soil and groundwater via the same discharge, including SVOCs (such as polynuclear aromatic hydrocarbons [PAHs]) and inorganics (such as aluminum, cadmium, cobalt, iron, lead, and vanadium). With the exception of TCE and cobalt, none of these contaminants are observed to have migrated from the source area in the 35 years since discharge to the Seepage Pit began.

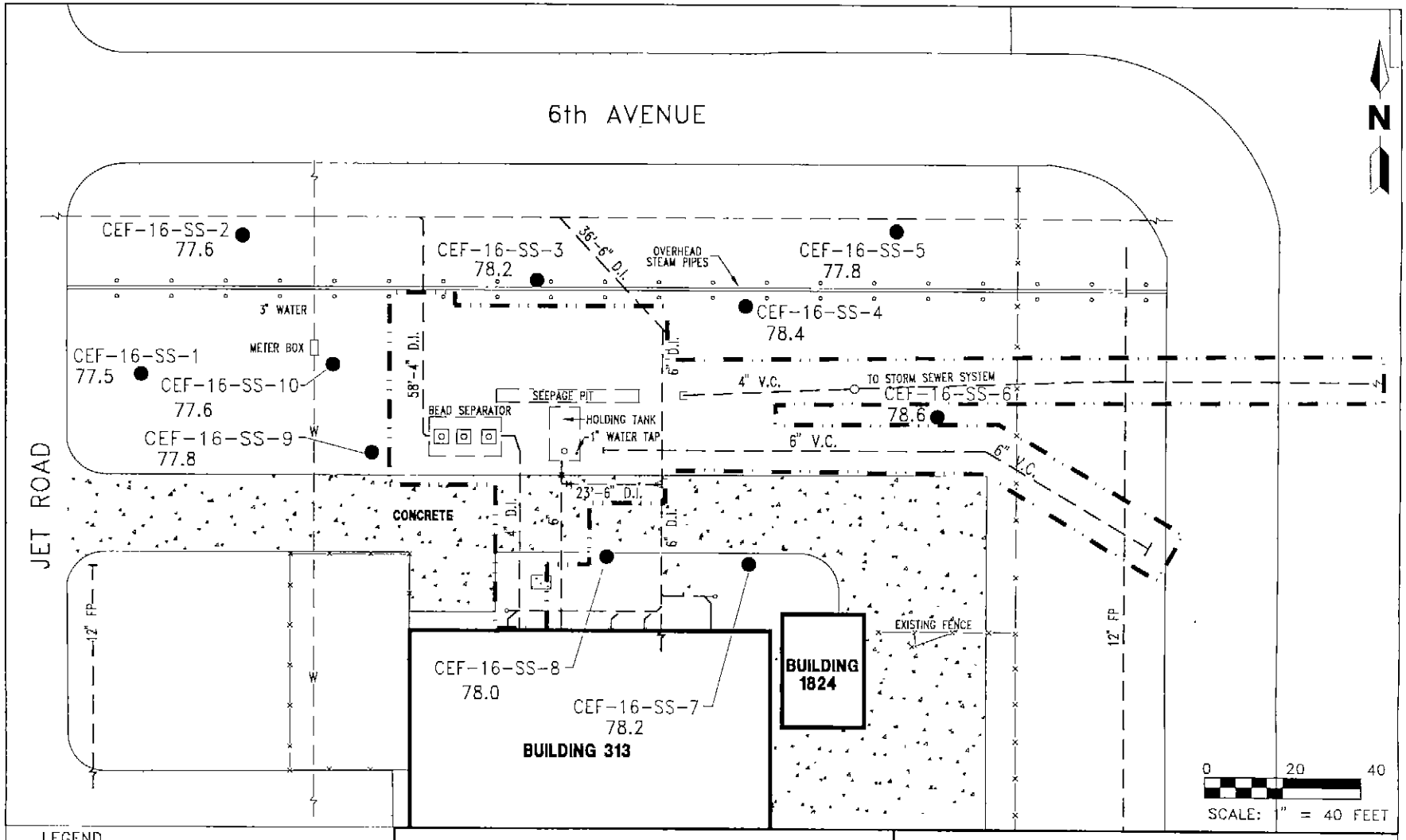
A conceptual model of the TCE contamination is shown on Figure 2-9. The results of the RI are summarized, by medium, in the following subsections.

2.2.2.1 Soil When wastewater was discharged to the Seepage Pit, it apparently caused the water table to mound. This mounding spread contaminants radially (horizontally and vertically). When the discharge stopped, the mound subsided and left contaminants in what is now the unsaturated soil above the water table (vadose zone).

Evaluation of analytical results for 10 surface soil samples (0 to 2 feet bls) indicate the presence of VOCs (TCE and its transformation product, 1,2-dichloroethene [DCE]), SVOCs (PAHs), pesticides, polychlorinated biphenyls (PCBs), and inorganics. However, the Seepage Pit is not a likely source of these chemicals because they are randomly distributed. Chemicals that may be associated with the Seepage Pit, such as TCE, may have been introduced to the surface soil during the IRA. TCE was primarily detected in areas where excavated contaminated soil was stockpiled during the IRA. Other contaminants are likely associated with activities that are not related to the Seepage Pit, such as vehicular traffic, drilling operations, and pesticide application.

Evaluation of analytical results for the 24 subsurface soil samples (greater than 2 feet bls) also indicate the presence of VOCs, SVOCs, pesticides, PCBs, and inorganics. The VOCs, SVOCs, and inorganics appear to be related to the past discharge because the highest concentrations were detected near the Seepage Pit. However, the pesticides and PCBs have a sporadic distribution, indicating that they are not related to the Seepage Pit. The VOCs include TCE and 1,2-DCE as well as methylene chloride, 2-butanone, and acetone (a common laboratory and sampling artifact). The SVOCs include 11 PAHs, 2 phthalates, and phenol. The inorganics that most frequently exceed background screening concentrations are aluminum, calcium, cobalt, and magnesium. Cadmium, cobalt, thallium, and zinc were detected in the subsurface soil samples at the site but not in the background data set.

During the IRA, TCE-contaminated soil with concentrations above 1 mg/kg (1,000 micrograms per kilogram [μg/kg]), was removed from the vadose zone at the source area and replaced with clean fill. Based on the results of the confirmatory soil



LEGEND

- ● Surface soil sample
- 77.8 Land surface elevation, in feet NVGD
- D.I. Ductile Iron
- V.C. Vitrified clay
- W Water main
- SS Sanitary sewer
- FP Firemain pipe

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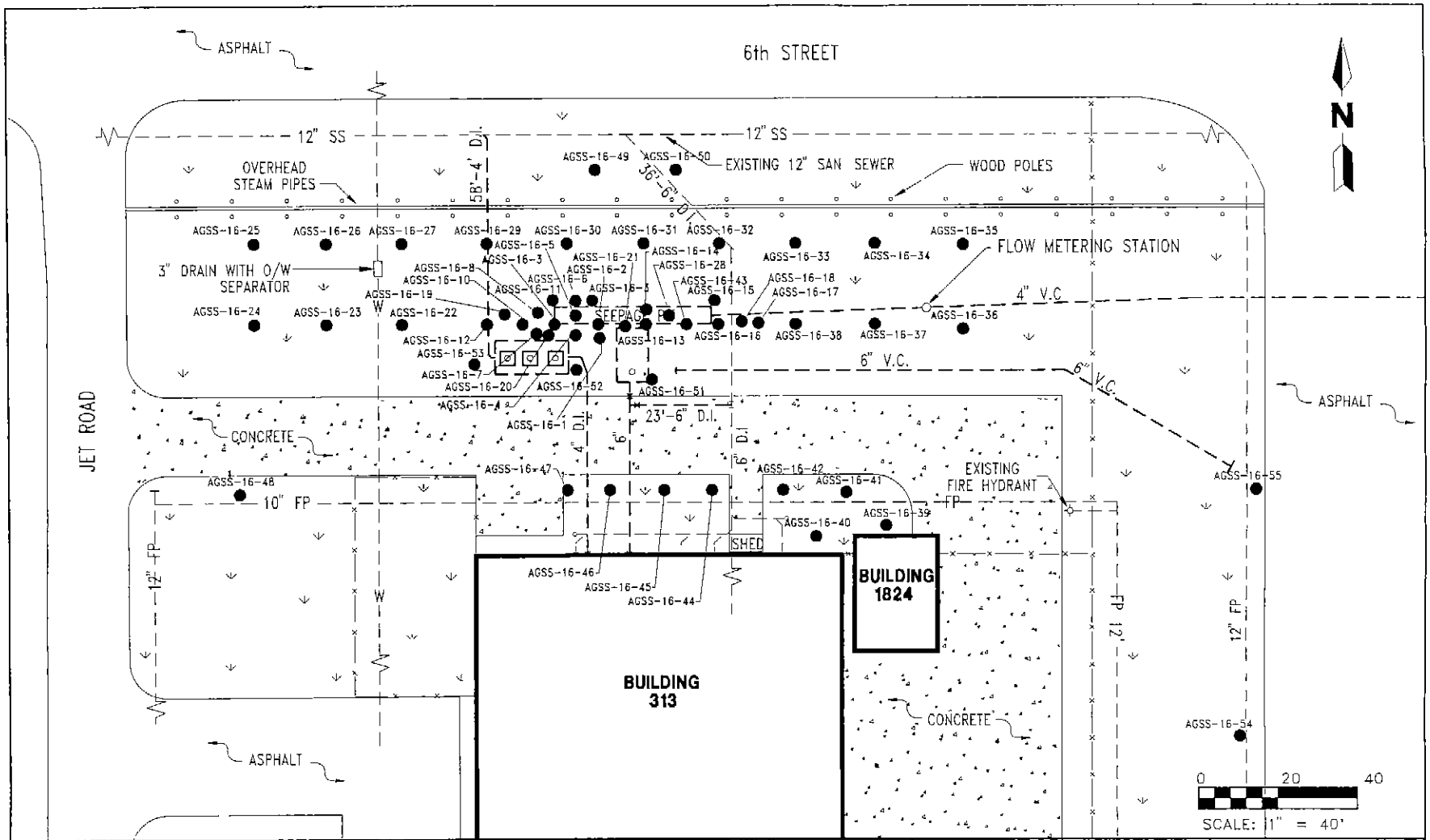
FIGURE 2-3
CONFIRMATORY SURFACE SOIL SAMPLING LOCATIONS

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA



LEGEND

D.I. Ductile iron

V.C. Vitrified clay

FP Fire main pipe

● Site screening sample location

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FIGURE 2-4
SOIL SCREENING LOCATIONS (AGSS SERIES)

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

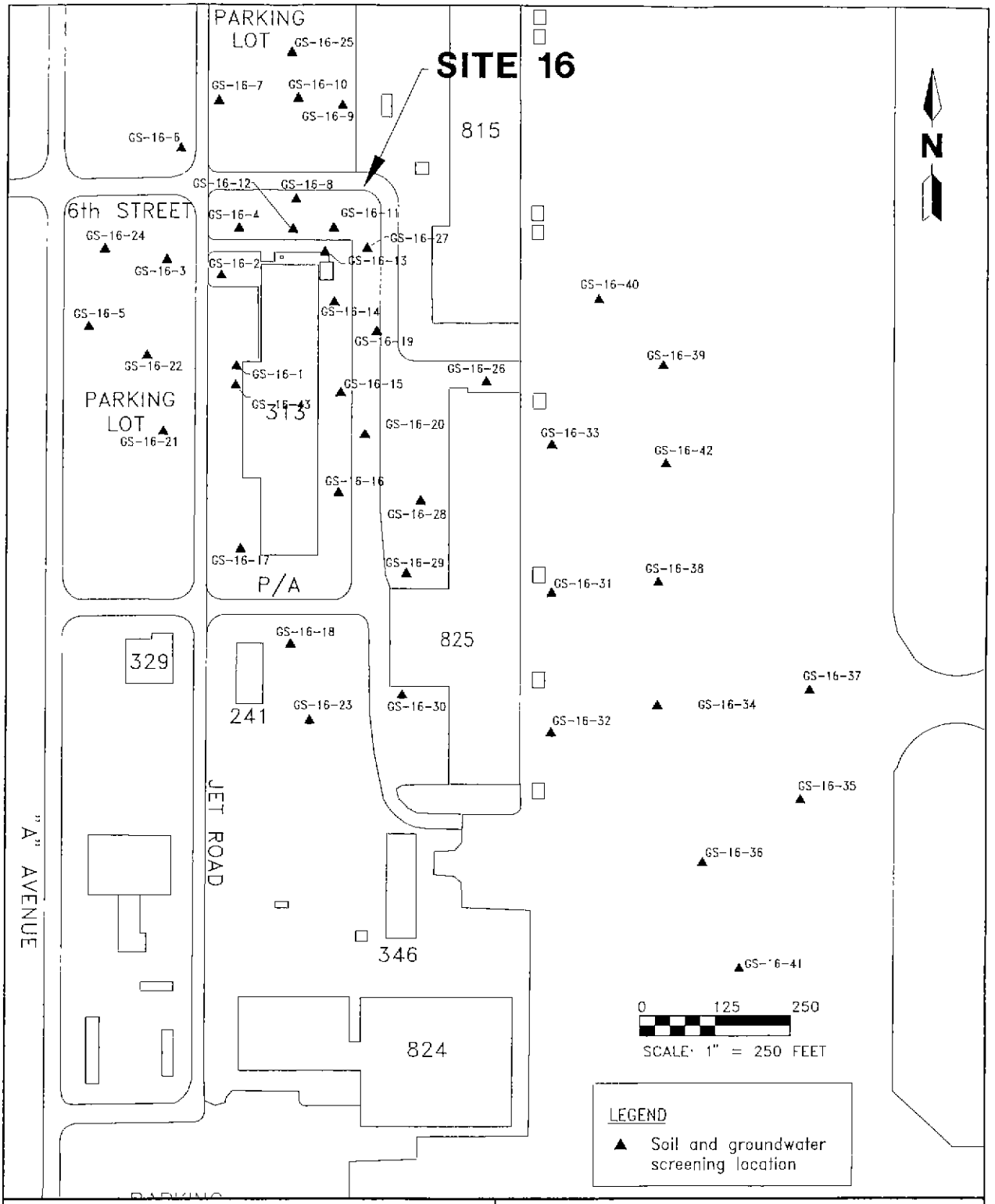

FIGURE 2-5
SOIL AND GROUNDWATER SCREENING LOCATIONS (GS SERIES)

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FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

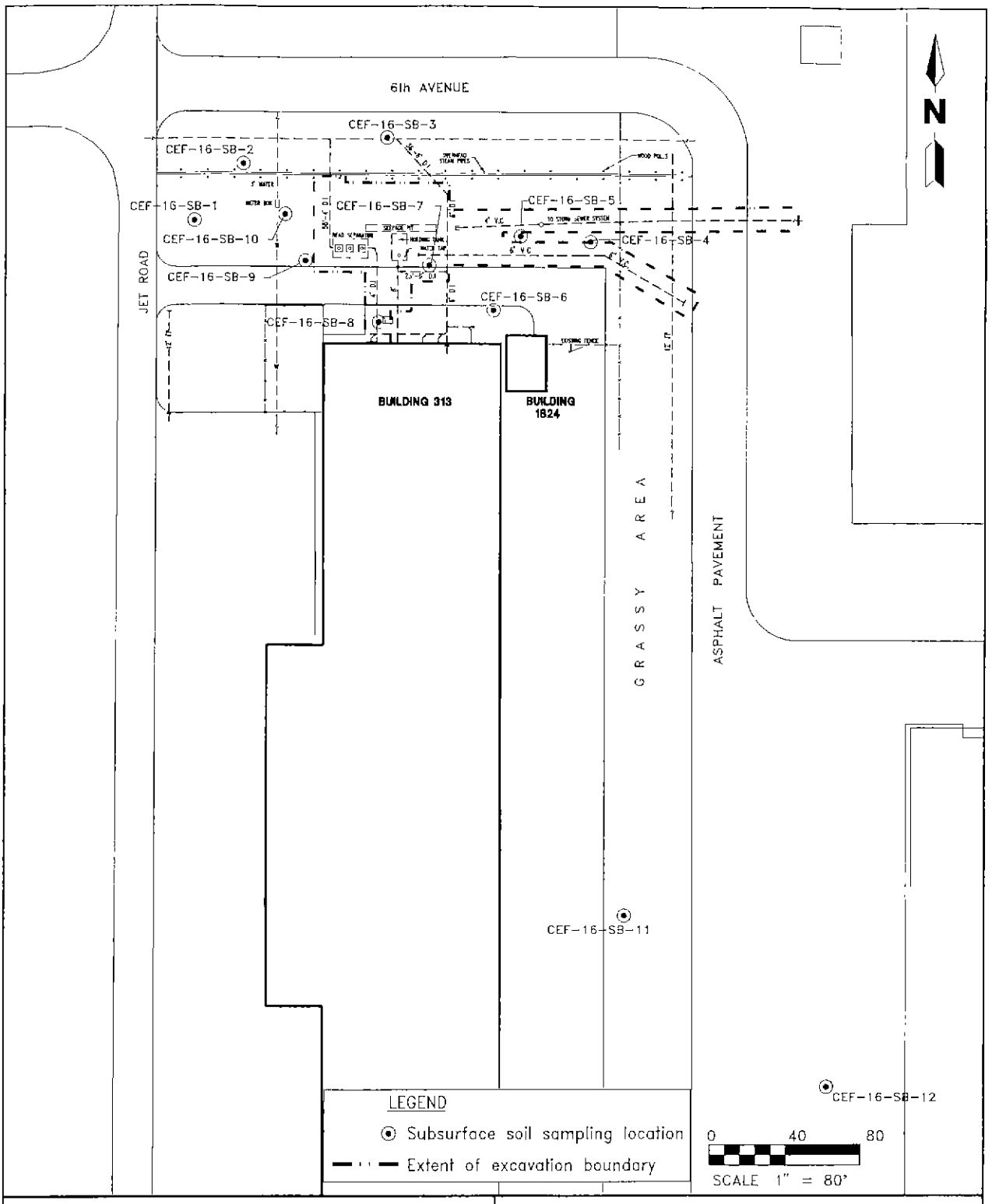

FIGURE 2-6
CONFIRMATORY SUBSURFACE SOIL SAMPLING LOCATIONS

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

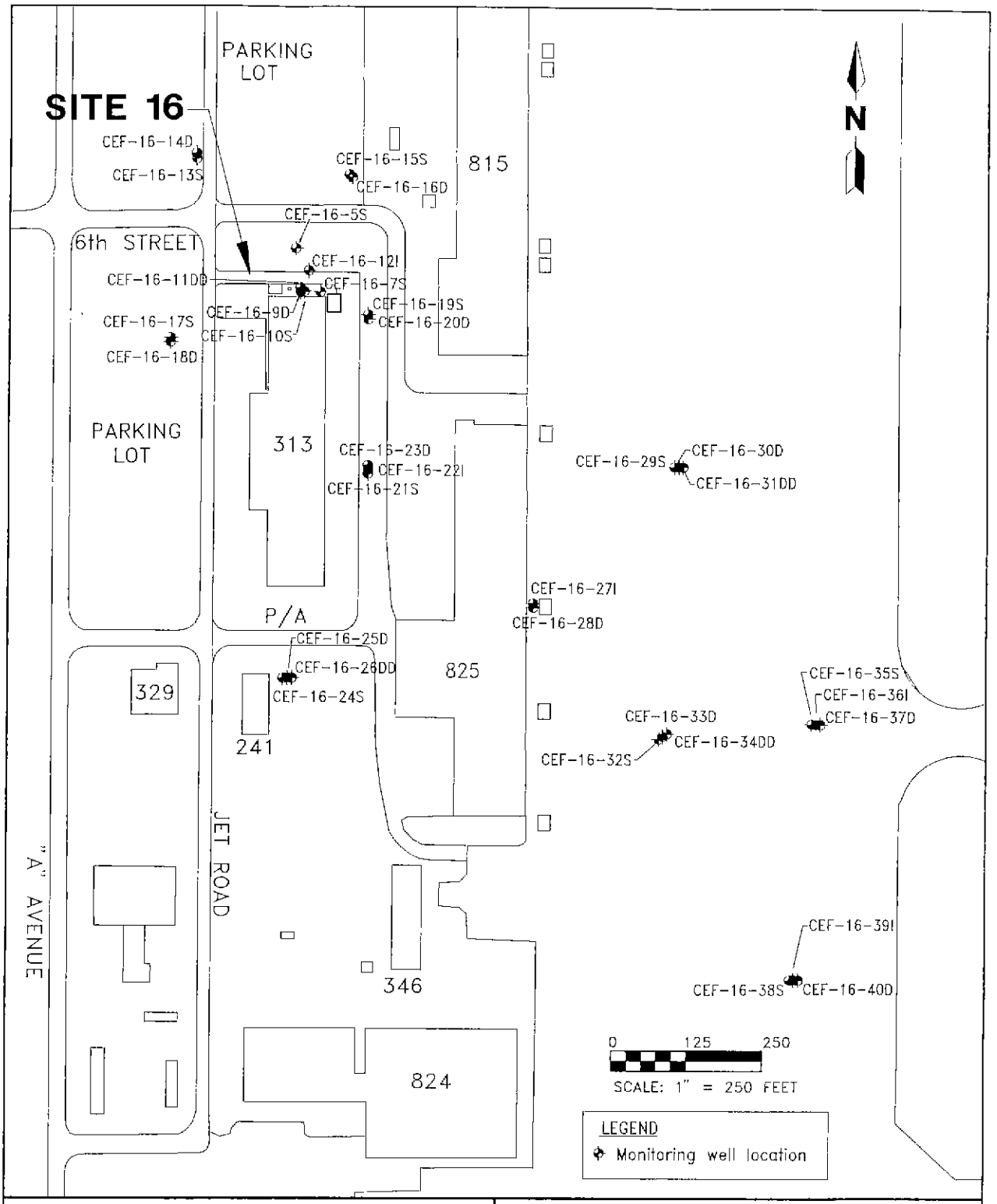

FIGURE 2-7
MONITORING WELL LOCATIONS

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FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

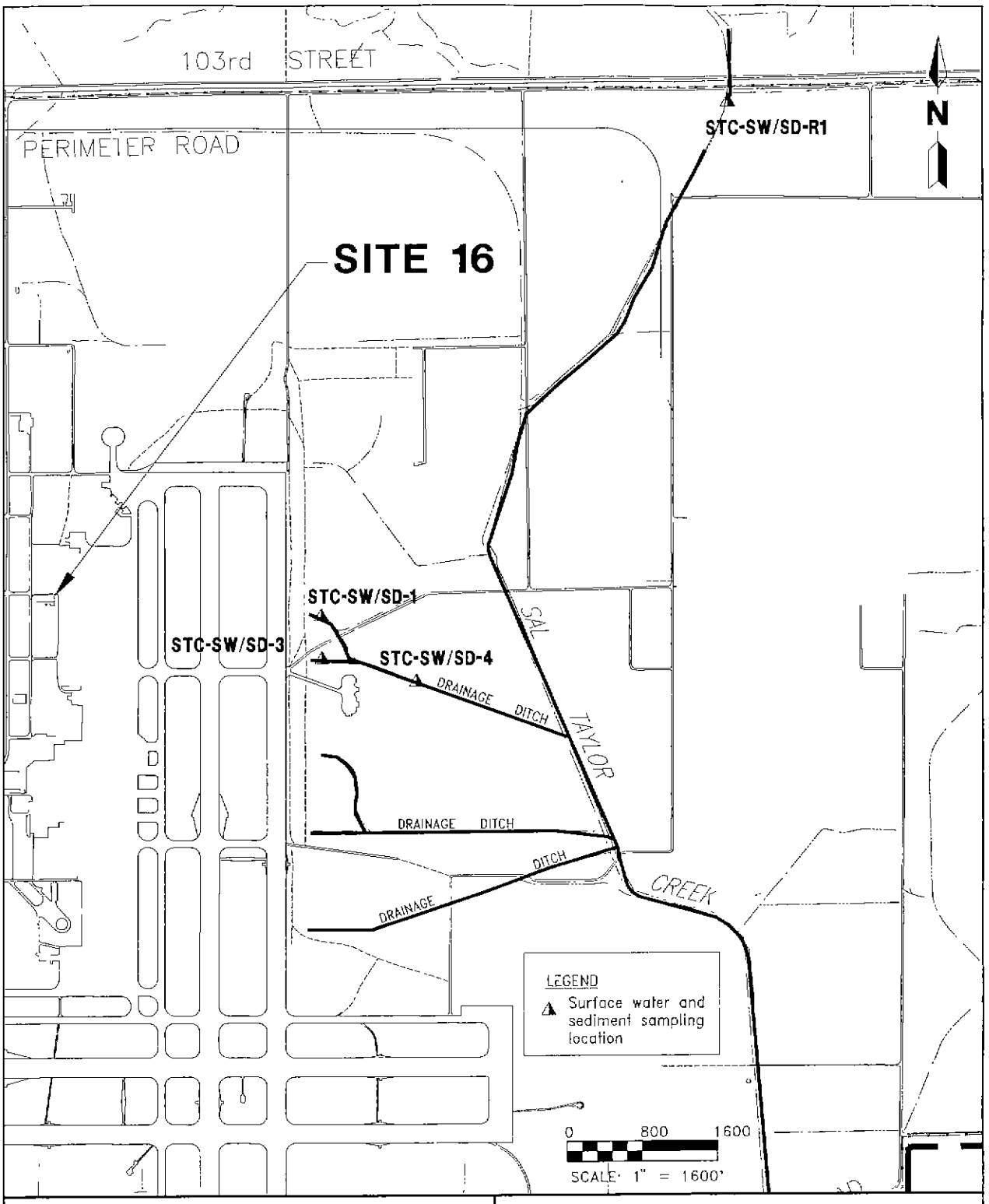

FIGURE 2-8
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

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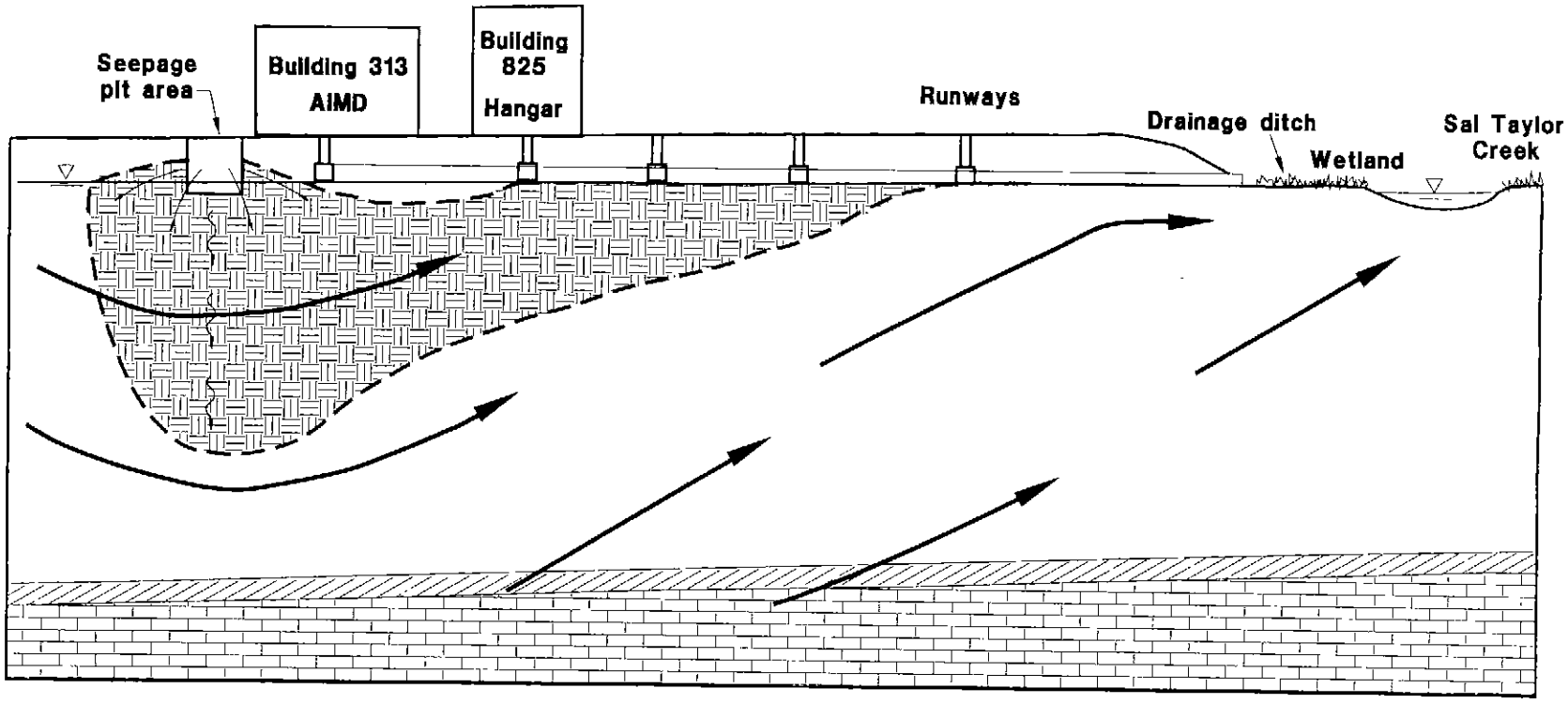
FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA



LEGEND

- Groundwater flow direction
- Estimated extent of TCE plume
- Possible traces of NAPL
- Sand
- Clay and dolomite
- Dolomite
- Water table
- Stormwater sewer system

NOTES:

NAPL Nonaqueous phase liquid

AIMD Aircraft intermediate maintenance department

TCE Trichloroethene

H:\CFOIL\TCE-EXT\NP\08-21-95

FIGURE 2-9
CONCEPTUAL MODEL OF THE EXTENT OF TRICHLOROETHENE CONTAMINATION

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

sampling and analysis, it is estimated that an average TCE concentration of 137 $\mu g/kg$ remains in the vadose zone soil (0 to 6 foot bls) over an area of approximately 5,000 ft^2 located around the perimeter of the original source area. It was estimated (using the Summers Model) that the TCE concentration in leachate generated by precipitation infiltrating the soil would be approximately 217 $\mu g/\ell$. Based on these estimates, it will take approximately 30 years for infiltrating precipitation to reduce the concentration of the leachate to a level that would not cause concentrations in groundwater to exceed the Federal and State drinking water criterion of 5 $\mu g/\ell$. These estimates assume that all TCE in the soil above and below the water table will migrate, TCE is not present as a nonaqueous phase liquid (NAPL), and leachate will mix with the top 10 feet of the surficial aquifer.

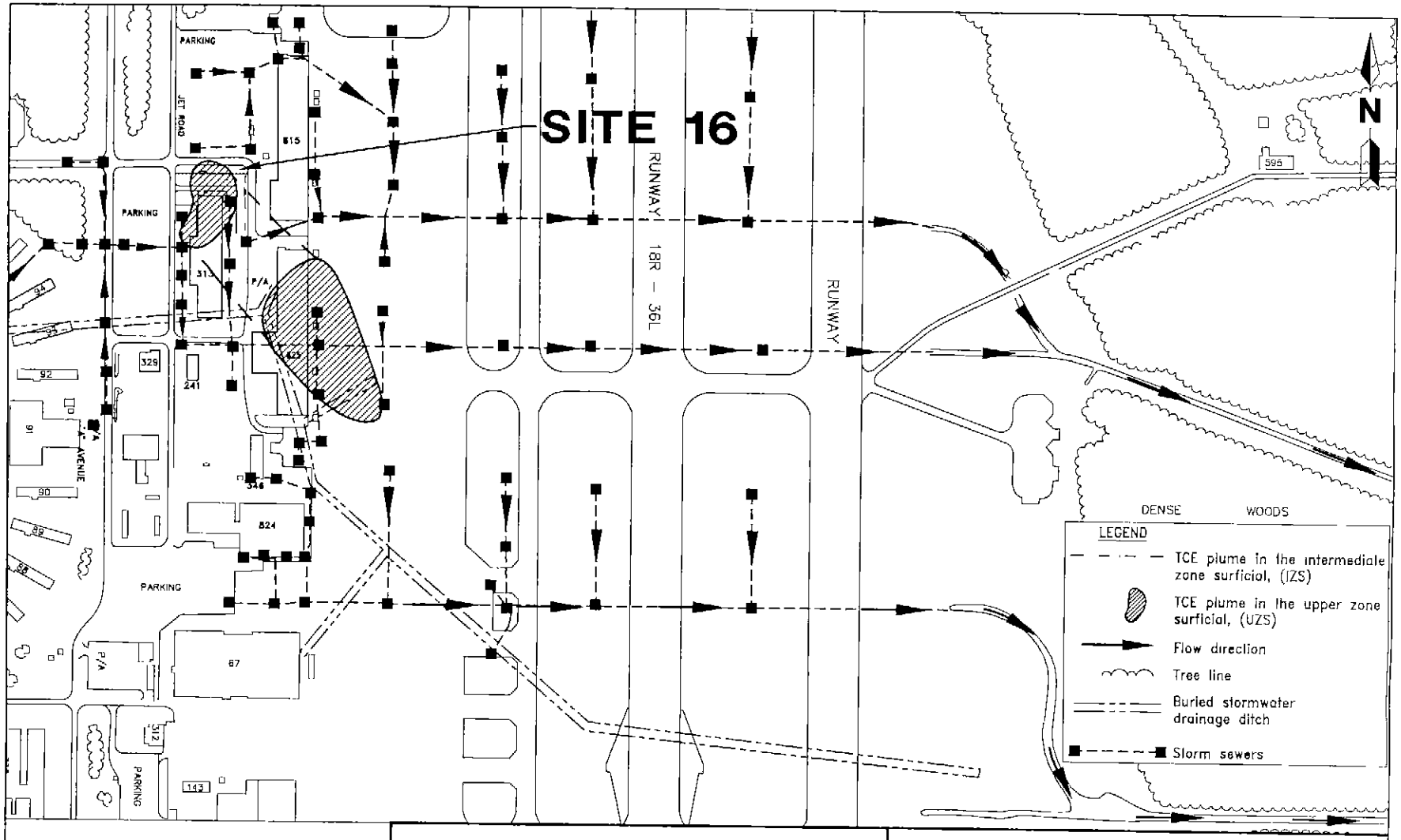
2.2.2.2 **Groundwater** Because the invert for the Seepage Pit was below the water table, contaminants were discharged directly to the groundwater. Groundwater mounding caused radial dispersion of the contaminants both horizontally and vertically. Evaluation of groundwater analytical results from 43 temporary groundwater sampling probes (Aquaprobe borings) and 34 monitoring wells indicates that contaminants, primarily TCE, extend radially outward approximately 60 feet and downward approximately 65 feet from the source area into both the UZS and IZS. The lateral extent of contaminants to the southeast in the direction of groundwater flow in the UZS is greater than 150 feet.

The leading edge of the TCE plume has migrated approximately 1,000 feet downgradient of the source in the 35 years since discharge to the Seepage Pit began (Figure 2-10). This is approximately 300 feet further than would be expected based on the estimated groundwater seepage velocity of 21 ft/yr. This observation is interpreted to be the result of longitudinal dispersion.

The groundwater flow pattern appears to influence the distribution of TCE. Groundwater flow in the surficial aquifer is downward near the source area, horizontal in the middle of the plume, and upward at the leading edge. For the part of the plume that is approximately 150 feet to 500 feet downgradient of the source, TCE was detected only in IZS wells. The TCE reappears in the UZS approximately 500 feet downgradient of the source area, at the point where upward flow from the intermediate aquifer to the surficial aquifer begins, and upward components of groundwater flow in the surficial aquifer bring the plume from the IZS to the UZS.

The highest groundwater concentrations of TCE were detected in an Aquaprobe at the source area. The highest of these detections was 1,500,000 $\mu g/\ell$ (aqueous solubility is 1,100,000 $\mu g/\ell$) in the 28 to 32 feet bls interval and suggests the possible presence of residual NAPL. Based on the USEPA batch model, it is estimated to take approximately 20 years for the flow of groundwater to reduce the TCE concentration at this location to 5 $\mu g/\ell$. This estimate also assumes the TCE present in soil will respond as adsorbed and dissolved TCE.

The projected path of the TCE plume is to the southeast, ultimately discharging into a drainage ditch and wetland that are, in turn, drained by Sal Taylor Creek. Using a two-dimensional contaminant transport model (which takes into account longitudinal and lateral dispersion) it is estimated that the plume will reach the drainage ditch in approximately 105 years (i.e., the year 2099). Assuming a constant, continuing release of TCE at the seepage pit, the concentration of



0 300 600
SCALE: 1" = 600'

CECIL\STORMWAT\NP\03-28-95

FIGURE 2-10
TRICHLOROETHENE PLUME TODAY (1994)

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

the TCE plume would reach a maximum discharge concentration of 730 $\mu g/\ell$ in approximately 195 years (i.e., by the year 2189). However, based on previous estimates, the TCE concentration in groundwater at the source will be 5.0 $\mu g/\ell$ in 20 years (55 years since the discharge to the seepage pit began, and 39 years since the discharge ceased). Therefore, the TCE concentration of the discharge from the plume to the wetland (drainage ditch) should actually begin to decrease approximately 55 years after the leading edge arrives at the wetland, or in 160 years (i.e., the year 2154).

Some transformation products of TCE (e.g., 1,2-DCE and 1,1-DCE) were detected in the soil and groundwater near the seepage pit area, but none were detected in any of the monitoring wells further downgradient of the source area, and only low levels (2 to 7 $\mu g/\ell$) were detected in a few downgradient Aquaprobe locations. Since no transformation products of TCE were observed in the monitoring wells downgradient of the source area, no degradation factor was included in the transport model, nor was any TCE loss by volatilization from the water table considered. As a result, the estimated future concentrations of TCE are considered conservative.

From approximately 500 feet to over 1,000 feet downgradient of the source, bis(2-ethylhexyl)phthalate is detected in the intermediate aquifer and the LZS and IZS of the surficial aquifer. Bis(2-ethylhexyl)phthalate, a common sampling and laboratory contaminant, is detected over 1,000 feet downgradient of the source area in a pattern which appears to be associated with the upward flow of water from the intermediate aquifer to the surficial aquifer. Groundwater elevations indicate the potential for this upward flow and several inorganics demonstrate this same distribution pattern, supporting the interpretation of flow from the intermediate aquifer to the surficial aquifer.

Several inorganics were detected in the UZS at the source area (including aluminum, cadmium, cobalt, lead, sodium, and vanadium), but, with the exception of cobalt, they do not appear to migrate from the source area as TCE does. Antimony and zinc appear to originate in the intermediate aquifer and flow up into the surficial aquifer downgradient of the OU 7 source area. Aluminum and iron appear at concentrations above background screening criteria at the source area, but, if transport is occurring, their migratory concentration distribution is being masked by widespread detections of these inorganics below the background screening concentrations. Thallium is detected at three scattered locations in the surficial aquifer, and its origin is unknown.

2.2.2.3 **Surface Water and Sediment** Three surface water and sediment samples were collected from drainage ditches (east of the runways) that receive water from two stormwater sewer lines that may drain the seepage pit area. The stormwater sewer lines have many inlets throughout the industrial area and runways, which indicates that the samples may represent the collective effect of multiple contaminant sources. This is supported by the detection of inorganics and petroleum-related compounds that are not associated with the OU 7 plume.

TCE and 1,2-DCE were detected in one of the drainage ditches. The stormwater sewer that discharges to this ditch runs along the west side of Building 313 and intersects the TCE plume southeast of the source area. The inverts of these storm sewers are below the water table, and dry-weather flow in the lines was observed. The detections of the TCE and 1,2-DCE in the drainage ditch samples

are interpreted to be the result of some contaminated groundwater entering the storm drain line through joints or cracks.

The leading edge of the TCE plume is not expected to reach the wetlands and drainage ditches until 105 years from now (i.e., the year 2199). As the plume discharges and mixes with surface water, some dilution is expected to occur. Upon discharging to and mixing with the water in the drainage ditch, TCE concentrations are interpreted to be diluted by a factor of approximately 17. Upon discharging directly to and mixing with the water in Sal Taylor Creek, the TCE plume is expected to be diluted by a factor of approximately 4,400. Water in the drainage ditch would be expected to be diluted by a factor of approximately 270 upon discharging to and mixing with the water in Sal Taylor Creek.

2.2.3 Data Limitations and Recommendations for Future Work The purpose of the data limitations section is to outline the limits within which the conclusions of the RI are made and to identify areas for which use of the data, findings, and conclusions developed during the RI may be inappropriate. This information will assist in the evaluation of RI data during the FS and assist the Navy and regulatory agencies during the selection of the final remedy for OU 7.

2.2.3.1 **Data Limitations** Based on the evaluation of data gathered during the OU 7 RI, the following data limitation was identified.

- Contaminants in surface water and sediments in the tributaries east of the north to south runways cannot be solely attributable to OU 7 operations and existing soil and groundwater contamination in the source area. Based on the nature of the contaminants (i.e., petroleum-related and inorganics) several other industrial activities (i.e., former and current runway and hangar operations) appear to be the major contaminant contributors (e.g., TPH) to surface water and sediment.

2.2.3.2 **Data Gaps** Based on the evaluation of data gathered during the OU 7 RI, the following data gaps were identified.

- The volume of contaminated groundwater entering the stormwater sewer has not been quantified.

- The distribution of TCE in vadose and phreatic soil on the west side of Building 313 (in the area of Aquaprobe groundwater screening locations GS-16-1 and GS-16-43) is not known.

No data gaps were identified that would prevent the development and selection of a remedial action for OU 7.

2.2.3.3 **Recommendations** Based on the evaluation of data gathered during the OU 7 RI,the following recommendations are presented.

- A control program should be instituted for contaminants in groundwater at OU 7 to prevent risks associated with possible future use of groundwater as a potable water supply.

- Conduct an investigation of the contaminants present in surface water and sediment in the stormwater sewer network in order to identify sources of contamination to the Sal Taylor Creek tributaries.

- Include as part of any subsequent remedial activity a definition of contamination in soil and groundwater west of Building 313.

3.0 SUMMARY OF BASELINE RISK ASSESSMENT

A baseline RA was completed at OU 7 to characterize the risks associated with exposure to site-related contaminants for human health and ecological receptors (ABB-ES, 1995a). This section presents a summary of the human health and ecological baseline RAs for OU 7. Although the baseline RA is presented as a separate document, it is summarized here to provide the rationale for developing remedial action objectives and alternatives as part of the FS.

3.1 APPROACH TO THE BASELINE RISK ASSESSMENT. The baseline RA was completed in accordance with the USEPA's human health risk assessment guidance for Superfund (USEPA, 1989b; USEPA, 1989c; USEPA, 1991a; USEPA, 1991d; USEPA, 1992d), Region IV Risk Assessment Guidance (USEPA, 1991c), Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (USEPA, 1989a); and Ecological Assessment of Superfund Sites: An Overview (USEPA, 1991f). Recent risk assessment guidance including the USEPA "Eco Update" bulletins (USEPA, 1991e; 1992b; 1992c) and recent publications (Maughan 1993; Suter, 1993) were also consulted.

The baseline RA for OU 7 consisted of three primary components: (1) data evaluation, (2) human health risk assessment, and (3) ecological assessment. The purpose of the baseline RA was to evaluate whether or not contamination present at OU 7 poses unacceptable risks to human health and/or environmental receptors in the absence of any remedial action.

3.2 DATA EVALUATION. The purpose of the data evaluation process was to identify the environmental data suitable for use in the baseline RA based on results of the RI. The data from OU 7 were evaluated to determine what data were of sufficient quality for use in a quantitative risk assessment. Data from the RI were first compiled and sorted by environmental medium (i.e., surface and subsurface soil, groundwater, surface water, and sediment). Then, based on results of the data validation, overall quality of the data was reviewed to determine what data were of sufficient quality for use in a quantitative risk assessment.

In the human health and ecological risk assessments (ABB-ES, 1995a), the analytical data were used to select chemicals of potential concern (CPCs). Data collected from previous investigations were evaluated qualitatively.

3.3 HUMAN HEALTH RISK EVALUATION. The purpose of the human health risk assessment (HHRA) was to characterize the risks associated with potential exposure to site-related contaminants at OU 7 for human health receptors. Four components for the HHRA were completed: (1) data evaluation (including selection of human health chemicals of potential concern [HHCPCs]), (2) exposure assessment, (3) toxicity assessment, and (4) risk characterization (including an uncertainty analysis). In addition, a review of available regulatory criteria is presented.

3.3.1 Selection of Chemicals of Potential Concern Generally, chemicals for which data of sufficient quality are available and which are potentially site-

related are defined as HHCPCs. These chemicals are typically a subset of all inorganic and organic chemicals detected in the various media at the site and are selected based on concentration; physical, chemical, and toxicological characteristics; frequency of detection (normally greater than 5 percent of the total sample set); comparison of detected values to background or baseline concentrations and associated blanks; and comparison to USEPA Region III risk-based concentrations (USEPA, 1993; USEPA, 1994d). The HHCPCs for OU 7 for each medium (surface soil, surface water, sediment, and groundwater) are presented in Table 3-1.

3.3.2 **Exposure Assessment** OU 7 was evaluated to identify actual or hypothetical populations that could contact site-related contaminants and the pathways through which exposure could occur. There are five potential sources of exposure associated with OU 7: surface soil, subsurface soil, surface water, sediment, and groundwater. Based on current site uses, surface soil, surface water, and sediment are the only media that are appropriate for evaluation because there is no current exposure of humans to subsurface soil or groundwater at OU 7. Under future land use, all the media were evaluated in the assessment based on the assumptions that subsurface soil may be exposed for contact and that groundwater may be used as an alternate potable water supply at OU 7 (Figure 3-1).

As a result of the exposure assessment, the following exposure scenarios were identified as being possible at OU 7 under current use conditions: (1) incidental ingestion, direct contact, and inhalation of fugitive dust associated with surface soil by a child and adult trespasser, an adult site worker, and an adult maintenance worker; (2) incidental ingestion and direct contact with surface water or sediment by a child and adult trespasser; and (3) consumption of fish tissue (fish in surface water) by an adult and child transient. Under future land use, the following exposure scenarios were identified as being possible at OU 7: (1) incidental ingestion, direct contact, and inhalation of fugitive dust associated with surface soil by an adult and child resident; (2) incidental ingestion, direct contact, and inhalation of fugitive dust associated with subsurface soil by an adult excavation worker; (3) domestic use of groundwater by an adult resident; (4) incidental ingestion and dermal contact with surface water and sediment by an adult and child resident wader; and (5) consumption of fish tissue by an adult and child resident.

Generally, exposure scenarios associated with future land use are difficult to predict. Residential land use was selected as a future land use scenario at OU 7 based on USEPA Region IV guidance (USEPA, 1991c). The inclusion of a residential land use scenario at OU 7 is intended to represent a worst-case scenario. Future residential land use at or near OU 7 is possible, but not probable. Because NAS Cecil Field is scheduled for closure in the late 1990s as part of BRAC, land use near OU 7 may be altered from its current industrial daily use. However, it is likely based on BRAC reuse plans and the interest of future land users that the area near OU 7 will remain industrial after the facility closure.

3.3.3 **Toxicity Assessment** A toxicity assessment was conducted to identify the relevant oral, dermal, and inhalation toxicity values for carcinogenic and non-carcinogenic effects of OU 7 HHCPCs. These values were identified from either the USEPA's Integrated Risk Information System database (USEPA, 1994c) or USEPA's Health Effects Assessment Summary Tables (USEPA, 1994b).

Table 3-1
Summary of Human Health Chemicals of Potential Concern

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Environmental Medium	Human Health Chemicals of Potential Concern[1]
Surface Soil	**Inorganics**: calcium, cobalt, and sodium **Organics**: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluorantnene, chrysene, dibenz(a,h)anthracene, indeno(1,2,3-dc)pyrene, and dibenzofuran
Subsurface Soil	**Inorganics**: arsenic, calcium, cobalt, and thallium **Organics**: none
Surface Water	**Inorganics**: beryllium, cadmium, and iron **Organics**: 1,2-dichloroethene and trichloroethene
Sediment	**Inorganics**: cadmium and sodium **Organics**: none
Surficial Aquifer	**Inorganic**: antimony, arsenic, cobalt, iron, magnesium, manganese, and thallium **Organics**: 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, bis(2-ethylhexyl)phthalate, and trichloroethene
Intermediate Aquifer	**Inorganics**: antimony and manganese **Organic**: bis(2-ethylhexyl)phthalate

[1] HHCPCs were selected for each medium in the Baseline Risk Assessment Report (ABB-ES, 1995).

Note: HHCPC = human health chemicals of potential concern.

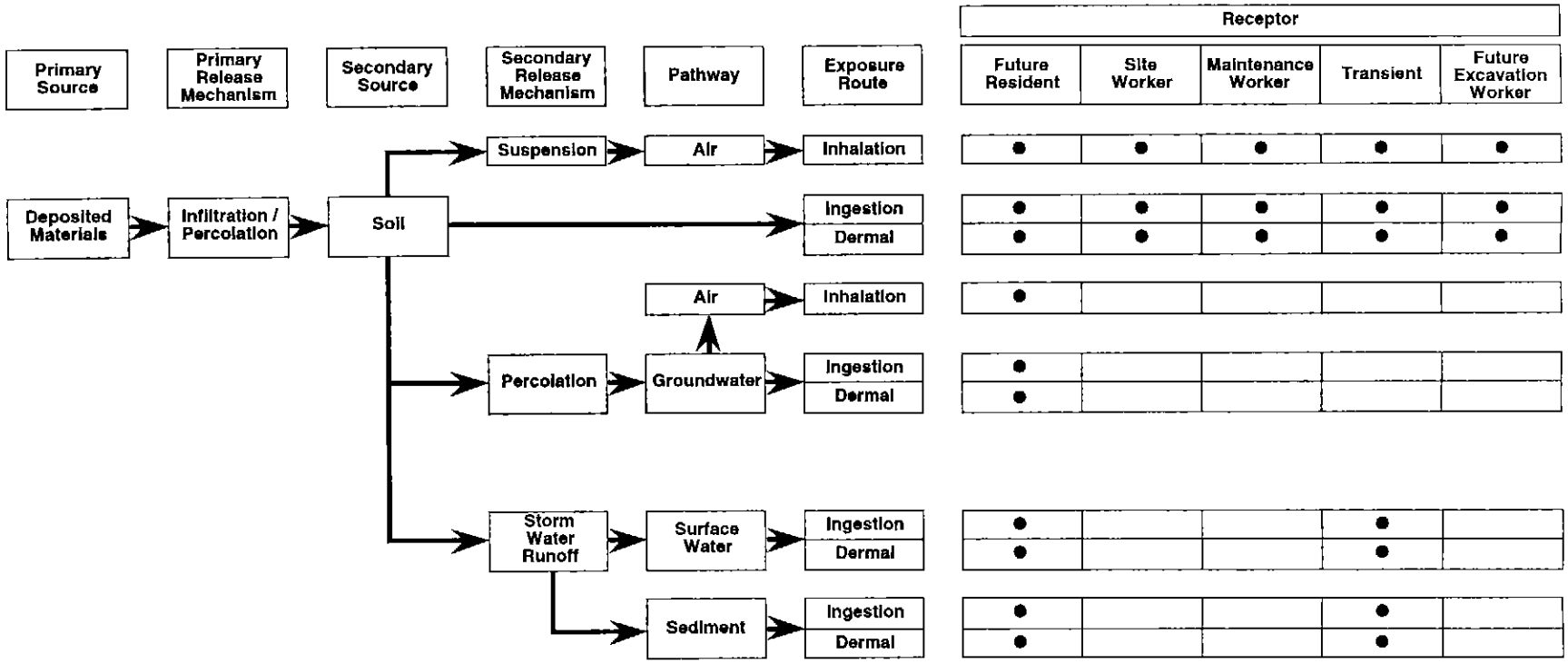


FIGURE 3-1

COMPLETE EXPOSURE PATHWAYS FOR HUMAN RECEPTORS

FEASIBILITY STUDY, OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

3.3.4 Risk Characterization Quantitative estimates of both carcinogenic and non-carcinogenic risks were calculated for each HHCPC and each complete exposure scenario selected for evaluation in the exposure assessment.

Carcinogenic risks associated with exposure to individual chemicals were estimated by multiplying the estimated chemical intake for each carcinogen (in units of milligram of chemical per kilogram of body weight each day [mg/kg-day]) by its USEPA cancer slope factor (CSF) (in units of $(mg/kg\text{-}day)^{-1}$). The result is a chemical-specific excess lifetime cancer risk (ELCR). This value represents the probability of developing cancer over the course of a 70-year lifetime as a result of the assumed exposure to site chemicals. The term excess refers to the increase in risk of cancer associated with exposure to site-related chemicals that is above and beyond baseline cancer risks. The average cancer burden in the United States in 1993 was 1 in 3 for women and 1 in 2 for men (American Cancer Society, 1994).

Within each exposure pathway, cancer risks associated with multiple carcinogenic compounds are determined by summing the chemical-specific risks to yield a pathway-specific ELCR. USEPA's guidelines state that the acceptable total incremental carcinogenic risk for an individual resulting from exposure at a hazardous waste site is in a range of 1 in 1,000,000 (10^{-6}) to 1 in 10,000 (10^{-4}) (USEPA, 1990b).

Noncarcinogenic risk estimates are determined by dividing estimated chemical intakes (in units of mg/kg-day) by the appropriate reference dose (RfD) developed by USEPA (in units of mg/kg-day). The resulting ratio is called the hazard quotient (HQ). The HQs for individual compounds within an exposure pathway were totalled, resulting in a hazard index (HI) for that pathway. An HI equal to 1 represents concentrations and levels of exposure that are generally considered to be without deleterious effects for a lifetime exposure, even for sensitive individuals. As the HI increases above 1, the risk of adverse effects also increases if the toxic endpoint (organic or bodily function) is the same and if the effects are additive.

3.3.4.1 **Risk Characterization for Human Health at OU 7** Health risks for carcinogens and noncarcinogens associated with current land use at OU 7 are not of concern.

Cancer risk estimates associated with future use of OU 7 surface soil, subsurface soil, surface water, sediment, and the intermediate aquifer are all below or within the acceptable risk range defined by USEPA (10^{-6} to 10^{-4}). The risk estimate for the surficial aquifer under future land use conditions (adult resident) is 3×10^{-3} which is at a level of concern. The major contaminant contributing cancer risk to the ELCR for the resident is 1,1-dichloroethene (ELCR=3×10^{-3}).

Noncancer risk estimates associated with future use of OU 7 surface soil, subsurface soil, surface water, sediment, and the intermediate aquifer are all equal to or less than an HI of 1. The noncancer risk estimate (HI) for the surficial aquifer under future land use conditions (adult resident) is 50. Major contributors to this HI are 1,2-dichloroethene (HQ=38), 1,1-dichloroethene (HQ=1.2), trichloroethene (HQ=2.5), antimony (HQ=1.1), and thallium (HQ=1.8).

Human exposure to fish tissue was not evaluated in the risk characterization of the HHRA because lipophilic compounds that commonly accumulate in fish tissue were not detected in the surface water or sediment collected in the drainage ditches associated with OU 7. Further, fish that might be consumed by humans are not present in the drainage ditches.

3.3.5 Comparison to Available Criteria Available criteria for groundwater (USEPA, 1994a; Florida Legislature, 1994b; FDEP, 1994b), surface soil (FDEP, 1994a), and subsurface soil (FDEP, 1994a) were considered in the HHRA for OU 7. A comparison (see Appendix A) of the maximum detected concentrations for each chemical detected in the groundwater (surficial aquifer; Table A-1), intermediate aquifer (Table A-2), surface soil (Table A-3), and subsurface soil (Table A-4) was compared to available criteria.

Groundwater. In the surficial aquifer, the maximum detected concentration of 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, trichloroethene, bis(2-ethylhexyl)phthalate, aluminum, antimony, arsenic, iron, manganese, and thallium exceeded its respective Federal primary (health-based) or secondary (aesthetic-based) maximum contaminant level (MCL), Florida Standard, and Florida guidance value. Each of these chemicals was retained as an HHCPC (except aluminum) in the surficial aquifer because it was detected at a concentration that exceeded background (upgradient) or risk-based screening concentrations. Aluminum was not selected as an HHCPC because the maximum concentration detected was less than its risk-based screening concentration.

In the intermediate aquifer, the maximum concentration of bis(2-ethylhexyl)phthalate (a common laboratory contaminant), antimony, iron, and manganese exceeded its respective Federal primary or secondary MCL, Florida Standard, and Florida guidance value. Each of these chemicals was retained as an HHCPC (except iron) in the intermediate aquifer because it was detected at a concentration that exceeded a risk-based screening concentration. Iron was not selected as an HHCPC because it is an essential nutrient and its MCL is based on aesthetic, not health, considerations.

Soil. The concentrations of contaminants detected in OU 7 surface soil did not exceed any of the available FDEP guidance concentrations established for direct contact and inhalation exposures at military sites.

However, the maximum concentrations of acetone, methylene chloride, and trichloroethene exceed available FDEP guidance concentrations established for soil leaching to groundwater at military sites. This comparison was conducted because subsurface soil may be contributing to contamination in the surficial aquifer. It should be noted that acetone and methylene chloride are both common laboratory contaminants. Both had low frequencies of detection.

TPH data were collected in surface and subsurface soil as well as sediments at OU 7. The TPH value for each sample location was compared to the available Florida criterion for thermally-treated petroleum-contaminated soil (50 mg/kg) (Florida Legislature, 1992). Each medium exceeds the 50 mg/kg at one or more sample locations; however, significant quantities of TPH were not disposed of or released at OU 7 (ABB-ES, 1995a). Therefore, the source of TPH near OU 7 may be from other sources such as motorized equipment and associated fuel releases as is commonly found at parking lots and roadways which exist adjacent to OU 7.

3.3.6 Summary of Human Health Risk Assessment The purpose of the HHRA at OU 7 was to characterize the risks associated with the potential exposures to site-related contaminants. Potential health risks were evaluated under current and assumed future land use conditions for a subset of contaminants detected in surface soil, subsurface soil, surface water, sediment, and groundwater (surficial and intermediate aquifers) associated with OU 7.

In summary, the risk estimates for surface soil, subsurface soil, surface water, sediment, and the intermediate aquifer indicate that human exposure to these media at OU 7, under the conditions evaluated in this assessment, is not associated with unacceptable risk of adverse health effects (cancer or noncancer). Concern over the contamination in the surficial aquifer may be warranted, however, because of the risk of adverse health effects (cancer and noncancer) associated with assumed future use of the groundwater as a potable water supply. It should be noted, however, that continued industrial use of OU 7 is planned. Use of the surficial aquifer as a drinking water supply at OU 7 may never occur because the area is served by a community water supply system.

Based on the results of the human health portion of the baseline RA, including the results of the criteria comparison (Subsection 3.3.5), the development of remedial action strategies may be necessary for the surficial aquifer at OU 7.

3.4 ECOLOGICAL RISK EVALUATION. The purpose of the ecological risk assessment for OU 7 was to assess potential adverse effects to ecological receptors resulting from contamination from OU 7. The components of the ERA include: (1) problem formulation, (2) selection of ecological contaminants of potential concern, (3) ecological effects assessment, and (4) risk characterization.

3.4.1 Problem Formulation The problem formulation component of the ecological risk evaluation identifies ecological receptors and exposure pathways for the receptors. Exposure pathways are discussed for two groups of ecological receptors: terrestrial wildlife and aquatic receptors. An exposure pathway includes a source of contamination, contaminated media (surface water, sediment, groundwater, and food), and an exposure route. The ecological assessment is based on those pathways for which contaminant exposures are believed to be the highest and most likely to occur for the receptors. The assessment is also focused on those pathways for which there are adequate data (pertaining to the receptors, contaminant exposures, and toxicity) to complete the risk analyses.

The exposure pathways evaluated for terrestrial wildlife at OU 7 include ingestion of surface water, indirect ingestion of sediment, and ingestion of aquatic prey that have accumulated contaminants from surface water and/or sediment. Surface soil contamination was not evaluated for terrestrial receptors as part of the ERA for OU 7 because it is unlikely that terrestrial receptors would be exposed to surface soil contamination, as the majority of OU 7 is located in an industrial area surrounded by paved roads and mowed grass (Figure 3-2).

Exposure pathways evaluated for aquatic receptors (including invertebrates, plants, amphibians, algae, and fish) include direct contact with surface water, sediment, and groundwater (as it discharges to surface water).

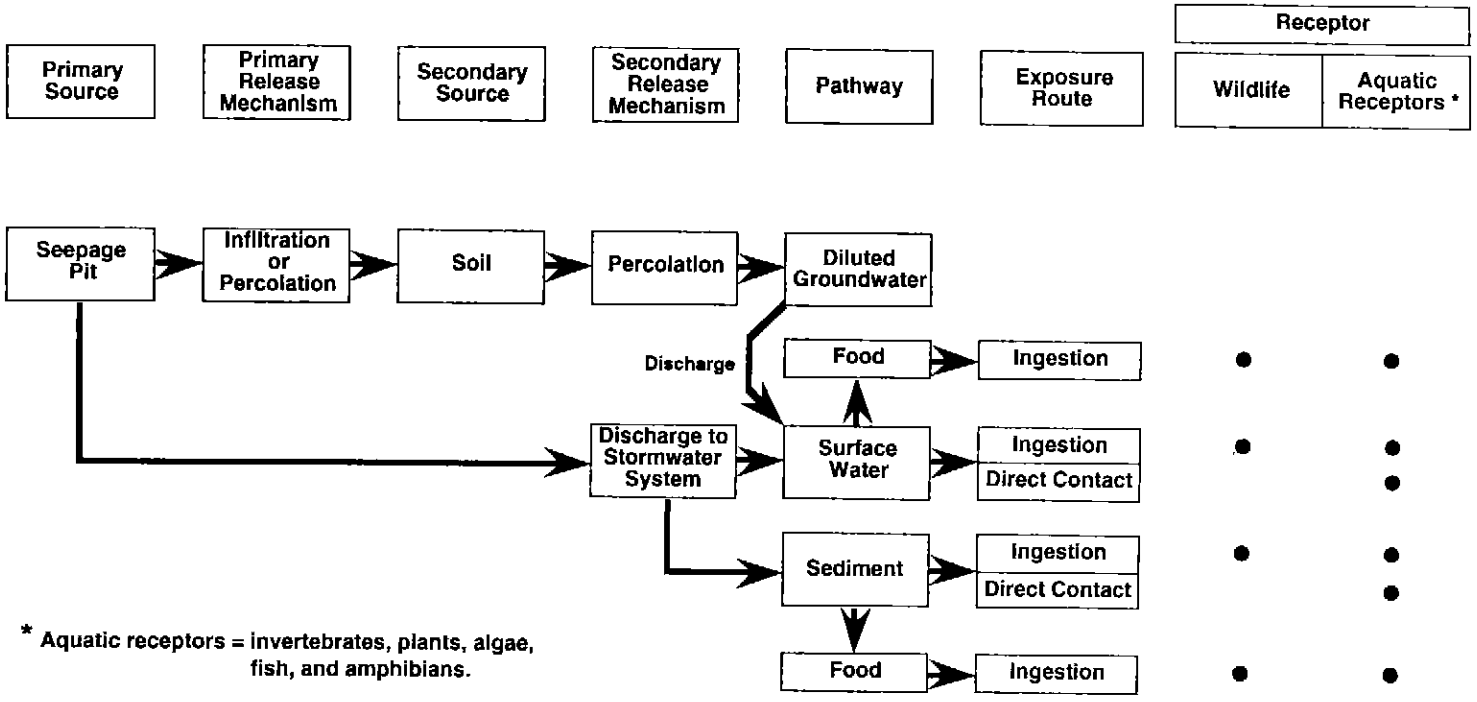


FIGURE 3-2

CONTAMINANT PATHWAY MODEL FOR ECOLOGICAL RECEPTORS

FEASIBILITY STUDY, OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

3.4.2 Selection of Ecological Chemicals of Potential Concern Ecological chemicals of potential concern (ECPCs) represent the analytes detected in evaluated media (surface water, sediment, and groundwater) that were considered in the risk assessment process. The ECPCs are assumed to be associated with hazardous waste practices at OU 7 that could possibly present a potential risk for ecological receptors. ECPCs were selected separately for surface water, sediment, and groundwater. For surface water and sediment, ECPCs were selected separately for terrestrial wildlife and aquatic receptors. Table 3-2 provides a summary of the ECPCs selected for OU 7.

3.4.3 Ecological Effects Assessment The ecological effects assessment describes the potential adverse effects to ecological receptors associated with the ECPCs.

Surface Water and Sediment. The measure of adverse ecological effects for exposure of terrestrial wildlife receptors to ECPCs in surface water and sediment was based on the identification of a reference toxicity value (RTV). Lethal and sublethal RTVs were identified from the literature for each ECPC in surface water and sediment for each representative wildlife species (avian and mammalian). The RTV relates the dose (oral exposure) of a respective ECPC with an adverse effect.

The RTVs are assumed to be a measure of the goal for protection of the survival, growth, and reproduction of terrestrial wildlife populations.

Potential adverse ecological effects for aquatic life based on exposure to sediment are directly measured (i.e., by sediment sampling for toxicity and chemical analyses) for all sediment ECPCs. Sediment toxicity (i.e., mortality and reproduction) to aquatic receptors was evaluated with: (1) a short-term chronic test using the water flea, *Ceriodaphnia dubia*, and (2) an acute test using the amphipod *Hyallela azteca* (Springborn Laboratories, 1993). The biological responses observed in these toxicity tests were then compared to the results of the chemical analyses of the sediment samples to assess the effects of sediment contamination to aquatic receptors.

Toxicity benchmarks were used to assess the potential for adverse effects to aquatic receptors from exposure to surface water ECPCs. These benchmarks include the State of Florida Surface Water Quality Standards (Florida Legislature, 1995) and USEPA Ambient Water Quality Criteria (AWQC) (USEPA, 1991a).

Analyses of the benthic macroinvertebrate community in the drainage ditches were also completed to further characterize risks for aquatic receptors to surface water and sediment.

Groundwater. Potential adverse effects to aquatic receptors associated with groundwater ECPCs are available in the form of laboratory aquatic toxicity testing results for individual ECPCs. Aquatic toxicity information for the ECPCs was obtained from searches of the USEPA Aquatic Information Retrieval (AQUIRE) database. Additional toxicity benchmarks used to assess the potential for adverse effects to ecological receptors from groundwater ECPCs include the State of Florida Surface Water Quality Standards (Florida Legislature, 1995) and USEPA AWQC (USEPA, 1991a).

3.4.4 Risk Characterization The following sections describe how risks were characterized for ecological receptors at OU 7.

Table 3-2
Summary of Ecological Chemicals of Potential Concern (ECPCs)

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Environmental Medium	Ecological Chemicals of Potential Concern[1]
Surface Water	**Inorganics:** Aquatic and wildlife receptors: cadmium (Cd), copper (Cu), iron (Fe), lead (Pb), and zinc (Zn). Wildlife only: beryllium (Be). **Organics:** Aquatic and wildlife receptors: 1,2-dichloroethene and trichloroethene. Wildlife only: toluene.
Sediment	**Inorganics:** Aquatic and wildlife receptors: aluminum (Al), barium (Ba), Cd, hexavalent chromium (Cr^{+6}), Fe, Pb, manganese (Mn), mercury (Hg), vanadium (V), and Zn. Wildlife only: Cr and Cu. **Organics:** Aquatic and wildlife receptors: 2-butanone, acetone, and toluene.
Groundwater	**Inorganic:** Aquatic receptors only: Al, arsenic (As), cobalt (Co), Fe, Mn, thallium (Tl), V, and Zn. **Organics:** Aquatic receptors only: 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethene, 4-methyl-2-pentanone, trichloroethene, and bis(2-ethylhexyl)phthalate.

[1] ECPCs were selected for each medium in the Baseline Risk Assessment Report (ABB-ES, 1995)

Terrestrial Wildlife Exposure to Surface Water and Sediment. Risks for the representative wildlife species associated with the ingestion of surface water, potentially contaminated aquatic life, and sediment were quantitatively evaluated using HQs. HQs were calculated for each ECPC by dividing the estimated potential dietary exposure (PDE) concentration by the toxicological benchmark (RTV). HIs were determined for each Representative Wildlife Species by totalling the HQs for all ECPCs. When the estimated exposure concentration was less than the RTV, the contaminant exposures were assumed to fall below the range considered to be associated with adverse effects for growth, reproduction, and survival (of the individual organism), and no risks to the wildlife populations were assumed. When the estimated exposure concentration was greater than the RTV, a discussion of the ecological significance was included and risk was assumed.

Aquatic Receptor Exposure to Surface Water and Sediment. Risks for aquatic receptors were characterized for each of the three sampling locations within the drainage ditches based on a weight-of-evidence evaluation (analysis of toxicity testing, chemical analyses, and the benthic macroinvertebrate community) of the following factors:

- presence or absence of analytes in surface water and sediment samples,
- concentrations of analytes measured in surface water and sediment samples,
- responses, mortality, and reproduction in *C. dubia* and mortality in the *H. azteca* in the sediment toxicity tests,
- evaluation of the aquatic macroinvertebrate community structure and function,
- concentrations of ECPCs in surface water relative to benchmarks such as the reported toxicity of the ECPC in laboratory tests (AQUIRE information) and the State of Florida Surface Water Quality Standards (Florida Legislature, 1995),
- concentrations of ECPCs in sediment relative to National Oceanic and Atmospheric Administration (NOAA) effects range-low and effects range-medium sediment guidelines (Long and Morgan, 1990), and
- physical and chemical factors in the aquatic environment (other than chemical contamination) such as presence of an oil sheen.

Aquatic Receptor Exposure to Groundwater. Risks were evaluated for aquatic life associated with exposures to ECPCs in groundwater as it discharges to: (1) Sal Taylor Creek, and (2) the wetland adjacent to (or located west of) Sal Taylor Creek.

A simple modeling effort was completed to estimate a dilution factor for groundwater entering Sal Taylor Creek. No dilution of groundwater was assumed for groundwater discharging to the wetland.

Predicted concentrations of the ECPCs in Sal Taylor Creek and the wetland (resulting from discharge of groundwater) were compared to State of Florida Surface Water Quality Standards (Florida Legislature, 1995) and AWQC (USEPA,

1991a). Where exposure concentrations exceed the standards or standards are unavailable, risks were characterized based on comparisons of the exposure concentrations with aquatic toxicity information from AQUIRE.

3.4.4.1 Risk Characterization for OU 7

Terrestrial Wildlife Exposure to Surface Water and Sediment. All of the exposure concentrations for ECPCs in surface water and sediment were less than the RTV, indicating no potential adverse effects to reproduction, growth, or survival for representative wildlife species exposed to ECPCs in the surface water and sediment of the drainage ditches.

Aquatic Receptor Exposure to Surface Water. Risks for aquatic receptors resulting from exposure to the ECPCs in surface water were characterized based on an evaluation of the field measurements of the benthic macroinvertebrate community and comparison of the concentration of ECPCs in surface water samples to their respective toxicity benchmarks or standards. The results of the comparisons show that maximum concentrations of cadmium, copper, iron, lead, and zinc exceed the aquatic toxicity benchmarks. Although concentrations of cadmium, copper, lead, iron, and zinc exceed available toxicity benchmarks, it is suspected that the presence of these metals in the surface water of the drainage ditches is not site-related because the ditches receive stormwater drainage from the runway area and much of the developed area west of the runways.

Aquatic Receptor Exposure to Sediment. Adverse biological effects were measured at two of the three sample locations in the drainage ditches. Based on weight-of-evidence of available data (toxicity testing results, benthic community, and chemical analyses) for each sampling location, the following statements concerning risks for aquatic life associated with sediment contamination can be made.

- Risks may be present for certain macroinvertebrate receptors at two of the three drainage ditch sampling stations (STC-SD-01 and STC-SD-03, see Figure 2-8). For station STC-SD-01, risks are based on mortality of amphipods in sediment toxicity testing. At sampling station STC-SD-03, risks are based on toxicity of the sediment to amphipods and toxicity of the sediment elutriate (i.e., water extracted from the pore spaces within the sediment sample) to the water flea.

- Based on the results of the toxicity testing, the risks for aquatic life may be associated with elevated concentrations of TPH in sediment (concentrations detected ranged from 214 to 1,920 mg/kg).

- Analysis of the benthic community metrics relative to contaminant concentrations in surface water and sediment are inconclusive because no adequate reference location was available for comparative purposes.

Aquatic Receptor Exposure to Groundwater. Risks to aquatic receptors from exposures to groundwater as it discharges to Sal Taylor Creek are not expected. The exposure concentrations of all groundwater ECPCs in Sal Taylor Creek are less than the respective lowest aquatic toxicity benchmarks.

Risks to aquatic receptors from exposures to groundwater as it discharges to the wetland were predicted. Maximum concentrations of bis(2-ethylhexyl)phthalate,

aluminum, iron, and zinc exceed surface water toxicity benchmarks. However, the following statements can be made.

- The maximum concentration of bis(2-ethylhexyl)phthalate exceeds both the Florida Surface Water Quality Standard and the lowest reported adverse effect concentration; however, bis(2-ethylhexyl)phthalate does not appear to be associated with OU 7. Concentrations of bis(2-ethylhexyl)phthalate are greater in the intermediate aquifer and are interpreted to flow up into the surficial aquifer downgradient of the OU 7 source area.

- Exposures to aluminum in surface water and subsequent risks for aquatic life are not currently occurring, although predicted. If the maximum or average detected concentration of aluminum in groundwater is transported to the surface water of the wetland, then the exposure concentrations would be toxic to aquatic life at pH ranging from 6.5 to 9.0, because the toxicity of aluminum is pH-dependent. However, as no surface water samples were collected in the wetland, the pH of the surface water in the wetland is unknown, and it is not possible to predict the toxicity associated with aluminum in groundwater as it discharges to the wetland. Aluminum in surface water, as measured by the total digestion analyses procedure (unfiltered samples), includes both dissolved and suspended matter. The dissolved fraction represents the amount of aluminum that is biologically available to aquatic organisms. The dissolved concentration of aluminum in filtered surface water would be lower than that measured as the total. Therefore, the predicted concentration of aluminum in surface water in the wetland (as discharged from groundwater) is an overestimate; therefore, the predicted risks to aquatic receptors may also be overestimated.

- The presence of iron and zinc in the surficial aquifer is also related to an upwelling of groundwater from the intermediate aquifer in the OU 7 study area; therefore, it is not interpreted to represent contamination emanating from OU 7.

In summary, groundwater discharges to the surface water of Sal Taylor Creek do not pose a risk to aquatic receptors. However, groundwater discharges to the wetland have risks to aquatic life associated with potential future exposures to bis(2-ethylhexyl)phthalate, aluminum, iron, and zinc under assumed worst-case conditions (i.e., that maximum concentrations observed in groundwater near the seepage pit will actually discharge to the wetland). Due to alternative processes such as dispersion, it is not likely that the assumed conditions will occur. Concentrations of bis(2-ethylhexyl)phthalate, iron, and zinc appear to originate in the intermediate aquifer, which has not received wastes from OU 7, and flow upward to the surficial aquifer; therefore, these detections are not believed to be associated with contamination from OU 7. Future exposures of aluminum in the wetland may pose a risk to aquatic receptors; however, variables such as pH and bioavailability may limit these exposures and subsequent risk.

<u>3.4.5 Summary of Ecological Risk Assessment</u> The purpose of the ERA at OU 7 was to characterize the risks associated with potential exposures of ecological receptors to site-related contaminants. Potential risks for ecological receptors were evaluated for ECPCs in surface water, sediment, and groundwater.

There were no risks identified for terrestrial wildlife resulting from exposures to ECPCs in surface water and sediment.

Evaluation of the sediment toxicity data suggest that certain types of macroinvertebrates (i.e., aquatic receptors) may be impacted by exposure to sediment. This response may be associated with elevated concentrations of TPH. Because the ditches receive stormwater drainage from the runway area and much of the developed area west of the runways, it is believed that the presence of TPH in the sediment of the drainage ditches is not site-related.

Potential risks for aquatic receptors were evaluated for exposures to ECPCs in groundwater as it discharges to both the wetland downgradient of surficial groundwater flow for OU 7 and Sal Taylor Creek. The risk characterization did not identify risks for aquatic receptors in Sal Taylor Creek associated with ECPCs in groundwater. However, risks associated with exposures to bis(2ethylhexyl)-phthalate, aluminum, iron, and zinc are possible for aquatic receptors in the wetland. Concentrations of bis(2-ethylhexyl)phthalate, iron, and zinc appear to originate in the intermediate aquifer and flow upward to the surficial aquifer; therefore, these detections are not believed to be associated with OU 7. Future exposures of aluminum in the wetlands may pose a risk to aquatic receptors; however, factors such as pH and bioavailability may limit these exposures and subsequent risk.

4.0 SUMMARY OF INTERIM REMEDIAL ACTION

An IRA was implemented for OU 7. This chapter presents a summary of the IRA. Section 4.1 presents a summary of the purpose of the IRA at OU 7. Section 4.2 summarizes the process that was followed to select the IRA. Section 4.3 describes the IRA, as documented in the IROD for the site and the NDI Holding Tank Closure Certification and Report.

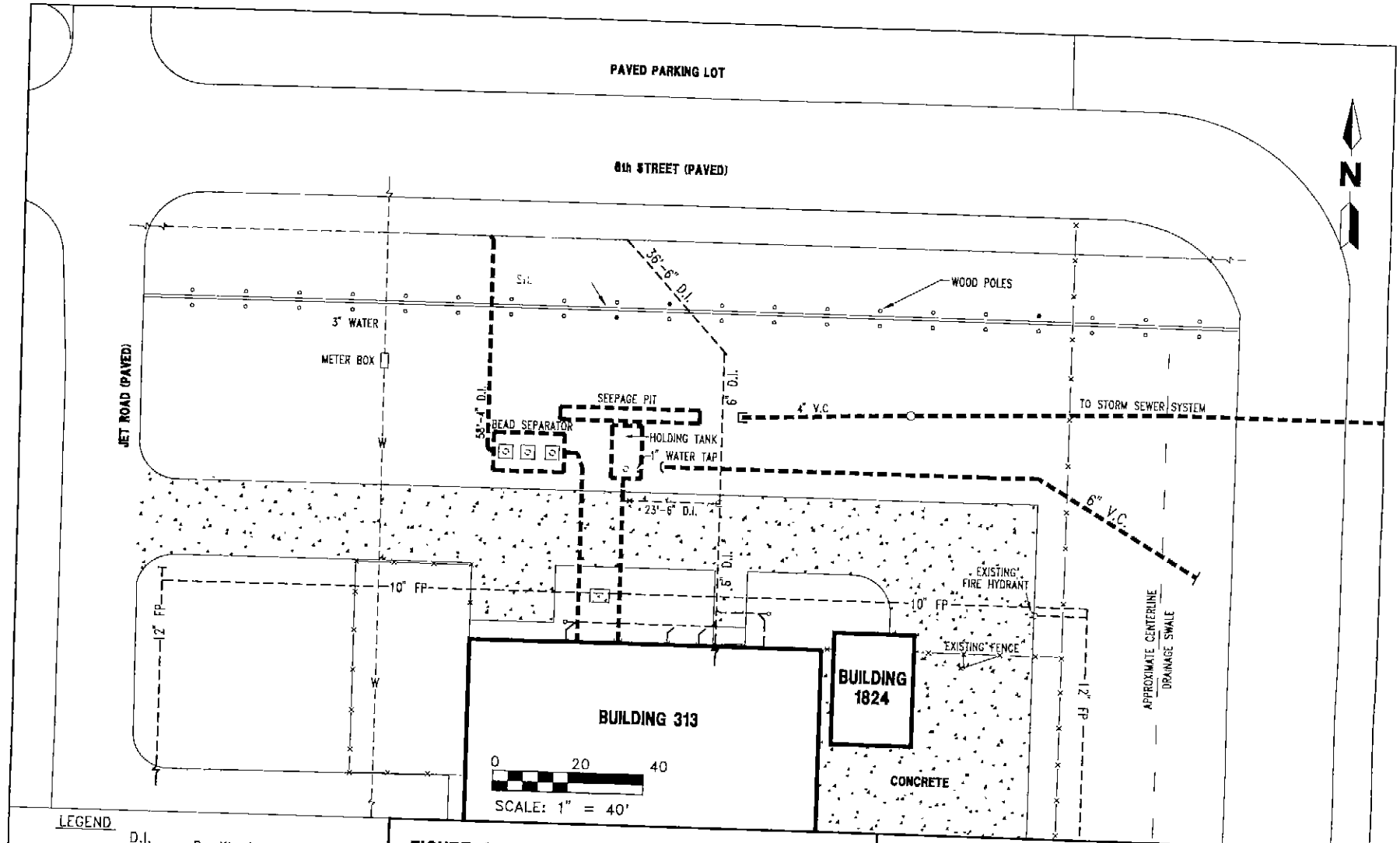
4.1 PURPOSE OF IRAs. The purpose of the IRA at OU 7 was to remove the soil, holding tank, seepage pit, bead separator, and associated piping that acted as a source of groundwater contamination (Figure 4-1). The IRA was intended to provide a rapid response to the worst source of ongoing groundwater contamination at the OU. A secondary purpose of the IRA was to comply with the RCRA permit for the holding tank that stipulated that the tank must be closed in accordance with RCRA by June 4, 1994.

4.2 SUMMARY OF IRA SELECTION PROCESS. The IRA for OU 7 was selected using a process very similar to the FS process. The first step was preparation of an FFS to develop interim action alternatives. The FFS is similar to the FS in that it presents a summary of site conditions, develops RAOs, develops and screens alternatives, analyzes alternatives in detail, and compares alternatives. Site conditions were described based on information available at the time and not the more comprehensive data and evaluation as is now available in the RI and RA. A limited number of interim action alternatives were developed and screened according to the procedures defined in CERCLA, SARA, and the NCP. A no-action alternative was not considered because of the focused nature of the interim action that assumes some action is necessary. Four alternatives were retained for detailed analysis (Table 4-1).

Following preparation of the FFS, a Proposed Plan was developed that presented a summary of the alternatives and identified the preferred alternative for implementation. These documents were made available to the general public, and a public meeting was held to present the proposed interim actions. Comments were received during a 30-day public comment period. Comments were addressed in a responsiveness summary, and an IROD was signed by the USEPA, FDEP, and the Navy in March 1994.

4.3 DESCRIPTION OF THE IRA FOR OU 7. The preferred alternative for OU 7 was a combination of Alternative 1 and Alternative 2. Alternative 1 includes excavation, onsite treatment of debris (e.g., piping and tank), and offsite disposal of debris and contaminated soil. Alternative 2 includes excavation, onsite treatment of debris, offsite disposal of debris, and offsite treatment and disposal of contaminated soil. Activities conducted for the IRA are depicted on Figure 4-2.

The field activities for the IRA occurred in May 1994, and a closure report was issued in November 1994. Below is a description of the actions undertaken during the IRA. For a detailed description of IRA activities, refer to the closure report (ABB-ES, 1994b).



LEGEND

- D.I. — Ductile iron
- V.C. — Vitrified clay
- W — Water main
- SS — Sanitary sewer
- FP — Fire main pipe

NOTE: Bold dashed lines include structures associated with OU7 waste disposal.

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FIGURE 4-1
SITE CONDITIONS PRIOR TO INTERIM REMOVAL ACTION

FEASIBILITY STUDY
OPERABLE UNIT 7

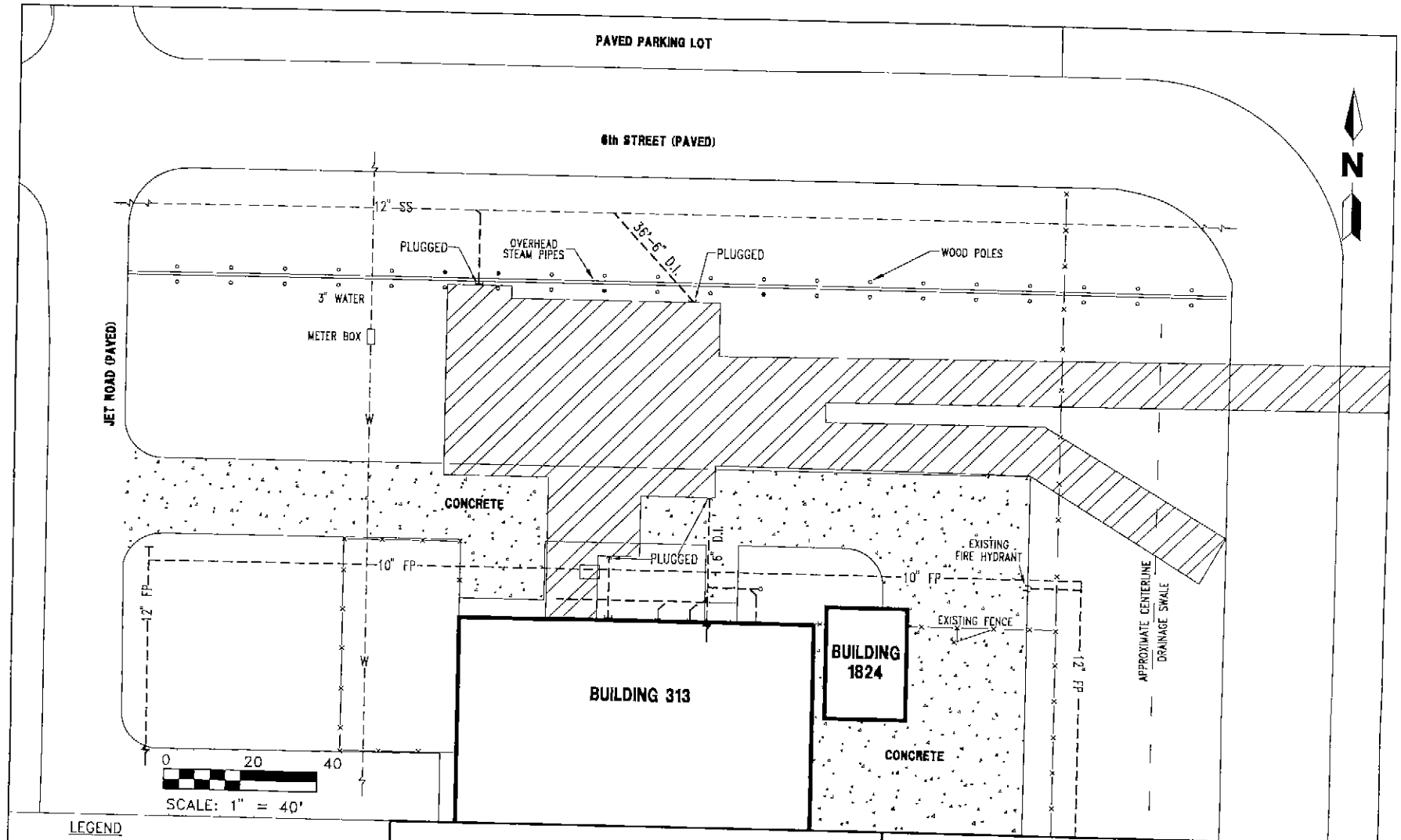
NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Table 4-1
Remedial Alternatives Evaluated in the FFS

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Alternative	Description
1	Offsite disposal of soil to a Subtitle C landfill and onsite treatment of debris and disposal to a Subtitle D landfill.
2	Offsite treatment of soil and disposal to a Subtitle C landfill and onsite treatment of debris and disposal to a Subtitle D landfill.
3	Onsite treatment of soil and offsite disposal to a Subtitle C landfill and onsite treatment of debris and disposal to a Subtitle D landfill.
4	Offsite disposal of soil and debris to a Subtitle D landfill without prior treatment.

Note: FFS = Focused Feasibility Study.



LEGEND

- D.I. — Ductile iron
- V.C. — Vitrified clay
- W — Water main
- SS — Sanitary sewer
- FP — Fire main pipe
- Clean backfill

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FIGURE 4-2
SITE CONDITIONS AFTER INTERIM REMOVAL ACTION

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

The NDI holding tank was uncovered, and 2,000 gallons of contained liquid were pumped out and stored temporarily in an aboveground storage tank (AST). The liquid was disposed of offsite at an appropriately permitted hazardous waste facility. Once the liquid was removed, 150 gallons of sludge were removed from the bottom of the tank and placed in three 55-gallon metal drums for subsequent disposal. The tank was then removed, cleaned by abrasive blasting to remove a minimum 6 millimeters from the tank surface (to comply with the RCRA Debris Rule), and disposed of offsite in a solid waste landfill. The blasting residuals were disposed of offsite at a hazardous waste landfill.

The cinder blocks used to construct the seepage pit were removed and disposed of offsite at a hazardous waste landfill. The concrete slab used to construct the seepage pit and the glass bead separator were removed, decontaminated with wash water, and disposed of offsite at a solid waste landfill.

Piping associated with the AIMD seepage pit was either: (1) removed entirely, or (2) partially removed, cut at appropriate locations, and plugged with grout. Removed piping was decontaminated with wash water, and disposed of offsite at a solid waste landfill. The piping leading from the seepage pit to the stormwater sewer system was found to contain nonfriable asbestos. This piping was removed and disposed of in a permitted landfill as Class III nonfriable asbestos.

Soil contaminated with TCE concentrations above an action level of 1 mg/kg were excavated and transported offsite to a hazardous waste landfill. A total of 1,578 tons of soil was disposed of. The majority of the soil removed was in the vicinity of the NDI holding tank and the seepage pit (See Figure 4-2).

5.0 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES (RAOs)

This chapter presents the RAOs for OU 7. The RAOs will provide the basis for selecting appropriate remedial technologies and developing remedial alternatives from those technologies for OU 7. Section 5.1 presents the chemical-, location-, and action-specific ARARs that were considered prior to defining alternatives for OU 7. Section 5.2 presents an overview of various remedial considerations, such as regulatory drivers and risk issues, that are evaluated prior to defining RAOs. Section 5.3 presents the RAOs for the OU.

5.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs). ARARs are Federal and State human health and environmental requirements used to: (1) evaluate the appropriate extent of site cleanup, (2) scope and formulate remedial alternatives, and (3) control the implementation and operation of a selected remedial action. CERCLA and the NCP require that remedial actions comply with State ARARs that are more stringent than Federal ARARs, legally enforceable, and consistently enforced statewide.

CERCLA, SARA, and the NCP require that ARARs be identified during the development of remedial alternatives. ARARs are used to define the appropriate extent of site cleanup, identify sensitive land areas or land uses, develop remedial alternatives, and direct site remediation. Potential ARARs in each category (i.e., chemical-, location-, and action-specific) are described in detail in the *Handbook of ARARs for Navy Sites within the State of Florida* (ABB-ES, 1995b).

5.1.1 Definition of ARARs The NCP defines two ARAR components: (1) applicable requirements, and (2) relevant and appropriate requirements.

> Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, or other circumstance found at a CERCLA site. Only those State standards that are: (1) identified by the State in a timely manner, (2) consistently enforced, and (3) more stringent than Federal requirements may be applicable.
>
> Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements under Federal and State environmental and facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, or remedial action, address situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

"Applicability" is a legal determination of jurisdiction of existing statutes and regulations whereas "relevant and appropriate" is a site-specific determination of the appropriateness of existing statutes and regulations. Therefore, relevant and appropriate requirements allow flexibility not provided by applicable requirements in the final determination of cleanup levels. Once a requirement is identified as an ARAR, the selected remedy must comply with ARARs, even if the

ARAR is not required to assure protectiveness. The general relevant and appropriate requirements apply only to actions at the site. Applicable requirements apply to both on- and offsite remedial actions.

Other requirements "to be considered" (TBCs) are Federal and State nonpromulgated advisories or guidance that are not legally binding and do not have the status of potential ARARs (have not been promulgated by statute or regulation). However, if there are no specific ARARs for a chemical or site condition, or if ARARs are not deemed sufficiently protective, then guidance or advisory criteria should be identified and used to ensure the protection of human health and the environment.

Under the description of ARARs set forth in the NCP and SARA, State and Federal ARARs are categorized as:

- chemical-specific (i.e., governing the extent of site remediation with regard to specific contaminants and pollutants),
- location-specific (i.e., governing site features such as wetland, floodplains, and sensitive ecosystems and pertaining to existing natural and manmade site features such as historical or archaeological sites), and
- action-specific (i.e., pertaining to the proposed site remedies and governing the implementation of the selected site remedy).

During the detailed analysis of remedial alternatives, each alternative will be analyzed to determine its compliance with ARARs. Chemical-, location-, and action-specific ARARs are discussed in the following subsections.

5.1.2 Chemical-Specific ARARs Chemical-specific requirements are standards that limit the concentration of a chemical found in or discharged to the environment. They govern the extent of site remediation by providing either actual cleanup levels or the basis for calculating such levels. Chemical-specific ARARs for a site may also be used to indicate acceptable levels of discharge in determining treatment and disposal requirements, and to assess the effectiveness of future remedial alternatives. Table B-1 in Appendix B presents and discusses the chemical-specific ARARs identified for OU 7.

Currently, there are no promulgated Federal or State chemical-specific ARARs that provide limits for the concentration of chemicals in soil. However, the State of Florida has provided guidance values for cleaning soil at military sites (Soil Cleanup Goals for the Military Sites in Florida, Florida Department of Environmental Protection, 1994a). Appendix A of this document provides a comparison of chemicals detected in soil at OU 7 compared to these Florida Guidance values which are identified as TBC criteria.

Federal and State chemical-specific ARARs are available for groundwater. Table B-2 in Appendix B provides the Federal and State chemical-specific ARARs and TBCs for groundwater: Federal MCLs (Safe Drinking Water Act Regulations,[40 CFR 141]), State of Florida Drinking Water Standards (Chapter 62-550, FAC, September, 1994a), and State of Florida Groundwater Guidance Concentrations (Groundwater Guidance Concentrations, Bureau of Groundwater Protection, June, 1994b).

5.1.3 Location-Specific ARARs Location-specific ARARs govern site features (e.g., wetland, floodplains, wilderness areas, and endangered species) and manmade features (e.g., places of historical or archaeological significance). These ARARs place restrictions on concentrations of hazardous substances or the conduct of activities solely based on the site's particular characteristics or location. ARARs addressing floodplains and wetland are considered at OU 7 because it is located near Sal Taylor Creek and a wetland area. Table B-5 in Appendix B presents the location-specific ARARs identified for OU 7.

5.1.4 Action-Specific ARARs Action-specific ARARs are technology- or activity-based limitations controlling activities for remedial actions. Action-specific ARARs generally set performance or design standards, controls, or restrictions on particular types of activities. To develop technically feasible alternatives, applicable performance or design standards must be considered during the detailed analysis of remedial alternatives (see Chapter 6.0).

Certain action-specific ARARs include permit requirements. Under CERCLA Section 121(e), permits are not required for remedial actions conducted entirely onsite at Superfund sites. This permit exemption applies to all administrative requirements, including approval of or consultation with administrative bodies, documentation, record keeping, and enforcement. However, the substantive requirements of these ARARs must be attained.

Table B-6 in Appendix B summarizes potential action-specific ARARs for OU 7. During the detailed analysis of alternatives, each alternative will be analyzed to determine compliance with action-specific ARARs.

5.1.5 To Be Considered Criteria Other criteria not promulgated as statutes or regulations are identified as TBCs and are summarized in Table B-7 in Appendix B.

5.2 REMEDIAL CONSIDERATIONS. Prior to establishing RAOs for OU 7, the identification of NAS Cecil Field for BRAC was considered. NAS Cecil Field is scheduled for closure in September 1998. As a standard procedure for closing military bases, a Base Reuse Plan is developed. A Draft Base Reuse Plan has been developed for NAS Cecil Field, but this plan has not yet been finalized. Because of this, the future use of the base, and subsequently OU 7, has not clearly been identified. Currently, activities at OU 7 are considered commercial and/or industrial with potable water supplied by a community system.

The RA completed for OU 7 assumed a future residential scenario (i.e., humans living on OU 7 and consuming unfiltered water from the surficial aquifer), but this scenario is unlikely for OU 7 according to the current Draft Base Reuse Plan. OU 7 is located near the runways at NAS Cecil Field, and current speculation is that OU 7 will remain industrial or that the runways could be used for a global airport for supersonic transport aircraft because population density in the vicinity of NAS Cecil Field is low. If this is the case, it is unlikely that humans will ever establish residence at OU 7, and it is further unlikely that humans will consume water from the surficial aquifer (without a filter) due to existing availability of a community potable water supply.

However, for the purpose of this FS, RAOs and action levels (see subsections 5.3.1 and 5.3.2) were developed based on the RA completed for OU 7 that assumed

a future residential scenario. Pending consensus with the USEPA and FDEP and acceptance by the community, it is likely that the action levels established in this FS are more stringent than necessary for the predicted future use of OU 7 as a global airport or for continued industrial and/or commercial use. The stringency of these action levels, as well as the ability of any proposed remedial alternative to meet the established action levels, is discussed in the detailed analysis of alternatives in Chapter 7.0.

5.3 REMEDIAL ACTION OBJECTIVES AND CRITERIA. This section presents the goals and objectives for remedial action at OU 7. First, RAOs are established for the OU based on consideration of the RI, RA, and ARARs. Next, action levels, or the concentration of a chemical above which remedial action (e.g., extraction and treatment, *in situ* treatment, or natural attenuation) would be necessary, are defined for media of concern. Treatment levels, or the concentration of a chemical that any treatment technology would achieve if implemented, are also defined. Treatment levels would be achieved if an excavation or extraction technology were chosen for OU 7. Next, volumes and physical characteristics of media of concern are summarized for OU 7. Information presented in this section will be used to identify appropriate remedial technologies for OU 7 (i.e., Chapter 6.0).

5.3.1 Remedial Action Objectives RAOs are defined in the CERCLA RI/FS guidance manual as media-specific goals that are established to protect human health and the environment (USEPA, 1988). The RAOs are typically based on chemicals of concern, exposure routes, and receptors present or available at the site. Additionally, RAOs are developed to ensure compliance with ARARs; these ARARs were identified in Section 5.1. RAOs will be identified for OU 7 by consideration of the RI, the human health risk assessment, the ecological risk assessment, and ARARs.

Consideration of the RI. The results of the investigation to delineate the nature and extent of contamination resulting from the past discharge to the seepage pit and affected area indicates the presence of chemicals in all media sampled. However, not all of these detections appear related to the source area, as is the case for surface soil, surface water, sediment, and various contaminants detected in groundwater.

Sampling and analytical results from subsurface vadose zone and saturated soil indicate the presence of TCE and other chemicals. As previously discussed, the discharge of wastewater to the seepage pit apparently caused the water table to mound and spread contaminants radially (horizontally and vertically). When the discharge ceased, the mound subsided and left concentrations of chemicals in what is now the vadose zone. During the IRA, soil within the vadose zone that contained TCE concentrations in excess of 1,000 $\mu g/kg$ (it was assumed that if TCE-contaminated soil were removed, then soil contaminated with other chemicals would be removed) was removed and replaced with clean fill. Based on the results of the confirmatory soil sampling and analysis for vadose soil, it is estimated that an average TCE concentration of 137 $\mu g/kg$ remains. The RI further estimated that continued leaching of this soil from infiltrating rainfall would take 30 years before TCE in the soil would no longer cause the groundwater to exceed the MCL of 5 $\mu g/\ell$. The RI also estimated that it would take 160 years for the aquifer to flush, under existing conditions, to a TCE concentration less than 5

$\mu g/\ell$. Since the aquifer will take longer to clean up than the overlying contaminated soil in the vadose zone, an RAO specific to this soil was not developed.

The RI evaluated subsurface saturated soil and concluded that soil samples did not identify the presence of free or recoverable NAPL at OU 7. However, several Aquaprobe samples from beneath the former seepage pit area show concentrations of TCE exceeding 1 percent of its solubility in water (i.e., the rule-of-thumb method for estimating if NAPL is present). Although this observation may indicate the presence of some NAPL, the NAPL is not believed to be present in significant volume, but rather as small streaks or globules scattered in a relatively narrow column extending to approximately 40 feet directly beneath the former seepage pit area. At this time, an RAO to address NAPL at OU 7 will not be identified. If the presence of this NAPL impacts the effectiveness of any remedial alternative, it will be addressed at that time.

Consideration of Human Health Risk Assessment. The human health risk assessment conducted for OU 7 evaluated current and future land use conditions for a subset of contaminants detected in surface soil, subsurface soil, surface water, sediment, and groundwater (both the surficial aquifer and the intermediate aquifer). Chapter 3.0 provides a more detailed discussion of this assessment.

Cancer and noncancer risk estimates calculated for surface soil, subsurface soil, surface water, sediment, and the intermediate aquifer are below or within acceptable risk ranges as defined by USEPA. Therefore, the development of RAOs for these media at OU 7 is not necessary for protection of human health. Also, no risks were identified for nonresidential exposure to surficial aquifer groundwater.

Cancer and noncancer risk estimates were calculated for the surficial aquifer for the future resident exposure scenario. This scenario assumes that a human being would establish residency at the OU and install a drinking (potable) water well without a filter. The cancer risk estimate for this scenario was calculated at $3x10^{-3}$; the major chemical contributing to this risk was 1,1-DCE. The noncancer risk estimate (or the HI) was calculated at 50; the major chemicals contributing to this risk estimate include 1,2-DCA, 1,1-DCE, TCE, antimony, and thallium. Based on this analysis, the following RAO is established:

RAO 1: Protect humans from unacceptable risk by preventing potable water use of surficial aquifer groundwater that exceeds site-specific health-based risk criteria.

Consideration of the Ecological Risk Assessment. The ecological assessment conducted for OU 7 evaluated potential risks for ecological receptors for a subset of contaminants (i.e., ECPCs) found in surface water, sediment, and groundwater. Chapter 3.0 provides a more detailed discussion of this assessment.

Risks were evaluated for exposure of terrestrial wildlife receptors to ECPCs in surface water and sediment and for exposure of aquatic life to ECPCs in surface water, sediment, and groundwater.

Risks were not identified for terrestrial wildlife resulting from exposures to ECPCs in surface water or sediment.

Risks were not identified for aquatic life resulting from exposures to ECPCs in surface water.

Risks to aquatic receptors may be associated with exposures to sediments. However, the ECPCs detected in sediments that contribute to this finding are most likely not related to activities conducted at OU 7; instead, the presence of ECPCs in sediments is most likely a result of fuel spills to the drainage ditch or runoff from the aircraft runways.

Risks were evaluated for exposure of aquatic receptors to groundwater based on the maximum concentration of ECPCs measured in unfiltered groundwater. The risk characterization did not identify risks for aquatic receptors in Sal Taylor Creek associated with ECPCs in groundwater. Risks may be associated with exposure of aquatic receptors to bis(2-ethylhexyl)phthalate, aluminum, iron, and zinc in the wetland. However, concentrations of bis(2-ethylhexyl)phthalate, iron, and zinc appear to originate in the intermediate aquifer and flow upward to the surficial aquifer; therefore, these detections are not believed to be associated with OU 7. In addition, concentrations of aluminum in groundwater are not believed to be associated with activities conducted at OU 7 because aluminum was most likely not discharged to the seepage pit.

The development of RAOs for protection of exposure of ecological receptors to surface water, sediment, or groundwater are, therefore, not necessary for OU 7.

Consideration of ARARs and TBCs. The concentration of 11 chemicals detected in unfiltered groundwater samples collected from the upper and lower zone of the surficial aquifer were greater than the Federal MCL, the Florida Drinking Water Standard, or Florida Guidance Concentrations (Table B-3 in Appendix B). The concentration of four chemicals detected in unfiltered groundwater samples collected from the upper zone of the Hawthorn was greater than the Federal MCL, the Florida Drinking Water Standard, or Florida Guidance Concentrations (Table B-4 in Appendix B). However, the RI concluded that the concentrations of the chemicals detected in the upper zone of the Hawthorne were not site-related.

Based on the above comparison and the RI, the following RAO was developed:

RAO 2: Prevent the use of surficial aquifer groundwater that exceeds chemical-specific ARARs and TBCs.

Summary. Two RAOs are identified for OU 7. These RAOs are applicable to the groundwater media at the OU. Table 5-1 summarizes the two RAOs developed for OU 7.

5.3.2 Action Levels and Chemicals of Concern (COCs) This subsection presents the action levels for OU 7. Action levels are the concentrations of chemicals in contaminated media above which remedial action or control would be necessary. Specifically, action levels are identified in this subsection for groundwater at OU 7, as the RAOs established for the OU relate to that medium only.

5.3.2.1 Considerations for Defining Action Levels Action levels are assigned based on the possible future use of groundwater as a potable water supply at the OU 7 property, the risk assessment completed for OU 7, and ARARs.

Table 5-1
Summary of Remedial Action Objectives for Operable Unit (OU) 7

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Remedial Action Objective	Description
1	Protect humans from unacceptable risk by preventing potable water use of surficial aquifer groundwater that exceeds site-specific health-based risk criteria.
2	Prevent the use of surficial aquifer groundwater that exceeds chemical-specific ARARs and TBCs.

Notes: ARAR = applicable or relevant and appropriate requirement.
TBC = to be considered.

Future Land Use. There are two possibilities for future use of the OU 7 property: industrial use and unrestricted future land use. Under the industrial use scenario, the area in the vicinity of the OU would continue to be used for various industrial activities, such as aircraft activities. This future land use is reasonable because NAS Cecil Field may become a global airport upon closure. Under the unrestricted future land use scenario, the area in the vicinity of OU 7 would be used for human residence with private wells screened in the surficial aquifer. The possibility of this future land use at OU 7 is unlikely because of the close proximity of the site to the runways and the assumption that the runways will continue to be used upon closure of NAS Cecil Field.

Risk Assessment. The risk assessment evaluated the potential that future residents would install a drinking water well within the surficial aquifer and consume unfiltered water (i.e., the surficial-unfiltered scenario). Action levels could be based on the risks posed by the surficial-unfiltered groundwater consumption scenario. However, it is more reasonable to base action levels on the risk that would be posed to humans who consume water from the Floridan aquifer (as this is the only potable source currently used at NAS Cecil Field). Action levels could also be based on the risks posed to industrial users of OU 7. These risks include the risk to the excavation worker from dermal or inhalation exposure to groundwater. However, the risk assessment did not evaluate an industrial use scenario for groundwater for OU 7, and action levels cannot be identified because these risks have not been quantified.

ARARs and TBCs. Action levels can be based on chemical-specific ARARs and TBCs for groundwater. Chemical-specific ARARs are available for groundwater (see Subsection 5.1.2); therefore, action levels can be established for OU 7.

Summary. Action levels identified for OU 7 considered the above future uses of OU 7 property, the risk assessment, and ARARs. For the purpose of this FS, action levels will be based on chemical-specific ARARs for assumed future use of surficial groundwater as a potable water supply.

5.3.2.2 Identification of Action Levels for OU 7 In order to establish action levels for OU 7, the first step was to determine the set of chemicals associated with the site. This was accomplished by listing all chemicals detected in groundwater samples in the surficial aquifer at OU 7.

The second step is to select a set of criteria (i.e., the selection criteria [see Appendix C]) that may be appropriate for the anticipated groundwater use (e.g., ARARs and TBCs discussed in Paragraph 5.3.2.1). The selection criteria for this FS were considered to be the higher value of:

- the lowest value of the Federal MCL, State of Florida MCL, or Florida Groundwater Guidance Concentrations; or
- the background (upgradient) concentration of a chemical in groundwater.

Where no Federal MCL, State of Florida MCL, or Florida Groundwater Guidance Concentrations was available, the chemical was deleted from further consideration unless the chemical contributed to the total risk presented by the site.

The third step in identifying action levels at OU 7 was to compare the concentration of the chemicals detected in groundwater to the selection criteria.

If the maximum concentration of the chemical in groundwater was greater than the selection criterion, then the chemical was considered a chemical of concern for this FS (see Appendix C). Bis-(2-ethylhexyl)phthalate and iron were deleted from further consideration because the RI concluded that the presence of these chemicals was not related to OU 7, but to a second upgradient source. The comparison shows that groundwater at OU 7 contains detections of chemicals at concentrations greater than the selected criteria.

For the purpose of this FS, the selection criteria were considered the action levels for groundwater remedial action at OU 7. Alternatives identified will be evaluated on the practicability of achieving these action levels for the chemicals listed on Table 5-2.

5.3.3 Treatment Levels If groundwater were addressed via a treatment alternative, it would be treated one of two ways: *in situ* or *ex situ*. Depending on the remedial alternative chosen, treatment levels (or the concentration of a chemical to which groundwater would be treated) would vary.

5.3.3.1 ***In Situ* Treatment Alternatives** For an *in situ* treatment alternative, the treatment level would be the action level, as described in paragraph 5.3.2.2. These chemicals, along with their respective treatment-action level, are listed in Table 5-3.

5.3.3.2 ***Ex Situ* Treatment Alternatives** For an *ex situ* treatment alternative, the treatment level would depend on: (1) the concentration of chemicals in extracted groundwater, and (2) acceptance criteria of the receiving water for treated groundwater (e.g., groundwater, surface water, or local wastewater treatment plant). Any *ex situ* treatment alternative would be designed to treat chemicals in extracted groundwater at concentrations higher than these acceptance criteria. The following paragraphs present the chemicals of concern in extracted groundwater and the selection criteria for each receiving body.

Chemicals of Concern in Extracted Groundwater. Before identifying the selection criteria, the concentrations of chemicals in extracted groundwater must be evaluated.

First, all chemicals detected in groundwater at OU 7 were listed. All chemicals are listed at this step because the extraction system would be designed to extract groundwater at OU 7 and not just those chemicals above action levels.

Next, the concentration of each chemical in the extracted groundwater was estimated using groundwater modeling techniques provided by the FDEP. Appendix D presents these calculations as well as the estimated concentrations in extracted groundwater.

Treated Groundwater Discharged to Groundwater. An *ex situ* treatment alternative that included a discharge to groundwater component would be designed to treat chemicals whose concentrations are greater than MCLs (Federal or State). These criteria are the same as the action levels for an *in situ* treatment alternative, and are summarized in Table 5-3. This table also indicates the percent removal that needs to be achieved by an *ex situ* treatment alternative prior to discharge to groundwater.

Table 5-2
Action Level Exceedances Summary

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Maximum Detected Concentration	Selected GW Criteria[3]
Volatiles (μg/ℓ)					
1,1,1-Trichloroethane	1/21	3,000	3,000	3,000	200
1,1-Dichloroethene	1/21	400	400	400	7
1,2-Dichloroethene (total)	2/21	270 to 12,500	6,360	12,500	70
Trichloroethene	7/21	12 to 630	238	630	3
Inorganics (μg/ℓ)					
Aluminum	12/21	176 to 7,970	1,480	7,970	750
Antimony	3/21	2.2 to 16.0	7.3	16.0	6
Arsenic	10/21	3.6 to 56.2	13.2	56.2	50
Manganese	18/20	4.9 to 56.8	27.4	56.8	50
Thallium	3/21	6 to 6.3	6.2	6.3	2

[1] Frequency of detection is the number of confirmatory samples in which the analyte was detected divided by the total number of confirmatory samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all confirmatory samples in which the analyte was detected. It does not include those confirmatory samples in which the analyte was not detected.
[3] Refer to shaded values in Appendix C.

Notes: GW = groundwater.
μg/ℓ = micrograms per liter.

Table 5-3
Groundwater *In Situ* Treatment Requirements

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Maximum Detected Concentration	Selected GW Criteria[3]	Percent Removal Required[4]
Volatiles (μg/ℓ)						
1,1,1-Trichloroethane	1/21	3,000	3,000	3,000	200	93.3
1,1-Dichloroethene	1/21	400	400	400	7	98.3
1,2-Dichloroethene (total)	2/21	270 to 12,500	6,360	12,500	70	99.4
Trichloroethene	7/21	12 to 630	238	630	3	99 5
Inorganics (μg/ℓ)						
Aluminum	12/21	176 to 7,970	1,480	7,970	750	90.6
Antimony	3/21	2.2 to 16.05	7.3	16.0	6	62 6
Arsenic	10/21	3.6 to 56.2	13.2	56.2	50	11.0
Manganese	18/20	4.9 to 56.8	27.4	56.8	50	12.0
Thallium	3/21	6 to 6.3	6.2	6.3	2	68.3

[1] Frequency of detection is the number of confirmatory samples in which the analyte was detected divided by the total number of confirmatory samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all confirmatory samples in which the analyte was detected. It does not include those confirmatory samples in which the analyte was not detected.
[3] Refer to shaded values in Appendix C, Table C-1.
[4] Percent removal required for groundwater at operable unit (OU) 7 to meet the selected groundwater (GW), selection criteria.

Notes: GW = groundwater.
μg/ℓ = micrograms per liter.

Treated Groundwater Discharged to Surface Water. An *ex situ* treatment alternative that included a discharge to surface water component would most likely discharge water to Sal Taylor Creek via the existing stormwater system. The selection criteria for this discharge option are the Florida surface water standards, the Federal AWQC (where a Florida Surface Water Standard was not available), or background (upstream) concentrations, whichever was higher (see Appendix C). Florida surface water standards considered at this step were for Class III surface water, as the receiving water body (i.e., Sal Taylor Creek) under this scenario is a Class III surface water. A Class III designation means the surface water is used for recreation and propagation and maintenance of a healthy, well-balanced population of fish and wildlife.

In order to identify which chemicals in the extracted groundwater would require treatment prior to discharge to surface water, the estimated concentrations of each chemical in extracted groundwater at OU 7 was compared to the selected surface water criteria (see Appendix C). Most point source discharges to surface water in the State of Florida are issued permits for "end of pipe" effluent quality, which is typically based on attaining the Florida surface water standards at the perimeter of a mixing zone. Under this scenario, a permit for a discharge from OU 7 to Sal Taylor Creek may contain effluent criteria that could be up to several times the Florida surface water standards. Pending discussion with the FDEP regarding these effluent criteria, the selection criteria discussed in the previous paragraph were used. Chemicals for which treatment would be necessary and the percent removal that should be achieved prior to discharge to surface water are summarized in Table 5-4.

Treated Groundwater Discharged to the Local Wastewater Treatment Plant. An *ex situ* treatment alternative that included a discharge to a wastewater treatment plant, would discharge to the NAS Cecil Field Federally Owned Treatment Work (FOTW). The selection criteria for this discharge option were determined in the following manner.

First, discharge criteria for the NAS Cecil Field FOTW were considered. The FOTW discharges to surface water, and the National Discharge Pollutant Elimination System (NPDES) permit granted for this discharge indicates that the FOTW must provide treatment of chemicals to the Florida Surface Water Standards (see Appendix C). Based on this information, the percent removal the FOTW is able to achieve was estimated for chemicals in extracted groundwater from OU 7. The percent removal was estimated through use of the USEPA Fate and Treatability Estimator (FATE) model (USEPA, 1990c). In using this model, the plant-specific operating parameters of the FOTW were obtained and used to predict the percent removal of chemicals.

Second, once the percent removal achievable by the FOTW is known, the degree of pretreatment (i.e., treatment of the extracted groundwater prior to discharge to the FOTW) can be estimated (see Table 5-5). This analysis indicates that TCE and iron require pretreatment prior to discharge of groundwater from OU 7 to the FOTW. TCE must be reduced by at least 98 percent and iron by 43 percent.

Summary. If an *in situ* treatment alternative is selected, the chemicals listed on Table 5-3 are the primary chemicals of concern. This table also indicates the approximate percent removal required for each chemical.

Table 5-4
Groundwater *Ex Situ* Treatment Requirements for Discharge to Surface Water

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Estimated Concentration in Extracted Groundwater[3]	Selected SW Criteria[4]	Percent Removal Required[5]
Volatiles (μg/ℓ)						
1,1-Dichloroethene	1/21	400 to 400	400	32.5	3.2	90.2
Trichloroethene	7/21	12 to 630	238	[6]21,800	80 7	99 6
Semivolatiles (μg/ℓ)						
Phenanthrene	1/21	3	3	0.06	0.03	50.0
bis(2-Ethylhexyl)phthalate	17/21	0.5 to 20 5	5 7	5.7	3	47.4
Inorganics (μg/ℓ)						
Copper	5/21	2.1 to 3.8	3	3 8	2.9	22.7
Iron	20/20	260 to 9,150	1,830	1,900	381	79.9
Nickel	2/21	11 to 12.5	11.8	11 5	8 3	27 8
Thallium	3/21	6 to 6.3	6.2	8.8	6.3	28.0

[1] Frequency of detection is the number of confirmatory samples in which the analyte was detected divided by the total number of confirmatory samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all confirmatory samples in which the analyte was detected. It does not include those confirmatory samples in which the analyte was not detected.
[3] Estimated contaminant concentrations in extracted groundwater are provided in Appendix C and the calculations are presented in Appendix D.
[4] Refer to shaded values Appendix C, Table C-3.
[5] Percent removal required for groundwater at operable unit (OU) 7 to meet the selected surface water (SW) criteria.
[6] Value estimated from confirmatory and screening data.

Notes SW = surface water
μg/ℓ = micrograms per liter.

Table 5-5
Groundwater *Ex Situ* Pretreatment Requirements for Discharge to Federally Owned Treatment Work (FOTW)

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Estimated Concentration in Extracted Groundwater[3]	FOTW Discharge Criteria[4]	Overall Percent Removal Required[5]	Percent Removal Achievable by FOTW[6]	Pretreatment Percent Removal Required[7]
Volatiles (μg/ℓ)								
1,1-Dichloroethene	1/21	400 to 400	400	33	3 2	90 2	90.6	NA
Trichloroethene	7/21	12 to 630	238	[8]21,800	80.7	99.6	73.1	98.6
Semivolatiles (μg/ℓ)								
Phenanthrene	1/21	3	3	0.06	0 03	50 0	84 1	NA
bis(2-Ethylhexyl) phthalate	17/21	0.5 to 20.5	5.7	5.7	3	47.4	99.9	NA
Inorganics (μg/ℓ)								
Copper	5/21	2.1 to 3.8	3	3.8	2.9	22.7	61 7	NA
Iron	20/20	260 to 9,150	1,828	1,900	300	84.2	75.3	36.0
Nickel	2/21	11 to 12.5	11.8	11.5	8.3	27.8	49 8	NA
Thallium	3/21	6 to 6.3	6.2	8.8	6.3	28.0	80.0	NA

[1] Frequency of detection is the number of confirmatory samples in which the analyte was detected divided by the total number of samples analyzed (confirmatory samples only).
[2] The average of detected concentrations is the arithmetic mean of all confirmatory samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.
[3] Estimated contaminant concentrations in extracted groundwater are provided in Appendix C and the calculations are presented in Appendix D
[4] Discharge criteria that the FOTW must meet (Florida Surface Water Standards).
[5] Percent removal required for extracted groundwater to meet the FOTW discharge criteria.
[6] Percent removal able to be achieved by the FOTW (predicted using the U.S. Environmental Protection Agency [USEPA] Fate and Treatability Estimator [FATE]) Model, 1989).
[7] Percent removal required for pretreatment prior to discharge to FOTW (where NA, the FOTW can provide the percent removal necessary)
[8] Value estimated from confirmatory and screening data.

Notes: μg/ℓ = micrograms per liter.
NA = not available.

For this FS, *ex situ* treatment alternatives would need to provide a level of treatment to meet criteria assumed for discharge to groundwater (Table 5-3), discharge to surface water (Table 5-4), or discharge to the FOTW (Table 5-5).

5.3.4 Volume of Contaminated Groundwater The volume of contaminated groundwater at OU 7 is estimated based on the observed horizontal and vertical migration of TCE (because TCE is the primary chemical of concern) from the source area. The RI indicates that, at the source, the groundwater analytical results show that the concentration of TCE extends radially outward approximately 265 feet and downward approximately 65 feet,and that the downgradient extent of TCE concentration is 1,000 feet to the southeast. Using a porosity of 0.2 the estimated volume of groundwater with TCE concentrations above the action level is approximately 26 million gallons.

5.3.5 Physical Characteristics of Organic Chemicals of Concern Table 5-6 presents physical characteristics of the organic chemicals of concern (identified in Subsection 5.3.3). A brief explanation of the physical characteristics follows.

Specific density, also known as relative density, is defined as ratio of the density of a substance to the density of distilled water. The density of water is 1.00 gram per milliliter (g/mℓ) at 4 degrees Celsius (°C). The density of a substance is an indicator of whether it will tend to sink or float in water. If a substance is less dense than water, it will float; if it is more dense, it will sink.

Solubility is defined as a compound's saturated concentration in water at a given temperature and pressure. Compounds with high solubilities tend to desorb from soil, are less likely to volatilize from water, and tend to biodegrade. Compounds with low solubilities tend to adsorb to soil, volatilize from water, and bioconcentrate in aquatic organisms. The COCs identified have solubilities ranging from 6,300 mg/ℓ for 1,2-dichloroethene to 0.4 mg/ℓ for bis(2ethylhexyl)-phthalate. The volatile COCs have solubilities in the mid-range, and the semivolatiles have low solubilities.

Vapor pressure is defined as the pressure exerted by the vapor of a substance when it is under equilibrium conditions. The vapor pressure of all liquids increases with temperature. Vapor pressure provides a rough estimation of how well a substance will volatilize from soil and/or water. The vapor pressure of water at 20 °C is 18 millimeters of mercury (mm Hg). The volatile COCs have vapor pressures in the mid-range, and the semivolatiles have low vapor pressures.

Henry's law constant (H), also known as the air-water partitioning coefficient, is defined as the ratio of a compound's partial pressure in air to the concentration of the compound in water at a given temperature and under equilibrium conditions. Henry's law constant provides an indication of the relative volatility of a substance. The following guidelines are for Henry's constants in atmospheres times cubic meters per mole (atm-m^3/mole).

Table 5-6
Characteristics of Organic Chemicals of Concern

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

CAS Number	[1]Contaminant	Molecular Weight (g/mole)	[2]Specific Density	[3]Solubility (mg/ℓ) at 25 °C	[4]Vapor Pressure at 20 °C (mm Hg)	[5]Henry's Law Constant (atm-m^3)/mole	[6]log-K_{ow}	[7]log-K_{oc}	Estimated Aqueous Biodegradation Half-life		Relative Degradability Classification	
									Anaerobic (GW)	Aerobic (SW)	Anaerobic	Aerobic
75-35-4	1,1-Dichloroethene	96 94	1.22	5,000	495	0.021	2.13	1.81	8 to 19 weeks	4 to 26 weeks	Slow	Slow
156-60-5	1,2-Dichloroethene	96.94	1.26	6,300	265	0.0072	2.09	1.77	16 to 104 weeks	4 to 26 weeks	Resistant	Slow
79-01-6	Trichloroethene	131.39	1.46	1,100	58	0.0117	2.53	2.03	0 9 to 4.5 years	0.5 to 1 year	Resistant	Resistant
71-55-6	1,1,1-Trichloroethane	133.40	1.34	950	100	0.0162	2.48	2.18	20 to 78 weeks	20 to 39 weeks	Resistant	Slow
117-81-7	bis(2-Ethylhexyl)-phthalate	390.57	0.98	0.4	$2x10^{-7}$	$1x10^{-5}$	4.20	5.0	10 to 389 days	5 to 23 days	Resistant	Moderately Fast
85-01-8	Phenanthrene	178.24	0.98	1.18	21,000	$3.9x10^{-5}$	4.57	4 36	1 to 13 months	3 to 25 hours	Resistant	Fast

[1] The contaminants presented are organic contaminants of concern identified in the human health and ecological baseline risk assessment.
[2] Specific density, also known as relative density, is defined as ratio of the density of a substance to the density of distilled water. The density of water is 1.00 g/mℓ at 4 °C.
[3] Solubility is defined as a compound's saturated concentration in water at a given temperature and pressure.
[4] Vapor pressure is defined as the pressure exerted by the vapor of a substance when it is under equilibrium conditions.
[5] Henry's law constant, also known as the air-water partitioning coefficient, is defined as the ratio of a compound's partial pressure in air to the concentration of the compound in water at a given temperature and under equilibrium conditions
[6] Log K_{ow}, the n-octanol/water partition coefficient, is defined as the ratio of the solute concentration in the water-saturated n-octanol phase to the solute concentration in the n-octanol-saturated water phase.
[7] Log K_{oc}, the soil/sediment partition coefficient, is defined as the ratio of adsorbed chemical per unit weight of organic carbon to the aqueous solute concentration.

Sources: Montgomery, J. H., and L.M Welkom, 1991, "Groundwater Chemicals Desk Reference", Lewis Publishers, Chelsea, Michigan.
P H. Howard, and others, 1991, "Environmental Degradation Rates", Lewis Publishers, Chelsea, Michigan.

Notes: CAS = Chemical Abstract Service.
g/mole = grams per mole
mg/ℓ = milligrams per liter.
°C = degrees Celsius.
g/mℓ = grams per milliliter
mm Hg = millimeter of mercury.
atm-m^3/mole = atmospheres times cubic meters per mole.
K_{ow} = octanol-water partition coefficient.
K_{oc} = soil-sediment partition coefficient.
GW = groundwater.
SW = surface water.

$H > 10^{-3}$	rapid volatilization
$10^{-5} < H < 10^{-3}$	volatilization
$10^{-7} < H < 10^{-5}$	slow volatilization
$H < 10^{-7}$	extremely low volatilization

Henry's constants of the volatile COCs indicate they are in the rapid to mid-range volatilization. The semivolatiles are in the slow volatilization range.

The octanol water partition coefficient, K_{ow}, is defined as the ratio of the solute concentration in the water-saturated octanol phase to the solute concentration in the octanol-saturated water phase. It is used to estimate the hydrophobicity and sorptive tendencies of hydrocarbons. For convenience, K_{ow} is often reported in logarithmic form ($\log K_{ow}$) because values from the class of immiscible hydrocarbons that are of environmental concern span several orders of magnitude. Negative $\log K_{ow}$ values indicate a preference for the aqueous phase (hydrophilicity). Positive $\log K_{ow}$ values indicate a hydrocarbon's preference to form separate phases (hydrophobicity), sorb strongly to solids, or potentially volatilize. All of the COCs are hydrophobic, and the semivolatiles have a greater sorptive tendency than the volatiles.

The soil and/or sediment partition coefficient, K_{oc}, is defined as the ratio of adsorbed chemical per unit weight of organic carbon to the aqueous solute concentration. K_{oc} is a measure of a chemical's relative adsorption potential, i.e., a chemical's tendency to sorb to particulate or organic matter. This is largely dependent on the organic content of soil. For convenience, K_{oc} is often reported in logarithmic form ($\log K_{oc}$) because values that are of environmental concern span several orders of magnitude. Sorption is generally considered to be high for $\log K_{oc}$ values of 5 to 6, moderate for $\log K_{oc}$ values of 3, and weak for values of 2.2 or less. Compounds that bind strongly to organic carbon have low solubilities, whereas compounds that do not tend to adsorb to organic materials have high solubilities. The volatile COCs adsorb weakly, and the semivolatiles adsorb strongly.

5.4 IDENTIFICATION OF GENERAL RESPONSE ACTIONS. General response actions describe potential medium-specific measures that may be employed to address RAOs. Potential response actions for OU 7 are developed for groundwater. When applied to groundwater they are referred to as management of migration actions. These response actions include no action, intrinsic bioremediation, removal and treatment, and *in situ* treatment.

6.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The approach and rationale leading to the development of remedial alternatives are presented in this chapter. The development of remedial alternatives for CERCLA sites consists of identifying applicable technologies, screening those technologies, and using the selected technologies to develop remedial alternatives that accomplish the identified RAOs.

The NCP requires that a range of remedial alternatives be considered. SARA emphasizes the use of treatment technologies that reduce the toxicity, mobility, or volume of contaminants rather than technologies that solely prevent exposure. The primary goal of alternative development for OU 7 is to comply with this aspect of SARA: specifically, to reduce the human health risk posed by exposure to groundwater. To achieve this goal, the following three categories of remedial alternatives were identified for evaluation:

- groundwater extraction, treatment, and discharge (pump-and-treat);
- *in situ* groundwater treatment; and
- enhanced bioremediation (supplemented natural attenuation).

The remaining sections of this chapter identify the types of technologies that contribute to achieving the RAOs, evaluate and select representative technologies for each technology type, and develop remedial alternatives using the selected technologies. A detailed evaluation of remedial alternatives is presented in Chapter 7.0. Specific constituents detected in groundwater at OU 7 are listed in Appendix C.

6.1 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES. Traditional and innovative technologies have been researched and categorized based on their basic operating principles. One representative technology was then selected from each technology type for subsequent screening (Section 6.2). For example, a packed tower was selected as a representative air stripping and aeration technology to treat organic compounds in extracted groundwater. This approach allows an effective comparison of technologies based on their basic operating principles rather than more subtle vendor-specific characteristics or variable configuration. Additionally, emerging technologies are continually introduced; if a new technology uses the same operating principles and achieves the same objectives as the technology selected in the ROD, it could be considered for implementation during the remedial design.

Plume immobilization techniques, such as subsurface barriers, reduce plume mobilization, but do not provide reduction in toxicity or volume of contaminants in the aquifer and would not achieve the treatment levels identified for OU 7. Thus, to achieve the treatment levels and to be consistent with the intent of the NCP and SARA, only those technologies that can potentially reduce the concentrations of groundwater contaminants are identified in this chapter.

Supplemental technologies may be required for residuals and emissions generated during groundwater treatment. For example, the vapor collection portion of an air sparging system requires treatment of organic vapors prior to exhaust. Also,

chemical precipitation requires treatment and disposal of separated solids. The effective treatment of residuals and emissions is dependent upon the treatment used. The appropriate method of conditioning and dewatering sludge from chemical precipitation may be different than conditioning and dewatering sludge from a biological process. Thus, the identification of required supplemental technologies will be deferred to the detailed evaluation of remedial alternatives (Chapter 7.0).

6.1.1 Collecting Groundwater for Treatment To implement *ex situ* treatment technologies, contaminated groundwater must be extracted from the aquifer. The practicality of groundwater extraction depends on the hydrogeologic conditions at a site. Hydrogeologic investigations at OU 7 indicate that groundwater extraction is practical. Extraction is a proven technology and has been successfully implemented at sites with conditions similar to OU 7.

Groundwater can be extracted through wells or trenches. Wells can be used to extract groundwater from various depths within an aquifer; however, trenches can typically extract only shallow groundwater. Extraction wells would be used at OU 7 because the plume extends approximately 65 feet below the water table, too deep to be effectively captured by trenches.

As extraction wells are pumped, a cone of depression is created around each well. This influences the local hydrogeology and causes groundwater to flow toward the wells, flushing contaminants from the aquifer. During the feasibility study, the number of wells, well locations, and pumping rates are estimated; during detailed design, the estimated configuration is refined to improve efficiency while still capturing and extracting the contaminated groundwater.

For a groundwater extraction system to be fully effective, it may have to be modified during the course of the remedial action. When multiple wells are pumped simultaneously, stagnation zones (areas where there is no groundwater flow) can develop. This can leave behind pockets of contaminants. To capture these remaining pockets, the pumping operational scheme may have to be changed by adjusting pumping rates, injecting clean water into some wells, or installing additional wells to replace wells no longer effective.

6.1.2 Treatment of Organic Compounds in Extracted Groundwater Selected organic compounds have been identified as chemicals of concern (COCs) at OU 7. These compounds include VOCs such as TCE and DCE and SVOCs such as bis-(2-ethylhexyl)-phthalate. Specific constituents and their respective treatment levels are dependent upon the method of discharge. Anticipated treatment levels for each method of discharge were presented in Tables 5-3, 5-4, and 5-5 in Chapter 5.0. This section presents treatment technologies that remove organic compounds from extracted groundwater to achieve these treatment levels.

6.1.2.1 Air Stripping and Aeration Air stripping and aeration are used to remove VOCs from contaminated water. It is generally considered to be only partially effective for SVOCs. The VOCs are transferred from the liquid to the vapor phase by contacting the water with a continuous supply of clean air. Although many vendor-specific air stripping and aeration units exist, they can be grouped into the following four categories:

- packed towers,
- diffused aeration,

- cascade towers, and
- tray towers.

Packed Towers. A typical packed tower system consists of a tower (or column) in which influent groundwater flows downward from the top, while a stream of air flows upward from the bottom. The tower is filled with an inert packing material. Plastic packing is usually used in water treatment operations and provides a large surface area for air-water interface. As clean air moves upward, the VOCs are transferred from the water to the air stream. The liquid effluent is discharged from the bottom, and the air containing VOCs is discharged from the top (American Water Well Association [AWWA], 1990). The presence of inorganic compounds can potentially clog packing material. Frequent cleaning, adjustment, or replacement of packing may be required to maintain effective removal efficiencies (Air Stripping Design and Costing Computer Program, Dzombak-Roy-Fang, 1993).

Diffused Aeration. Diffused aeration is a process of bringing air bubbles in contact with contaminated water. This process is similar in principle to a packed tower, but it is typically accomplished by a "low profile" unit that requires less operating space. Air is bubbled into a tank containing contaminated water. A variety of aeration rates and bubble diffusers are available to achieve different effects. Diffused aeration generally requires a higher power cost than packed towers and can be accomplished in tanks (AWWA, 1990). Similar to packed towers, inorganic compounds can be troublesome, potentially clogging diffuser mechanisms, requiring cleaning or replacement (Air Stripping Design and Costing Computer Program, Dzombak-Roy-Fang, 1993).

Cascade Towers. Cascade towers are gravity-fed, stepped systems that aerate contaminated water by continually "splashing" the water onto subsequent steps. Small pools of water are exposed to air as thin sheets cascade down each step. The number and height of the required steps can be designed to achieve the desired contact time for air-water interface (Metcalf and Eddy, 1991).

Tray Towers. Tray towers are similar in principle to cascade towers. Rather than a series of steps, a series of stacked trays are used to maximize air-water interface. Water flows over a flat tray, discharges to a lower tray, and continues to pass over the required number of trays to achieve the desired removal efficiency. Trays may consist of slats or porous bottoms, and contain stones or other packing to increase turbulence and aeration. Tray towers are typically used for oxidation of iron and manganese. Additives, such as potassium permanganate, can improve oxidation. Tray tower aeration maximizes air-water contact by using multiple trays. If a greater air-water contact time is desired, additional trays may be added (Peavy, Rowe, Tchobanoglous, 1985).

Recommendation. These air-stripping and aeration technologies have similar effectiveness in volatilizing VOCs. Packed tower air stripping is a demonstrated technology that is easily obtained to achieve a variety of treatment levels. For comparative purposes, a packed tower air stripper will be used as a representative air-stripping and aeration technology for subsequent screening. Alternate innovative or vendor-specific processes that accomplish the same type of treatment as air stripping could be used in lieu of a packed tower.

6.1.2.2 Oxidation Oxidation involves destroying VOCs in groundwater by changing the oxidation state of target contaminants. This process is also effective for

precipitating selected inorganic compounds, such as iron and other multivalent cations. Oxidation is usually not effective for the removal of SVOCs. The following four general categories of oxidation have been identified:

- ultraviolet light,
- ozone,
- H_2O_2, and
- other chemical oxidants.

Ultraviolet Light. Ultraviolet light oxidation (UV/OX) is a process that enhances chemical oxidation using the hydroxyl ion by exposing contaminated water to ultraviolet light. In this process, hydrocarbons are broken down into carbon dioxide and water. Oxidizers typically used with UV/OX include hydrogen peroxide and ozone. UV/OX occurs in a stainless-steel chamber containing vertically or horizontally mounted ultraviolet lamps. The process is the same for either oxidant (i.e., hydrogen peroxide or ozone); however, the manner in which the oxidant is introduced into the waste stream may differ. Hydrogen peroxide is blended into the waste stream prior to entering the reactor, and ozone is piped to a sparging tank, and diffused as a gas into the reactor. UV/OX is expected to achieve more than 99 percent destruction efficiency of organic compounds. Treatability studies would be required to determine optimum operating parameters such as pH and chemical dosage (ABB-ES, 1994a).

Ozone. Ozone is a highly reactive gas that is typically generated onsite. It can be used alone or in combination with UV/OX. Alone, it is bubbled as a gas through diffusers into the water. In contrast to other types of chemical oxidants, ozone does not typically create organic residuals that remain in the waste stream after treatment. Ozone is an extremely powerful oxidant because it nonselectively oxidizes compounds dissolved in groundwater. However, ozone does have its limitations. Ozone is very reactive, and it may dissipate rapidly in natural water either by reacting with natural constituents or by spontaneous decomposition. The primary difference between ozone and other chemical oxidants is that ozone does not produce residuals (AWWA, 1990).

Hydrogen Peroxide. Hydrogen peroxide is a moderately powerful liquid oxidizing agent that is usually shipped to the treatment plant and not generated onsite. Hydrogen peroxide with ultraviolet light is more powerful than hydrogen peroxide or ozone used alone. This process generates hydroxyl radicals that effectively oxidize VOCs and SVOCs (AWWA, 1990).

Other Chemical Oxidants. Chlorine is an effective oxidant frequently used for the disinfection of water supplies. It can be added to water in liquid or gas form. Hypochlorous acid (HOCl) is the most effective form of chlorine for oxidation. However, if inappropriately applied, it can combine with organic matter to form trihalomethanes (THMs). THMs are potentially carcinogenic compounds, such as chloroform and bromoform (AWWA, 1990). Other chlorinated compounds that can be used to oxidize organic matter include chloramines and chlorine dioxide. These compounds are generally less powerful than hypochlorous acid and are not as effective in oxidizing high concentrations of organic compounds (AWWA, 1990).

Potassium permanganate is another chemical oxidant that has been used to treat organic compounds. Potassium permanganate is typically fed into a waste stream as either a solid or a liquid solution, prepared onsite. Potassium permanganate

can be used to oxidize the majority of organic compounds, as well as selected inorganic compounds. However, similar to other chemical additives, precipitation from the application of potassium permanganate requires subsequent treatment and disposal (AWWA, 1990).

Recommendation. When comparing various methods of oxidation, chlorine is typically used for the disinfection of water supplies. The advantage of chlorine is the formation of a chlorine residual. This residual continues to disinfect water through distribution systems or receiving water bodies. Those same residuals can also react with organic matter and form THMs. However, destruction of organic compounds, not disinfection, is the objective of oxidizing groundwater extracted from OU 7. Thus, UV/OX with ozone or hydrogen peroxide is a more effective oxidation technique. To minimize residuals created during oxidation and ensure complete destruction of organic compounds, UV/OX with hydrogen peroxide is selected as the representative oxidation technology for subsequent screening. It is anticipated that UV/OX with hydrogen peroxide can destroy VOCs and oxidize inorganic compounds for subsequent precipitation and removal.

Acidification of the influent with a strong acid, such as sulfuric acid, can be used prior to the UV/OX unit to keep inorganic compounds in solution and avoid fouling the system. After UV/OX, the pH can be raised with a strong base, such as sodium hydroxide or potassium permanganate, to achieve precipitation of inorganic compounds for subsequent removal.

Alternate oxidants could be used in place of hydrogen peroxide if they do not produce residuals that require additional treatment and disposal.

6.1.2.3 Biological Treatment Biological treatment is a common method of reducing the concentration of organic compounds in wastewater. The same techniques typically applied in wastewater treatment can be applied to groundwater treatment. TCE typically degrades faster in anaerobic conditions, while DCE and lesser-chlorinated compounds degrade faster in aerobic conditions. Degradation of SVOCs may require many different types of microorganisms, operating under different environmental conditions, to efficiently degrade organic matter. Thus, both aerobic and anaerobic conditions (applied individually or sequentially) will be considered for biological treatment. Biological treatment can be further categorized as either of the following processes:

- suspended growth and
- attached growth.

Suspended Growth. Suspended growth systems include digesters and activated sludge processes. In these systems, the active biomass that metabolizes organic matter is suspended in the liquid and requires subsequent separation. The most critical parameter in the operation of a suspended growth process is the "sludge age." The sludge age is the average cell residence time in the reaction tank, prior to removing and settling the accumulated biomass. A portion of the biomass is then returned to the reaction tank to stimulate continued microbial growth. This is a well-demonstrated, effective technology to biodegrade organic matter. The primary disadvantage is its susceptibility to toxic shocks, residuals created, and O&M required to maintain an effective biomass.

Attached Growth. Attached growth systems include trickling filters, rotating biological contactors (RBCs), and packed-bed reactors. In these systems, the

active biomass is attached to an inert medium and forms a "fixed film" to biologically filter organic matter. Attached growth can be effective in reducing the concentrations of organic matter that pass near the biomass. Frequent cleaning, stimulation, and distribution of the biomass along the surface of the medium is required to maintain effective treatment.

Recommendation. If biological treatment of extracted groundwater is desired, the onsite wastewater treatment plant (i.e., the NAS Cecil Field Federally Owned Treatment Work [FOTW]) could provide that treatment through their activated sludge process. This could potentially be used as a biological "polishing" step to augment other treatment processes.

6.1.2.4 Organic Adsorption Adsorption is a process in which a substance is transferred from water to a solid medium. This technology is effective for VOCs and SVOCs. When compared to air stripping, aeration, and oxidation, organic adsorption is more effective for the removal of SVOCs.

The molecule that accumulates or adsorbs at the water-solid interface is called the adsorbate, and the solid on which the adsorption occurs is the adsorbent. Common adsorbents in water treatment include activated carbon, ion exchange resins, adsorbent resins, metal oxides, and carbonates. While some of these technologies are used primarily for the treatment of inorganic compounds, this discussion will focus on the following technologies for the treatment of organic compounds:

- granular activated carbon (GAC) and
- powdered activated carbon (PAC).

Granular Activated Carbon. GAC is a physical treatment technology in which groundwater is passed through a packed-bed reaction vessel filled with activated carbon. GAC adsorbs organic compounds and inorganic constituents. The particle shape of crushed activated carbon is irregular, while extruded activated carbon is smooth and cylindrical. The basic manufacturing process includes carbonization, or conversion of the raw material to a char, and activation (or oxidation) to develop the internal pore structure. Carbonization is usually performed in the absence of air at temperatures less than 700 °C (AWWA, 1990).

GAC adsorption is applicable to different water flow rates and concentrations. Two GAC canisters are typically used in series to monitor breakthrough and to ensure treatment effectiveness. GAC can be used as either a polishing step or a pretreatment step, depending upon the other technologies used in the treatment system. The primary cost consideration is the regeneration or disposal of spent carbon.

Powdered Activated Carbon. PAC is used in a sequential process, by adding it to groundwater within a holding tank and then separating the water and PAC. After the PAC contacts the water, the carbon is allowed to settle, and the treated water is removed. PAC particles are typically smaller than GAC particles and are supplied in bulk rather than in canisters (Burton and Tchobanoglous, 1991).

PAC has advantages over GAC in that it has lower capital costs and allows greater flexibility in altering carbon doses as the water quality changes. The disadvantages are that the PAC can not be regenerated, it attains lower TOC

removal, the sludge in the bottom of the tank must be disposed of, and it is difficult to remove the spent carbon from the water.

Recommendation. These technologies have similar effectiveness in removing organic contaminants from groundwater. However, for comparative purposes, GAC will be used as the representative organic adsorption technology for screening. GAC is easy to implement and has demonstrated effectiveness for removing organic compounds, such as those present in groundwater at OU 7. If an alternate adsorption media is identified that has advantages over GAC, it could also be used. An alternate adsorbent could be used in series with GAC or in place of GAC.

6.1.3 Treatment of Inorganic Compounds in Extracted Groundwater Selected inorganic compounds have been identified as COCs in extracted groundwater, including copper, iron, nickel, and thallium. Specific constituents and their respective treatment levels are dependent upon the method of discharge. Anticipated treatment levels for each method of discharge are presented in Tables 5-3, 5-4, and 5-5 in Chapter 5.0. In addition to inorganic compounds that exceed action levels, the presence of inorganic compounds can alter the performance effectiveness of certain types of groundwater treatment processes. This section identifies treatment technologies that remove inorganic compounds from extracted groundwater to achieve treatment levels and to avoid impacting groundwater treatment processes.

It is anticipated that extracted groundwater not contain bulk solids because extraction wells will be fully developed. Thus, bulk solids removal processes such as screening, flotation, and primary settling will not be required. Extracted groundwater will likely contain a mixture of dissolved and suspended solids.

Solids removal typically requires a sequence of treatment technologies. Specifically, an efficient removal process would transform the majority of dissolved solids into suspended solids, and then separate those solids from the effluent groundwater. Combinations of treatment technologies that achieve this objective are described below.

6.1.3.1 Chemical Precipitation and Separation Chemical precipitation is a treatment process typically used for the removal of heavy metals. The general principle of chemical precipitation is transforming solids from a dissolved form into a suspended form by increasing their oxidation state. Heavy metals are generally present as cations in groundwater. By adding an oxidation agent such as potassium permanganate or a coagulent and forming insoluble hydroxides (OH^-) and carbonates (CO_3^-), the metal cations can be precipitated out of solution. Coagulant aids such as organic (anionic) polymers are used to improve the settling characteristics of precipitates. Coagulants commonly used included aluminum salts (e.g. alum), lime, and iron salts (e.g., ferric and ferrous sulfate) with lime.

Lime and related chemical additives may generate too much sludge for subsequent handling. Additionally, at the low flow rates typically used to extract groundwater (gallons per minute), lime may settle too quickly and form hard solids that bind and foul equipment surfaces. Lime is generally less expensive than other chemicals, but it is more appropriate for large-scale operations at high flow rates (millions of gallons per day) to avoid the formation of hard

residual solids. Thus, anionic polymers may be preferable [illegible]

Packed tower air stripping is selected as the representative pretreatment technology to remove TCE prior to treatment in the FOTW. Because oxidation and other technologies typically generate solid residuals that require subsequent treatment and disposal, an air stripping and aeration technology would be preferable if oxidation of inorganic compounds is not required. Packed tower air stripping achieves this objective. Based on existing groundwater data and knowledge of FOTW operations, the FOTW should be capable of effectively treating the effluent from the air stripper without impacting the sludge quality or discharge limitations of the FOTW.

Although iron removal is not required prior to treatment of extracted groundwater in the FOTW, it may impede the effectiveness of the air stripper if it accumulates in the unit. If this happens, this alternative may be modified by lowering the pH of extracted groundwater with sulfuric acid prior to pretreatment with the air stripper. This pH reduction would help keep iron at its lower oxidation state, in a dissolved form (Fe^{2+}). It is estimated that the concentration of dissolved iron in treated groundwater, combined with other influent streams into the FOTW, will not deter attainment of FOTW's discharge limits. No treatability studies are included in the cost estimate for this alternative; it is anticipated that an observational approach would be used to modify the system, if required.

Administrative activities would be required as part of this alternative, including 5-year reviews, groundwater monitoring, and groundwater use restrictions until action levels are met.

7.0 DETAILED ANALYSIS OF ALTERNATIVES

This chapter presents the detailed analyses of alternatives for OU 7 at NAS Cecil Field. A detailed analysis is performed to provide decision makers with sufficient information to select the appropriate remedial alternative for OU 7. The detailed analyses have been conducted in accordance with CERCLA Section 121, the NCP, and USEPA RI/FS guidance. The detailed evaluation of each remedial alternative includes the following:

- a detailed description of the alternative, emphasizing the applications of the technology or actions proposed for each alternative; and
- a detailed analysis of the alternative against eight of the nine criteria.

The remedial alternatives are examined with respect to the requirements stipulated by CERCLA and factors described in the USEPA RI/FS guidance manual (USEPA, 1988). The nine criteria from the RI/FS guidance document are:

- overall protection of human health and the environment;
- compliance with ARARs;
- long-term effectiveness and permanence;
- reduction of toxicity, mobility, and volume of contaminants through treatment;
- short-term effectiveness;
- implementability;
- cost (to the nearest $1,000);
- State acceptance; and
- community acceptance.

Because the State (FDEP) and USEPA have participated in the review and have concurred with the issuance of this FS, the only criterion not specifically addressed by this FS is community acceptance. Community acceptance will be addressed upon receipt of public comments on the FS and Proposed Plan (USEPA, 1988). The ROD, including its reponsiveness summary (which is a reponse to comments received from the public on the FS and Proposed Plan) will address community acceptance. The detailed analysis presented in this FS presents the evaluation of the first seven criteria in the alternative evaluation process. Table 7-1 outlines the specific elements considered for these seven criteria.

7.1 DETAILED ANALYSIS FOR ALTERNATIVE MM-1: NO ACTION. Alternative MM-1 is a no-action alternative. Under this alternative, only administrative actions would be taken to reduce the risk to human receptors posed by consumption of contaminated groundwater at OU 7. A description of this alternative is presented

Table 7-1
Factors for Detailed Analysis of Remedial Alternatives

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Factors	Criteria to Consider
Overall protection of human health and the environment	How risks are eliminated, reduced, or controlled. Short-term or cross-media effects.
Compliance with ARARs	Compliance with chemical-specific ARARs. Compliance with location-specific ARARs. Compliance with action-specific ARARs.
Long-term effectiveness and permanence	Magnitude of residual risk. Adequacy of controls. Reliability of controls.
Reduction of mobility, toxicity, and volume	Treatment process and remedy. Amount of hazardous materials destroyed or treated. Reduction of mobility, toxicity, or volume through treatment. Irreversibility of treatment. Type and quantity of treatment residual.
Short-term effectiveness	Protection of community during remedial action. Protection of workers during remedial action. Environmental effects. Time until RAOs are achieved.
Implementability	Ability to construct technology. Reliability of technology. Ease of undertaking additional remedial action, if necessary. Coordination with other agencies.
Cost	Capital cost. Operation and maintenance cost. Total present worth of alternative.

Notes: ARARs = Applicable or Relevant and Appropriate Requirements.
RAO = Remedial Action Objective.

in Subsection 7.1.1 and a technical assessment of this alternative is presented in Subsection 7.1.2.

7.1.1 **Detailed Description of Alternative MM-1** In accordance with the NCP, the no-action alternative is used as a baseline for comparison against alternatives that incorporate remedial actions (i.e., Alternatives MM-2 through MM-5). Because hazardous substances, pollutants, or contaminants would be left in place at OU 7 as part of this alternative, it would include the following components:

- groundwater monitoring,
- groundwater use restrictions, and
- 5-year site reviews.

7.1.1.1 **Groundwater Monitoring** Monitoring would occur on an annual basis and would consist of collecting groundwater samples from 12 monitoring wells for laboratory analysis. A total of 16 samples (12 monitoring wells and 4 quality control) would be sampled. Ten of the wells proposed for the monitoring program are already installed at OU 7; two additional wells would be installed within the source area to monitor contaminant concentrations over time. The wells proposed for use for groundwater monitoring are shown on Figure 7-1. These wells were chosen because their spatial locations are useful for monitoring the size, constituent concentrations, and movement of the groundwater plume over time. As the plume migrates toward the wetland and Sal Taylor Creek, additional wells will be needed.

Groundwater at OU 7 was previously analyzed for all TCL and TAL analytical parameters. Analytical results showed detections of a select number of compounds. Thus, for the annual monitoring program for Alternative MM-1, groundwater would be analyzed for only those compounds that were previously detected. Every fifth year, sampling of groundwater would consist of all VOC, SVOC, TAL, and pesticide analytical parameters. All data would be used to evaluate the movement of the contaminant plume and to assess whether site contaminant concentrations are continually decreasing, or whether a plume of contaminants may be migrating toward a potential receptor. Data would be summarized and managed on an annual basis for use in the five-year reviews.

7.1.1.2 **Groundwater Use Restrictions** Land use plans and property deeds for land in the vicinity of the aerial extent of the contaminant plume at OU 7 would be annotated to indicate that groundwater extraction for potable use in this area may pose a significant health risk if consumed untreated. The annotation would reference the RI, baseline RA, FS, PP, and ROD. The agency currently responsible for administering the well installation permit program will be formally requested not to issue permits for installation of potable wells screened in the surficial aquifer. Planning agencies, permitting agencies, and owners of property affected by the OU 7 plume would be reminded annually of the groundwater use restrictions. These restrictions would be removed when a 5-year site review indicates, based on the groundwater monitoring program results, that the OU 7 action levels have been achieved.

7.1.1.3 **Five-Year Site Reviews** Since wastes and associated risks are left on site, the Navy, USEPA, and FDEP must review site conditions and determine that the continued implementation of this alternative is appropriate. Site reviews would occur every 5 years until the action levels are attained. Reviews would

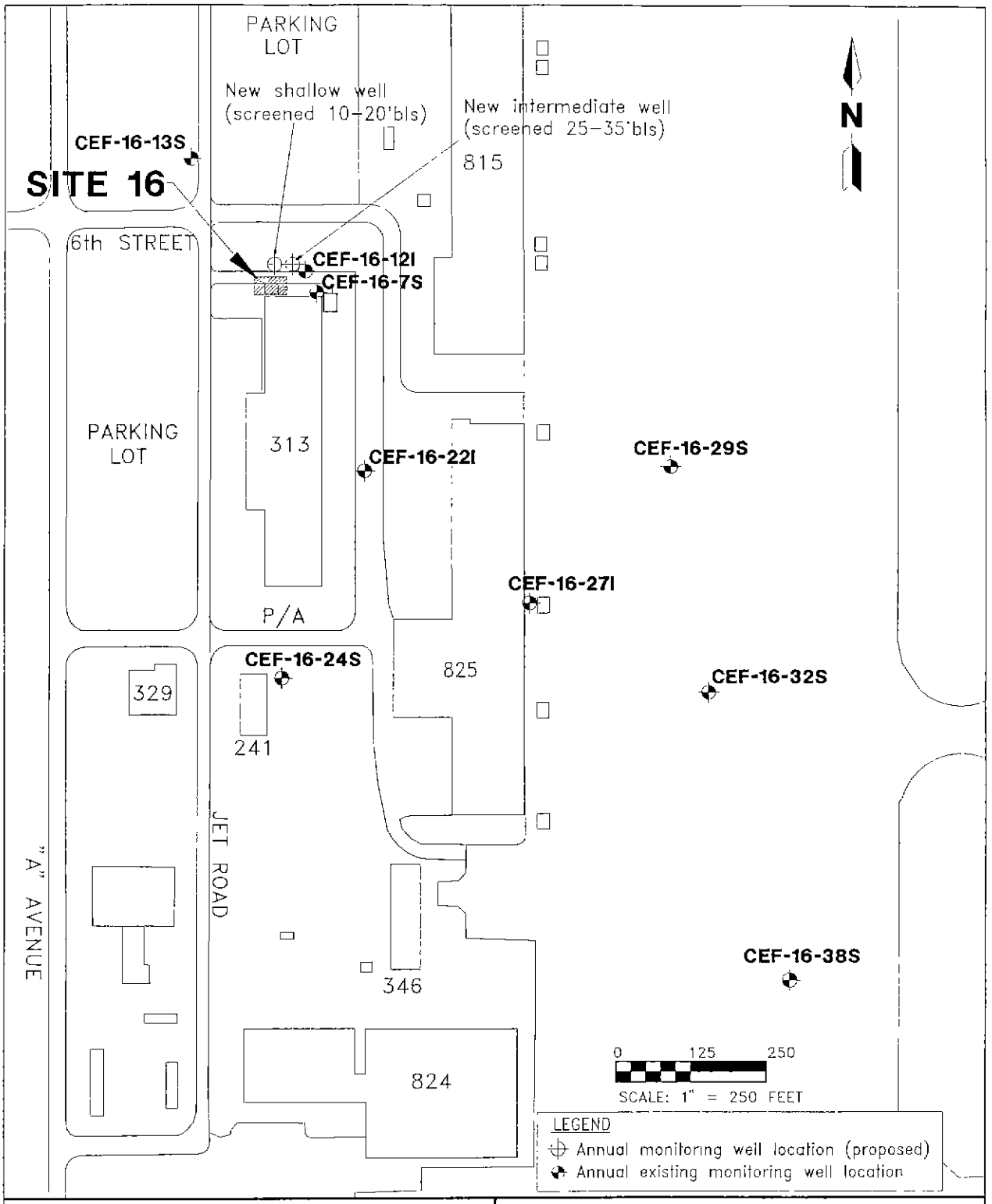

FIGURE 7-1
WELLS TO BE USED FOR ANNUAL MONITORING

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consist of evaluating monitoring data and assessing changes in site conditions (e.g. construction, demolition, receptors, migration pathways, and qualitative risks). The appropriateness of this alternative would be compared to other remedial alternatives to confirm that this alternative was still the most appropriate selection for OU 7.

7.1.2 Technical Assessment of Alternative MM-1 This subsection provides the technical assessment of Alternative MM-1 against seven criteria.

Overall Protection of Human Health and the Environment. This alternative would provide a minimum standard of protection to future human receptors who may use OU 7 groundwater as a potable water supply. Exposure to contaminated groundwater would be addressed via groundwater use restrictions. Humans would be prevented from developing a drinking water well within the surficial aquifer at OU 7 and drinking untreated groundwater. This alternative would not provide a maximum standard of protection to humans (i.e., groundwater treatment).

No adverse short-term or cross-media effects are anticipated with this no-action alternative. However, contaminated groundwater is expected to discharge ultimately to the wetland near Sal Taylor Creek.

Compliance with ARARs. This alternative would not comply with chemical-specific ARARs (e.g., MCLs or Florida Guidance Concentrations, FDEP, 1994b) in the short term. Eventually, this alternative may comply with ARARs if natural processes including physical, chemical, and biological changes in the aquifer reduce contaminant concentrations.

Long-Term Effectiveness and Permanence. Naturally occurring processes, such as biological activity, may reduce contaminant concentrations in the aquifer over the long term. However, human risks due to ingestion of groundwater from the surficial aquifer would not be addressed via treatment and would remain over a period of several decades until concentrations are reduced by natural processes.

Groundwater monitoring would provide a means of evaluating the concentrations of contaminants in groundwater and predicting the degradation rate of contaminants. Administrative actions proposed in this alternative would provide a means of exposure control, but would not provide a permanent remedy for risks posed by the site. Groundwater monitoring and administrative actions are considered reliable controls.

Reduction of Toxicity, Mobility, and Volume Through Treatment. Although no treatment is included in this alternative, this alternative provides some reduction in contaminant toxicity of VOCs and SVOCs through natural degradation processes. However, this alternative would not provide a reduction in contaminant mobility or volume because no groundwater extraction or treatment is proposed. This alternative would not enhance or increase the rate of natural transformation processes that reduce the toxicity, mobility, or volume of contaminants in groundwater. The volume of contaminated groundwater will increase until it discharges to the wetland.

Human health toxicity posed by ingestion of groundwater contaminations would remain over a period of several decades until concentrations are reduced by natural processes. No treatment residuals would be produced if this alternative were implemented.

Short-Term Effectiveness. This alternative would reduce human health risks in the short term because groundwater use restrictions would be implemented. Humans would be prevented from drinking untreated water from the surficial aquifer.

This alternative would not comply with RAOs in the short term because the only means of contaminant reduction posed by this alternative is natural degradation. Based on the baseline RA, this alternative does not pose a threat to workers through exposure to contaminated groundwater.

Implementability. This alternative does not require remedial construction for implementation. Other activities, such as groundwater monitoring, implementation of groundwater use restrictions, and 5-year site reviews are easily implemented, although administratively burdensome. Several vendors provide these services in the Jacksonville area. Monitoring equipment is easily obtained.

Cost. The present worth cost of Alternative MM-1 is presented on Table 7-2. This estimate includes the cost of the groundwater monitoring program, groundwater use restrictions, and 5-year site reviews over a 30-year period, as suggested by USEPA guidance (USEPA, 1988). Based on conservative projections in the RI, contaminants in the groundwater may require 160 years to degrade and achieve action levels.

The cost estimate for Alternative MM-1 is presented in Appendix E. Direct costs for Alternative MM-1 include installing two groundwater monitoring wells and establishing groundwater use restrictions for OU 7. Direct costs are estimated to be $13,000, and indirect costs are estimated to be $7,800. Total Operation and Maintenance costs are approximately $36,600 per year, and include labor and analytical costs for the groundwater monitoring program and the annualized cost for the 5-year site reviews.

The total present worth cost of Alternative MM-1 is approximately $524,000. CERCLA guidance suggests that the cost of alternatives presented in the FS should be accurate within +50 percent to -30 percent of the estimated cost. Table 7-2 presents the total estimated cost of Alternative MM-1.

7.2 DETAILED ANALYSIS FOR ALTERNATIVE MM-2: ENHANCED BIOREMEDIATION.

Alternative MM-2 consists of administrative actions to limit the use of groundwater as a drinking water source at OU 7 and the enhancement of natural biological degradation processes to reduce contaminants in groundwater. A description of this alternative is presented in Subsection 7.2.1 and a technical assessment of this alternative is presented in Subsection 7.2.2.

7.2.1 Detailed Description of Alternative MM-2 This alternative, enhanced bioremediation, would be achieved by reducing concentrations of organic compounds in groundwater through natural biological, chemical, and physical processes (natural attenuation). These naturally occurring processes and indigenous microorganisms would use organic contaminants as substrate (food), thus reducing contaminant concentrations through metabolic growth. This is an *in situ* process that requires no excavation of soil or extraction of groundwater. Preliminary testing indicates the presence of TCE biodegradation byproducts. Biological treatability studies and modeling and groundwater monitoring would be required to assess methods to improve the effectiveness of microbial activity. Growth

Table 7-2
Cost Summary Table for Alternative MM-1: No Action

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Cost Item	Cost
DIRECT COST	
Groundwater monitoring well installation (2)	$3,000
Groundwater use restrictions	$10,000
Total direct cost	$13,000
INDIRECT COST	
Health and safety (20 percent)	$2,600
Engineering (20 percent)	$2,600
Direct cost contingency (20 percent)	$2,600
Total indirect cost	$7,800
OPERATION AND MAINTENANCE COST (Annual)	
Annual groundwater monitoring	$24,000
5-year reviews (annualized)	$12,600
Present worth of Operation and Maintenance (over 30-year period)	$503,000
Total cost	$524,000

inhibitors and nutrient limitations would be continuously identified and would be corrected through subsurface injection (e.g., injection wells).

Because anaerobic conditions may be desired at the source area to degrade TCE, and aerobic conditions may be desired at more downgradient portions of the plume, this alternative would be divided into two separate portions. This would allow implementation of either or both of these portions based on the microbial conditions desired. The addition of nutrients would be included for both portions of the plume to develop cost estimates for this alternative. The following components would be included as part of this alternative:

- microbial growth enhancement,
- 5-year reviews,
- groundwater and system monitoring,
- biodegradation monitoring, and
- groundwater use restrictions.

A treatment train schematic for Alternative MM-2 is depicted on Figure 7-2.

7.2.1.1 Microbial Growth Enhancement For cost estimating purposes, it is assumed that nitrogen and phosphorus are growth-limiting nutrients indigenous to OU 7. Additional nutrients to promote microbial activity include glucose and lactic acid. It is anticipated that this alternative would consist of low-flow injection of these nutrients. No groundwater extraction or recirculation is proposed. Nutrients would be introduced as liquids into the aquifer through injection wells or galleries (trenches).

For the source area of the plume, it is estimated that six nutrient injection wells would be required. Three existing monitoring wells (CEF-16-10S, 19S, and 21S) would be used, and three additional wells (one shallow and two intermediate) would be installed. For the downgradient area of the plume, no sufficient nutrient-injection wells currently exist. Thus, it is estimated that three new wells (one shallow and two intermediate) would be required.

These wells would be constructed with 2-inch inside diameter (ID), schedule 40, PVC, screened in the plume. The total depth of the wells would extend to the bottom of the plume in their respective locations (approximately 15 to 35 feet bls).

Powdered nitrogen can be purchased as ammonia chloride, and powdered phosphorus can be purchased as tripolyphosphate ammonia chloride. Glucose and lactic acid may be purchased in liquid or crystalline form. These chemicals would be placed in an onsite mixing tank for pumping into the injection wells. Generally, a 1:1:1 weight ratio of these chemicals is recommended to initiate a microbial response. Fresh feed water is supplied to dilute the nutrients in the mixing tank. The initial concentration of the nutrients ranges from 25 to 50 mg/ℓ (ppm). The dose could then be altered based on growth observations.

The cumulative injection rate (flow rate) of the diluted nutrients into the wells is approximately 30 gpm. Additionally, an external carbon source may be required if anaerobic growth is to be encouraged. This is not included in the cost estimate for this alternative and would be a relatively minor additional expenditure as it would be added with the other growth amendments. Based on the

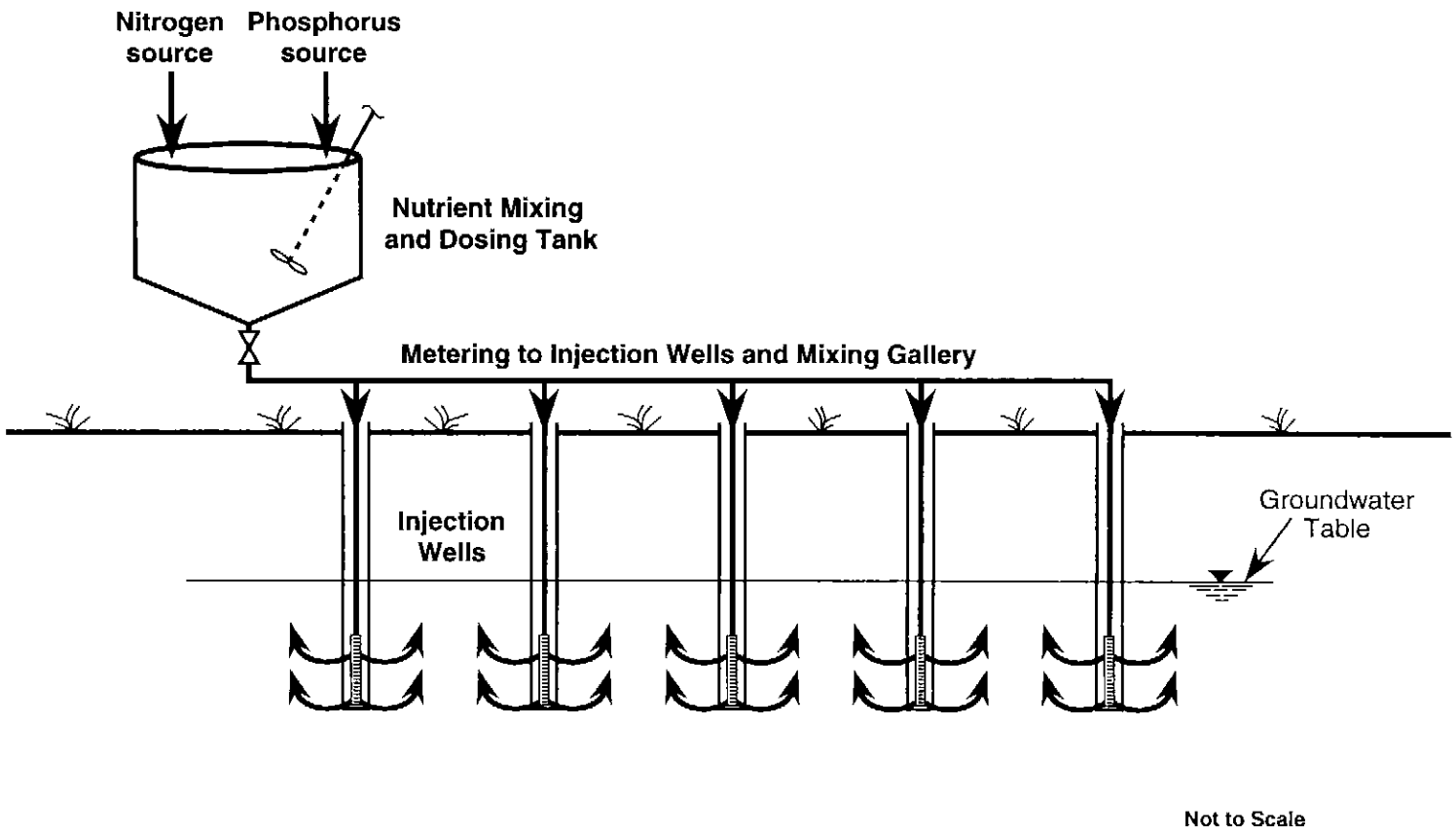

FIGURE 7-2

SCHEMATIC OF NUTRIENT ADDITION FOR ALTERNATIVE MM-2

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preliminary treatability evaluation (that indicates biodegradation is occurring) and experience with TCE at other sites, it is expected that enhanced bioremediation will require 12 years to meet action levels for VOCs.

7.2.1.2 **Five-Year Site Reviews** Refer to paragraph 7.1.1.1 for a detailed description. In addition to the basic report, a summary of the actions taken, qualities and types of growth amendments used, and effectiveness of the enhanced activity will be presented.

7.2.1.3 **Groundwater and System Monitoring** Refer to paragraph 7.1.1.2 for a detailed description. In addition to the groundwater monitoring activities for Alternative MM-2, the treatment effectiveness and the operation of the nutrient injection system would also be monitored on a continual basis throughout remedy implementation. Activities would include dose adjustment, flow rate modification, mixing tank maintenance, and other process monitoring requirements.

7.2.1.4 **Biodegradation Monitoring** Samples of groundwater would be collected for analysis of indicator parameters to determine the rate of *in situ* degradation. The same wells used for groundwater monitoring would be used for this purpose (see Alternative MM-1). The following biological indicator parameters would be analyzed on a quarterly basis for a period of 5 years, and then annually for the remainder of the groundwater monitoring program:

- TCE, DCE, vinyl chloride, and ethene;
- biochemical oxygen demand (BOD) and chemical oxygen demand (COD);
- total Kjeldahl nitrogen (TKN), ammonia, nitrite, and nitrate;
- sulfide and sulfate;
- total and dissolved (field-filtered) iron; and
- indicator parameters such as oxidation-reduction potentials, pH, and dissolved oxygen.

An evaluation of the difference in these parameters between wells and their variation over time would be used to model the type, degree, and rate of biodegradation in the saturated subsurface of OU 7.

7.2.1.5 **Groundwater Use Restrictions** Refer to paragraph 7.1.1.3 for a detailed description.

<u>7.2.2 Technical Assessment of Alternative MM-2</u> This subsection presents the technical assessment of Alternative MM-2.

<u>Overall Protection of Human Health and the Environment</u>. This alternative would eventually provide protection to human receptors who may use OU 7 groundwater as a potable water supply in the future. Contaminated groundwater would be treated through the promotion of natural degradation processes through nutrient addition. A minimum standard of protection to human receptors would also be provided in this alternative because groundwater use restrictions would prevent humans from consuming untreated water from the surficial aquifer until complete aquifer restoration (i.e., when action levels are achieved).

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. In the short-term, this alternative would not achieve chemical-specific ARARs. This alternative would eventually achieve chemical-specific ARARs for VOCs and SVOCs through natural and enhanced biological mechanisms. This alternative would not reduce the concentrations of inorganic constituents such as aluminum, antimony, arsenic, manganese, and thallium. Groundwater and biological monitoring will be used to model biological degradation to evaluate compliance with ARARs.

Action-specific ARARs, such as Florida underground injection control regulations, would need to be met by the alternative.

Long-Term Effectiveness and Permanence. This alternative offers a long-term and permanent remedy for groundwater contamination. Biological activity would be enhanced through nutrient addition, thus promoting contaminant reduction. Groundwater use restrictions would also prevent human consumption of groundwater until treatment levels are achieved through enhanced biological remediation. It is anticipated that treatment duration would be approximately 12 years to reduce organic contaminant concentrations to action levels for VOCs and SVOCs.

Biological monitoring would provide a means of evaluating the biological activity at the site. The mixture and dosing rate of nutrient addition would be altered based on the results of biological monitoring. Groundwater monitoring would provide a means of evaluating the concentrations of contaminants in groundwater and predicting the degradation rate of contaminants. Administrative actions proposed in this alternative would provide a means of preventing exposure until action levels are met. All controls proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, and Volume Through Treatment. This alternative would accelerate reduction in contaminant toxicity of VOCs and SVOCs by enhancing natural degradation processes. However, during degradation, this alternative would not provide a significant reduction in contaminant mobility or volume because groundwater extraction is not proposed.

The possibility of human health risks posed if groundwater is ingested would remain until concentrations are reduced by the enhanced biological processes.

The implementation of this alternative would provide no additional risks to human or ecological receptors over baseline conditions. This is because all treatment proposed by this alternative occurs *in situ*, making exposure to groundwater contamination limited. Furthermore, no residuals are produced by this alternative.

Short-Term Effectiveness. This alternative would eventually reduce human health risks posed by groundwater contamination because natural microbes present in the aquifer would be encouraged, through nutrient addition, to degrade contaminants in groundwater. Also, groundwater use restrictions would be implemented, providing further protection of human health.

This alternative would not comply with RAOs in the short term because microbes present in the groundwater generally require time to acclimate and utilize the injected nutrients to reduce contaminant concentrations to meet action levels.

This alternative does not pose a threat to workers through exposure to contaminated groundwater because, other than well installation, remedial construction activities are not proposed under this alternative.

Implementability. Natural biological activity enhancement is relatively easy to implement and would not pose a threat to the workers or the community. Monitoring equipment is easily obtained and biological monitoring, groundwater monitoring, 5-year site reviews, and groundwater use restrictions are easily implemented.

Cost . The present worth cost for Alternative MM-2, Enhanced Bioremediation, would be approximately $2,256,000. This cost would include the direct, indirect, and O&M costs for the treatment system in addition to the direct cost and the O&M cost for the groundwater monitoring program presented in Alternative MM-1. A complete cost summary is presented in Table 7-3.

The direct cost is approximately $654,000, which includes site preparation, treatment system, treatability studies, groundwater monitoring wells, and groundwater use restrictions. The indirect cost is approximately $320,000. The detailed cost calculations are included in Appendix E.

The present worth O&M cost would be approximately $586,000 for the groundwater and biodegradation monitoring over a 30-year period and $696,000 for system maintenance and utilities over a 12-year treatment duration.

7.3 DETAILED ANALYSIS FOR ALTERNATIVE MM-3: GROUNDWATER EXTRACTION, TREATMENT, AND DISCHARGE TO SURFACE WATER. Alternative MM-3 consists of extraction, treatment via UV/OX and GAC, and discharge to surface water. A description of this alternative is presented in Subsection 7.3.1 and a technical criteria assessment of this alternative is presented in Subsection 7.2.2.

7.3.1 Detailed Description of Alternative MM-3 This alternative would consist of collecting groundwater, providing treatment to achieve treatment levels, and discharging the treated effluent to surface water. The components of Alternative MM-2 include:

- groundwater extraction,
- pH adjustment and UV/OX,
- polymer addition and clarification,
- GAC adsorption,
- treated groundwater discharge,
- 5-year reviews,
- groundwater and system monitoring, and
- groundwater use restrictions.

A treatment train schematic for Alternative MM-3 is shown on Figure 7-3.

Table 7-3
Cost Summary Table for Alternative MM-2: Enhanced Bioremediation

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Cost Item	Cost
DIRECT COST	
Site preparation	$23,000
Treatment system	
Injection wells (6)	$15,000
Pumps (6), piping, and injection equipment	$107,000
Monitoring equipment	$30,000
Nutrients (for 12 year treatment duration)	$326,000
Biodegradation monitoring	$120,000
Treatability studies	$20,000
Groundwater monitoring well installation (2)	$3,000
Groundwater use restrictions	$10,000
Total direct cost	$654,000
INDIRECT COST	
Health and safety (4 percent)	$26,000
Administration and permitting (5 percent)	$33,000
Engineering and design (10 percent)	$65,000
Construction support services (10 percent)	$65,000
Direct cost contingency (20 percent)	$131,000
Total indirect cost	$320,000
OPERATIONS AND MAINTENANCE COST (O&M) (Annual)	
Administrative O&M (30-year period)	
Annual groundwater monitoring	$24,000
Biodegradation monitoring	$6,000
5-year reviews (annualized)	$12,600
Present worth - administrative O&M (over 30-year period)	$586,000
Treatment system O&M (12-year period)	
System maintenance	$27,000
Utilities	$56,000
Present worth - treatment system O&M (over 12-year period)	$696,000
Total cost	$2,256,000

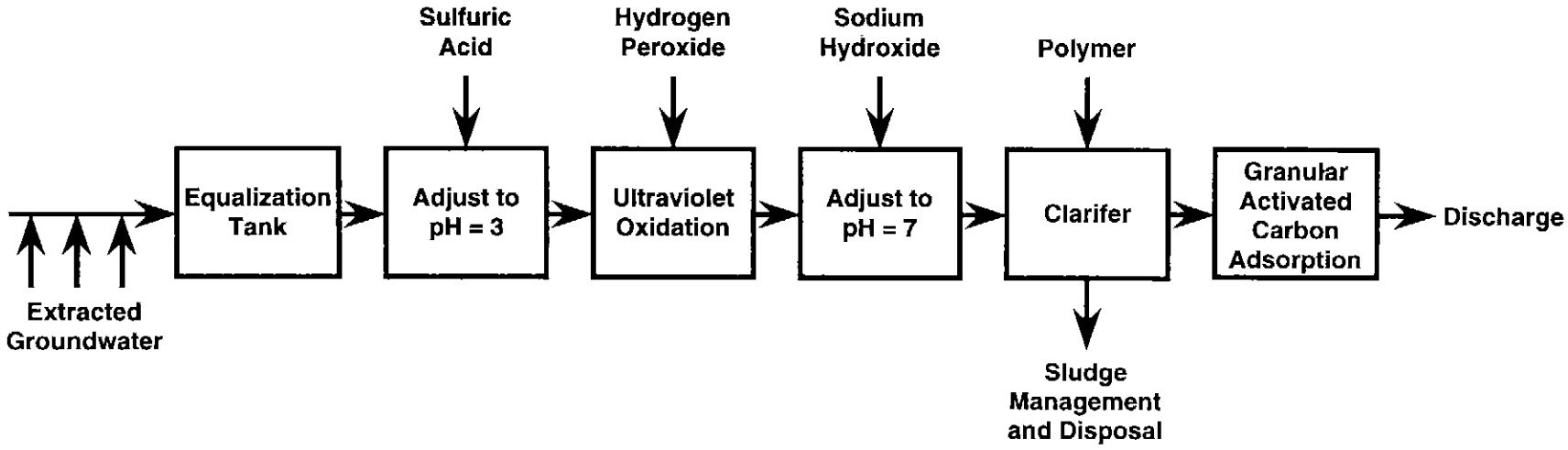

FIGURE 7-3

TREATMENT PROCESS TRAIN FOR ALTERNATIVE MM-3

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7.3.1.1 **Groundwater Extraction** Contaminated groundwater would be captured and removed from the aquifer by an extraction well network. A numerical model was used to develop one possible configuration of a groundwater extraction system. These data appear in Appendix F. The modelled system would consist of six extraction wells that would be installed along the length of the plume at OU 7. To capture the entire plume, these wells would be pumped at a combined rate of approximately 26 gallons per minute (gpm). Action levels for groundwater are presented in Table 5-4. It is estimated that groundwater in most of the plume would be at or below action levels after approximately 30 years of groundwater extraction. Calculations to support this estimate are provided in Appendix F.

Stagnation zones of negligible groundwater flow would be created between each pair of pumping wells; contaminated groundwater in these zones would not be drawn into the extraction system. The stagnation zones could be minimized by changing the pumping rates for each well during the course of the remediation. This would help flush the stagnation zones. Additionally, after contaminant concentrations in the plume have been reduced to below action levels, several of the wells could be converted from extraction to injection wells. Clean water would be injected into the aquifer to flush out the stagnation zones so the remaining contaminated groundwater could be drawn into the extraction system. Approximately five additional years of operation would be required to flush out the stagnation zones. Calculations to support this estimate are provided in Appendix F.

Groundwater wells would be connected via manifold to a groundwater treatment facility adjacent to OU 7.

7.3.1.2 **pH Adjustment and UV/OX** Following extraction, the pH of extracted groundwater would be lowered with sulfuric acid to prevent inorganics from precipitating (and thus fouling equipment) during UV/OX treatment.

After pH adjustment, hydrogen peroxide would be added and water would be sent through the UV/OX contactor. A diagram of a typical UV/OX system with hydrogen peroxide addition is shown on Figure 7-4. UV/OX with hydrogen peroxide has proven effective in removing VOCs and oxidizing inorganics in water. The pH of the effluent from the UV contactor would be raised using sodium hydroxide in order to begin precipitation of oxidized inorganic compounds.

7.3.1.3 **Polymer Addition and Clarification** Once the pH of the effluent was raised, an anionic polymer would be added to enable flocculation of oxidized inorganic cations. The resultant particle mass would settle and be removed by a mechanical clarifier. Periodically, sludge from the clarifier would be removed, thickened and dewatered onsite. Excess liquid from the thickened and dewatered sludge would be returned to the headworks of the UV/OX treatment train. The dewatered sludge would be sampled, analyzed, and transported offsite to an approved disposal facility.

7.3.1.4 **GAC Adsorption** As a polishing step prior to discharge, clarifier effluent would be passed through a canister containing GAC. GAC treatment would remove any remaining VOCs, as well as low concentrations of detected SVOCs and other synthetic organics. Periodically, the GAC would require replacement, and spent GAC would be shipped offsite for disposal or regeneration.

7.3.1.5 **Treated Groundwater Discharge** Treated groundwater would be discharged to a stormwater drain near the site. Compliance sampling would occur prior to

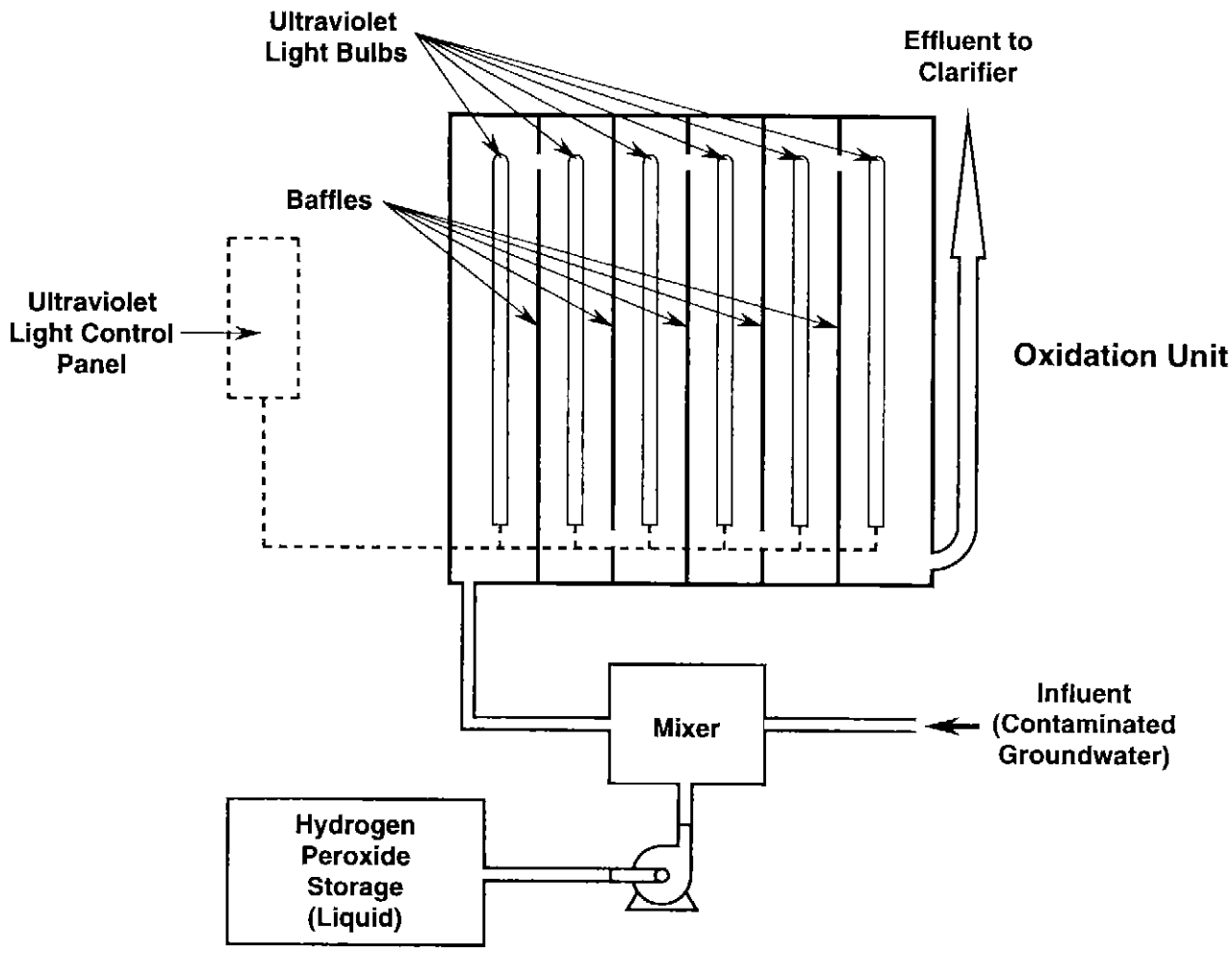

FIGURE 7-4

TYPICAL ULTRAVIOLET OXIDATION CONTACTOR
FOR ALTERNATIVE MM-3

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Not to Scale

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the effluent entering the stormwater system. The eventual outfall of the stormwater system in this area of the base is Sal Taylor Creek. Therefore, treated water discharge would then be required to satisfy the substantive requirements of a NPDES permit, as administered by FDEP and based on the criteria presented in Table 5-4.

7.3.1.6 **Five-Year Site Reviews** Refer to paragraph 7.1.1.1 for a detailed description of the basic site review. In addition, extraction and treatment performance will be summarized and evaluated. Compliance with treatment levels will also be evaluated. The summary will include monitoring results, quantities of contaminants removed or treated, and amounts and quality of residuals produced and removed from the site. Since TCE in the groundwater is interpreted to have been derived from a listed hazardous waste, the treatment plant would comply with all appropriate substantive record keeping, monitoring, and reporting requirements.

7.3.1.7 **Groundwater and System Monitoring** Refer to paragraph 7.1.1.2 for a detailed description. In addition to the groundwater monitoring activities included for Alternative MM-1, the extraction and treatment effectiveness would also be monitored on a continual basis throughout remedy implementation. Operational activities would include pH adjustment, reagent dose alterations, sludge management, and other process monitoring requirements. Additional monitoring performance would include extraction system performance (e.g., flow and capture zone), treatment plant influent quality, and effluent quality.

7.3.1.8 **Groundwater Use Restrictions** Refer to paragraph 7.1.1.3 for a detailed description.

7.3.2 **Technical Assessment of Alternative MM-3** This subsection presents the technical assessment of Alternative MM-3 against the seven criteria.

Overall Protection of Human Health and the Environment. This alternative would provide protection to future human receptors who may use OU 7 groundwater as a potable water supply. Humans would be protected in the short term because they would be prohibited from consuming water from the surficial aquifer until complete aquifer restoration (i.e., when action levels are achieved). This alternative provides a maximum standard of protection to humans (i.e., groundwater treatment).

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. This alternative would comply with all ARARs.

Long-Term Effectiveness and Permanence. This alternative offers a long-term and permanent remedy for groundwater contamination, without relying on natural transformation processes.

Extraction and treatment via UV/OX and GAC would reduce organic contaminant concentrations, and treatment via chemical precipitation and clarification would reduce inorganic contaminant concentrations. Groundwater use restrictions would also prevent human consumption of groundwater until action levels are achieved. Groundwater monitoring would provide a means of evaluating the concentrations of

contaminants in groundwater over time. All controls proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, and Volume Through Treatment. This alternative would reduce the toxicity, mobility, and volume of VOC, SVOC, and inorganic contaminants in extracted groundwater. VOCs such as 1,1-DCE and TCE would be destroyed in the UV/OX system. SVOCs such as phenanthrene and bis(2ethylhexyl)phthalate would be transferred onto activated carbon in the GAC system and subsequently treated offsite during carbon regeneration. Inorganics such as copper, iron, nickel, and thallium would be separated from the waste stream via chemical separation, thus requiring subsequent offsite transport and disposal.

Short-Term Effectiveness. This alternative would comply with RAOs in the short term though groundwater use restrictions and because contaminated groundwater would be collected and treated, thus reducing the rate of downgradient contaminant migration through the aquifer.

Installation of extraction wells, treatment of the groundwater, and discharge to surface water would not pose a significant risk to workers or the community. Residuals produced through implementing this alternative (e.g., sludge and spent carbon) would be collected for offsite transport, treatment, and/or disposal at appropriately permitted facilities.

Implementability. Construction of the extraction and treatment system is relatively easy to implement and would not pose a threat to workers or the community. Discharge to surface water through the storm sewer system is the most direct method of discharge. Discharge directly to Sal Taylor Creek is an alternate option, but construction of piping under the runways would be required.

Monitoring equipment is easily obtained, and groundwater monitoring, 5-year site reviews, and groundwater use restrictions are easily implemented.

Cost. The present worth cost of Alternative MM-3 is presented on Table 7-4. This estimate includes site preparation, a groundwater extraction system, a full treatment system, discharge to FOTW, system maintenance, and utilities for the 30-year system duration. The estimate also includes the cost of the operation and maintenance for a 30-year duration for administrative activities such as a groundwater monitoring program, groundwater use restrictions, and 5-year site reviews over a 30-year period. A 30-year period was chosen only because that is the length of time that costs can be accurately predicted.

The cost estimate for Alternative MM-3 is presented in Appendix E. Direct costs include site preparation, treatment system costs, pH adjustment, a UV/OX system, a clarifier, miscellaneous piping and equipment, and liquid phase carbon (including regeneration). Other direct costs for operation and maintenance items included in Alternative MM-3 are for items such as installing two monitoring wells for the proposed groundwater monitoring program and establishing groundwater use restrictions. Total direct costs are estimated to be $1,096,000 and total indirect costs are estimated to be $483,000. Total Operation and Maintenance costs are approximately $36,600 per year for administrative O&M and $265,000 for treatment system O&M.

Table 7-4
Cost Summary Table for Alternative MM-3: Groundwater Extraction, Treatment, and Discharge to Surface Water

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Cost Item	Cost
DIRECT COST	
Site preparation	$39,000
Groundwater extraction system	$280,000
pH adjustment	$18,000
Ultraviolet oxidation (UV/OX) system	$150,000
Inclined-plate clarifier	$165,000
Miscellaneous piping and equipment	$50,000
Liquid-phase granular activated carbon (GAC) (including regeneration)	$381,800
Groundwater monitoring well installation (2)	$3,000
Groundwater use restrictions	$10,000
Total direct cost	$1,096,000
INDIRECT COST	
Health and safety (2 percent)	$22,000
Administration and permitting (2 percent)	$22,000
Engineering and design (10 percent)	$110,000
Construction support services (10 percent)	$110,000
Direct cost contingency (20 percent)	$219,000
Total indirect cost	$483,000
OPERATIONS AND MAINTENANCE (O&M) COST (Annual)	
Administrative (30-year period)	
Annual groundwater monitoring	$24,000
5-year reviews (annualized)	$12,600
Present worth - administrative O&M (over 30-year period)	$503,000
System O&M (30-year period)	
System maintenance	$190,000
Utilities	$75,000
Present worth - system O&M (over 30-year period)	$3,650,000
Total cost	$5,732,000

The total present worth cost of Alternative MM-3 is approximately $5,732,000. The RI/FS guidance manual suggests that the cost of an alternative presented in the FS should be accurate within +50 percent to -30 percent of the actual cost.

7.4 DETAILED ANALYSIS FOR ALTERNATIVE MM-4: SPARGING OF GROUNDWATER.

Alternative MM-4 consists of installing an air sparging system with soil vapor extraction. A description of this alternative is presented in Subsection 7.4.1 and a technical criteria assessment of this alternative is presented in Subsection 7.4.2.

7.4.1 Detailed Description of Alternative MM-4 Similar to Alternative MM-2, this alternative is intended to reduce concentrations of organic compounds in groundwater without excavating soil or extracting groundwater. This alternative consists of the *in situ* technique: air sparging of groundwater with supplemental extraction of volatiles from the soil.

The design of this alternative was based on ABB-ES's experience with pilot-scale tests at a nearby location that contains similar stratigraphy and contaminants. This design was also based on air sparging guidance documents (Wisconsin, 1993a and 1993b). It is anticipated that an observational approach would be used to continually modify this design based on system performance.

Air sparging would be divided into two separate portions to address the source area of the plume and the downgradient area of the plume. The primary objective of air sparging in the source area of the plume would be to strip VOCs out of the groundwater through turbulence and gas transfer. Conversely, the primary objective of air sparging in the downgradient area of the plume would be to maintain the dissolved oxygen concentration to continue to promote biodegradation of organic compounds in this area. These two systems will be developed in this FS and costed separately to allow the use of one or both, if desired. For example, air sparging in the source area of the plume may be used in conjunction with Alternative MM-3 or MM-5 to increase the rate of contaminant and residual NAPL removal from aquifer materials during groundwater extraction. Conversely, air sparging in the downgradient area of the plume may be used in conjunction with Alternative MM-2 to induce aerobic biodegradation of less-chlorinated organic compounds (such as DCE).

The following components would be included in this alternative:

- air injection,
- vapor extraction,
- vapor-phase treatment and monitoring,
- 5-year reviews,
- groundwater and system monitoring, and
- groundwater use restrictions.

A typical air sparging system is depicted on Figure 7-5.

7.4 .1 **Air Injection** It is estimated that 10 air injection wells would be sufficient to influence the source area of the plume (Figure 7-6). The wells would be constructed with 2-inch ID, schedule 40, PVC, with a 5-foot screen at the bottom of each well. The total depth of the wells would extend to the bottom

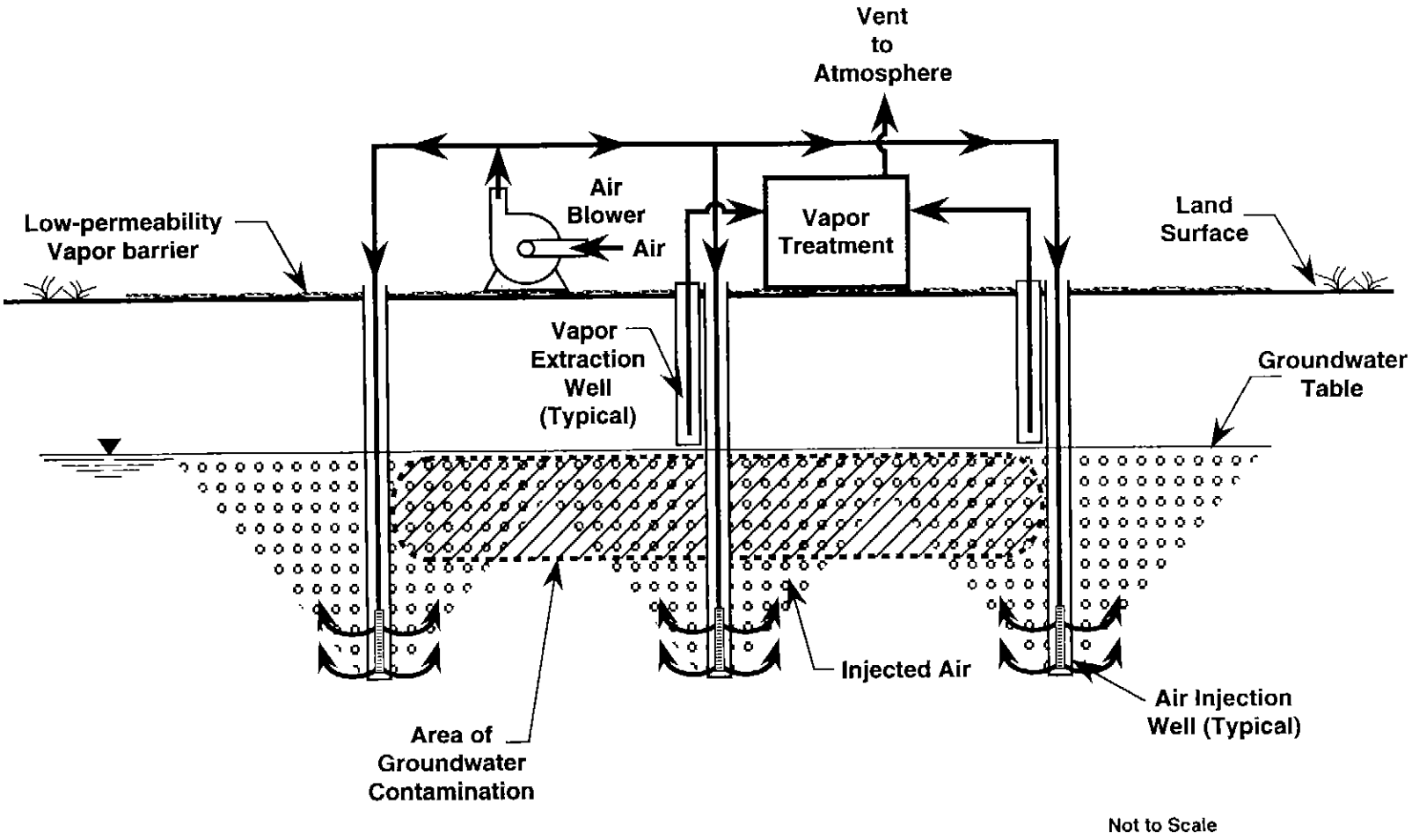

FIGURE 7-5

SCHEMATIC OF AIR SPARGING FOR
ALTERNATIVE MM-4

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

8500-16 CF OU7 FS 950331WEM

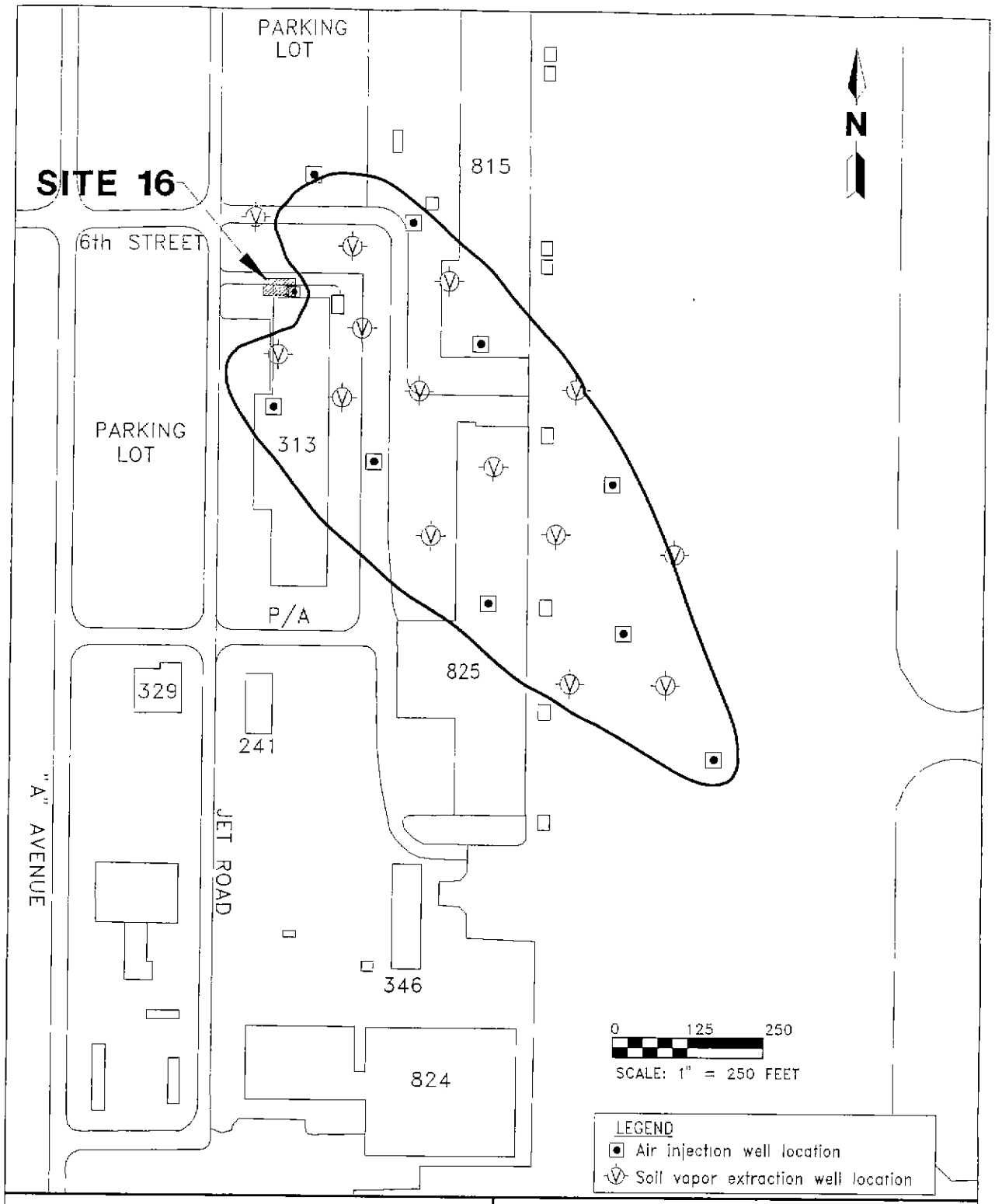

FIGURE 7-6
APPROXIMATE LOCATIONS OF AIR SPARGING AND SOIL VAPOR EXTRACTION WELLS

CECIL\CE-GSL\NP-NAB\08-18-95

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

of the plume in their respective locations (approximately 45 to 60 feet bls) and an air compressor that induces a flow of 20 to 30 cubic feet per minute (ft^3/min) would be sufficient.

Based on ABB-ES's experience with pilot-scale tests at a nearby location in an area with similar stratigraphy, an air compressor that delivers a pressure of 80 to 100 inches of water and induces a flow of 20 to 30 ft^3/min would be sufficient.

It is estimated that four air injection wells would be sufficient to influence the downgradient area of the plume. None of the existing monitoring wells would be sufficient for this purpose. Thus, four new air injection wells would be required. These wells would have similar construction as those described for the source area of the plume, and a similar air flow rate would be required.

7.4.1.2 **Vapor Extraction** The vapor extraction portion of the air sparging system would be required to capture volatilized contaminants. Additionally, sample ports would be installed on these wells to allow the collection of vapor samples for laboratory analysis. Vapor extraction wells would be used in lieu of trenches because of the anticipated difficulty in clearing subsurface structures and utilities. If a utility survey reveals sufficient clearance to install trenches, they could be used in lieu of the recommended well configuration.

Because of the unique construction required for vapor extraction wells, none of the existing monitoring wells could be used. Thus, it is estimated that 14 vapor extraction wells would be installed to capture volatilized contaminants from the source area of the plume. These wells would be constructed with 6-inch ID, schedule 40, PVC. The depth of each well would extend to the groundwater table (approximately 10 feet bls), with well-screens that extend to within a few feet of the ground surface. Typically, at least a 1-foot riser pipe is required above the well-screen for structural stability.

Based on ABB-ES's experience with pilot-scale tests at nearby locations in areas with similar stratigraphy, a regenerative vacuum blower that can maintain a flow of 30 ft^3/min would be sufficient.

Vapor extraction in the downgradient area of the plume would be similar to that in the source area of the plume. It is estimated that eight vapor extraction wells would be installed to capture volatilized contaminants. These wells would have similar construction as those described for the source area of the plume, and a similar air flow rate would be required.

7.4.1.3 **Vapor-Phase Treatment and Monitoring** Vapor-phase treatment of the off-gas collected from the vapor extraction system may be required to remove organic vapors prior to discharge to comply with the Clean Air Act regulations (see Chapter 5.0). It is estimated that vapor-phase GAC would be sufficient to remove the types of chlorinated compounds detected at OU 7. Two GAC canisters, connected in series, would be installed at the discharge end of the regenerative vacuum blower. A 12-foot vertical pipeline would then be installed after the second GAC canister to adequately disperse the treated exhaust. A separate vapor-phase treatment system would be required for each area of the plume (i.e., source area and downgradient area).

Samples of organic vapors in the extraction system would be required to assess the rate of gas transfer, the effectiveness of vapor-phase treatment, and compliance with air discharge limitations. It is estimated that analysis of total organic vapors would be sufficient for this purpose. Additionally, analysis of carbon dioxide and methane would be performed to assess whether the captured off-gas indicates the presence of microbial activity.

7.4.1.4 **Five-Year Site Reviews** Refer to paragraph 7.3.1.6 for a detailed description. In addition, treatment performance will be summarized and evaluated. Compliance with action levels will be evaluated. The summary will include monitoring results, quantities of contaminants removed or treated, and amounts and quality of residuals produced and removed from the site.

7.4.1.5 **Groundwater and System Monitoring** Refer to paragraph 7.1.1.2 for a detailed description. In addition to the groundwater monitoring activities included in Alternative MM-1, the treatment effectiveness and the operation of the air sparging system would also be monitored on a continual basis throughout remedy implementation. Activities would include air emissions monitoring, monitoring of the areal extent of treatment by sparging and VES, air flow rate and pressure adjustments, vacuum and temperature measurements, as well as other process monitoring requirements.

7.4.1.6 **Groundwater Use Restrictions** Refer to paragraph 7.1.1.3 for a detailed description.

7.4.2 Technical Assessment of Alternative MM-4 This subsection presents the technical assessment of Alternative MM-4.

Overall Protection of Human Health and the Environment. This alternative would provide protection to future human receptors who may use OU 7 groundwater as a potable water supply. Humans would be protected in the short term because they would be prohibited from consuming water from the surficial aquifer until complete aquifer restoration (i.e., when action levels are achieved).

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. In the short-term, this alternative would not achieve chemical-specific ARARs. This alternative would eventually achieve chemical-specific ARARs for VOCs such as 1,1,1-TCA, 1,1-DCE, 1,2-DCE, and TCE and SVOCs such as bis(2-ethylhexyl)phthalate through air sparging. However, this alternative would not increase the rate of achieving chemical-specific ARARs for inorganic contaminants such as aluminum, antimony, arsenic, manganese, and thallium. Groundwater and biological monitoring will be used to model biological degradation to ensure compliance with ARARs.

Long-Term Effectiveness and Permanence. This alternative offers a long-term and permanent remedy for VOC and SVOC groundwater contamination. Treatment via air sparging with soil vapor extraction would reduce VOC and SVOC contaminant concentrations in groundwater. This alternative does not address inorganic contamination in groundwater.

Groundwater use restrictions would prevent human consumption of groundwater until the action levels for VOCs and SVOCs are achieved. Groundwater monitoring would

provide a means of evaluating the concentrations of contaminants in groundwater over time.

All controls proposed in this alternative are considered reliable.

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment. This alternative would reduce the toxicity, mobility, and volume of VOC and SVOC contaminants in groundwater. This would be accomplished through volatilization of dissolved contaminants and capture of the organic vapors for subsequent destruction offsite.

This alternative would not reduce the toxicity, mobility, or volume of inorganic contaminants in groundwater such as aluminum, antimony, arsenic, calcium, iron, manganese, magnesium, potassium, sodium, and thallium.

Short-Term Effectiveness. This alternative would comply with RAOs in the short term because volatilization and gas transfer is a relatively rapid treatment process. However, this alternative is only effective for VOC and SVOC contaminants in groundwater.

Installation of sparging and vapor extraction wells and treatment of the offgas would not pose a significant risk to workers or the community. Residuals produced through implementing this alternative (e.g., spent carbon) would be collected for transport to an appropriately permitted treatment and disposal facility.

Implementability. Construction of the air sparging system is relatively easy to implement and would not pose a significant risk to workers or the community. Monitoring equipment is easily obtained, and groundwater monitoring, 5-year site reviews, and groundwater use restrictions are easily implemented.

Cost. The present worth cost of Alternative MM-4 is presented on Table 7-5. This estimate includes site preparation, air sparging and SVE treatment system costs, a treatability study, system maintenance, and utilities for the 12 year system duration. The estimate also includes the cost of the operation and maintenance for a 30 year duration for administrative activities such as a groundwater monitoring program, groundwater use restrictions, and 5-year site reviews over a 30-year period. A 30-year period was chosen only because that is the length of time that costs can be accurately predicted.

The cost estimate for Alternative MM-4 is presented in Appendix E. Direct costs include site preparation, treatment system costs (including compressors, blowers, generators, flow equipment, well installation, and vapor phase carbon for SVE off-gases), and a treatability study. Direct costs for O&M items included in Alternative MM-4 are items such as installing two monitoring wells for the proposed groundwater monitoring program and establishing groundwater use restrictions. Total direct costs are estimated to be $436,000 and total indirect costs are estimated to be $261,000. Total O&M costs are approximately $36,600 per year for administrative O&M and $75,000 for treatment system O&M.

The total present worth cost of Alternative MM-4 is approximately $1,829,000. The RI/FS guidance manual suggests that the cost of an alternative presented in the FS should be accurate within +50 percent to -30 percent of the actual cost.

Table 7-5
Cost Summary Table for Alternative MM-4: Air Sparging

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Cost Item	Cost
DIRECT COST	
Site preparation	$33,000
Treatment system	
Compressors (2)	$20,000
Blowers (2)	$15,000
Generators (4)	$30,000
Miscellaneous flow equipment	$102,000
Pipes, valves, and miscellaneous materials	$150,000
Well installation (for air sparging and soil vapor extraction [SVE])	$30,000
Vapor phase carbon (includes regeneration over treatment duration)	$23,000
Treatability studies	$20,000
Groundwater monitoring well installation (2)	$3,000
Groundwater use restrictions	$10,000
Total direct cost	$436,000
INDIRECT COST	
Health and safety (5 percent)	$22,000
Administration and permitting (5 percent)	$22,000
Engineering and design (15 percent)	$65,000
Construction support services (15 percent)	$65,000
Direct cost contingency (20 percent)	$87,000
Total indirect cost	$261,000
OPERATIONS AND MAINTENANCE (O&M) COST (Annual)	
Administrative O&M (30-year period)	
Annual groundwater monitoring	$24,000
5-year reviews (annualized)	$12,000
Present worth-administrative O&M (over 30-year period)	$503,000
Treatment system O&M (12-year period)	
System maintenance	$44,000
Utilities	$31,000
Present worth - system O&M (over 12-year period)	$629,000
Total cost	$1,829,000

7.5 DETAILED ANALYSIS OF ALTERNATIVE MM-5: GROUNDWATER EXTRACTION, PRETREATMENT, AND DISCHARGE TO THE FOTW. Alternative MM-5 consists of extraction, pretreatment of extracted groundwater via air stripping, and further treatment at the NAS Cecil Field FOTW. A description of this alternative is presented in Subsection 7.5.1 and a technical criteria assessment of this alternative is presented in Subsection 7.5.2.

7.5.1 Detailed Description of Alternative MM-5 This alternative is essentially a modification of Alternative MM-3. Rather than providing complete treatment to achieve treatment levels for discharge to surface water, this alternative consists of providing only the pretreatment required to discharge the groundwater to the sanitary sewer for treatment in the FOTW. It is anticipated that only TCE requires removal prior to discharge. Because iron is naturally occurring at OU 7, and it is not likely the result of the waste disposal activities, further calculations were performed to assess whether pretreatment of iron was required. Using estimated flow rates of 30 gpm for extracted groundwater and 0.67 MGD for the existing FOTW influent, an iron concentration of 119 $\mu g/\ell$ in the combined influent was calculated. This concentration is below the 300 $\mu g/\ell$ discharge limit for the FOTW. Thus, it is estimated that the iron in extracted groundwater will not impact the FOTW's discharge limits. Packed tower air stripping would be used to achieve the treatment levels for the discharge to FOTW component.

This alternative consists of the following components:

- groundwater extraction,
- packed tower air stripping,
- vapor-phase treatment and monitoring,
- treated groundwater discharge,

- 5-year reviews,
- groundwater and system monitoring, and
- groundwater use restrictions.

A treatment train for this alternative is depicted on Figure 7-7.

7.5.1.1 Groundwater Extraction Refer to paragraph 7.3.1.1 for a detailed description.

7.5.1.2 Packed Tower Air Stripping The following two sets of discharge criteria are associated with discharge from the FOTW:

- surface water discharge criteria (see Appendix C), and
- the FOTW's NPDES operating permit criteria (Table 7-6).

The first set of discharge criteria (surface water ARARs) consists of TAL and TCL parameters. Of these parameters, only TCE requires pretreatment to ensure compliance with ARARs. It is estimated that a 22-foot high packed tower with 17 feet of packing material would be effective in reducing the concentration of TCE in extracted groundwater for subsequent treatment in the FOTW. Based on tower design calculations and anticipated influent and effluent concentrations, a vendor-supplied tower was selected with a 1.5-foot diameter and 19 feet of packing material.

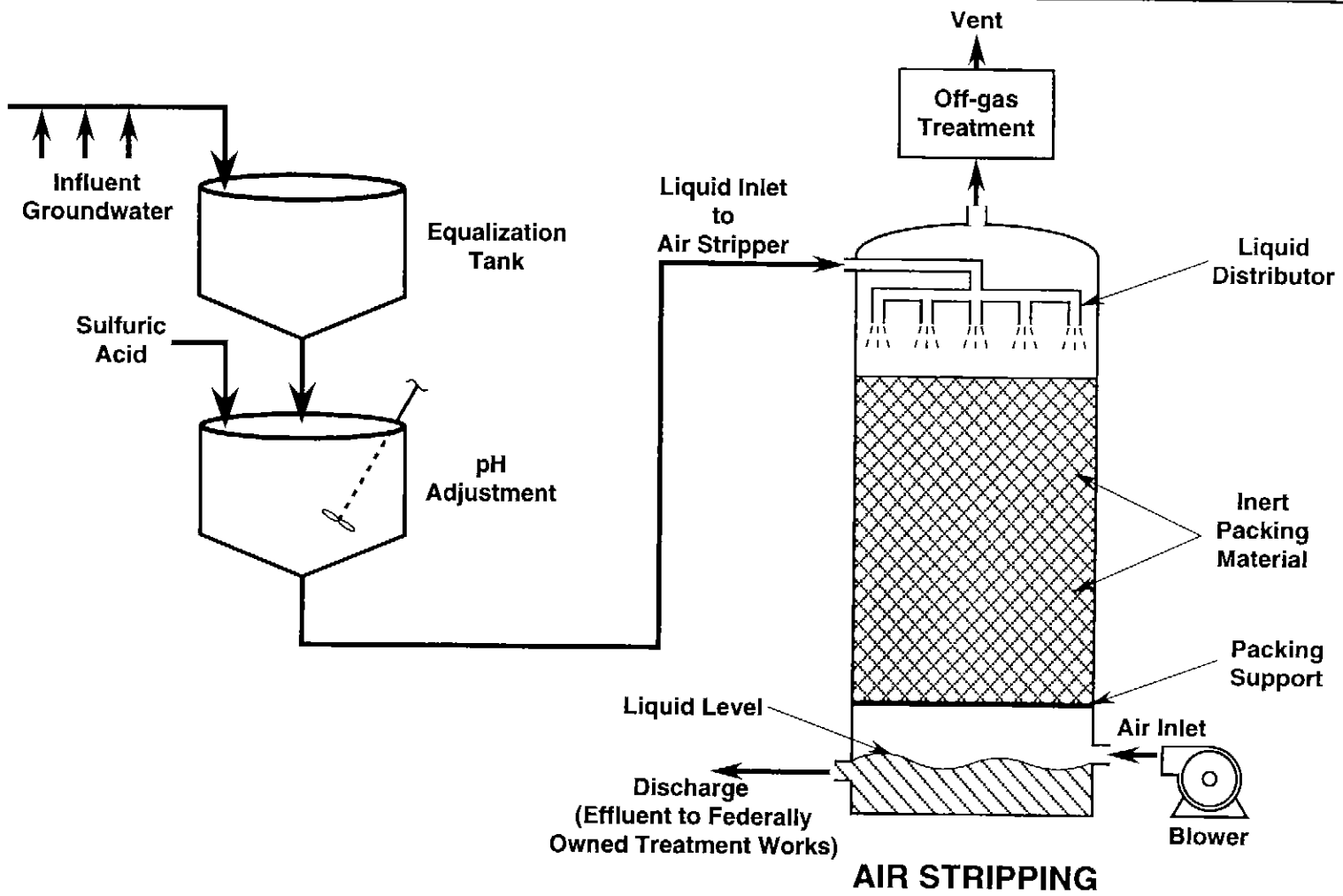

FIGURE 7-7

PRETREATMENT PROCESS TRAIN FOR ALTERNATIVE MM-5

FEASIBILITY STUDY
OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

Not to Scale

8500-16 CF OU7 FS 950331WEM

Table 7-6
FOTW State Operating and NPDES Permit Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Parameters	State Operating Permit Discharge Effluent Limitations	NPDES Permit Effluent Discharge Limitations
Flow	Average daily flow shall not exceed 1.2 MGD[1]	Monthly average 0.82 MGD
BOD_5 (5 day)	5.0 mg/ℓ (30 day average maximum)	Monthly average 30 mg/ℓ Weekly average 45 mg/ℓ
DO	6.0 mg/ℓ (30 day average maximum)	Monthly average 5.0 mg/ℓ
TSS	Annual average = 20 mg/ℓ Monthly average = 30 mg/ℓ Weekly average = 45 mg/ℓ Instantaneous Maximum = 60 mg/ℓ	Monthly average 30 mg/ℓ Weekly average 45 mg/ℓ
NH_3-N	5.7 mg/ℓ (30 day average max)	NA
pH units	6.0 to 8.5	6.0 to 9.0
Total chlorine residual	Minimum 0.01mg/ℓ Maximum 0.5 mg/ℓ	NA
Fecal coliform	Average <=200/100 ml Maximum 800/100 ml	Monthly average 200 Weekly average 400
Acute toxicity	Greater than 20% lethality	NA

[1] Average daily flow is currently 0.6 MGD.

Notes: FOTW = Federally Owned Treatment Work.
NPDES = National Pollutant Discharge Elimination System.
MGD = millions of gallons per day.
BOD = biological oxygen demand, 5 days.
mg/ℓ = milligrams per liter.
DO = dissolved oxygen.
TSS = total suspended solids.
NH_3-N = ammonia as nitrogen.
NA = values not given in the permit.
% percent.

The second set of discharge criteria (operating permit requirements) consist of surface water quality parameters, such as BOD, dissolved oxygen (DO), and total suspended solids (TSS). Introduction of extracted groundwater to the FOTW would not be expected to cause these criteria to be exceeded if pretreated for TCE removal.

7.5.1.3 **Vapor-Phase Treatment and Monitoring** Vapor-phase treatment of off-gas from the air stripper would be used to remove vapor-phase TCE and other organic vapors in accordance with action-specific ARARs for air discharges prior to discharge. It is estimated that vapor-phase GAC would achieve this objective. Two GAC canisters (1,200 pounds each), connected in series, would be installed at the exhaust from the air stripper (Delta Cooling Towers, 1995). A 12-foot vertical exhaust pipe would then be installed after the second GAC canister to adequately disperse the treated exhaust.

Samples of organic vapors would be collected and analyzed for the same parameters described for Alternative MM-4. The system would be fully automated. For the first 3 months, a person would be monitoring the system 7 days per week. After 4 months, one person would be monitoring the system for 50 hours per month.

7.5.1.4 **Treated Groundwater Discharge** As described above, treated groundwater from the air stripper would be discharged to the facility's sanitary sewer system for treatment in the FOTW. This discharge would adhere to all general (i.e., the introduction of contaminants to the FOTW would not cause interference with the operation of the FOTW, and would not pass through the system) and specific prohibitions (i.e., would not create a fire or explosion hazard in the sewer or FOTW, would not cause corrosive damage to the FOTW, and would not obstruct the flow of water to the FOTW) of the Clean Water Act (see Chapter 5.0).

7.5.1.5 **5-Year Site Reviews** Refer to paragraph 7.1.1.1 for a detailed description. In addition, extraction and treatment performance will be summarized and evaluated. Compliance with treatment levels will also be evaluated. The summary will include monitoring results, quantities of contaminants removed or treated, and amounts and quality of residuals produced and removed from the site.

7.5.1.6 **Groundwater and System Monitoring** Refer to paragraph 7.1.1.2 for a detailed description. In addition to the groundwater monitoring activities included in Alternative MM-1, the treatment effectiveness and the operation of the air stripping system would also be monitored on a continual basis throughout remedy implementation. Activities would include influent and effluent monitoring, packing material replacement, liquid and air flow measurements, and other process monitoring requirements.

7.5.1.7 **Groundwater Use Restrictions** Refer to paragraph 7.1.1.3 for a detailed description.

<u>7.5.2 Technical Assessment of Alternative MM-5</u> This subsection presents the technical assessment of Alternative MM-5.

<u>Overall Protection of Human Health and the Environment</u>. This alternative would provide protection to future human receptors by preventing use of OU 7 groundwater as a potable water supply until contaminated groundwater is cleaned-up via extraction and treatment. Humans would be protected in the short term

because they would be prevented from consuming water from the surficial aquifer until complete aquifer restoration (i.e., when treatment levels are achieved). This alternative provides a maximum standard of protection to humans (i.e., groundwater treatment).

By implementing this alternative, no adverse short-term or cross-media effects are anticipated.

Compliance with ARARs. This alternative would comply with all ARARs.

Long-Term Effectiveness and Permanence. This alternative offers a long-term and permanent remedy for groundwater contamination, without relying on natural transformation processes.

Extraction and pretreatment via air stripping and further treatment at the FOTW would reduce VOC, SVOC, and inorganic contaminant concentrations in extracted groundwater. Groundwater use restrictions would also prevent use of groundwater as a potable water supply until action levels are achieved. Groundwater monitoring would provide a means of evaluating the concentrations of contaminants in groundwater over time. All controls proposed in this alternative are considered reliable.

Discharge to the FOTW relies on the successful operation of the FOTW. If the FOTW becomes inoperable due to NAS Cecil Field closure activities, additional treatment of the extracted groundwater would be required for direct discharge to surface water (similar to Alternative MM-3).

Reduction of Toxicity, Mobility, and Volume of Contaminants Through Treatment. This alternative reduces the toxicity, mobility, and volume of VOC, SVOC, and inorganic contaminants in extracted groundwater. VOCs would be treated via air stripping, and the off-gas from the air stripper would be collected on GAC for subsequent offsite treatment or disposal. The treated groundwater would be discharged to the FOTW for further treatment of all contaminants. The air stripper would reduce TCE concentrations by 98 percent to prevent overloading the FOTW treatment system and to comply with effluent permit conditions of the FOTW.

Short-Term Effectiveness. This alternative would comply with RAOs in the short term because contaminated groundwater would be collected and treated, preventing downgradient migration of contaminants through the aquifer.

Installation of extraction wells, treatment of the groundwater, and discharge to the FOTW would not pose a significant risk to workers or the community. Residuals produced through implementing this alternative (e.g., column packing) would be collected for offsite transport and disposal.

Implementability. Construction of the extraction and treatment system is relatively easy to implement and would not pose a threat to workers or the community. Monitoring equipment is easily obtained and groundwater monitoring, 5-year site reviews, and groundwater use restrictions are easily implemented.

Cost. The present worth cost of Alternative MM-5 is presented on Table 7-7. This estimate includes site preparation, a groundwater extraction system, an air stripping with carbon off-gasing unit, discharge to FOTW, system maintenance, and utilities for the 30-year system duration. The estimate also includes the cost

Table 7-7
Cost Summary Table for Alternative MM-5: Groundwater Extraction, Pretreatment, and Discharge to FOTW

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Cost Item	Cost
DIRECT COST	
Site preparation	$69,000
Treatment system	
Extraction wells and pumps (6)	$126,000
Piping for injection well water and piping to treatment facility	$76,000
Miscellaneous pumping materials	$78,000
Air stripper and vapor phase carbon unit (includes regeneration or replacement over treatment duration)	$41,000
pH adjustment	$12,000
Groundwater monitoring well installation (2)	$3,000
Groundwater use restrictions	$10,000
Total direct cost	$415,000
INDIRECT COST	
Health and safety (5 percent)	$21,000
Administration and permitting (5 percent)	$21,000
Engineering and design (15 percent)	$62,000
Construction support services (15 percent)	$62,000
Direct cost contingency (20 percent)	$83,000
Total indirect cost	$249,000
OPERATION AND MAINTENANCE COST (Annual)	
Administrative O&M (30-year period)	
Annual groundwater monitoring	$24,000
5-year reviews (annualized)	$12,600
Present worth - administrative O&M (over 30-year period)	$503,000
Treatment system O&M (30-year period)	
System maintenance	$134.000
Utilities	$48,000
Present worth - system O&M (over 30-year period)	$2,505,000
Total costs	$3,672,000

of the O&M for a 30-year duration for administrative activities such as a groundwater monitoring program, groundwater use restrictions, and 5-year site reviews over a 30-year period. A 30-year period was chosen only because that is the length of time that costs can be accurately predicted.

The cost estimate for Alternative MM-5 is presented in Appendix E. Direct costs include site preparation, treatment system costs, pH adjustment, and an air stripper with carbon regeneration costs. Direct costs for O&M items for Alternative MM-5 are items such as installing two monitoring wells for the proposed groundwater monitoring program and establishing groundwater use restrictions. Total direct costs are estimated to be $415,000 and total indirect costs are estimated to be $249,000. Total O&M costs are approximately $36,600 per year for administrative O&M and $182,000 for treatment system O&M.

The total present worth cost of Alternative MM-5 is approximately $3,672,000. The RI/FS guidance manual suggests that the cost of an alternative presented in the FS should be accurate within +50 percent to -30 percent of the actual cost.

8.0 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Remedial alternatives for OU 7 were developed in Chapter 6.0 and were individually evaluated in Chapter 7.0 using the technical criteria recommended by the NCP. For comparative purposes, NCP criteria are grouped into the following categories:

- threshold criteria,
- primary balancing criteria, and
- modifying criteria.

As presented in Chapter 7.0, only the first two sets of criteria are evaluated during the FS. The final set of criteria (i.e., modifying criteria consisting of State and community acceptance) is more appropriately evaluated after the public comment period for the Proposed Plan. This chapter presents a comparison of remedial alternatives with respect to threshold and primary balancing criteria.

This comparison is intended to provide technical information required to support the selection of a preferred alternative. It is anticipated that modifying criteria (i.e. State and community acceptance) will be used in conjunction with the information presented herein to select an appropriate remedial alternative for OU 7.

The following sections present the overall approach to comparative analysis, the comparative analysis, and some considerations for combining alternatives, if desired.

8.1 OVERALL APPROACH TO COMPARATIVE ANALYSIS. As presented in Chapter 6.0, remedial alternatives were developed to accomplish the RAOs identified for OU 7. The RAOs are based on protection of human exposure to groundwater and attainment of ARARs and TBCs for groundwater at OU 7. SARA emphasizes the use of treatment technologies that reduce the toxicity, mobility, or volume of contaminants rather than technologies that solely prevent exposure.

The three sets of criteria identified above are used to streamline the comparison between alternatives, while ensuring compliance with RAOs. Components of these criteria are described below.

8.1.1 Threshold Criteria Because the selected remedy must be protective of human health and the environment, as well as comply with ARARs, the following two threshold criteria are essential:

- overall protection of human health and the environment and
- compliance with ARARs.

An individual assessment of each alternative with respect to these criteria was presented in Chapter 7.0. An overall comparative analysis of alternatives using threshold criteria is presented in subsection 8.2.1.

8.1.2 Primary Balancing Criteria Primary balancing criteria consist of the following five components:

- long-term effectiveness and permanence;
- reduction of toxicity, mobility, and volume;
- short-term effectiveness;
- implementability; and
- cost.

These criteria are used to provide an assessment of the permanence of each remedial alternative, while ensuring their implementability and cost-effectiveness. These criteria ensure the use of treatment technologies that reduce the toxicity, mobility, or volume of contaminants rather than technologies that solely prevent exposure. An individual assessment of each alternative with respect to these criteria is presented in Chapter 7.0. An overall comparative analysis of alternatives using primary balancing criteria is presented in subsection 8.2.2.

8.1.3 Modifying Criteria The final two criteria required by the NCP are listed below:

- State acceptance and
- community acceptance.

While the FDEP and USEPA have reviewed this FS, these criteria are more appropriately evaluated after public notice and review of the Proposed Plan. It is anticipated that these criteria will be used in conjunction with threshold and primary balancing criteria to select an appropriate remedial alternative in the ROD for OU 7.

8.2 COMPARATIVE ANALYSIS

The following sections present a comparison between each alternative with respect to threshold and primary balancing criteria.

8.2.1 Implementation Time Conceptual time comparisons between alternatives are presented on Figure 8-1. This figure shows the relative remediation time required for VOCs, SVOCs, and inorganic compounds for each alternative. Qualitatively, Alternatives MM-2 and MM-4 would achieve the quickest removal of VOCs, but would rely on natural transformation processes for other constituents. Alternatives MM-3 and MM-5 would achieve the quickest removal of SVOCs and inorganics through groundwater extraction and treatment. Alternative MM-1 would rely primarily on natural transformation processes for all constituents and, thus, would require a longer remediation time than other alternatives.

Based on the time to reduce TCE to the desired level in the aquifer, estimated times of implementation and associated costs are shown on Figure 8-2.

8.2.2 Comparison of Threshold Criteria

Overall Protection of Human Health and the Environment. The environment is not at risk from OU 7 contaminants. Alternative MM-1 would only protect human health through imposing groundwater use restrictions. Action levels could eventually be achieved through natural transformation processes (i.e., physical, chemical, and biological), but, based on current site information, the rate of transformation is anticipated to be slow without intervention.

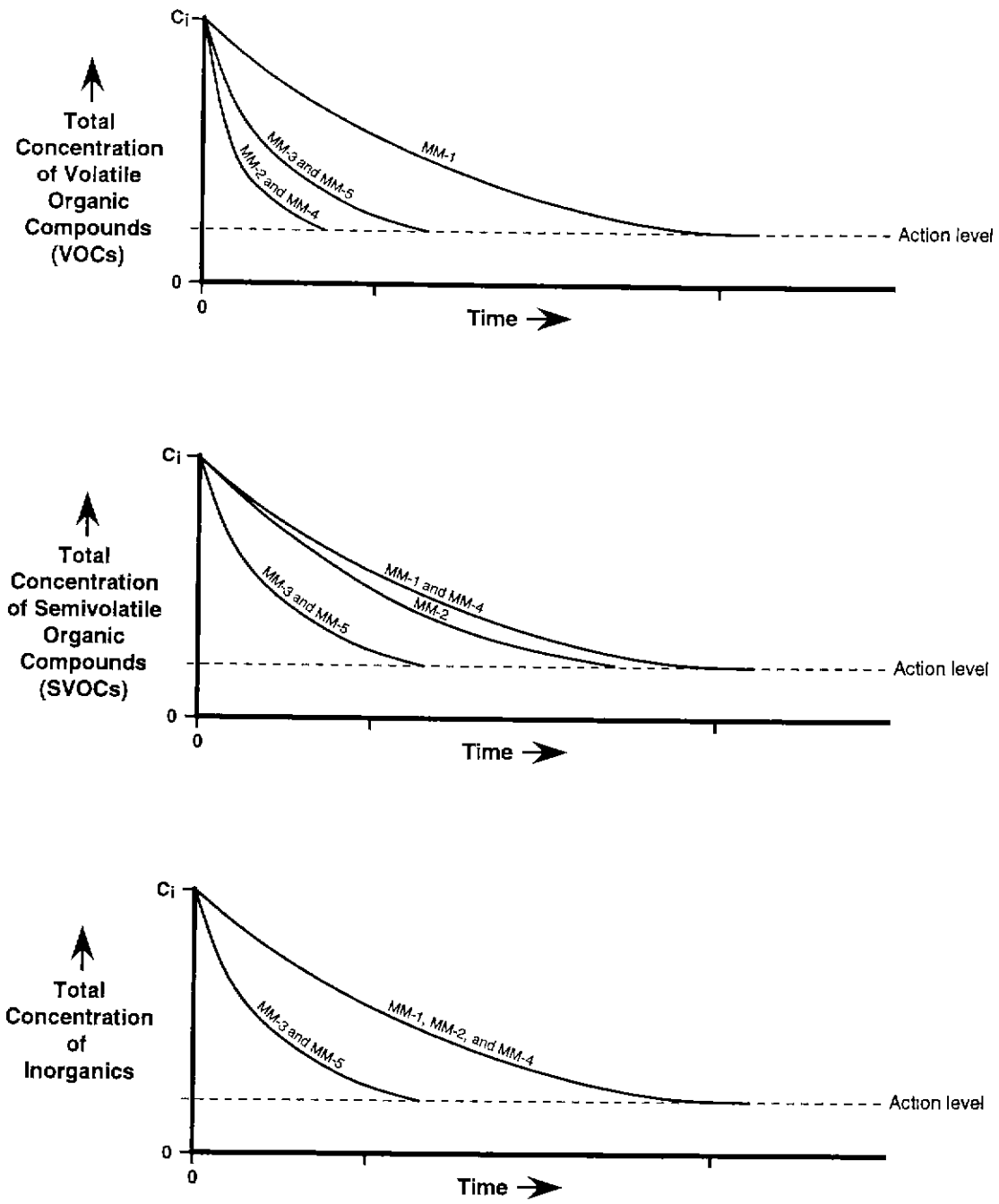

FIGURE 8-1

CONCEPTUAL TIME COMPARISON AMONG ALTERNATIVES

FEASIBILITY STUDY, OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

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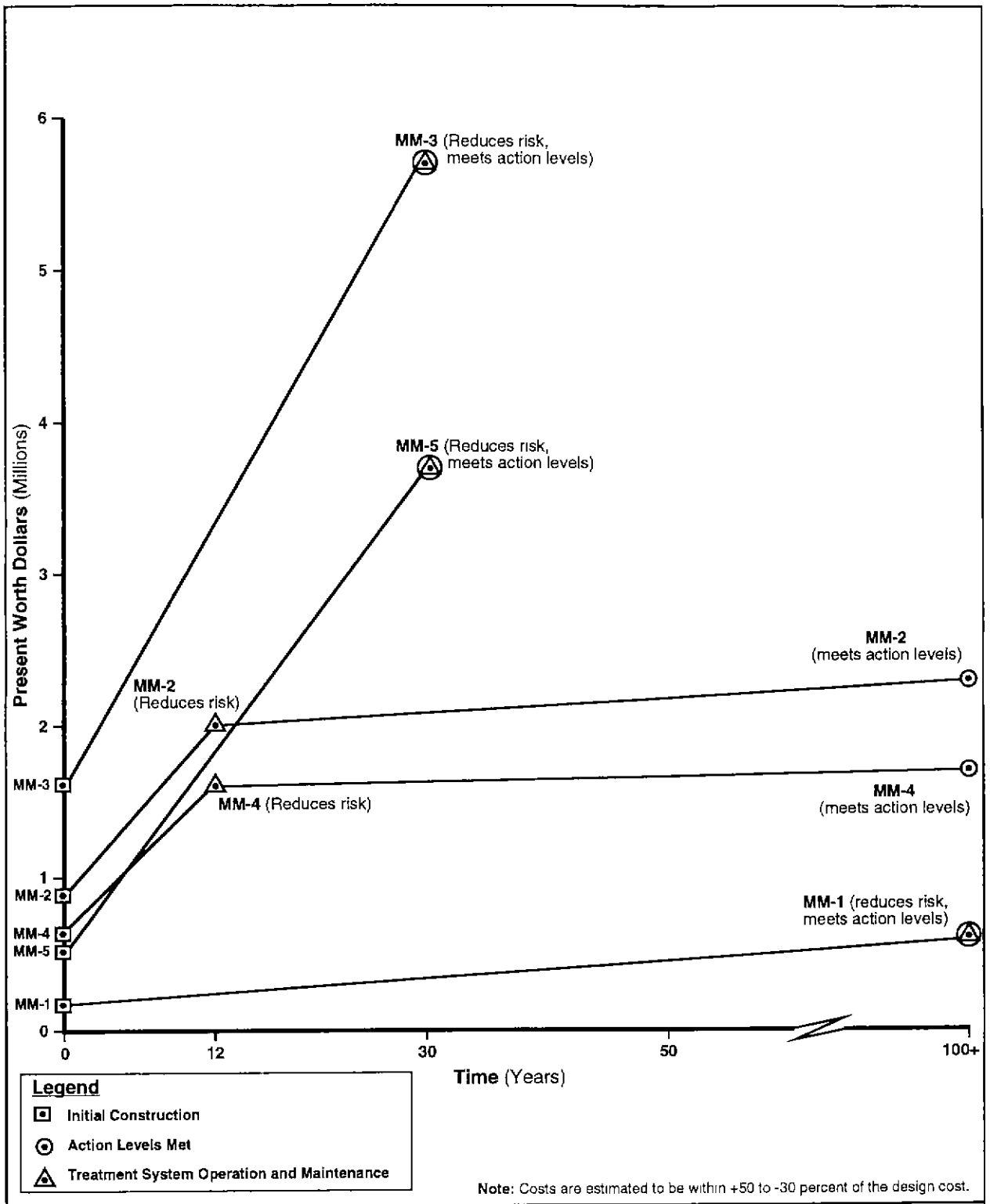
Cec-OU7.FS
ASW.08.95



Note: Costs are estimated to be within +50 to -30 percent of the design cost.

FIGURE 8-2

ESTIMATED TIMES OF IMPLEMENTATION AND ASSOCIATED COSTS

FEASIBILITY STUDY, OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

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Alternatives MM-3 and MM-5 would provide an aggressive groundwater extraction and treatment system (i.e., pump-and-treat) to directly remove dissolved contaminants from the shallow aquifer. These alternatives are proven techniques for removing the bulk of contamination, but experience has shown that attainment of drinking water criteria may be technically impractical.

Alternatives MM-2 and MM-4 are also protective of human health, but they are not as well demonstrated as Alternatives MM-3 and MM-5. Although mechanical intervention is included in Alternatives MM-2 and MM-4, their effectiveness is less predictable as they rely on natural transformation processes and conditions at the site.

Compliance with ARARs. All alternatives are anticipated to eventually achieve chemical-specific ARARs. Alternatives MM-3 and MM-5 would be expected to meet all ARARs as they include mechanical treatment processes to address both organic and inorganic contaminants. Alternative MM-2 is focused solely on organic contaminants and Alternative MM-4 is focused solely on volatile organic contaminants and they may not attain ARARs for inorganic compounds at the same time as the ARARs for the organic compounds are achieved. Alternative MM-2 relies primarily biodegradation, while Alternative MM-4 relies primarily on volatilization. ARARs for inorganic contaminants could potentially be achieved using MM-2 and MM-4; however, their rate of removal is dependent upon natural, unassisted, transformation processes.

8.2.3 Comparison of Primary Balancing Criteria

Long-term Effectiveness and Permanence. It is anticipated that all five alternatives would be effective at achieving action levels and after a sufficient period of time (see Figure 8-1), would comply with ARARs. Alternatives MM-3, MM-4, and MM-5 would likely achieve action levels sooner than Alternatives MM-1 and MM-2. However, given sufficient time for natural transformation processes to occur, even the no-action alternative (MM-1) would eventually achieve action levels.

While Alternatives MM-1, MM-2, MM-3, and MM-4 are independent systems, Alternative MM-5 is dependent upon the facility's FOTW. If the FOTW was to close in the future before action levels are met in the aquifer, additional treatment would be required for discharge directly to surface water.

Reduction of Toxicity, Mobility, and Volume. Other than that accomplished through natural transformation processes, Alternative MM-1 would not reduce the toxicity, mobility, or volume of contaminants.

Alternatives MM-3 and MM-5 provide mechanical treatment processes to extract and treat contaminated groundwater. By extracting groundwater from strategic locations, the hydraulic flow paths would be controlled, preventing contaminant migration. The selected technologies for treatment would provide reduction in toxicity, mobility, and volume of both organic and inorganic contaminants.

Conversely, Alternatives MM-2 and MM-4 would not include groundwater extraction. Alternative MM-2 includes nutrient injection and Alternative MM-4 includes air injection. Other than collecting organic vapors from the vadose zone (Alternative MM-4), neither MM-2 nor MM-4 include a method of controlling organic contaminant migration (i.e., mobility).

Short-Term Effectiveness. Alternatives MM-3, MM-4, and MM-5 would likely have the quickest impact (i.e., contaminant concentrations would be reduced sooner than if Alternatives MM-1 or MM-2 were implemented) on groundwater contaminants. All three of these alternatives include mechanical treatment process for contaminant removal.

Alternative MM-2 relies primarily on biological processes to reduce organic contaminant concentrations. While aerobic degradation of DCE and other organic compounds can occur rapidly, bacteria require conditions conducive to their metabolism. Additionally, an acclimation period is generally required before substantial bacterial growth occurs.

Implementability. Because Alternative MM-1 includes only administrative actions, it would be the easiest to implement. Similarly, Alternative MM-2 includes only nutrient injection, monitoring, and administrative actions in addition to groundwater use restrictions and, thus, would be relatively easy to implement.

Alternative MM-4 includes the installation of air sparging and vapor extraction wells; it is also relatively easy to implement.

Alternatives MM-5 and MM-3 include a similar type of remedial action (i.e., pump-and-treat). However, Alternative MM-5 would be easier to construct because it only includes minimal pretreatment of extracted groundwater (i.e., construction of an air stripper) for acceptance in the facility's FOTW, whereas Alternative MM-3 includes the construction of a more comprehensive treatment system for all contaminants (e.g., UV/OX system, clarifier, and GAC).

Cost. The relative present-worth cost estimate for each alternative, based on a 30-year (in accordance with USEPA guidance) operating time, are presented on Figure 8-3. Also shown are the estimated costs for the period of time estimated to complete each alternative.

Alternative MM-1 includes only groundwater use restrictions, monitoring, and 5-year reviews, and thus has the lowest associated cost. Alternative MM-2 adds nutrient injection in addition to the actions of Alternative MM-1 and, thus, would also have a relatively low cost.

Alternative MM-4 includes the installation of air sparging and vapor extraction wells, along with monitoring of the system. While more expensive than Alternative MM-1, its cost is less than that of Alternatives MM-3 and MM-5.

Alternatives MM-5 and MM-3 include a similar type of remedial action (i.e., pump-and-treat). However, Alternative MM-5 would have a lower cost because it only includes minimal pretreatment of extracted groundwater for acceptance in the facility's FOTW.

8.2.4 Summary Table 8-1 presents a summary of the comparative analysis for OU 7 remedial alternatives.

8.3 CONSIDERATIONS FOR COMBINING ALTERNATIVES. Based on regulatory agency and public comments received on the Proposed Plan, the Navy may consider a combination of remedial alternatives for OU 7. Alternatives described in Chapter 7.0, or portions thereof, could be combined to form an optimum site response.

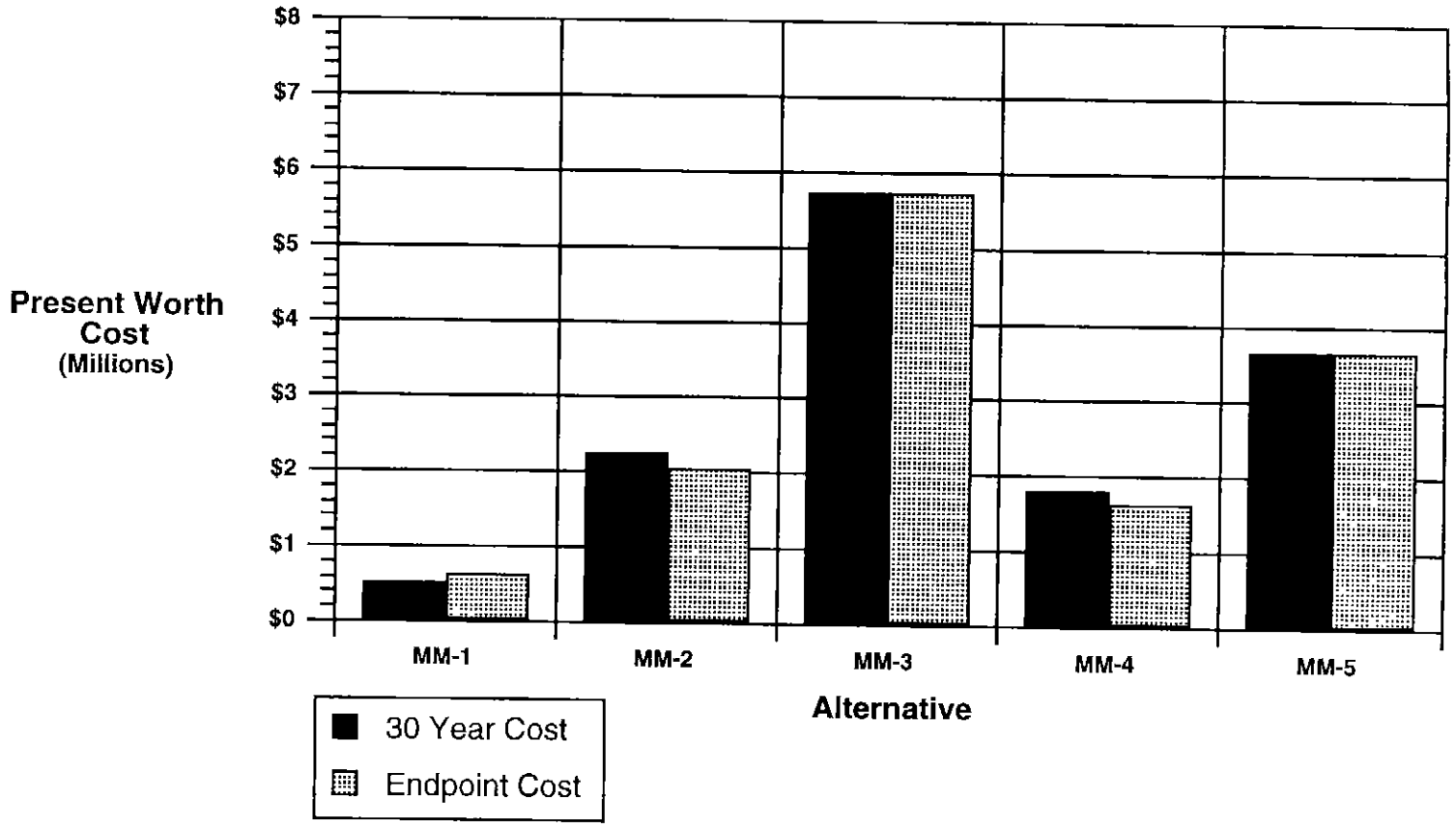


FIGURE 8-3

PRESENT WORTH COST ESTIMATES FOR REMEDIAL ALTERNATIVES

FEASIBILITY STUDY, OPERABLE UNIT 7

NAS CECIL FIELD
JACKSONVILLE, FLORIDA

8500-16 CF FS OU7 950403WEM

Table 8-1
Summary of Comparative Analysis

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Alternative:	MM-1	MM-2	MM-3	MM-4	MM-5
Aquifer Restoration					
Organics destroyed?	No	Yes	Yes	Yes	Yes
Inorganics removed from aquifer?	No	No	Yes	No	Yes
Estimated time to achieve action levels (years)	100+	12 to 100+	30	12 to 100+	30
Plume contained?	No	No	Yes	Partially	Yes
Plume toxicity reduced?	No	Partially	Yes	Partially	Yes
Remedy permanent?	No	Yes	Yes	Yes	Yes
Uncertainty of attaining action levels	Moderate	Moderate	Low	Moderate	Low
Treatment Residuals					
Organics destroyed onsite	No	Yes	Yes	No	No
Organics destroyed offsite	No	NA	NA	Yes	Yes
Contaminants Released/Remaining in Environment					
Organic	Yes	No	No	No	No
Inorganics	Yes	Yes	No	Yes	No
Cost					
Present Worth (30-years)	524,000	2.256,000	5,732,000	1.829,000	3,672,000

Notes: MM-1 = no action alterative.
MM-2 = enhanced bioremediation alternative.
MM-3 = groundwater extraction, treatment, and discharge to surface water alternative.
MM-4 = sparging of groundwater alternative.
MM-5 = groundwater extraction, pretreatment, and discharge to FOTW alternative.
NA = not applicable.

Because enhanced bioremediation and air sparging could potentially augment other remedial alternatives, the cost estimates provided for those alternatives (MM-2 and MM-4) are divided into the following two portions:

- source area of the plume and
- downgradient area of the plume.

If Alternatives MM-3 or MM-5 were the preferred alternative for OU 7, the rate of remediation may be increased by augmenting the system with either enhanced bioremediation or air sparging. For example, DCE and lesser-chlorinated organic compounds present in the downgradient area of the plume may effectively be aerobically biodegraded. Nutrients could be injected to stimulate aerobic microbial activity, and air sparging could be used to maintain aerobic conditions. This would result in a preferred alternative that is a combination of Alternative MM-3 or MM-5, with Alternative MM-2 or MM-4 in the downgradient area of the plume.

Alternately, if high concentrations of contaminants are present in the source area, and are providing a continuing source of dissolved contaminants, the required duration of the pump-and-treat system could be extended. In this case, air sparging could be used in the source area of the plume to create turbulence and break up the pockets of high concentrations of contaminants, thus increasing the rate of contaminant dissipation for subsequent extraction. This would result in a preferred alternative that is a combination of Alternative MM-3 or MM-5, with Alternative MM-4 in the source area of the plume.

A method of documenting the selected remedial action, while allowing operational flexibility for future modifications, is to identify a "base action" (selected alternative) and a "contingent action" (system modification). For example, Alternative MM-3 or MM-5 could be designed as the base action, while Alternatives MM-2 and MM-4 could be designed as contingent actions if the base action is not as effective as anticipated.

8.4 SENSITIVITY ANALYSIS FOR MANAGEMENT OF MIGRATION ALTERNATIVES. According to RI/FS guidance (USEPA, 1988), a sensitivity analysis may be useful in assessing the relative impacts of various cost components for remedial alternatives. One of the major cost components for each MM alternative for OU 7 is the present worth of the annual O&M cost.

Consistent with RI/FS guidance, the present worth of O&M costs presented in Chapter 7.0 include administrative costs (groundwater monitoring and 5-year reviews) over a 30-year period and treatment system costs (systems maintenance and utilities) over the treatment duration period. However, the actual length of time O&M costs (administrative and treatment system) would be incurred may vary for each alternative because O&M costs are directly related to treatment duration. Treatment duration is primarily controlled by the following factors:

- size of groundwater plume,
- concentration levels of contaminants in groundwater,
- sustainable flow rates for extraction, and

- efficiency and rate of contaminant removal.

Therefore, a sensitivity analysis of administrative costs based on treatment duration was developed for OU 7 (see Appendix G). This sensitivity analysis is presented on Table 8-2.

A comparison between the total cost of the alternatives shown on Table 8-2 to those costs presented on Chapter 7.0, shows that the total cost of each alternative would not significantly change if both administrative and treatment system O&M costs were applied throughout the treatment duration. If O&M activities were conducted for Alternative MM-1 for a period of 160 years rather than 30 years, the cost would increase by 20 percent. Similarly, if O&M activities were conducted for Alternatives MM-2 and MM-4 for a period of 12 years rather than 30 years, the cost would decrease by 10 and 11 percent, respectively. There would be no change in cost for Alternatives MM-3 and MM-5 because the estimated treatment duration is equal to the projected 30-year O&M period.

Table 8-2
Sensitivity Analysis for Administrative Costs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Alternative	Assumed Administration Duration[1]	Present Worth of Administrative O&M	Total Cost of Alternative[2]	Adjusted Administration Duration[3]	Present Worth of Administrative O&M	Total Cost of Alternative	Percent Change of Total Costs
MM-1	30	503,000	524,000	160	610,000	630,800	+20
MM-2	30	586,000	2,256,000	12	357,000	2,027,000	-10
MM-3	30	503,000	5,732,000	30	503,000	5,732,000	0
MM-4	30	503,000	1,829,000	12	307,000	1,633,000	-11
MM-5	30	503,000	3,672,000	30	503,000	3,672,000	0

[1] Monitoring and 5-year review used in Chapter 7.0
[2] Direct, indirect, and present worth of administrative and treatment O&M used in Chapter 7.
[3] Based on treatment duration.

REFERENCES

ABB Environmental Services Inc. (ABB-ES), 1992. Technical Memorandum for Supplemental Sampling, Operable Units 1, 2, and 7, Naval Air Station Cecil Field. Jacksonville, Florida; prepared for Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), North Charleston, South Carolina.

ABB-ES, 1993, Focused Feasibility Study Operable Unit 7, Source Control Remedial Alternatives, Naval Air Station (NAS) Cecil Field: prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

ABB-ES. 1994a, Feasibility Study Operable Unit 2, NAS Cecil Field: prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

ABB-ES, 1994b, Non-destructive Inspection (NDI) Holding Tank Closure Certification and Report, NAS Cecil Field: prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

ABB-ES, 1995a, Baseline Risk Assessment Operable Unit 7, NAS Cecil Field: prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

ABB-ES 1995b, Handbook of Applicable or Relevant and Appropriate Requirements for Navy Sites within the State of Florida: prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

ABB-ES, 1995c, Remedial Investigation Operable Unit 7, NAS Cecil Field: prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina.

American Cancer Society, 1994, Cancer Facts and Figures, 1994

American Water Works Association, 1990. Water Quality and Treatment; McGraw-Hill, Inc.

Dzombak, D.A., Roy, S.B., Fang, H., 1993. "Air-Stripper Design and Costing Computer Program"; Journal; Vol. 85, No.10; p.63.

Envirodyne Engineers, 1985. Initial Assessment Study of Naval Air Station Cecil Field, Jacksonville, Florida; prepared for Naval Energy and Environmental Support Activity (NEESA), NEESA 13-073, Port Hueneme, California; July 1985.

Fairchild, R.W., 1972. The Shallow-Aquifer System in Duval County, Florida; Florida Bureau of Geology, Report of Investigations No. 59; Tallahassee, Florida; January, 1972.

Florida Department of Environmental Protection (FDEP), 1992. Guidelines for the Assessment and Remediation of Petroleum Contaminated Soil: prepared by the Bureau of Waste Cleanup, May 1992.

FDEP, 1994a. Cleanup Goals for Military Sites in Florida. Memorandum from Ligia Mora-Applegate, Technical Review Section, Bureau of Waste Cleanup; Tallahassee, FL. July 5, 1994.

FDEP, 1994b. Florida Ground Water Guidance Concentrations. Division of Water Facilities, Bureau of Ground Water Protection; June 1994.

Florida Legislature, 1992. "Soil Thermal Treatment Facilities," Chapter 62-775, Florida Administrative Code (FAC); Tallahassee, Florida; November 1992.

Florida Legislature, 1994a. Safe Drinking Water Act; Chapter 62-550, Florida Administrative Code (FAC); Tallahassee, Florida; September, 1994.

Florida Legislature, 1994b. Water Quality Standards, Minimum Criteria for Groundwater; Chapter 17-3.402, Florida Administrative Code (FAC); Tallahassee, Florida; January, 1994.

Florida Legislature, 1995. Surface Water Quality Standards; Chapter 62-302, Florida Administrative Code (FAC); Tallahassee, FL; January 1995.

Geraghty and Miller, 1983. Hydrogeologic Assessment and Ground-Water Monitoring Plan, NAS Cecil Field, Jacksonville, Florida; prepared for Department of the Navy, Southern Division, Charleston, South Carolina; October 1983.

Groundwater Guidance Concentration, Bureau of Groundwater protection, June 1994b.

Harding Lawson Associates, Inc., 1988. Draft Final RCRA Facilities Investigation (RFI) Report, NAS Cecil Field, Jacksonville, Florida; prepared for Department of the Navy, Southern Division, Charleston, South Carolina; March 17, 1988.

Johnson, R.L., Johnson, P.C., McWhorter, R.E., Hinchee, R.E., and Goodman, I., 1993. "An Overview of *In situ* Air Sparging"; Ground Water Monitoring Review; p.127-135.

Leve, G. W., 1966. Ground Water in Duval and Nassau Counties, Florida: Report of Investigations No. 43; Florida Geological Survey; Jacksonville, Florida; May 19, 1966.

Long, E.R., and Morgan, L.G, 1990. The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program; Seattle, WA, NOAA Technical Memorandum NOS OMA 52; 1990.

Maughan, J. T., 1993. Ecological Assessment of Hazardous Waste Sites; New York, New York; Van Nostrand Reinhold; 1993.

McGhee, T.J., 1991. Water Supply and Sewerage; Sixth Edition; McGraw-Hill, Inc.

Metcalf & Eddy, Inc., 1991. Wastewater Engineering, 3rd Edition; Authors: Burton, F.L., Tchobanoglous, G.; McGraw-Hill, Inc.

Peavy, H.S., Rowe, D.R., Tchobanoglous, G., 1985. Environmental Engineering; McGraw-Hill, Inc.

Radian Corporation, 1993, Pre-RI Tentative Assessment of Remediation Technologies, Desk Reference Memorandum.

Southeastern Geological Society (SEGS), compiler, 1986, Hydrogeological Units of Florida: Florida Geological Survey Special Publication 28, 8 p.

Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), 1989. Southern Division, Naval Facilities Engineering Command; Master Plan for NAS Cecil Field; Jacksonville, Florida; November 1989.

SOUTHNAVFACENGCOM, 1993. Site Management Plan for NAS Cecil Field; Jacksonville, Florida; October 1993.

Springborn Laboratories, 1993. Toxicity Evaluation of the Sediment and Soil from the Cecil Field Naval Air Station in Jacksonville, Florida; prepared for ABB Environmental Services, Inc.; SLI Report #93-07-4874; 1993.

Suter, G. W., 1993. Ecological Risk Assessment; Chelsea, Michigan; Lewis Publishers; 1993.

Tchobanoglous, G., Schroeder, E.D., 1985. Water Quality; Addison-Welsley Publishing Company, Inc.

USEPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final; Office of Solid Waste and Emergency Response, Washington, DC; EPA/540/G-89/004; October 1988.

USEPA, 1989a. Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference; Environmental Research Laboratory, Corvallis, Oregon; EPA 600/3-89/013; March 1989.

USEPA, 1989b. Risk Assessment Guidance for Superfund, Vol. I, Human Health Evaluation Manual; Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/002; 1989.

USEPA, 1989c. Risk Assessment Guidance for Superfund: Environmental Evaluation Manual; Volume 2; Office of Emergency and Remedial Response; Washington, DC;EPA/540/1-89/002; December, 1989.

USEPA, 1990a. Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters; Office of Research and Development, Washington DC; EPA/600/4-90/030; November 1990.

USEPA, 1990b. National Oil and Hazardous Substances Pollution Contingency Plan, Final Rule: 40 CFR Part 300, Federal Register 55(46):8718.

USEPA, 1990c. CERCLA Site Discharges to POTWs Treatability Manual; Office of Solid Waste and Emergency Response, Washington, DC; EPA/540/2-90-007; August.

USEPA, 1991a. Ambient Water Quality Criteria (AWQC) Summary; Office of Water/ Regulations and Standards Division, Washington DC, May 1, 1991.

USEPA, 1991b. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance, Standard Default Exposure Factors; Office of Emergency and Remedial Response, Toxics Integration Branch, Washington, D.C., OSWER Directive 9285.6-03; Interim final; 1991.

USEPA, 1991c. Letter from Elmer W. Aiken, Health Assessment Officer, to Hazardous Waste Contractors, re. Region IV Risk Assessment Guidance; Atlanta, Georgia; March 20, 1991.

USEPA, 1991d. Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors; OSWER DIRECTIVE 9285.6-03; March 25, 1991.

USEPA, 1991e. ECO Update; Volume 1: Number 1, December, 1991; Publication 9345.0-051; 1991.

USEPA, 1991f. Ecological Assessment of Superfund Sites: An Overview; Publication 9345.0-05I; Washington, D.C.; U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response; December, 1991.

USEPA, 1992a. Guidelines for Exposure Assessment; Federal. Register, vol. 57, No. 104; p. 22888-22938; Friday, 29 May 1992

USEPA, 1992b. ECO Update; Volume 1: Number 2, May, 1992; Publication 9345.0-051; 1992.

USEPA, 1992c. ECO Update; Volume 1: Number 3, August, 1992. Publication 9345.0-051; 1992.

USEPA, 1992d. Region III Risk Based Concentration Table; Referenced in Selecting Exposure routes and Contaminants of Concern by Risk-Based Screening, Region III, Technical Guidance Manual, Risk Assessment, January, 1993; EPA/903/R-93-001; October 1992.

USEPA, 1993. Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening; Region III, Technical Guidance Manual, Risk Assessment; EPA/903/R-93-001; January, 1993.

USEPA, 1994a. "Drinking Water Regulations and Health Advisories"; Office of Water; Washington, DC; May 1994.

USEPA, 1994b. Health Effects Summary Tables (HEAST), Annual Update; Office of Solid Waste and Emergency Response; EPA 540-R-93-058; PB93-921199; March 1994.

USEPA, 1994c. Integrated Risk Information System (IRIS); On-line database search; November 1994.

USEPA, 1994d. Region III Screening Table referenced in Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening; Region III, Technical Guidance Manual, Risk Assessment; EPA/903/R-93-001; March, 1994.

Vargas, C., and Associates, Ltd., 1981, Drawings of the Industrial Wastewater Disposal Area, Building 313: prepared for the Department of the Navy, Southern Division, March 1981.

Wisconsin Department of Natural Resources (DNR), Emergency and Remedial Response Program, 1993a, Guidance for Design, Installation, and Operation of *In situ* Bioventing Systems, July.

Wisconsin DNR, Emergency and Remedial Response Program, 1993b, Guidance for Design, Installation, and Operation of *In situ* Air Sparging Systems, September.

APPENDIX A

COMPARISON OF SITE MEDIA WITH CRITERIA

Table A-1
Surficial Aquifer Comparison with Drinking Water Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Federal Primary MCL[4]	Florida Primary Standard[5]	Florida Guidance Concentration[6]	Exceedance?[7] (Yes/No)
Volatiles (μg/ℓ)								
1,1,1-Trichloroethane	1/21	[8]3,000	3,000	Yes	200	200	200	Yes[13,14,15]
1,1-Dichloroethane	1/21	1	1	No	NA	NA	700	No
1,1-Dichloroethene	1/21	[8]400	400	Yes	7	7	7	Yes[13,14,15]
1,2-Dichloroethene (total)	2/21	270 to [8]12,500	6,360	Yes	[9]70	[9]70	[9]70	Yes[13,14,15]
4-Methyl-2-pentanone	1/16	1	1	No	NA	NA	350	No
Trichloroethene	7/21	12 to [8]630	238	Yes	5	3	3	Yes[13,14,15]
Semivolatiles (μg/ℓ)								
2-Methylnaphthalene	1/21	[8]2.75	2.8	No	NA	NA	NA	NA
Diethylphthalate	2/21	1 to 1	1	No	NA	NA	5,600	No
Naphthalene	1/21	[8]3.5	3.5	No	NA	NA	6.8	No
Phenanthrene	1/21	3	3	No	NA	NA	10	No
Phenol	3/21	0.8 to [8]1.45	1.1	No	NA	NA	10	No
bis(2-Ethylhexyl) phthalate	17/21	0.5 to [8]20.5	5.7	Yes	6	6	6	Yes[13,14,15]
Pesticides/PCBs (μg/ℓ)								
Endrin	1/20	0.02	0.02	No	2	2	2	No
Inorganics (μg/ℓ)								
Aluminum	12/21	[8]176 to [8]7,970	1,490	No	[10]200	[11]200	200	Yes[13,14,15]
Antimony	3/21	2.2 to [8]16.0	7.3	Yes	6	6	6	Yes[13,14,15]
Arsenic	10/21	3.6 to 56.2	13.2	Yes	50	50	50	Yes[13,14,15]
Barium	21/21	6.5 to 108	27.5	No	2,000	2,000	2,000	No
Cadmium	1/21	[8]3.3	3.3	No	5	5	5	No
Calcium	21/21	603 to [8]58,500	19,800	No	NA	NA	NA	NA
Chromium	4/21	2.2 to 7.9	4.8	No	100	100	100	No
Cobalt	3/21	[8]2.3 to 5.9	4.6	Yes	NA	NA	NA	NA
Copper	5/21	[8]2.1 to 3.8	3	No	[10]1,000	[11]1,000	1,000	No
Iron	20/20	[8]260 to 9,150	1,830	Yes	[10]300	[11]300	300	Yes[13,14,15]

See notes at end of table.

Table A-1 (Continued)
Surficial Aquifer Comparison with Drinking Water Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Federal Primary MCL[4]	Florida Primary Standard[5]	Florida Guidance Concentration[6]	Exceedance?[7] (Yes/No)
Lead	1/21	[8]2.55	2.6	No	[12]15	15	15	No
Magnesium	21/21	254 to 28,000	8,190	Yes	NA	NA	NA	NA
Manganese	18/20	[8]4.9 to 56.8	27.4	Yes	[10]50	[11]50	50	Yes[13,14,15]
Mercury	1/21	1	1	No	2	2	2	No
Nickel	2/21	[8]11 to 12.5	11.8	No	100	100	100	No
Potassium	21/21	125 to [8]4,470	806	No	NA	NA	NA	NA
Sodium	21/21	[8]2,670 to [8]31,700	7,510	No	NA	NA	NA	NA
Thallium	3/21	6 to 6.3	6.2	Yes	2	2	2	Yes[13,14,15]
Vanadium	13/21	1.1 to 14.3	4.1	No	NA	NA	49	No
Zinc	8/21	[8]16.0 to 89.5	40.4	No	[10]5,000	[11]5,000	5,000	No

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected
[3] HHCPCs were selected for groundwater associated with Site 16 surficial aquifer as described in the baseline risk assessment (ABB-ES, 1995).
[4] Federal Primary MCLs are taken from USEPA Drinking Water Regulations and Health Advisories (May 1994).
[5] Florida Primary Standards are taken from Chapter 1 (Primary Standards) of the Florida Department of Environmental Protection (FDEP) Groundwater Guidance Concentrations (June 1994).
[6] Florida Guidance Concentrations are taken from Chapter 6 (Guidance Concentrations Index) of the FDEP Groundwater Guidance Concentrations (June 1994).
[7] An exceedance of the available criteria is identified when the maximum detected site concentration is greater than one or more of the criteria.
[8] Value is the average of a sample and its duplicate(s).
[9] Primary MCL is for cis-1,2-Dichloroethylene.
[10] Value is a Federal Secondary MCL.
[11] Value is a Florida Secondary MCL.
[12] Treatment technology action limit for lead in drinking water distribution system identified in the U.S. Environmental Protection Agency (USEPA) Drinking Water Standards and Health Advisories (May, 1994).
[13] The maximum detected concentration of the contaminant exceeds the Federal Primary MCL.
[14] The maximum detected concentration of the contaminant exceeds the Florida Primary Standard.
[15] The maximum detected concentration of the contaminant exceeds the Florida Guidance Concentration.

Notes: HHCPC = human health chemical of potential concern.
MCL = maximum contaminant level.
$\mu g/\ell$ = micrograms per liter.
NA = not available
PCB = polychlorinated biphenyls.

Table A-2
Intermediate Aquifer Comparison with Drinking Water Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Federal Primary MCL[4]	Florida Primary MCL[5]	Florida Guidance Concentration[6]	Exceedance?[7] (Yes/No)
Semivolatiles (µg/ℓ)								
Di-n-butylphthalate	1/4	1	1	No	NA	NA	700	No
bis(2-Ethylhexyl) phthalate	4/4	1 to 10	5.5	Yes	6	6	6	Yes[10,11,12]
Inorganics (µg/ℓ)								
Antimony	2/4	3.1 to 10.3	6.7	Yes	6	6	6	Yes[10,11,12]
Barium	4/4	7 to 41.8	27.3	No	2,000	2,000	2,000	No
Calcium	4/4	9,160 to 63,400	49,300	No	NA	NA	NA	NA
Chromium	1/4	9.8	9.8	No	100	100	100	No
Copper	2/4	8 to 8.2	8.1	No	[8]1,000	[9]1,000	1,000	No
Iron	4/4	69.6 to 444	250	No	[8]300	[9]300	300	Yes[10,11,12]
Magnesium	4/4	16,000 to 28,700	24,500	No	NA	NA	NA	NA
Manganese	4/4	6.7 to 57.5	40.5	Yes	[8]50	[9]50	50	Yes[10,11,12]
Potassium	4/4	853 to 39,900	10,700	No	NA	NA	NA	NA
Sodium	4/4	8,050 to 30,600	14,800	No	NA	NA	NA	NA
Zinc	3/4	48.6 to 98.5	75.7	No	[8]5,000	[9]5,000	5,000	No

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.
[3] HHCPCs were selected for groundwater associated with Site 16 intermediate aquifer in the baseline risk assessment (ABB-ES, 1995).
[4] Federal Primary MCLs are taken from USEPA Drinking Water Regulations and Health Advisories (May 1994).
[5] Florida Primary Standards are taken from Chapter 1 (Primary Standards) of the Florida Department of Environmental Protection (FDEP) Groundwater Guidance Concentrations (June 1994).
[6] Florida Guidance Concentrations are taken from Chapter 6 (Guidance Concentrations Index) of the FDEP Groundwater Guidance Concentrations (June 1994).
[7] An exceedance of the criteria is identified when the maximum detected site concentration is greater than one or more criteria.
[8] Value is a Federal Secondary MCL.
[9] Value is a Florida Secondary MCL.
[10] The maximum detected concentration of the contaminant exceeds the Federal Primary MCL.
[11] The maximum detected concentration of the contaminant exceeds the Florida Primary Standard
[12] The maximum detected concentration of the contaminant exceeds the Florida Guidance Concentration.

Notes: HHCPC = human health chemical of potential concern.
MCL = Maximum Contaminant Level.
µg/ℓ = micrograms per liter.
NA = not available

Table A-3
Surface Soil Comparison with Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Range of Reporting Limits	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Background Screening Concentration[4]	FDEP Clean-up Goals[5]	Exceedance? (Yes/No)[6]
Volatiles (µg/kg)								
1,2-Dichloroethene (total)	1/10	[7]6.5	5 to 11	6.5	No	NA	NP	NA
Trichloroethene	6/10	3 to 150	5 to 12	43.2	No	NA	12,000	No
Semivolatiles (µg/kg)								
Acenaphthene	3/10	32 to 82	360 to 380	55	No	NA	4,000,000	No
Acenaphthylene	1/10	31	360 to 380	31	No	NA	ND	NA
Anthracene	3/10	46 to 170	360 to 380	102	No	NA	18,300,000	No
Benzo (a) anthracene	3/10	200 to 420	360 to 380	340	Yes	NA	1,480	No
Benzo (a) pyrene	5/10	[7]29 to 310	360 to 380	178	Yes	NA	148	No
Benzo (b) fluoranthene	9/10	23 to 620	360 to 380	193	Yes	NA	1,480	No
Benzo (g,h,i) perylene	5/10	82 to 140	360 to 380	110	No	NA	ND	NA
Benzo (k) fluoranthene	5/10	[7]20 to 180	360 to 380	103	Yes	NA	1,470	No
Butylbenzylphthalate	6/10	32 to 140	360 to 380	78.2	No	NA	15,300,000	No
Carbazole	3/10	65 to 140	360 to 380	94.7	No	NA	58,100	No
Chrysene	7/10	26 to 360	360 to 380	150	Yes	NA	14,800	No
Dibenz (a,h) anthracene	3/10	29 to 52	360 to 380	41.7	Yes	NA	148	No
Dibenzofuran	1/10	44	360 to 380	44	Yes	NA	290,000	No
Fluoranthene	7/10	41 to 870	360 to 380	351	No	NA	2,990,000	No
Fluorene	3/10	26 to 97	360 to 380	55.3	No	NA	2,760,000	No
Indeno (1,2,3-cd) pyrene	5/10	62 to 190	360 to 380	125	Yes	NA	1,480	No
Naphthalene	1/10	28	360 to 380	28	No	NA	2,290,000	No
Phenanthrene	6/10	[7]39 to 740	360 to 380	288	No	NA	ND	NA
Pyrene	8/10	24 to 600	360 to 380	203	No	NA	2,224,000	No
Pesticides/PCBs (µg/kg)								
4,4-DDD	1/10	[7]5.85	3.6 to 4	5.9	No	NA	4,740	No
4,4-DDE	7/10	0.32 to 3.1	3.6 to 4	0.97	No	NA	3,340	No
Aroclor-1260	4/10	5.5 to 33	36 to 38	21.1	No	NA	NP	NA

See notes at end of table.

Table A-3 (Continued)
Surface Soil Comparison with Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Range of Reporting Limits	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Background Screening Concentration[4]	FDEP Clean-up Goals[5]	Exceedance? (Yes/No)[6]
Pesticides/PCBs (µg/kg)--continued								
Endosulfan sulfate	1/10	0.27	3.6 to 4	0.27	No	NA	NP	NA
alpha-Chlordane	4/10	0.6 to [7]26	1.9 to 2	7.4	No	NA	869	No
gamma-Chlordane	1/10	[7]30	1.9 to 2	30	No	NA	869	No
Inorganics (mg/kg)								
Aluminum	10/10	932 to [7]6,000	40 to 40	2,780	No	29,000	ND	No[8]
Barium	10/10	1.7 to 8.7	40 to 40	5.8	No	21	NP	No[8]
Cadmium	5/10	[7]0.35 to 0.94	1 to 1	0.69	No	-	37.5	No
Calcium	10/10	994 to 13,000	1,000 to 1,000	4,040	Yes	-	NP	NA
Chromium	10/10	1.8 to [7]13	2 to 2	6.5	No	31.2	[9]201	No[8]
Cobalt	4/10	0 49 to 0.71	10 to 10	0.61	Yes	-	ND	No
Copper	9/10	0.81 to 3.1	5 to 5	1 7	No	-	2,880	No
Iron	10/10	207 to 1,030	20 to 20	603	No	8,060	ND	No[8]
Lead	10/10	3.9 to 32.1	0.6 to 0.6	16.1	No	15.6	ND	No
Magnesium	10/10	66 to [7]173	1,000 to 1,000	114	No	474	NP	No[8]
Manganese	10/10	2.9 to 14	3 to 3	7.7	No	18	5,710	No[8]
Nickel	9/10	0.81 to 2.6	8 to 8	1.6	No	8	1,510	No[8]
Potassium	9/10	21.7 to 93.7	1,000 to 1,000	45.3	No	310	NP	No[8]
Silver	1/10	0.4	2 to 2	0.4	No	-	NP	No
Sodium	10/10	143 to 192	1,000 to 1,000	164	Yes	-	NP	No
Vanadium	10/10	1.2 to 5	10 to 10	2.9	No	34.2	501,000	No[8]

See notes at end of table.

Table A-3 (Continued)
Surface Soil Comparison with Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Range of Reporting Limits	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Background Screening Concentration[4]	FDEP Clean-up Goals[5]	Exceedance? (Yes/No)[6]
Inorganics (mg/kg)--continued								
Zinc	8/10	9.4 to 25.2	4 to 4	14.2	No	-	23,330,000	No

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (16SS01, 16SS02, 16SS03, 16SS04, 16SS05, 16SS06, 16SS07, 16SS08, 16SS09, and 16SS10, including a duplicate at 16SS08).
[2] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.
[3] HHCPCs were selected for surface soil as described in the baseline risk assessment (ABB-ES, 1995).
[4] Twice the average of detected concentrations for inorganic analytes at BSS01, BSS02, BSS03, and BSS04, including a duplicate at BSS02 (Arents soil unit).
[5] Florida Department of Environmental Protection (FDEP) memorandum dated July 5, 1994. Values presented are the lesser of the clean-up goals based on the hazard index for the child resident or the cancer risk for the aggregate resident.
[6] An exceedance of the FDEP clean-up goal is identified when the maximum detected analyte concentration is greater than the clean-up goal concentration Pursuant to FDEP guidance (July, 1994), an analyte that has a maximum detected concentration that is less than the background concentration is not listed as exceeding the FDEP clean-up goal.
[7] Value is the average of a sample and its duplicate.
[8] This analyte is not listed as exceeding the FDEP clean-up goal because the maximum detected concentration of the analyte is less than the background soil screening concentration.
[9] Value is for chromium VI.

Notes: HHCPC = human health chemical of potential concern.
FDEP = Florida Department of Environmental Protection.
μg/kg = micrograms per kilogram.
NA = not applicable.
NP = analyte is not presented in FDEP guidance.
ND = analyte is presented in FDEP guidance but no data is provided
PCB = polychlorinated biphenyl.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethylene
- = not detected in any background samples.

Table A-4
Subsurface Soil Comparison with Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Range of Reporting Limits	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Background Screening Concentration[4]	FDEP Clean-up Goals Based on Leachability[5]	Exceedance-?[6] (Yes/No)
Volatiles (µg/kg)								
1,2-Dichloroethene (total)	3/24	[7]3 to [7]350	5 to 28	145	No	NA	NP	NA
2-Butanone	1/24	6	11 to 54	6	No	NA	878	No
Acetone	4/24	46 to 220	11 to 150	169	No	NA	143	Yes
Methylene chloride	10/24	[7]2.5 to 10	5 to 28	6	No	NA	1.13	Yes
Trichloroethene	9/24	3 to 650	5 to 54	146	No	NA	1.46	Yes
Semivolatiles (µg/kg)								
2-Methylnaphthalene	1/24	21	360 to 410	21	No	NA	ND	NA
Benzo (a) pyrene	2/24	20 to 21	360 to 410	20.5	No	NA	2,200	No
Benzo (b) fluoranthene	6/24	23 to 49	360 to 410	32.4	No	NA	4,400	No
Benzo (g,h,i) perylene	2/24	19 to 21	360 to 410	20	No	NA	32,000	No
Butylbenzylphthalate	4/24	21 to 750	360 to 410	244	No	NA	24,200	No
Chrysene	1/24	46	360 to 410	46	No	NA	2,000	No
Diethylphthalate	1/24	23	360 to 410	23	No	NA	NP	NA
Dimethylphthalate	1/24	29	360 to 410	29	No	NA	NP	NA
Fluoranthene	2/24	[7]23.5 to 28	360 to 410	25.8	No	NA	21,300	No
Indeno (1,2,3-cd) pyrene	1/24	20	360 to 410	20	No	NA	24,000	No
Phenol	2/24	20 to 33	360 to 410	26.5	No	NA	NP	NA
Pyrene	2/24	21 to [7]23	360 to 410	22	No	NA	16,000	No
bis(2-Ethylhexyl) phthalate	8/24	23 to 600	360 to 410	108	No	NA	NP	NA
Pesticides/PCBs (µg/kg)								
4,4-DDD	2/24	0.99 to 3.1	0.6 to 4 1	2	No	NA	154	No
4,4-DDE	8/24	0.27 to [7]4.2	3.6 to 4.1	1 2	No	NA	880	No
4,4-DDT	1/24	0 31	2.25 to 4.1	0.31	No	NA	48.6	No
Aroclor-1248	2/24	[7]15.8 to 30	33 to 41	22.9	No	NA	NP	NA
Aroclor-1254	3/24	[7] 15 to 66	36 to 41	43.3	No	NA	NP	NA
Aroclor-1260	4/24	3 1 to 49	36 to 41	16.5	No	NA	NP	NA

See notes at end of table

Table A-4 (Continued)
Subsurface Soil Comparison with Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Range of Reporting Limits	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Background Screening Concentration[4]	FDEP Clean-up Goals Based on Leachability[5]	Exceedance?[6]- (Yes/No)
Heptachlor epoxide	1/24	1.5	0.4 to 2.1	1.5	No	NA	0.128	No
alpha-Chlordane	5/24	[7]1.25 to 19	1.8 to 2.1	6.8	No	NA	560	No
gamma-Chlordane	7/24	1 to 22	1.8 to 2.1	5.9	No	NA	560	No
Inorganics (mg/kg)								
Aluminum	24/24	882 to 15,300	40 to 140	6,150	No	11,200	ND	NA
Arsenic	5/24	0.75 to 1.9	2 to 2	1.1	Yes	1.64	ND	NA
Barium	22/24	1.6 to 15.6	40 to 40	7.1	No	16	NP	NA
Cadmium	1/24	0.93	1 to 1	0.93	No	-	ND	NA
Calcium	18/24	304 to 45,500	1,000 to 1,000	4,370	Yes	320	NP	NA
Chromium	24/24	[7]1.4 to 19.5	2 to 2	8.3	No	16	ND	NA
Cobalt	14/24	0.49 to [7]2.85	10 to 10	1	Yes	-	ND	NA
Copper	16/24	[7]0.525 to 2.1	5 to 5	0.84	No	1 16	ND	NA
Cyanide	2/23	1.7 to 2	0.5 to 0.5	1.9	No	-	NP	NA
Iron	24/24	191 to 4,420	20 to 20	1,030	No	2,840	ND	NA
Lead	24/24	1 6 to 55	0.6 to 0.6	7.6	No	14	ND	NA
Magnesium	18/24	39.7 to 339	1,000 to 1,000	189	No	268	NP	NA
Manganese	24/24	2.8 to 8	3 to 3	4.8	No	7.8	ND	NA
Mercury	4/24	0.12 to [7]0.13	0.1 to 0.1	0.13	No	1.1	NP	NA
Nickel	22/24	0 48 to 5	8 to 8	2.2	No	5.4	ND	NA
Potassium	18/24	33.6 to [7]277	1,000 to 1,000	103	No	152	NP	NA
Sodium	8/24	142 to 781	1,000 to 1,000	239	No	312	NP	NA
Thallium	2/24	2.1 to 2.6	2 to 2	2.4	Yes	-	NP	NA
Vanadium	24/24	[7]1.1 to 17	10 to 10	5.7	No	16	ND	NA

See notes at end of table.

Table A-4 (Continued)
Subsurface Soil Comparison with Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Range of Reporting Limits	Mean of Detected Concentrations[2]	Analyte HHCPC?[3] (Yes/No)	Background Screening Concentration[4]	FDEP Clean-up Goals Based on Leachability[5]	Exceedance-?[6](Yes/No)
Zinc	2/24	9.4 to 25 8	4 to 4	17.6	No	-	ND	NA

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed (16SB10S2, 16SB10S4, 16SB11S2, 16SB11S6, 16SB12S2, 16SB12S6, 16SB1S0, 16SB1S6, 16SB2S2, 16SB2S4, 16SB3S0, 16SB3S6, 16SB4S2, 16SB4S6, 16SB5S2, 16SB5S6, 16SB6S2, 16SB6S4, 16SB7S2, 16SB7S4, 16SB8S2, 16SB8S4, 16SB9S4, 16SB9S6, including duplicates at 16SB10S2, 16SB5S2, and 16SB7S2).

[2] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.

[3] HHCPCs were selected for subsurface soil as described in the baseline risk assessment (ABB-ES, 1995).

[4] Twice the average of detected concentrations for inorganic analytes at CEFBBMS1S0, CEFBBMS1S6, CEFBBMS2S2, CEFBBMS2S6, CEFBBMS312, CEFBBMS316, CEFBBMS4S2, CEFBBMS4S4, CEFBBMS5S2, CEFBBMS5S6, CEFBBMS610, CEFBBMS616, CEFBBMS7S0, CEFBBMS7S4, CEFBBMS8S2, CEFBBMS8S6, CEFBBMS910, and CEFBBMS916, including a duplicate at CEFBBMS7S0 (background).

[5] Florida Department of Environmental Protection (FDEP) memorandum dated July 5, 1994. Values presented are the clean-up goals based on leachability.

[6] An exceedance of the FDEP clean-up goal is identified when the maximum detected analyte concentration is greater than the clean-up goal concentration. Pursuant to FDEP guidance (July, 1994), an analyte that has a maximum detected concentration that is less than the background concentration is not listed as exceeding the FDEP clean-up goal

[7] Value is the average of a sample and its duplicate.

Notes: HHCPC = human health chemical of potential concern.
FDEP = Florida Department of Environmental Protection.
μg/kg = micrograms per kilogram.
NA = not applicable.
NP = FDEP clean-up criterion for this analyte not presented in guidance.
ND = analyte is presented in FDEP guidance but no criterion is provided.
PCB = polychlorinated biphenyl.
DDD = dichlorodiphenyldichloroethane.
DDE = dichlorodiphenyldichloroethylene.
DDT = dichlorodiphenyltrichloroethane.
mg/kg = milligrams per kilogram.
- = not detected in any background samples.

APPENDIX B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Table B-1
Synopsis of Potential Federal and State Chemical-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	Federal	
Clean Water Act (CWA) Regulations, Ambient Water Quality Criteria [40 CFR Part 131]	Ecological and health-based Federal Ambient Water Quality Criteria (AWQC) are non-enforceable guidelines used by states to set their state-specific water standards for surface water. The criteria established in this section are also used as part of the National Pollutant Discharge Elimination System (NPDES) process to limit the discharges of pollutants to surface water bodies.	**Relevant and Appropriate.** AWQC should be used in the determination of cleanup goals involving surface water in the absence of state water quality standards at OU7 If a groundwater treatment system is installed at OU7 and the discharge from this system is sent to an onsite surface water body, Ambient Water Quality Criteria (AWQC) would be considered in the National Pollutant Discharge Elimination System (NPDES) permitting process. However, although Florida is not currently recognized as a "delegated" state, the Federal government uses the State surface water standards as identified in Florida Administrative Code (FAC) 62-302, not the AWQC, for limiting the discharges of pollutants to the surface waters of the State because they are more stringent than the Federal standards and are better suited for Florida waters.
Safe Drinking Water Act (SDWA) Regulations, Maximum Contaminant Level Goals (MCLGs) [40 CFR Part 141]	Establishes drinking water quality goals at levels of no known or anticipated adverse health effects with an adequate margin of safety. These criteria do not consider treatment feasibility or cost elements	**Relevant and Appropriate.** If MCLGs are greater than zero, these standards should be met for groundwater or surface water that are current or potential sources of drinking water, assuming that the treatment technique chosen, is capable of achieving this standard.
SDWA Regulations, National Primary Drinking Water Standards, Maximum Contaminant Levels (MCLs) [40 CFR Part 141]	Establishes enforceable standards for potable water distribution systems for specific contaminants that have been determined to adversely effect human health. These standards, MCLs, are protective of human health for individual chemicals and are developed using MCLGs, available treatment technologies, and cost data. Requirements for Secondary Maximum Contaminant Levels (SMCLs) are located at 40 CFR Part 143.	**Relevant and Appropriate.** MCLs can be used for groundwater or surface waters that are potential drinking water sources (i.e., OU7's ground and surface waters). MCLs would be relevant and appropriate requirements for groundwater at OU7 where non-zero MCLGs have not been promulgated.

See notes at end of table

Table B-1 (Continued)
Synopsis of Potential Federal and State Chemical-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	State	
Chapter 62-302, FAC Florida Surface Water Standards - August, 1994	Defines classifications of surface waters, and establishes water quality standards (WQS) for surface water within the classifications. The State's antidegradation policy is also established in this rule. Sal Taylor Creek is classified as a Class III surface water.	**Relevant and Appropriate.** State WQS should be used in the determination of cleanup goals for surface waters. The minimum WQSs mandate that all surface waters of the State must be "free from" contaminants as described at FAC 62-302.500. Remedial alternatives that address surface water contamination or include an option for discharge of treated groundwater or surface water to surface water will consider Florida WQSs.
Chapter 62-520, FAC Groundwater Classes, Standards, and Exemptions - October, 1994	Establishes the groundwater classification system for the State and provides qualitative minimum criteria for groundwater based on the classification Groundwater at OU7 is classified as G-II, designated for potable water use. This rule adopts the Federal primary and secondary drinking water standards and establishes some State standards that are more stringent than Federal standards. Like Federal MCLs, these standards are considered ARARs for cleanup of groundwater that is a potential source of drinking water.	**Applicable.** Groundwater subject to this rule must be "free from" components of discharges in concentrations that are harmful to the organisms responsible for treatment or stabilization of the discharge; are carcinogenic, mutagenic, teratogenic, or toxic to human beings; are acutely toxic to indigenous species of significance to the aquatic community; pose a serious danger to the public health, safety, or welfare; create or constitute a nuisance; or impair the reasonable and beneficial uses of the adjacent waters. "Free from" is further defined in the Florida Groundwater Guidance Concentrations.
Chapter 62-550, FAC Florida Drinking Water Standards - September, 1994	Established to implement the Federal Safe Drinking Water Act by adopting the national primary and secondary drinking water standards and by creating additional rules to fulfill state and federal requirements for community water distribution systems.	**Relevant and Appropriate.** MCLs are commonly considered relevant and appropriate where surface water and groundwater is considered a potential potable water supply source.
Chapter 62-650, FAC Florida Water Quality Based Effluent Limitations - November, 1989	All activities and discharges, except dredge and fill, must meet effluent limitations based on technology or water quality. This rule also states that in addition to any other technology based groundwater effluent limitation requirements, all sources will also meet water quality based effluent limitations where necessary to meet groundwater quality standards	**Applicable.** All activities and discharges, other than dredge and fill activities, are required to meet effluent limitations based on technology (technology based effluent limit) and/or water quality (water quality based effluent limit), as defined by this rule. The substantive permitting requirement established in this rule is a potential relevant and appropriate requirement for remedial actions where treated water (either groundwater or surface water) is discharge to a surface water body (e.g., Sal Taylor Creek).

See notes on following page.

Table B-1 (Continued)
Synopsis of Potential Federal and State Chemical-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Notes from previous pages.

Notes: ARARs = Applicable and/or Relevant and Appropriate Requirements.
AWQC = Ambient Water Quality Criteria.
CFR = Code of Federal Regulation.
CWA = Clean Water Act.
FAC = Florida Administrative Code.
FDEP = Florida Department of Environmental Protection.
MCLs = Maximum Contaminant Levels.
MCLGs = Maximum Contaminant Level Goals.
NCP = National Contingency Plan
NPDES = National Pollutant Discharge Elimination System.
OU = Operable Unit.
SDWA = Safe Drinking Water Act.
WQS = Water Quality Standard.

Table B-2
Chemical-Specific Standards and Guidance

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Chemical Name	FEDERAL STANDARDS AND GUIDANCE						FLORIDA STANDARDS AND GUIDANCE							
	Safe Drinking Water Act (SDWA) (a)		CWA Ambient Water Quality Criteria (b)				Drinking Water Standards (c) (i)	Surface Water Quality Standards (d)					Soil Thermal Treatment Facility Criteria for Clean Soil (e)	
			For Protection of Human Health		For Protection of Aquatic Life									
	MCL (f) (µg/ℓ)	MCLG (f) (µg/ℓ)	Water and Fish Consumption (µg/ℓ)	Fish Consumption only (µg/ℓ)	Fresh Water Acute/Chronic (µg/ℓ)	Marine Acute/Chronic (µg/ℓ)	MCL (µg/ℓ)	Class I (µg/ℓ)	Class II (µg/ℓ)	Class III Fresh/Marine (µg/ℓ)	Class IV (µg/ℓ)	Class V (µg/ℓ)	Max TCLP (mg/ℓ)	Total (mg/kg)
VOLATILE ORGANICS														
1,1-Dichloroethane	--	--	--	--	--/--	--/--	--	--	--	--/--	--	--	--	--
1,1-Dichloroethene (1,1-dichloroethylene)	7	7	0.033	1 85	--/--	--/--	7	0.057 (41)	3.2 (22)		--	--	--	--
cis-1,2-Dichloroethene (cis-1,2-dichloroethylene)	70	70	--	--	--/--	--/--	70	--	--	--/--	--	--	--	--
trans-1,2-Dichloroethene (trans-1,2-dichloroethylene)	100	100	--	--	--/--	--/--	100	--	--	--/--	--	--	--	--
4-Methyl-2-pentanone (methyl isobutyl ketone)	--	--	--	--	--/--	--/--	--	--	--	--/--	--	--	--	--
Toluene	1,000	1,000	14,300	424,000	17,500/-- (6)	6,300/5,000 (6)	1,000	--	--	--/--	--	--	--	0.1 (14)
Total recoverable petroleum hydrocarbon	--	--	--	--	--/--	--/--	5,000 (h)(1)	--	--	--/--	--	--	--	10 (25)
1,1,1-Trichloroethane	200	200	18,400	1,030,000	--/--	31,200/--(6)	200	3,100	173,000		--	--	--	-
Trichloroethene (trichloroethylene)	5	0	2 7	80.7	45,000/21,900 (6)	2,000/-- (6)	3	2 7 (22)(-43)	80.7 (22)		--	--	--	--

See notes at end of table.

Table B-2 (Continued)
Chemical-Specific Standards and Guidance

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Chemical Name	FEDERAL STANDARDS AND GUIDANCE						FLORIDA STANDARDS AND GUIDANCE							
	Safe Drinking Water Act (SDWA) (a)		CWA Ambient Water Quality Criteria (b)				Drinking Water Standards (c) (i)	Surface Water Quality Standards (d)					Soil Thermal Treatment Facility Criteria for Clean Soil (e)	
			For Protection of Human Health		For Protection of Aquatic Life									
	MCL (f) (µg/ℓ)	MCLG (f) (µg/ℓ)	Water and Fish Consumption (µg/ℓ)	Fish Consumption only (µg/ℓ)	Fresh Water Acute/Chronic (µg/ℓ)	Marine Acute/Chronic (µg/ℓ)	MCL (µg/ℓ)	Class I (µg/ℓ)	Class II (µg/ℓ)	Class III Fresh/Marine (µg/ℓ)	Class IV (µg/ℓ)	Class V (µg/ℓ)	Max TCLP (mg/ℓ)	Total (mg/kg)
SEMIVOLATILE ORGANICS														
Diethylphthalate	--	--	350,000	1,800,000	--/--	--/--	--	--	--	--/--	--	--	--	--
bis(2-Ethylhexyl) phthalate (di-2-ethylhexylphthalate)	6 (g)	0 (g)	15,000	50,000	2000/-160 (12)(49)	400 (12)(49)	6	--	--	3/-- (18)	--	--	--	--
2-Methylnaphthalene	--	--	--	--	--/--	--/--	100 (h) (21)	--	--	--/--	--	--	--	--
Naphthalene	--	--	--	--	2,300/620 (6)	2,350/-- (6)	100 (h) (21)	--	--	--/--	--	--	--	--
Phenanthrene	--	--	--	--	30/6.3 (12)	7.7/4.6 (12)	--	(19)			--	--	--	--
Phenol	--	--	3,500	--	10,200/2,560 (6)	5,800/-- (6)	--	21,000	4,600,000 (33)		200		--	--
PESTICIDES/PCBS														
Endrin	2 (g)	2 (g)	1	--	0.18/0.0023	0.037/-0 0023 (49)	2	0.0023			--	--	--	--
METALS/INORGANICS														
Aluminum	500-200 (10)	--	(3)	(3)	(3)	(3)	200 (10)	--	1,500	--/1,500	--	--	--	--

See notes at end of table.

Table B-2 (Continued)
Chemical-Specific Standards and Guidance

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Chemical Name	FEDERAL STANDARDS AND GUIDANCE						FLORIDA STANDARDS AND GUIDANCE							
	Safe Drinking Water Act (SDWA) (a)		CWA Ambient Water Quality Criteria (b)				Drinking Water Standards (c) (i)	Surface Water Quality Standards (d)					Soil Thermal Treatment Facility Criteria for Clean Soil (e)	
			For Protection of Human Health		For Protection of Aquatic Life									
	MCL (f) (µg/ℓ)	MCLG (f) (µg/ℓ)	Water and Fish Consumption (µg/ℓ)	Fish Consumption only (µg/ℓ)	Fresh Water Acute/Chronic (µg/ℓ)	Marine Acute/Chronic (µg/ℓ)	MCL (µg/ℓ)	Class I (µg/ℓ)	Class II (µg/ℓ)	Class III Fresh/Marine (µg/ℓ)	Class IV (µg/ℓ)	Class V (µg/ℓ)	Max TCLP (mg/ℓ)	Total (mg/kg)
Metals/Inorganics--continued														
Antimony	6 (g)	6 (g)	146	45,000	88/30 (12)	1,500/500 (12)	6	14	4,300		--	--	--	--
Arsenic	50 (4)	--	0.0022	0.0175	--/--	--/--	50	50					5	10
Arsenic (III)	--	--	--	--	360/190	69/36	--	--	36	--/36	--	--	--	--
Arsenic (V)	--	--	--	--	850/-- (6)	2,319/-- (6)	--	--	--	--/--	--	--	--	--
Barium	2,000	2,000	1,000	--	--/--	--/--	2,000	1,000	--	--/--	--	--	100	4,940
Beryllium	4 (g)	4 (g)	0.0037	0.0641	130/5.3 (6)	--/--	4	0.0077 (22)	0.13 (22)		100 (46)	--	--	--
Cadmium	5	5	10	--	3.9/1.1 (11)	43/9.3	5	10 (17)	9 3	(17)/9.3	--	--	1	37
Calcium	--	--	--	--	--/--	--/--	--	--	--	--/--	--	--	--	--
Chromium	100	100	--	--	--/--	--/--	100	--	--	--/--	--	--	5	50
Chromium (III)	--	--	170,000	3,433,000	1,700/210 (11)	10,300/-- (6)	--	(17)	673,-000	(17)/673,000	(47)		--	--

See notes at end of table.

Table B-2 (Continued)
Chemical-Specific Standards and Guidance

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Chemical Name	FEDERAL STANDARDS AND GUIDANCE						FLORIDA STANDARDS AND GUIDANCE							
	Safe Drinking Water Act (SDWA) (a)		CWA Ambient Water Quality Criteria (b)				Drinking Water Standards (c) (i)	Surface Water Quality Standards (d)					Soil Thermal Treatment Facility Criteria for Clean Soil (e)	
			For Protection of Human Health		For Protection of Aquatic Life									
	MCL (f) (µg/ℓ)	MCLG (f) (µg/ℓ)	Water and Fish Consumption (µg/ℓ)	Fish Consumption only (µg/ℓ)	Fresh Water Acute/Chronic (µg/ℓ)	Marine Acute/Chronic (µg/ℓ)	MCL (µg/ℓ)	Class I (µg/ℓ)	Class II (µg/ℓ)	Class III Fresh/Marine (µg/ℓ)	Class IV (µg/ℓ)	Class V (µg/ℓ)	Max TCLP (mg/ℓ)	Total (mg/kg)
Metals/Inorganics--continued														
Chromium (VI)	--	--	50	--	16/11	1,100 /50	--	11	50	11/50	(47)		--	--
Cobalt	--	--	--	--	--/--	--/--	--	--	--	--/--	--	--	--	--
Copper	TT 100 (10)	1,300	--	--	18/12 (11)	2.9/-	1,000 (10)	500 (17)	2.9	500 (17)/ 2.9	5,000		--	--
Iron	300 (10)	--	300	--	--/1,000	--/--	300 (10)	0.3	300	1,000/ 300	1,000	--	--	--
Lead	15 (j) (38)	0	50	--	83/3.2 (11)	220/8.5	15	50 (17)	5.6	50 (17)/ 5.6	50		5	108
Magnesium	--	--	--	--	--/--	--/--	--	--	--	--/--	--	--	--	--
Manganese	50 (10)	-- (12)	50	100	--/--	--/--	50 (10)	--	100	--/--	--	--	--	--
Mercury	2	2	0 144	0.146	2.4/ 0.012	2.1/ 0 025	2	0.012	0.025	0.012/ 0 25	0.2			23
Nickel	100 (g)	100 (g)	13.4	100	1,400/ 160 (11)	75/8.3	100	(17)	8.3	(17)/- 8.3	100		--	--
Nitrate (as N)	10,000	10,000	10,000	--	--/--	--/--	10,000	10,000	--	--/--	--	--	--	--
Nitrite (as N)	1,000	1,000	--	--	--/--	--/--	--	1,000	--	--/--	--	--	--	--

See notes at end of table.

Table B-2 (Continued)
Chemical-Specific Standards and Guidance

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Chemical Name	FEDERAL STANDARDS AND GUIDANCE						FLORIDA STANDARDS AND GUIDANCE							
	Safe Drinking Water Act (SDWA) (a)		CWA Ambient Water Quality Criteria (b)				Drinking Water Standards (c) (i)	Surface Water Quality Standards (d)					Soil Thermal Treatment Facility Criteria for Clean Soil (e)	
			For Protection of Human Health		For Protection of Aquatic Life									
	MCL (f) (µg/ℓ)	MCLG (f) (µg/ℓ)	Water and Fish Consumption (µg/ℓ)	Fish Consumption only (µg/ℓ)	Fresh Water Acute/Chronic (µg/ℓ)	Marine Acute/Chronic (µg/ℓ)	MCL (µg/ℓ)	Class I (µg/ℓ)	Class II (µg/ℓ)	Class III Fresh/Marine (µg/ℓ)	Class IV (µg/ℓ)	Class V (µg/ℓ)	Max TCLP (mg/ℓ)	Total (mg/kg)
Nitrate + nitrite (both as N)	10,000	10,000	--	--	--/--	--/--	--	1,000	--	--/--	--	--	--	--
Potassium	--	--	--	--	--/--	--/--	--	--	--	--/--	--	--	--	--
Sodium	-- (13)	--	--	--	--/--	--/--	160,000	--	--	--/--	--	--	--	--
Thallium	2 (g)	0.5 (g)	13 (49)	48 (49)	1400/40 (6) (49)	2130/-- (6) (49)	2	13	48	48/48	--	--	--	--
Vanadium	--	--	--	--	--/--	--/--	--	--	--	--/--	--	--	--	--
Zinc	5,000 (10)	--	--	--	120/110 (11)	95/86	5,000 (10)	1 0 (17)	86	1 0 (17)/86	1,000		--	--

Sources:
(a) U.S. Environmental Protection Agency (USEPA), SDWA National Primary Drinking Water Regulations per 40 CFR 141: MCLs and MCLGs.
(b) USEPA, Draft "Water Quality Criteria Summary", Office of Science and Technology, Health and Ecological Criteria Division, Washington, D.C.
(c) Florida Administrative Code, 62-550, "Safe Drinking Water Act", September, 1994.
(d) Florida Administrative Code, 62-302, "Surface Water Quality Standards", amended August, 1994.
(e) Florida Administrative Code, 62-775, "Soil Thermal Treatment Facilities", November, 1992.
(f) USEPA, "Drinking Water Standards and Health Advisories", Office of Water, Washington, DC, November, 1991.
(g) USEPA, "National Primary and Secondary Drinking Water Regulations; Synthetic Organic Chemicals and Inorganic Chemicals; Final Rule", 57FR31777, July 17, 1992.
(h) Florida Administrative Code, 62-770, "Petroleum Contamination Site Cleanup Criteria", February, 1990.
(i) Florida Administrative Code, 62-550, "Safe Drinking Water Phase V Standards", January 1, 1993.
(j) USEPA, "Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper", 56FR26460, June 7, 1991.

See additional notes on following page.

Table B-2 (Continued)
Chemical-Specific Standards and Guidance

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Footnotes from previous pages.

(1) Standard indicated is the cleanup criteria for kerosene or mixed product analytical group at a POL site.
(2) Standard for aldicarb sulfone is 4 $\mu g/\ell$ and aldicarb sulfoxide is 2 $\mu g/\ell$.
(3) Criteria are pH dependent. Refer to 53FR33178.
(4) MCL for arsenic currently under review.
(5) Secondary MCL of 8 $\mu g/\ell$ proposed for hexachlorocyclopentadiene.
(6) Insufficient data to develop criteria. Value presented is the Lowest Observed Effect Level (LOEL).
(7) Standard indicated is the standard for total trihalomethanes (i.e., the sum of concentrations of chloroform, bromodichloromethane, dibromochloromethane, and bromoform). Refer to 56FR3579 and Florida Administrative Code, 17-550.
(8) Proposed standard for aldicarb sulfone is 2 $\mu g/\ell$ and aldicarb sulfoxide is 4 $\mu g/\ell$.
(9) Treatment Technique (TT) requirement.
(10) Secondary MCL.
(11) Hardness dependent criteria (100 mg/ℓ $CaCO_3$ used).
(12) Proposed standard or criteria.
(13) No MCL has been set for sodium. However, a reporting level of 20 mg/ℓ has been established. Monitoring is required and data is reported to health officials to protect individuals on a highly restricted sodium diet.
(14) Standard indicated is for total Volatile Organic Aromatics (VOAs) (i.e., the sum of concentrations of benzene, toluene, ethylbenzene, and total xylene).
(15) Different levels are proposed (marine acute - 7.2 $\mu g/\ell$; marine chronic - 0.92 $\mu g/\ell$; freshwater acute - 0.92 $\mu g/\ell$).
(16) Not to exceed 1.3 $\mu g/\ell$ (Class II or Class III marine) or 3.0 $\mu g/\ell$ (Class III fresh water).
(17) Hardness-dependent (Values are in $\mu g/\ell$, with (ln H) = natural logarithm of the total hardness expressed as mg/ℓ calcium carbonate ($CaCO_3$)).

cadmium	$= e^{(0.7852(\ln H)-3.49)}$	lead	$= e^{(1.273(\ln H)-4.705)}$
chromium (III)	$= e^{(0.819(\ln H)+1.561)}$	nickel	$= e^{(0.846(\ln H)-1.1645)}$
copper	$= e^{(0.8545(\ln H)-1.465)}$	zinc	$= e^{(0.8473(\ln H)+0.7614)}$

(18) Standard indicated is for phthalate esters.
(19) Polycyclic aromatic hydrocarbons (PAHs) (i.e., the sum of concentrations of acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene) shall not exceed 0.0028 $\mu g/\ell$ (Class I) or 0.031 $\mu g/\ell$ (Class II) measured at annual average flow conditions.
(20) Standard includes $radium_{226+}$ and excludes radon and uranium.
(21) Standard indicated is the cleanup criteria for the sum of naphthalene and methylnaphthalene.
(22) At average annual flow conditions.
(23) This standard is pH dependent; 7.8 pH used. Refer to 51FR43666.
(24) Units for asbestos MCLs are millions of fibers per liter for fibers longer than 10 micrometers.
(25) The cleanup level for total recoverable petroleum hydrocarbons in soil may be increased to 50 mg/kg if total PAHs are $\leq$ 6 mg/kg and total Volatile Organic Halocarbons (VOHs) are $\leq$ 0.05 mg/kg.
(26) Not to exceed 0.004 $\mu g/\ell$ (Class II or Class III marine) or 0.0043 $\mu g/\ell$ (Class III fresh water) at any time.
(27) Not to exceed 0.001 $\mu g/\ell$ at any time.
(28) Not to exceed 0.0019 $\mu g/\ell$ at any time.
(29) Not to exceed 0.0036 $\mu g/\ell$ (Class II or Class III marine) or 0.0038 $\mu g/\ell$ (Class I or Class III fresh water) at any time.

Table B-2 (Continued)
Chemical-Specific Standards and Guidance

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Footnotes--continued

(30) Not to exceed 0.16 $\mu g/\ell$ (Class II or Class III marine) or 0.08 $\mu g/\ell$ (Class I or Class III fresh water) at any time.
(31) Not to exceed 0 03 $\mu g/\ell$ (Class II or Class III marine) or 0.014 $\mu g/\ell$ (Class I or Class III fresh water) at any time.
(32) This standard is pH dependent. Concentration limit ($\mu g/\ell$) = $e^{(1.005(pH)-5.29)}$, not to exceed 30 at any time. [Not to exceed 8.2 $\mu g/\ell$ at average annual flow conditions. See source (d), above.]
(33) Phenolic compounds as listed - Total chlorinated phenols, including trichlorophenols, and chlorinated creosols shall not exceed 50 $\mu g/\ell$.
(34) Standard indicated is for chlorinated benzenes as a group.
(35) Standard indicated is for chlorinated naphthalenes as a group.
(36) Fluoride also has a secondary MCL of 2,000 $\mu g/\ell$
(37) The given value is tentative, based on current data or other information. It is anticipated that this value will be proposed in the near future.
(38) The MCL for lead is a treatment technique; however, an action level for lead of 15 $\mu g/\ell$ measured at the tap in the recommended value to propose as a preliminary cleanup goal.
(39) Not to exceed the hardness dependent criteria (see Note 17) or 10 $\mu g/\ell$ at any time.
(40) Refer to Class III standards. Use marine values for predominantly marine waters and freshwater standards for predominantly fresh waters.
(41) Not to exceed 0.057 $\mu g/\ell$ at average flow conditions or 7 $\mu g/\ell$ at any time.
(42) This standard is pH dependent. Concentration limit ($\mu g/\ell$) = $e^{(1.005(pH)-5.29)}$, not to exceed 30 at any time.
(43) Not to exceed 3 $\mu g/\ell$ at any time.
(44) Not to exceed 0.0043 $\mu g/\ell$ at any time.
(45) This value is not specific to a particular configuration of 1,3-dichloropropene. The given value is tentative, based on current data or other information. It is anticipated this value will be proposed in the near future.
(46) [illegible] to exceed 100 $\mu g/\ell$ when hardness is less than or equal to 240 mg/ℓ or 500 $\mu g/\ell$ when hardness is greater than 250 mg/ℓ.
(47) For Chromium
(48) Values taken from the Draft "Quality Criteria for Water." The values will be updated as the standards become final, which is expected in early 1995.
(49) These values were established by the National Toxics Rule, 59FR60848, December 22, 1994.

Notes:
Class I = potable water supplies.
Class II = shellfish propagation or harvesting.
Class III = recreation, fish & wildlife propagation.
Class IV = agricultural water supplies.
Class V = navigation utility industrial.
CWA = Clean Water Act.
MCL = maximum contaminant level.
MCLG = maximum contaminant level goal.
mg/kg = milligrams per kilogram.
mg/ℓ = milligrams per liter
mrem/yr = millirem per year.
pCi/ℓ = picocuries per liter.
SDWA = Safe Drinking Water Act.
TCLP = Toxicity Characteristic Leachate Procedure.
TT = treatment technique.
USEPA = U.S. Environmental Protection Agency.
$\mu g/\ell$ = micrograms per liter.
$\mu g/kg$ = micrograms per kilogram.

Table B-3
Comparison with Criteria, Surficial Aquifer Groundwater

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Federal MCL[4]	Florida Standard[5]	Florida Guidance Concentration[6]	Exceedance?[7] (Yes/No)
Volatiles (μg/ℓ)							
1,1,1-Trichloroethane	1/21	[8]3,000 to [8]3,000	3,000	200	200	200	Yes[13,14,15]
1,1-Dichloroethane	1/21	1 to 1	1	NA	NA	700	No
1,1-Dichloroethene	1/21	[8]400 to[8]400	400	7	7	7	Yes[13,14,15]
1,2-Dichloroethene (total)	2/21	270 to [8]12,500	6,360	[9]70	[9]70	[9]70	Yes[13,14,15]
4-Methyl-2-pentanone	1/16	1 to 1	1	NA	NA	350	No
Trichloroethene	7/21	12 to [8]630	238	5	3	3	Yes[13,14,15]
Semivolatiles (μg/ℓ)							
2-Methylnaphthalene	1/21	[8]2.75 to [8]2.75	2.8	NA	NA	NA	NA
Diethylphthalate	2/21	1 to 1	1	NA	NA	5,600	No
Naphthalene	1/21	[8]3.5 to [8]3 5	3.5	NA	NA	6.8	No
Phenanthrene	1/21	3 to 3	3	NA	NA	10	No
Phenol	3/21	0.8 to [8]1.45	1.1	NA	NA	10	No
bis(2-Ethylhexyl) phthalate	17/21	0.5 to [8]20.5	5.7	6	6	6	Yes[13,14,15]
Pesticides/PCBs (μg/ℓ)							
Endrin	1/20	0 02 to 0.02	0.02	2	2	2	No
Inorganics (μg/ℓ)							
Aluminum	12/21	[8]176 to [8]7,970	1,480	[10]200	[11]200	200	Yes[13,14,15]
Antimony	3/21	2.2 to [8] 16.0	7.3	6	6	6	Yes[13,14,15]
Arsenic	10/21	3.6 to 56.2	13.2	50	50	50	Yes[13,14,15]
Barium	21/21	6.5 to 108	27.5	2,000	2,000	2,000	No
Cadmium	1/21	[8]3.3 to [8]3.3	3.3	5	5	5	No
Calcium	21/21	603 to [8]58,500	19,800	NA	NA	NA	NA
Chromium	4/21	2.2 to 7.9	4.8	100	100	100	No
Cobalt	3/21	[8]2 3 to 5.9	4.6	NA	NA	NA	NA
Copper	5/21	[8]2.1 to 3.8	3	[10]1,000	[11]1,000	1,000	No
Iron	20/20	[8]260 to 9,150	1,830	[10]300	[11]300	300	Yes[13,14,15]

See notes at end of table.

Table B-3 (Continued)
Comparison with Criteria, Surficial Aquifer Groundwater

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Federal MCL[4]	Florida Standard[5]	Florida Guidance Concentration[6]	Exceedance?[7] (Yes/No)
Inorganics ($\mu g/\ell$)--continued							
Lead	1/21	[8]2.55 to [8]2.55	2.6	[12]15	15	15	No
Magnesium	21/21	254 to 28,000	8,190	NA	NA	NA	NA
Manganese	18/20	[8]4.9 to 56.8	27.4	[10]50	[11]50	50	Yes[13,14,15]
Mercury	1/21	1 to 1	1	2	2	2	No
Nickel	2/21	[8]11 to 12.5	11.8	100	100	100	No
Potassium	21/21	125 to [8]4,470	806	NA	NA	NA	NA
Sodium	21/21	[8]2,670 to [8]31,700	7,510	NA	NA	NA	NA
Thallium	3/21	6 to 6.3	6.2	2	2	2	Yes[13,14,15]
Vanadium	13/21	1.1 to 14.3	4.1	NA	NA	49	No
Zinc	8/21	[8]16.0 to 89.5	40.4	[10]5,000	[11]5,000	5,000	No

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.
[4] Federal MCLs are taken from USEPA Drinking Water Regulations and Health Advisories (May 1994).
[5] Florida Standards are taken from Chapters 1 and 2 (Primary and Secondary Standards) of the FDEP Groundwater Guidance Concentrations (June 1994).
[6] Florida Guidance Concentrations are taken from Chapter 6 (Guidance Concentrations Index) of the FDEP Groundwater Guidance Concentrations (June 1994).
[7] An exceedance of the available criterion is identified when the maximum detected site concentration is greater than one or more of the criteria.
[8] Value is the average of a sample and its duplicate(s).
[9] Primary MCL is for cis-1,2-dichloroethene, detection concentrations are reported for the sum of cis- and trans-1,2-dichloroethene.
[10] Value is a Federal Secondary MCL.
[11] Value is a Florida Secondary MCL.
[12] Treatment technology action limit for lead in drinking water distribution system identified in the USEPA Drinking Water Standards and Health Advisories (May, 1994).
[13] The maximum detected concentration of the contaminant exceeds the Federal MCL.
[14] The maximum detected concentration of the contaminant exceeds the Florida Standard.
[15] The maximum detected concentration of the contaminant exceeds the Florida Guidance Concentration.

Notes: MCL = Maximum Contaminant Level.
$\mu g/\ell$ = micrograms per liter.
NA = not available.

Table B-4
Comparison with Criteria, Intermediate Aquifer Groundwater

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Federal MCL[4]	Florida Standard[5]	Florida Guidance Concentration[6]	Exceedance?[7] (Yes/No)
Semivolatiles (μg/ℓ)							
Di-n-butylphthalate	1/4	1 to 1	1	NA	NA	700	No
bis(2-Ethylhexyl) phthalate	4/4	1 to 10	5.5	6	6	6	Yes[10,11,12]
Inorganics (μg/ℓ)							
Antimony	2/4	3.1 to 10.3	6.7	6	6	6	Yes[10,11,12]
Barium	4/4	7 to 41.8	27.3	2,000	2,000	2,000	No
Calcium	4/4	9,160 to 63,400	49,300	NA	NA	NA	NA
Chromium	1/4	9.8 to 9.8	9 8	100	100	100	No
Copper	2/4	8 to 8.2	8.1	[8]1,000	[9]1,000	1,000	No
Iron	4/4	69.6 to 444	250	[8]300	[9]300	300	Yes[10,11,12]
Magnesium	4/4	16,000 to 28,700	24,500	NA	NA	NA	NA
Manganese	4/4	6 7 to 57.5	40.5	[8]50	[9]50	50	Yes[10,11,12]
Potassium	4/4	853 to 39,900	10,700	NA	NA	NA	NA
Sodium	4/4	8,050 to 30,600	14,800	NA	NA	NA	NA
Zinc	3/4	48.6 to 98.5	75.7	[8]5,000	[9]5,000	5,000	No

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.
[4] Federal Primary MCLs are taken from USEPA Drinking Water Regulations and Health Advisories (May 1994).
[5] Florida Primary Standards are taken from Chapters 1 and 2 (Primary and Secondary Standards) of the FDEP Groundwater Guidance Concentrations (June 1994)
[6] Florida Guidance Concentrations are taken from Chapter 6 (Guidance Concentrations Index) of the FDEP Groundwater Guidance Concentrations (June 1994).
[7] An exceedance of the criterion is identified when the maximum detected site concentration is greater than one or more criteria.
[8] Value is a Federal Secondary MCL.
[9] Value is a Florida Secondary MCL.
[10] The maximum detected concentration of the contaminant exceeds the Federal MCL.
[11] The maximum detected concentration of the contaminant exceeds the Florida Standard.
[12] The maximum detected concentration of the contaminant exceeds the Florida Guidance Concentration.

Notes: MCL = Maximum Contaminant Level.
μg/ℓ = micrograms per liter
NA = not available.

Table B-5
Synopsis of Potential Federal and State Location-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	Federal	
Endangered Species Act [50 CFR Part 402]	Requires remedial action to avoid jeopardizing the continued existence of Federally-listed endangered or threatened species. Requirements include notification to the USEPA and minimization of adverse effects to such endangered species.	**Applicable.** When choosing a remedial action, minimization of impact to endangered species existing in and around OU7 will be considered
National Environmental Policy Act (NEPA) Regulations; Protection of Wetland [Executive Order (EO 11990) and 40 CFR 6, Appendix A and 40 CFR 6 302(a)]	Requires that Federal agencies minimize the degradation, loss, or destruction of wetland, and preserve and enhance natural and beneficial values of wetland under EO 11990	**Applicable.** When choosing a remedial action, any possible impact to a wetland through discharge should be considered to ensure that degradation, loss, or destruction of wetland would be minimized
Protection of Floodplains, EO 11988	Federal agencies are required to reduce the risk of flood loss, to minimize impact of floods, and to restore and preserve the natural and beneficial values of floodplains.	**Applicable.** The potential effects of any action at OU7 will be evaluated to ensure that the planning and decision making reflect consideration of flood hazards and floodplains management, including restoration and preservation of natural, undeveloped floodplains.
	State	
Chapter 62-340, FAC Delineation of the Landward Extent of Wetland and Surface Waters	Provides a unified state-wide methodology for delineation of wetland and surface waters.	**Applicable.** The methodology defined in this rule is required for delineation of all wetland and surface waters at OU7.

Notes: ARARs = applicable and/or relevant and appropriate requirements.
CFR = Code of Federal Regulations
EO = Executive Order.
FAC = Florida Administrative Code.
NEPA = National Environmental Policy Act.
OU = operable unit.
USEPA = U.S. Environmental Protection Agency.

Table B-6
Synopsis of Potential Federal and State Action-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	Federal	
Clean Air Act (CAA) Regulations, Emissions Standards [40 CFR Part 50]	This rule provides emissions standards, which are promulgated to attain the National Ambient Air Quality Standards (NAAQSs), for hazardous air pollutants likely to cause an increase in mortality or a serious illness to humans.	**Relevant and Appropriate.** The substantive requirements for emissions standards and monitoring requirements promulgated in this rule are relevant and appropriate requirements for alternatives that involve the discharge to air (e g., air stripping) of pollutants regulated under the CAA. The state of Florida has jurisdiction for the implementation of these regulations through the State Implementation Plan.
CAA Regulations, New Source Performance Standards (NSPS) [40 CFR Part 60]	This rule establishes NSPS for specified sources that are similar to a source that has established NSPSs (such as air stripping technologies). The NSPSs limit the emissions of a number of different pollutants, including the six criteria pollutants list (for which NAAQSs are established) as well as fluorides, sulfuric acid mist, and total reduced sulfur (including hydrogen sulfide [H_2S]).	**Relevant and Appropriate.** This rule may be a relevant and appropriate requirement for a new source that is similar to a source that has established NSPSs (such as air stripping technologies). If it is determined that the remedy would create potential air impacts, the response action or the equipment for the response action may qualify as a new source; therefore, these requirements should be met.
Clean Water Act (CWA) Regulations, NPDES [40 CFR Parts 122 and 125]	Requires permits specifying the permissible concentration or level of contaminants in the effluent for the discharge of pollutants from any point source into waters of the United States.	**Applicable.** Treated groundwater from Superfund remedial actions that is discharged to onsite surface water must meet the substantive requirements of a NPDES permit, but would not have to meet the Resource Conservation and Recovery Act (RCRA) land disposal restriction levels, because discharges to surface waters that meet the requirements of an NPDES permit are exempt from the RCRA land disposal restrictions. Because the state of Florida is not recognized as "delegated" by the EPA, a facility discharging wastewater to the surface waters of the state would require a NPDES permit as well as a State wastewater discharge permit. When Florida becomes classified as a "delegated" state, a single permit will meet both Federal and State discharge requirements. All Federal NPDES permits must be certified by the state of Florida to confirm that Florida surface water standards are met.
CWA Regulations, National Pretreatment Standards [40 CFR Part 403]	Sets pretreatment standards through the National Categorical Standards or the General Pretreatment Regulations for the introduction of pollutants from non-domestic sources into Publicly Owned Treatment Works (POTWs) in order to control pollutants that pass through, cause interference, or are otherwise incompatible with treatment processes at a POTW.	**Applicable.** If groundwater is discharged to a POTW or the FOTW, the discharge must meet local limits imposed by the POTW. A discharge from a CERCLA site must meet the POTW's pretreatment standards in the effluent to the POTW. Discharge to a POTW is considered an offsite activity and is, therefore, subject to both the substantive and administrative requirements of this rule.

See notes at end of table.

Table B-6 (Continued)
Synopsis of Potential Federal and State Action-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	Federal--continued	
Federal Facilities Compliance Act of 1992 (HR 2194)	This Act amends the Solid Waste Disposal Act to clarify provisions concerning the application of certain requirements to federal facilities, such as providing a conditional exception to RCRA's domestic sewage exclusion for federally owned treatment works (FOTWs). In general, it allows state agencies and the U S. Environmental Protection Agency (EPA) to enforce hazardous waste laws at government sites.	**Applicable.** This Act expands the domestic sewage exclusion policy to FOTWs. Therefore, hazardous waste may enter the FOTW at OU7 and be excluded from coverage under the Solid Waste Disposal Act. In addition, when wastewater is considered a hazardous waste under RCRA, but is mixed with domestic waste as it flows through the sewer system to the FOTW, the FOTW would not be required to meet the additional regulatory requirements for a RCRA facility.
Occupational Safety and Health Act (OSHA) Regulations, General Industry Standards [29 CFR Part 1910]	Requires establishment of programs to assure worker health and safety at hazardous waste sites, including employee training requirements.	**Applicable.** Under 40 CFR 300.38, requirements apply to all response activities under the National Oil and Hazardous Substances Contingency Plan (NCP).
OSHA Regulations, Occupational Health and Safety Regulations [29 CFR Part 1910, Subpart Z]	Establishes permissible exposure limits for workplace exposure to a specific listing of chemicals.	**Applicable.** Standards are applicable for worker exposure to OSHA hazardous chemicals during remedial activities.
OSHA Regulations, Recordkeeping, Reporting, and Related Regulations [29 CFR Part 1904]	Provides recordkeeping and reporting requirements applicable to remedial activities.	**Applicable.** These requirements apply to all site contractors and subcontractors and must be followed during all site work.
OSHA Regulations, Health and Safety Standards [29 CFR Part 1926]	Specifies the type of safety training, equipment, and procedures to be used during site investigation and remediation.	**Applicable.** All phases of the remedial response project should be executed in compliance with this regulation.
RCRA Regulations, Contingency Plan and Emergency Procedures [40 CFR Part 264, Subpart D]	Outlines requirements for emergency procedures to be followed in the event of an emergency such as an explosion, fire, or other emergency event.	**Applicable.** The administrative requirements established in this rule should be met for remedial actions involving the management of hazardous waste. The groundwater at OU7 is considered a hazardous waste according to the "contained-in" rule.

See notes at end of table.

Table B-6 (Continued)
Synopsis of Potential Federal and State Action-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	Federal--continued	
RCRA Regulations, General Facility Standards [40 CFR Subpart B, 264.10-264.18]	Sets the general facility requirements including general waste analysis, security measures, inspections, and training requirements. Section 264.18 establishes that a facility located in a 100-year floodplain must be designed, constructed, and maintained to prevent washout of any hazardous wastes by a 100-year flood.	**Relevant and Appropriate.** If the remedial action involves construction of an onsite treatment facility, such as a groundwater treatment facility, the substantive requirements of this rule would be applicable requirements. A permitted treatment facility must be selected for offsite treatment. These regulations do not apply to the aboveground treatment or storage of hazardous waste before it is injected underground. However, this rule may be an applicable requirement for alternatives that do not involve groundwater reinjection.
RCRA Regulations, Identification and Listing of Hazardous Waste [40 CFR 261]	Defines those wastes subject to the regulation as hazardous wastes under 40 CFR Parts 262-265.	**Applicable.** These requirements define RCRA-regulated wastes, thereby delineating acceptable management approaches for listed and characteristically hazardous wastes that should be incorporated into the characterization and remediation elements of remedial response projects. Groundwater at OU7 that is contaminated with hazardous waste, is subject to these regulations because it "contains" hazardous waste. However, the groundwater must first be "generated" (i.e., pumped out of the ground) and be found to contain hazardous waste before the groundwater itself can be classified as a waste. If, as a result of treatment, the groundwater no longer contains hazardous waste, the groundwater would not be subject to the hazardous waste rules. A contained-in waste does not have to be delisted; it only has to "no longer contain" the hazardous waste. "No longer contains" is determined on a case-by-case basis.

See notes at end of table.

Table B-6 (Continued)
Synopsis of Potential Federal and State Action-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	Federal--continued	
RCRA Regulations, Land Disposal Restrictions (LDRs) [40 CFR Part 268]	Establishes restrictions on land disposal of hazardous wastes and provides standards for treatment of hazardous wastes prior to land disposal. Universal Treatment Standards (UTSs) for organic hazardous substances that are subject to LDRs became effective on December 19, 1994.	**Applicable.** Under the LDRs, treatment standards have been established for all listed wastes such as were released at OU7. Groundwater treatment residuals from Superfund remedial actions, such as spent carbon, that are contaminated with RCRA-listed waste for which treatment standards have been promulgated must either meet the LDRs or be delisted under RCRA before disposal. Groundwater treatment system residuals that exhibit the RCRA-hazardous waste toxicity characteristic will have to be treated until concentrations are below the characteristic levels established under RCRA before disposal once the LDRs for characteristic wastes become effective. Treated groundwater that is discharged to surface water must meet the substantive requirements of a NPDES permit, but would not have to meet the RCRA LDRs, because discharges to surface waters that meet the requirements of an NPDES permit are exempt from the RCRA LDRs. Therefore, groundwater itself is exempt from LDRs; however, the treatment residuals from the groundwater would be subject to LDRs and would need to be disposed of appropriately.
RCRA Regulations, Miscellaneous Units [40 CFR Part 264, Subpart X]	These standards are applicable to miscellaneous units not previously defined under existing RCRA regulations. Subpart X outlines performance requirements that miscellaneous units be designed, constructed, operated, and maintained to prevent releases to the subsurface, groundwater, and wetland that may have adverse effects on human health and the environment.	**Applicable.** The design of proposed treatment alternatives, not specifically regulated under other subparts of RCRA, must prevent the release of hazardous constituents and future impacts on the environment. This subpart would apply to onsite construction of any treatment facility that is not previously defined under the RCRA regulation.
RCRA Regulations, Preparedness and Prevention [40 CFR Part 264, Subpart C]	Outlines requirements for safety equipment and spill control for hazardous waste facilities. Facilities must be designed, maintained, constructed, and operated to minimize the possibility of an unplanned release that could threaten human health or the environment.	**Applicable.** Safety and communication equipment should be incorporated into all aspects of the remedial process and local authorities should be familiarized with site operations.
RCRA Regulations, Releases from Solid Waste Management Units [40 CFR Part 264, Subpart F]	Establishes the requirements for solid waste management units (SWMUs) at RCRA regulated TSDFs. The scope of the regulation encompasses groundwater protection standards, point of compliance, compliance period, and requirements for groundwater monitoring.	**Relevant and Appropriate.** This rule is a relevant and appropriate requirement for the treatment of hazardous waste (i.e., "generated" contaminated groundwater). This rule could be applicable if the site is designated as a SWMU. However, if the site is not a designated SWMU, but the hazardous waste contained onsite is the same as it would be at a SWMU, then this subpart would be considered relevant and appropriate.

See notes at end of table.

Table B-6 (Continued)
Synopsis of Potential Federal and State Action-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	Federal--continued	
RCRA Regulations, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities [40 CFR Part 264]	Establishes minimum national standards defining the acceptable management of hazardous wastes for owners and operators of facilities that treat, store, or dispose of hazardous wastes.	**Applicable.** If remedial actions involving management of RCRA wastes at an offsite Transportation, Storage, and Disposal Facility (TSDF) or if RCRA wastes are managed onsite, the requirements of this rule apply when groundwater is extracted.
RCRA Regulations, Use and Management of Containers [40 CFR Part 264, Subpart I]	Sets standards for the storage of containers of hazardous waste.	**Applicable.** This requirement would apply if a remedial alternative involves the storage of a hazardous waste (i.e., contaminated groundwater) in containers, prior to treatment. OU7 will have tanks, prior to treatment, that may be used to store a hazardous substance and would therefore require OU7 to comply with this subpart.
SDWA Regulations, Underground Injection Control Regulations [40 CFR Parts 144, 146, 147, and 1000]	Establishes minimum program and performance standards for underground injection programs. Technical criteria and standards for siting, operation, maintenance, reporting, and recordkeeping are included in Part 146. Also requires protection of underground sources of drinking water.	**Applicable.** Discharge of treated groundwater, by well injection, must be in accordance with all criteria and standards in these Federal regulations, as well as meet all State Underground Injection Control Program requirements. Treated groundwater must meet all SDWA standards for reinjection prior to well injection.
	State	
Chapter 62-2, FAC Florida Air Pollution Rules - October, 1992	Establishes permitting requirements for owners or operators of any source which emits any air pollutant. This rule also establishes ambient air quality standards for sulfur dioxide, PM_{10}, carbon monoxide, lead, and ozone.	**Applicable.** Although this rule is directly applicable to industrial polluters, these requirements are relevant and appropriate for a remedial action which could result in release of regulated contaminants to the atmosphere, such as may occur during air stripping or excavation, it may be subject to this regulation.
Chapter 62-4, FAC Florida Rules on Permits - November, 1994	Establishes procedures for obtaining permits for sources of pollution This rule also establishes a "mixing zone" rule for facilities that discharge wastewater into the surface waters of the State.	**Applicable.** These substantive requirements must be met during a CERCLA remediation. Through dilution, applying the "mixing zone" rule allows wastewater with higher concentrations of pollutants to be discharged into surface water, while still maintaining the Florida water quality standards. If OU7 chose to apply the "mixing zone" rule, a state "mixing zone" permit would be required according to this rule.
Chapter 62-25, FAC Florida Regulation of Stormwater Discharge - May, 1993	Establishes requirements for discharges of untreated stormwater to ensure protection of the surface water of the state.	**Applicable.** Remedial actions should consider the impact of construction of the discharge of untreated stormwater.
Chapter 62-28, FAC Florida Underground Injection Control Regulations - April, 1989	Establishes a State Underground Injection Control Program consistent with federal requirements and appropriate to the hydrogeology of Florida.	**Applicable.** These regulations should be considered if remedial actions as OU7 involve underground injection.

See notes at end of table.

Table B-6 (Continued)
Synopsis of Potential Federal and State Action-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	State--continued	
Chapter 62-272, FAC Ambient Air Quality Standards - December, 1994	Establishes ambient air quality standards necessary to protect human health and public welfare. It also establishes maximum allowable increases in ambient concentrations for subject pollutants to prevent significant deterioration of air quality in areas where ambient air quality standards are being met. Approved air quality monitoring methods are also specified.	**Applicable.** These ambient air quality standards should be met for remedial actions involving the possible release exposure of contaminants to the atmosphere.
Chapter 62-273, FAC Air Pollution Episodes - September, 1994	In order to prevent episode conditions (defined as a "condition which exists when meteorological conditions and rates of discharge of air pollutants combine to produce pollutant levels in the atmosphere which, if sustained, can lead to a substantial threat to the health of the people") from continuing or from developing into more severe conditions, action must be taken. This rule classifies an air episode as an air alert, warning or emergency and establishes criteria for determining the level of the air episode. It also establishes response requirements for each level	**Relevant and Appropriate.** Although this rule is directly applicable to industrial polluters, these requirements are relevant and appropriate for remedial actions that may result in the emission of sulfur dioxide, PM_{10}, carbon monoxide, ozone, or nitrogen dioxide to the atmosphere, these levels and response requirements should be reviewed.
Chapter 62-302, FAC Florida Surface Water Standards - August, 1994	Defines classifications of surface waters, and establishes water quality standards (WQSs) for surface water within the classifications. The State's antidegradation policy is also established in this rule.	**Applicable.** Remedial actions at OU7 that involve a discharge to a surface water of the State will consider surface WQSs.
Chapter 62-522, FAC Florida Groundwater Permitting and Monitoring Requirements - April, 1994	Establishes permitting and monitoring requirements for installations discharging to groundwater.	**Applicable.** The substantive requirements of this rule should be considered when discharge to groundwater is a possible remedial action If these requirements are met under another permit, a separate discharge permit may not be required
Chapter 62-532, FAC Florida Water Well Permitting and Construction Requirements - March, 1992	Establishes the minimum standards for the location, construction, repair, and abandonment of water wells. Permitting requirements and procedures are established.	**Applicable.** The substantive requirements for permitting should be met if remedial actions involve the construction, repair, or abandonment of monitoring, extraction, or injection wells
Chapter 62-730, FAC Florida Hazardous Waste Rules - October, 1993	Adopts, by reference, appropriate sections of 40 CFR and establishes minor additions to these regulations concerning the generation, storage, treatment, transportation, and disposal of hazardous wastes.	**Relevant and Appropriate.** The substantive permitting requirements for hazardous waste must be met where applicable for CERCLA remedial actions.

See notes at end of table.

Table B-6 (Continued)
Synopsis of Potential Federal and State Action-Specific ARARs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Standards and Requirements	Synopsis	Consideration in the Remedial Response Process
	State--continued	
Chapter 62-736, FAC Florida Rules on Hazardous Waste Warning Signs - July, 1991	Requires warning signs at NPL and FDEP identified hazardous waste sites to inform the public of the presence of potentially harmful conditions.	**Applicable.** This requirement should be met for sites which are on the NPL or which have been identified by the FDEP as potentially harmful. This is a CERCLA site; therefore, these requirements must be met.

Notes: ARARs = Applicable and/or Relevant and Appropriate Requirements.
AWQC = Ambient Water Quality Criteria.
CAA = Clean Air Act.
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
CFR = Code of Federal Regulations.
CWA = Clean Water Act
FAC = Florida Administrative Code
FOTW = Federally Owned Treatment Work.
H_2S = Hydrogen Sulfide.
LDRs = Land Disposal Restrictions.
MCLs = Maximum Contaminant Levels.
NAAQSs = National Ambient Air Quality Standards.
NCP = National Contingency Plan
NPDES = National Pollutant Discharge Elimination System
NSPS = New Source Performance Standards.
OSHA = Occupational Safety and Health Act
PM_{10} = Particulate Matter less than 10 micron in size.
POTWs = Publicly Owned Treatment Works.
ppmw = parts per million by weight.
RCRA = Resource Conservation and Recovery Act.
SDWA = Safe Drinking Water Act
SWMUs = Solid Waste Management Unit.
TBEL = Technology Based Effluent Limit.
TSDF = Transportation, Storage, and Disposal Facility.
USEPA = U.S. Environmental Protection Agency.
UTSs = Universal Treatment Standards.
WQBEL = Water Quality Based Effluent Limit.
WQS = Water Quality Standard.

Table B-7
Synopsis of Federal and State "To Be Considered" Documents

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Advisories and Guidance	Synopsis	Consideration in the Remedial Response Process
	Federal	
Clean Air Act (CAA) Regulations, National Ambient Air Quality Standards (NAAQSs) [40 CFR Part 50]	Establishes primary (health-based) and secondary (welfare-based) air quality standards for carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulfur oxides emitted from a major source of air emissions. The NAAQSs form the basis for all regulations promulgated under the CAA. However, the NAAQSs themselves are non-enforceable and are never ARARs.	Site remediation activities should comply with emission standards established to achieve NAAQs at OU7. The principal application of these standards is during remedial activities resulting in exposures to humans through dust and vapors
Safe Drinking Water Act (SDWA) Regulations, National Secondary Drinking Water Standards (SMCLs) [40 CFR Part 143]	Establishes welfare-based standards for public water systems for specific contaminants or water characteristics that may affect the aesthetic qualities of drinking water.	SMCLs are non-enforceable limits intended as guidelines for use by States in regulating water supplies.
USEPA Office of Drinking Water, Health Advisories	Health advisories are estimates of non-carcinogenic risk due to consumption of contaminated drinking water.	These advisories should be considered for contaminants in surface water and groundwater that is or could be used as a potable water source (i.e., OU7's ground and surface waters)
	State	
Chapter 62-611, FAC Florida Wetland Application Regulations - November, 1989	Sets requirements for discharge of domestic wastewater to wetland.	This rule mainly addresses the discharge of domestic wastewater to wetland. Discharge limits are established for CBOD, TSS, N, and phosphorus. This rule should be considered for remedial alternatives which would result in discharges to wetland where these limits may be approached.
Chapter 62-620, FAC Florida Wastewater Facility Permits	This rule establishes requirements for wastewater permits. It was published in November, 1994; however, it is not effective until Florida is recognized as a "delegated" state.	Upon delegation, facilities in Florida requiring a wastewater permit, will meet the permitting requirements under this rule. When Florida becomes a "delegated" state, facilities will be allowed to have a single permit to meet both Federal and State discharge requirements

See notes at end of table.

Table B-7 (Continued)
Synopsis of Federal and State "To Be Considered" Documents

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Advisories and Guidance	Synopsis	Consideration in the Remedial Response Process
	State--continued	
Groundwater Guidance Concentration, Bureau of Groundwater Protection - June, 1994	This document establishes maximum concentration levels of contaminants for groundwater in the state of Florida Groundwater with concentrations less than the listed values are considered "free from" contamination	The values provided in this document should be considered when determining cleanup levels for groundwater. These guidance values for groundwater are considered to be ARARs by the Florida Department of Environmental Protection (FDEP). However, by definition of ARARs in the National Contingency Plan (NCP), state requirements must be a state law or regulation; an environmental or facility siting law; promulgated; more stringent than the Federal requirement; identified in a timely manner; and consistently applied. All of these parameters must be met according to the NCP. The Groundwater Guidance Concentrations are not promulgated as law or regulation; however, it is recognized that the FDEP maintains the position that these guidance concentrations are considered ARARs

Notes: ARARs = Applicable and/or Relevant and Appropriate Requirements
CAA = Clean Air Act
CBOD = Carbonaceous Biological Oxygen Demand
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
CFR = Code of Federal Regulation
FAC = Florida Administrative Code
FDEP = Florida Department of Environmental Protection
FOTW = Florida Owned Treatment Work
N = Nitrogen
NAAQSs = National Ambient Air Quality Standards
OU = Operable Unit
POTWs = Publicly Owned Treatment Works
RCRA = Resource Conservation and Recovery Act
RI/FS = Remedial Investigation and Feasibility Study
SDWA = Safe Drinking Water Act
SMCLs = Secondary Drinking Water Standards
TSS = Total Suspended Solids
USEPA = U.S Environmental Protection Agency

APPENDIX C

DETERMINATION OF ACTION LEVELS AND TREATMENT LEVELS

Table C-1
Selected Groundwater Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte[1]	Federal MCL[2]	Florida Standard[3]	Florida Guidance Concentration[4]	Background Concentration[5]
Volatiles (µg/ℓ)				
1,1,1-Trichloroethane	200	200	200	NA
1,1-Dichloroethane	NA	NA	700	NA
1,1-Dichloroethene	7	7	7	NA
1,2-Dichloroethene (total)	[9]70	[9]70	[9]70	NA
4-Methyl-2-pentanone	NA	NA	350	NA
Trichloroethene	5	3	3	NA
Semivolatiles (µg/ℓ)				
2-Methylnaphthalene	NA	NA	NA	NA
Diethylphthalate	NA	NA	5,600	NA
Naphthalene	NA	NA	6.8	NA
Phenanthrene	NA	NA	10	NA
Phenol	NA	NA	10	NA
bis(2-Ethylhexyl)phthalate	6	6	6	NA
Pesticides (µg/ℓ)				
Endrin	2	2	2	NA
Inorganics (µg/ℓ)				
Aluminum	[10]200	[11]200	200	750
Antimony	6	6	6	ND
Arsenic	50	50	50	3
Barium	2,000	2,000	2,000	22.2
Cadmium	5	5	5	ND
Calcium	NA	NA	NA	12,600
Chromium	100	100	100	8.8
Cobalt	NA	NA	NA	ND
Copper	[10]1,000	[11]1,000	1,000	2.1
Iron	[10]300	[11]300	300	773
Lead	15	15	15	ND
Magnesium	NA	NA	NA	2,950
Manganese	[10]50	[11]50	50	18.2
Mercury	2	2	2	ND
Nickel	100	100	100	ND
Potassium	NA	NA	NA	584
Sodium	NA	NA	NA	5,090
Thallium	2	2	2	ND
Vanadium	NA	NA	49	2.7
Zinc	[10]5,000	[11]5,000	5,000	27.6

See notes on following page.

Table C-1 (Continued)
Selected Groundwater Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte[1]	Federal MCL[2]	Florida Standard[3]	Florida Guidance Concentration[4]	Background Concentration[5]

Notes from previous pages.

[1] Analytes listed are all those detected in unfiltered groundwater samples taken from the surficial aquifer at operable unit (OU) 7.
[2] Federal MCLs are taken from U.S. Environmental Protection Agency (USEPA) Drinking Water Regulations and Health Advisories (May 1994).
[3] Florida Standards are taken from Chapters 1 and 2 (Primary and Secondary Standards) of the Florida Department Environmental Protection (FDEP) Groundwater Guidance Concentrations (June 1994).
[4] Florida Guidance Concentrations are taken from Chapter 6 (Guidance Concentrations Index) of the FDEP Groundwater Guidance Concentrations (June 1994).
[5] Background concentration represents the mean of the detected chemicals in four background (upgradient) monitoring wells at OU 7 (CEF-16-13S, CEF-16-14D, CEF-16-15S, and CEF-16-16D).
[9] Primary MCL is for cis-1,2-Dichloroethene.
[10] Value is a Federal secondary MCL.
[11] Value is a Florida secondary MCL.

Notes: 1) Shading represents the selected groundwater (GW) criteria represented by the higher of the background concentration or the Florida Guidance Concentration.

MCL = maximum contaminant level.
$\mu g/\ell$ = micrograms per liter.
NA = not available.
ND = not detected.

Table C-2
Unfiltered Surficial Groundwater and Selected GW Criteria Comparison

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Maximum Detected Concentration	Selected GW Criteria[3]	Exceedance? (Yes/No)[4]
Volatiles (µg/ℓ)						
1,1,1-Trichloroethane	1/21	3,000	3,000	3,000	200	Yes
1,1-Dichloroethane	1/21	1	1	1	700	No
1,1-Dichloroethene	1/21	400	400	400	7	Yes
1,2-Dichloroethene (total)	2/21	270 to 12,500	6,360	12,450	70	Yes
4-Methyl-2-pentanone	1/16	1	1	1	350	No
Trichloroethene	7/21	12 to 630	238	630	3	Yes
Semivolatiles (µg/ℓ)						
2-Methylnaphthalene	1/21	2.75	2.8	2.8	NA	NA
Diethylphthalate	2/21	1 to 1	1	1	5,600	No
Naphthalene	1/21	3.5	3.5	3.5	6.8	No
Phenanthrene	1/21	3	3	3	10	No
Phenol	3/21	0.8 to 1.45	1.1	1.45	10	No
bis(2-Ethylhexyl)phthalate	17/21	0.5 to 20.5	5.7	20.5	6	Yes
Pesticides (µg/ℓ)						
Endrin	1/20	0.02	0.02	0.02	2	No
Inorganics (µg/ℓ)						
Aluminum	12/21	175 to 7,970	1,480	7,965	750	Yes
Antimony	3/21	2.2 to 16.05	7.3	16.05	6	Yes
Arsenic	10/21	3.6 to 56.2	13.2	56.2	50	Yes
Barium	21/21	6.5 to 108	27.5	108	2,000	No
Cadmium	1/21	3.3	3.3	3.3	5	No
Calcium	21/21	603 to 58,500	19,800	58,500	NA	NA
Chromium	4/21	2.2 to 7.9	4.8	7.9	100	No
Cobalt	3/21	2.3 to 5.9	4.6	5.9	NA	NA
Copper	5/21	2.1 to 3.8	3	3.8	1,000	No
Iron	20/20	260 to 9,150	1,830	9,150	773	Yes
Lead	1/21	2.55	2.6	2.55	15	No
Magnesium	21/21	254 to 28,000	8,190	28,000	NA	NA
Manganese	18/20	4.9 to 56.8	27.4	56.8	50	Yes
Mercury	1/21	1	1	1	2	No
Nickel	2/21	11 to 12.5	11.8	12.5	100	No
Potassium	21/21	125 to 4,470	806	4,470	NA	NA
Sodium	21/21	2,670 to 31,700	7,510	31,700	NA	NA
Thallium	3/21	6 to 6.3	6.2	6.3	2	Yes
Vanadium	13/21	1.1 to 14.3	4.1	14.3	49	No

See notes at end of table.

Table C-2 (Continued)
Unfiltered Surficial Groundwater and Selected GW Criteria Comparison

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Maximum Detected Concentration	Selected GW Criteria[3]	Exceedance? (Yes/No)[4]
Zinc	8/21	16.0 to 89.5	40.4	89.5	5.000	No

[1] Frequency of detection is the number of samples in which the analyte was detected divided by the total number of samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.
[3] Refer to shaded values in Table C-1.
[4] Exceedance indicates that the detected concentration of a chemical is at or above the selected groundwater criterion.

Notes: $\mu g/\ell$ = micrograms per liter.
GW = groundwater.
NA = not applicable.

Table C-3
Selected Surface Water Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte[1]	Florida Surface Water Standard[6]	Federal AWQC[7]	Background Concentration[8]
Volatiles (μg/ℓ)			
1,1,1-Trichloroethane	NA	31,200	ND
1,1-Dichloroethane	NA	NA	ND
1,1-Dichloroethene	[9]3.2	NA	ND
1,2-Dichloroethene (total)	NA	NA	ND
4-Methyl-2-pentanone	NA	NA	ND
Trichloroethene	[9]80.7	2,000	ND
Semivolatiles (μg/ℓ)			
2-Methylnaphthalene	NA	NA	ND
Diethylphthalate	NA	NA	ND
Naphthalene	NA	2,350	ND
Phenanthrene	[9]0.03	7.7	ND
Phenol	300	5,800	ND
bis(2-Ethylhexyl)phthalate	3	400	ND
Pesticides (μg/ℓ)			
Endrin	0.002	0.004	ND
Inorganics (μg/ℓ)			
Aluminum	1,500	NA	348
Antimony	4,300	1,500	ND
Arsenic	50	NA	1.9
Barium	NA	NA	14.3
Cadmium	9.3	43	ND
Calcium	NA	NA	33,000
Chromium	NA	10,300	ND
Cobalt	NA	NA	ND
Copper	2.9	2.9	ND
Iron	300	NA	381
Lead	5.6	220	2.9
Magnesium	NA	NA	1,280
Manganese	NA	NA	7.4
Mercury	0.25	2.1	ND
Nickel	8.3	75	ND
Potassium	NA	NA	1,560
Sodium	NA	NA	2,980
Thallium	6.3	2,130	ND
Vanadium	NA	NA	ND

See notes at end of table.

Table C-3 (Continued)
Selected Surface Water Criteria

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte[1]	Florida Surface Water Standard[6]	Federal AWQC[7]	Background Concentration[8]
Zinc	86	NA	18.4

[1] Analytes listed are all those detected in unfiltered groundwater samples taken from the surficial aquifer at Operable Unit (OU) 7.
[6] Florida Surface Water Standard taken from Chapter 62 (Surface Water Quality Standards) of the Florida Administrative Code (FAC 62-302), January 23, 1995.
[7] Federal Ambient Water Quality Criteria taken from U.S. Environmental Protection Agency (USEPA) Office of Guidance.
[8] Background concentration represents the concentrations of the detected chemicals in the background (upstream) surface water sample in Sal Taylor Creek (STCSWR1).

Notes: 1) Shading represents the selected surface water (SW) criteria represented by the higher of the background or the Florida Surface Water Standard (if neither the background nor the Florida Surface Water Standard was available, the Federal AWQC number was used to select the criterion).

AWQC = Ambient Water Quality Criteria.
$\mu g/\ell$ = micrograms per liter.
NA = not available.
ND = not detected.

Table C-4
Estimated Groundwater Quality and Selected SW Criteria Comparison

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Estimated Concentration in Extracted Groundwater[3]	Selected SW Criteria[4]	Exceedance (Yes/No) ?[5]
Volatiles (µg/ℓ)						
1,1,1-Trichloroethane	1/21	3,000	3,000	[6]165	31,200	No
1,1-Dichloroethane	1/21	1	1	[6]ND	NA	No
1,1-Dichloroethene	1/21	400	400	[6]33	3.2	Yes
1,2-Dichloroethene (total)	2/21	270 to 12,500	6,360	[6]697	NA	No
4-Methyl-2-pentanone	1/16	1	1	[6]ND	NA	No
Trichloroethene	7/21	12 to 630	238	[7]21,800	80.7	Yes
Semivolatiles (µg/ℓ)						
2-Methylnaphthalene	1/21	2.75	2.75	[6]0.03	NA	No
Diethylphthalate	2/21	1 to 1	1	[6]1	NA	No
Naphthalene	1/21	3.5	3.5	[6]0.22	2,350	No
Phenanthrene	1/21	3	3	[6]0.06	0.03	Yes
Phenol	3/21	0.8 to 1.45	1.1	[6]1.1	300	No
bis(2-Ethylhexyl)phthalate	17/21	0.5 to 20.5	5.7	[6]5.7	3	Yes
Pesticides (µg/ℓ)						
Endrin	1/20	0.02	0.02	[6]ND	0.002	No
Inorganics (µg/ℓ)						
Aluminum	12/21	176 to 7,970	1,480	[8]961	1,500	No
Antimony	3/21	2.2 to 16.0	7.3	[8]3	4,300	No
Arsenic	10/21	3.6 to 56.2	13.2	[8]17	50	No
Barium	21/21	6.5 to 108	27.5	[8]25	NA	NA
Cadmium	1/21	3.3	3.3	[8]1.3	9.3	No
Calcium	21/21	603 to 58,500	19,800	[8]17,900	NA	NA
Chromium	4/21	2.2 to 7.9	4.8	[8]3.8	10,300	No
Cobalt	3/21	2.3 to 5.9	4.6	[8]3.8	NA	No
Copper	5/21	2.1 to 3.8	3	[8]3.8	2.9	Yes

See notes at end of table.

Table C-4 (Continued)
Estimated Groundwater Quality and Selected SW Criteria Comparison

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Analyte	Frequency of Detection[1]	Range of Detected Concentrations	Mean of Detected Concentrations[2]	Estimated Concentration in Extracted Groundwater[3]	Selected SW Criteria[4]	Exceedance (Yes/No) ?[5]
Iron	20/20	260 to 9,150	1,828	[8]1,900	381	Yes
Lead	1/21	2.55	2.55	[8]1	5.6	No
Magnesium	21/21	254 to 28,000	8,188	[8]6,900	NA	NA
Manganese	18/20	4.9 to 56.8	27.4	[8]33.3	NA	NA
Mercury	1/21	1.0	1 0	[8]0.25	0.25	No
Nickel	2/21	11 to 12.5	11.8	[8]11.5	8.3	Yes
Potassium	21/21	125 to 4,470	806	[8]767	NA	NA
Sodium	21/21	2,670 to 31,700	7,500	[8]8,770	NA	NA
Thallium	3/21	6 to 6.3	6.2	[8]8.8	6.3	Yes
Vanadium	13/21	1.1 to 14.3	4.1	[8]2.8	NA	No
Zinc	8/21	16.0 to 89.5	40.4	[8]35.8	86	No

[1] Frequency of detection is the number of samples (from monitoring wells) in which the analyte was detected divided by the total number of samples analyzed.
[2] The average of detected concentrations is the arithmetic mean of all samples in which the analyte was detected. It does not include those samples in which the analyte was not detected.
[3] See Appendix D for calculations.
[4] Refer to shaded values in Table C-3.
[5] Exceedance indicates that the detected concentration of a chemical is at or above the selected SW criterion.
[6] Used Florida Department of Environmental Protection (FDEP) model with all ND = 0, Level IV data only (see Appendix D).
[7] Used average concentration of all detects and non-detects in Level IV and Aquaprobe data.
[8] Used FDEP model with all ND = IDL (see Appendix D).

Notes: SW = surface water.
$\mu g/\ell$ = micrograms per liter.
ND = not detected.
NA = not available.

APPENDIX D

ESTIMATED CHEMICAL CONCENTRATIONS IN EXTRACTED GROUNDWATER

Estimated Concentrations of Chemicals in Extracted Groundwater

Extraction System. The United States Geological Survey (USGS) evaluated a possible extraction system for removal of groundwater at Operable Unit 7. The system consisted of four extraction wells that are placed in strategic locations within the plume to capture groundwater exceeding the action level for trichloroethene (TCE). Each extraction well would remove groundwater at a rate of 5 gallons per minute (gpm); thus having a total system flow of 20 gpm. Each extraction well would have well screens extending to 60 feet below land surface. Although alternate extraction configurations may be used (e.g., 6 wells extracting 26 gpm), the estimate presented below is considered a reasonable approximation for the purposes of this FS.

Purpose of Estimate. The Feasibility Study (FS) for OU 7 at NAS Cecil Field includes five alternatives for control of contaminated groundwater. The five alternatives developed can be broken down into two broader categories of treatment: *in situ* and *ex situ*. *in situ* treatment involves treating the groundwater in place (i.e., within the plume). *Ex situ* treatment involves extracting groundwater from the aquifer for treatment. When the groundwater is extracted, the concentration of chemicals in the extracted water determines the type and amount of treatment necessary to meet discharge limitations. To estimate the concentration of chemicals in extracted groundwater, a modeling was performed. For TCE, confirmatory (level IV laboratory) and screening (Aquaprobe℠) data were used to predict the concentration in extracted groundwater (see Attachment C). For all other chemicals the following modeling was performed.

Description of Modeling. The model used to estimate the concentrations of chemicals in extracted groundwater from OU 7 was the Florida Department of Environmental Protection (FDEP) treatment system design contaminant concentration model (see Attachment A). This FDEP model, initially developed for petroleum contaminated sites, estimates the maximum chemical concentrations in extracted groundwater for remedial design purposes. The model uses the chemical concentrations in monitoring wells to estimate the chemical concentrations in extracted water.

The steps involved in defining how the monitoring and extraction wells overlap are:

(1) The extraction wells were drawn on a map of the plume at OU 7.

(2) Each monitoring well within the cone of influence of an extraction well was identified. Monitoring wells with well screens below 80 to 90 feet bls were not considered, because they are screened in the intermediate aquifer which is separated from the surficial aquifer with a layer of clay.

Each extraction well and the monitoring wells that would be influenced by the extraction well are listed in the table below:

Table D-1
Monitoring Wells Associated with Extraction Wells

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Extraction Well	Corresponding Monitoring Wells
Well 1	32S
	33D
	35S
	36I
	37D
Well 2	27I
	29S
	31DD
Well 3	7S
	10S
	12I
	13S
	15S
	19S
Well 4	17S
	21S
	22I

Next, all chemicals detected in groundwater at OU 7 were listed. The FDEP model was then used for these chemicals. The model uses a weight-averaging approach to determine the chemical concentration for each chemical at each extraction well. Then, the concentrations predicted at each well were averaged together (because the flow was the same for each well) to estimate the total concentration of a chemical in extracted groundwater. A safety factor of 1.25 was applied to the resulting concentration at each well before the final averaging. The formula for the weighted average is listed below:

$$Conc = \frac{\frac{C_1}{D_1} + \frac{C_2}{D_2} + \frac{C_3}{C_3} + \frac{C_N}{D_N}}{\frac{1}{D_1} + \frac{1}{D_2} + \frac{1}{D_3} + \frac{1}{D_N}}$$

With a Safety Factor:

$$C_{max} = 1.25 x Conc$$

The modeling is presented in Attachment B. The value of non-detect results from sampling and analysis of monitoring wells was taken as zero for this modeling effort.

APPENDIX D
ATTACHMENT A

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION
TREATMENT SYSTEM DESIGN CONTAMINANT CONCENTRATIONS

2.3 Treatment System Design Contaminant Concentrations

The following procedures may be used when establishing the maximum contaminant concentrations at the treatment unit for remedial design purposes. The preferred method is to use data obtained during pumping of the recovery well. A good, conservative rule of thumb is that maximum concentrations observed during pump operation will be less than half of the highest concentrations observed during static conditions. Actual concentrations may be as low as ten percent of the static condition concentrations.

If data are unavailable while pumping, maximum contaminant concentrations at the treatment unit may be estimated by calculating a weighted average of surrounding well contaminant concentrations under static conditions. The weighted average should be based on the inverse of the distances from the recovery well. When selecting well data to be used in the calculations, the following points should be considered:

1. The recovery well should be located near the area of highest concentrations. An exception to this point is when the recovery well is located near the leading edge of the plume. In this case, the highest contaminant levels may not be observed until after the system has operated for some time.

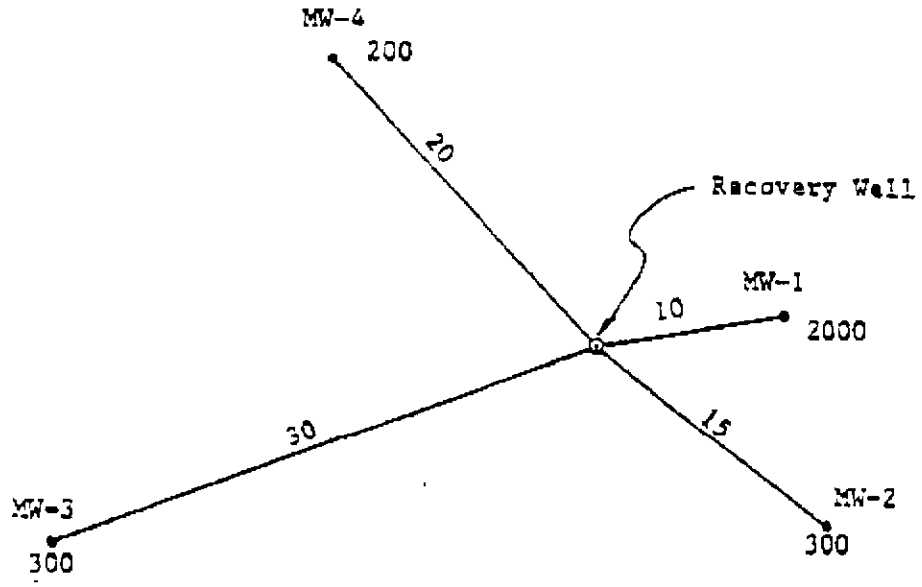
2. Selection of wells must be within the cone of influence of the recovery well.

3. Only wells with data from the same relative depth should be used.

4. Site conditions which might influence the assumption that concentrations decrease with distance must be considered.

For design purposes a 1.25 safety factor is recommended for sizing treatment equipment.

Example Problem: Given the following concentrations, c_n, and distances, d_n, from the recovery point, what is the maximum design concentration, C_{max}?



1. Determine the weighted average concentration at the recovery point by using the following formula.

$$C = \frac{(c_1/d_1 + c_2/d_2 + \ldots + c_n/d_n)}{(1/d_1 + 1/d_2 + \ldots + 1/d_n)}$$

therefore $$C = \frac{(2000/10 + 300/15 + 300/30 + 200/20)}{(1/10 + 1/15 + 1/30 + 1/20)}$$

$$C = 960$$

2. Apply a safety factor of 1.25 to calculate the C_{max} for design purposes.

$$C_{max} = 1.25C = 1200$$

3. The preceding formula may be set up in tabular form to solve for C as follows.

$1/d_n$	$1/d_n$	$\frac{1/d_n}{\Sigma(1/d_n)}$	X	c_n	=	C
1/10	.100	.400		2000		800
1/15	.067	.268		300		80
1/30	.033	.132		300		40
1/20	.050	.200		200		40
Total	.250	1.000		-		960

APPENDIX D
ATTACHMENT B

ESTIMATED CONCENTRATIONS IN OU 7 EXTRACTED GROUNDWATER

Organics

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

INSTRUCTIONS:
1. Input distance from monitoring well to recovery well in feet.
2. Spreadsheet calculates 1/distance.
3. Spreadsheet calculates 1/distance divided by the sum of all 1/distances. Total should equal 1.0.
4. Input contaminant concentration found in each well.
5. Spreadsheet multiplies column D times column F.
6. Spreadsheet totals column G.
7. Spreadsheet multiplies total by a safety factor of 1.25
8. Result is maximum contaminant concentration expected at a treatment unit. Use this number for remidial design purposes.

NOTES:
1. Use this method only if data obtained during a pumping test of the recovery well is unavailable.
2. Modify spreadsheet if using more or less than 5 wells.

Using 0 for ND's

updated on 2/24/95
see other sheet
added 3 chemicals

Average of all 4 extr wells (ug/l)

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= 1,1-DCE

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		0	0.00
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

32.5

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= TCE

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		470	145.12
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			146
					S.F. =	1.25
					Max. Conc.	181 ug/l

See Attachment C

~~105~~

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= bis(2-Ethylhexyl) pthalate

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		2	0.62
CEF-16-33D	60	0.017	0.371		8	2.96
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		13	1.38
CEF-16-37D	210	0.005	0.106		13	1.38
	TOTALS	0.045	1.000			6
					S.F. =	1.25
					Max. Conc.	8 ug/l

5.75

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Phenanthrene

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		0	0.00
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

0.06

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Endrin

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		~~0.1~~ 0	0.03
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		~~0.1~~ 0	0.01
CEF-16-36I	210	0.005	0.106		~~0.1~~ 0	0.01
CEF-16-37D	210	0.005	0.106		~~0.1~~ 0	0.01
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0.08 ug/l

as 0 for ND LDP ~~0.115~~ 0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= 1,1-Dichloroethane

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		0	0.00
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0.00 ug/l

0

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= 1,1,1-Trichloroethane

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		0	0.00
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0.00 ug/l

165

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= 1,2-Dichloroethene (total)

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		0	0.00
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0.00 ug/l

697

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Diethylpthalate

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		0	0.00
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0.00 ug/l

1.27

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Phenol

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		0	0.00
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0.00 ug/l

1.27

added

2-Methylnaphthalene 0.03 ug/l

4-Methyl-2-pentanone 0 ug/l

Naphthalene 0.22 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

INSTRUCTIONS:
1. Input distance from monitoring well to recovery well in feet.
2. Spreadsheet calculates 1/distance.
3. Spreadsheet calculates 1/distance divided by the sum of all 1/distances.
   Total should equal 1.0.
4. Input contaminant concentration found in each well.
5. Spreadsheet multiplies column D times column F.
6. Spreadsheet totals column G.
7. Spreadsheet multiplies total by a safety factor of 1.25
8. Result is maximum contaminant concentration expected at a treatment unit.
   Use this number for remidial design purposes.

NOTES:
1. Use this method only if data obtained during a pumping test of the recovery well is unavailable.
2. Modify spreadsheet if using more or less than 5 wells.

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= 1,1-DCE

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0	0.00
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
	TOTALS	0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= TCE

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		12	5.65
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
	TOTALS	0.016	1.000			6
					S.F. =	1.25
					Max. Conc.	7 ug/l

see Attachment C.

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= bis(2-Ethylhexyl) pthalate

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		7	3.30
CEF-16-29S	228	0.004	0.273		7	1.91
CEF-16-31DD	243	0.004	0.256		5	1.28
	TOTALS	0.016	1.000			6
					S.F. =	1.25
					Max. Conc.	8 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Phenanthrene

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0	0.00
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
	TOTALS	0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Endrin

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0.1	0.05
CEF-16-29S	228	0.004	0.273		0.1	0.03
CEF-16-31DD	243	0.004	0.256		0.1	0.03
TOTALS		0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0.13 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= 1,1-Dichloroethane

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0	0.00
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
TOTALS		0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= 1,1,1-Trichloroethane

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0	0.00
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
TOTALS		0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= 1,2-Dichloroethene (total)

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0	0.00
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
TOTALS		0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Diethylpthalate

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0	0.00
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
TOTALS		0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Phenol

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	008	0.471		0	0.00
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
	TOTALS	0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

INSTRUCTIONS:
1. Input distance from monitoring well to recovery well in feet.
2. Spreadsheet calculates 1/distance.
3. Spreadsheet calculates 1/distance divided by the sum of all 1/distances.
   Total should equal 1.0.
4. Input contaminant concentration found in each well.
5. Spreadsheet multiplies column D times column F.
6. Spreadsheet totals column G.
7. Spreadsheet multiplies total by a safety factor of 1.25
8. Result is maximum contaminant concentration expected at a treatment unit.
   Use this number for remidial design purposes.

NOTES:
1. Use this method only if data obtained during a pumping test of the recovery well is unavailable.
2. Modify spreadsheet if using more or less than 5 wells.

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= 1,1-DCE

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0	0.00
CEF-16-10S	45	0.022	0.176		590	103.71
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		0	0.00
CEF-16-19S	126	0.008	0.063		0	0.00
	TOTALS	0.126	1.000			103.71
					S.F. =	1.25
					Max. Conc.	130 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= TCE

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		500	77.55
CEF-16-10S	45	0.022	0.176		570	100.20
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		0	0.00
CEF-16-19S	126	0.008	0.063		0	0.00
	TOTALS	0.126	1.000			177.75
					S.F. =	1.25
					Max. Conc.	222 ug/l

see Attachment C

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= bis(2-Ethyl hexyl) pthalate

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0.5	0.08
CEF-16-10S	45	0.022	0.176		2	0.35
CEF-16-12I	15	0.067	0.527		3	1.58
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		0	0.00
CEF-16-19S	126	0.008	0.063		2	0.13
	TOTALS	0.126	1.000			2.14
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Phenanthrene

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0	0.00
CEF-16-10S	45	0.022	0.176		0	0.00
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		0	0.00
CEF-16-19S	126	0.008	0.063		3	0.19
	TOTALS	0.126	1.000			0.19
					S.F. =	1.25
					Max. Conc.	0.24 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Endrin

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0.1	0.02
CEF-16-10S	45	0.022	0.176		0.1	0.02
CEF-16-12I	15	0.067	0.527		0.1	0.05
CEF-16-13S	255	0.004	0.031		0.1	0.00
CEF-16-15S	165	0.006	0.048		0.1	0.00
CEF-16-19S	126	0.008	0.063		0.01	0.00
	TOTALS	0.126	1.000			0.09
					S.F. =	1.25
					Max. Conc.	0.12 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= 1,1-Dichloroethane

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0	0.00
CEF-16-10S	45	0.022	0.176		0	0.00
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		0	0.00
CEF-16-19S	126	0.008	0.063		0	0.00
	TOTALS	0.126	1.000			0.00
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= 1,1,1-Trichloroethane

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0	0.00
CEF-16-10S	45	0.022	0.176		3000	527.36
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		0	0.00
CEF-16-19S	126	0.008	0.063		0	0.00
	TOTALS	0.126	1.000			527.36
					S.F. =	1.25
					Max. Conc.	659 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= 1,2-Dichloroethene (total)

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		270	41.88
CEF-16-10S	45	0.022	0.176		12450	2188.55
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		0	0.00
CEF-16-19S	126	0.008	0.063		0	0.00
	TOTALS	0.126	1.000			2230.43
					S.F. =	1.25
					Max. Conc.	2788 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Diethylpthalate

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0	0.00
CEF-16-10S	45	0.022	0.176		0	0.00
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0.5	0.02
CEF-16-15S	165	0.006	0.048		0.9	0.04
CEF-16-19S	126	0.008	0.063		0	0.00
	TOTALS	0.126	1.000			0.06
					S.F. =	1.25
					Max. Conc.	0.07 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Phenol

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0	0.00
CEF-16-10S	45	0.022	0.176		0	0.00
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		1	0.05
CEF-16-19S	126	0.008	0.063		0	0.00
	TOTALS	0.126	1.000			0.05
					S.F. =	1.25
					Max. Conc.	0.06 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

INSTRUCTIONS:
1. Input distance from monitoring well to recovery well in feet.
2. Spreadsheet calculates 1/distance.
3. Spreadsheet calculates 1/distance divided by the sum of all 1/distances.
   Total should equal 1.0.
4. Input contaminant concentration found in each well.
5. Spreadsheet multiplies column D times column F.
6. Spreadsheet totals column G.
7. Spreadsheet multiplies total by a safety factor of 1.25
8. Result is maximum contaminant concentration expected at a treatment unit.
   Use this number for remidial design purposes.

NOTES:
1. Use this method only if data obtained during a pumping test of the recovery well is unavailable.
2. Modify spreadsheet if using more or less than 5 wells.

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= 1,1-DCE

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0	0.00
CEF-16-21S	192	0.005	0.342		0	0.00
CEF-16-22I	188	0.005	0.349		0	0.00
	TOTALS	0.015	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= TCE

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0	0.00
CEF-16-21S	192	0.005	0.342		0	0.00
CEF-16-22I	188	0.005	0.349		15	5.24
	TOTALS	0.015	1.000			5
					S.F. =	1.25
					Max. Conc.	7 ug/l

see Attachment C

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= bis(2-Ethyl hexyl) pthalate

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0	0.00
CEF-16-21S	192	0.005	0.342		0	0.00
CEF-16-22I	188	0.005	0.349		9	3.14
	TOTALS	0.015	1.000			3
					S.F. =	1.25
					Max. Conc.	4 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Phenanthrene

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0	0.00
CEF-16-21S	192	0.005	0.342		0	0.00
CEF-16-22I	188	0.005	0.349		0	0.00
	TOTALS	0.015	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Endrin

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0.1	0.03
CEF-16-21S	192	0.005	0.342		0.1	0.03
CEF-16-22I	188	0.005	0.349		0.1	0.03
	TOTALS	0.015	1.000			0
					S.F. =	1.25
					Max. Conc.	0.13 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= 1,1-Dichloroethane

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0	0.00
CEF-16-21S	192	0.005	0.342		0	0.00
CEF-16-22I	188	0.005	0.349		0	0.00
	TOTALS	0.015	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= 1,1,1-Trichloroethane

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0	0.00
CEF-16-21S	192	0.005	0.342		0	0.00
CEF-16-22I	188	0.005	0.349		0	0.00
	TOTALS	0.015	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= 1,2-Dichloroethene (total)

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0	0.00
CEF-16-21S	192	0.005	0.342		0	0.00
CEF-16-22I	188	0.005	0.349		0	0.00
	TOTALS	0.015	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Diethylpthalate

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		1	0.31
CEF-16-21S	192	0.005	0.342		1	0.34
CEF-16-22I	188	0.005	0.349		10	3.49
	TOTALS	0.015	1.000			4
					S.F. =	1.25
					Max. Conc.	5 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Phenol

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.306		1	0.31
CEF-16-21S	92	0.005	0.342		0.9	0.31
CEF-16-22I	188	0.005	0.349		10	3.49
	TOTALS	0.015	1.000			4
					S.F. =	1.25
					Max. Conc.	5 ug/l

Inorganics

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

w/ 0 as ND for
Barium
Iron
Magnesium
Manganese
Nickel
Sodium

INSTRUCTIONS:
1. Input distance from monitoring well to recovery well in feet.
2. Spreadsheet calculates 1/distance.
3. Spreadsheet calculates 1/distance divided by the sum of all 1/distances. Total should equal 1.0.
4. Input contaminant concentration found in each well.
5. Spreadsheet multiplies column D times column F.
6. Spreadsheet totals column G.
7. Spreadsheet multiplies total by a safety factor of 1.25
8. Result is maximum contaminant concentration expected at a treatment unit. Use this number for remidial design purposes.

NOTES:
1. Use this method only if data obtained during a pumping test of the recovery well is unavailable.
2. Modify spreadsheet if using more or less than 5 wells.

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Aluminum

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		292	90.16
CEF-16-33D	60	0.017	0.371		93.8	34.76
CEF-16-35S	204	0.005	0.109		304	33.13
CEF-16-36I	210	0.005	0.106		154	16.30
CEF-16-37D	210	0.005	0.106		60.6	6.42
	TOTALS	0.045	1.000			181
					S.F. =	1.25
					Max. Conc.	226 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Antimony

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		2	0.62
CEF-16-33D	60	0.017	0.371		2	0.74
CEF-16-35S	204	0.005	0.109		2	0.22
CEF-16-36I	210	0.005	0.106		2	0.21
CEF-16-37D	210	0.005	0.106		2	0.21
	TOTALS	0.045	1.000			2
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Arsenic

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		3	0.93
CEF-16-33D	60	0.017	0.371		4.3	1.59
CEF-16-35S	204	0.005	0.109		3.3	0.36
CEF-16-36I	210	0.005	0.106		4.5	0.48
CEF-16-37D	210	0.005	0.106		3	0.32
	TOTALS	0.045	1.000			4
					S.F. =	1.25
					Max. Conc.	5 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Barium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		19.5	6.02
CEF-16-33D	60	0.017	0.371		32.4	12.00
CEF-16-35S	204	0.005	0.109		16	1.74
CEF-16-36I	210	0.005	0.106		11.8	1.25
CEF-16-37D	210	0.005	0.106		35.1	3.72
	TOTALS	0.045	1.000			25
					S.F. =	1.25
					Max. Conc.	31 ug/l

25.25 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Beryllium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		1	0.31
CEF-16-33D	60	0.017	0.371		1	0.37
CEF-16-35S	204	0.005	0.109		1	0.11
CEF-16-36I	210	0.005	0.106		1	0.11
CEF-16-37D	210	0.005	0.106		1	0.11
	TOTALS	0.045	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Cadmium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		1	0.31
CEF-16-33D	60	0.017	0.371		1	0.37
CEF-16-35S	204	0.005	0.109		1	0.11
CEF-16-36I	210	0.005	0.106		1	0.11
CEF-16-37D	210	0.005	0.106		1	0.11
	TOTALS	0.045	1.000			1
					S.F. =	1.25
					Max. Conc	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Calcium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		1400	432.28
CEF-16-33D	60	0.017	0.371		55400	20527.04
CEF-16-35S	204	0.005	0.109		2530	275.71
CEF-16-36I	210	0.005	0.106		479	50.71
CEF-16-37D	210	0.005	0.106		54300	5748.42
	TOTALS	0.045	1.000			27034
					S.F. =	1.25
					Max. Conc.	33793 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Chromium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		2	0.62
CEF-16-33D	60	0.017	0.371		2	0.74
CEF-16-35S	204	0.005	0.109		2	0.22
CEF-16-36I	210	0.005	0.106		2	0.21
CEF-16-37D	210	0.005	0.106		2	0.21
	TOTALS	0.045	1.000			2
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Cobalt

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		2	0.62
CEF-16-33D	60	0.017	0.371		2	0.74
CEF-16-35S	204	0.005	0.109		2	0.22
CEF-16-36I	210	0.005	0.106		2	0.21
CEF-16-37D	210	0.005	0.106		2	0.21
	TOTALS	0.045	1.000			2
					S.F. =	1.25
					Max. Conc.	3 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Copper

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		2.1	0.65
CEF-16-33D	60	0.017	0.371		3.8	1.41
CEF-16-35S	204	0.005	0.109		2	0.22
CEF-16-36I	210	0.005	0.106		2	0.21
CEF-16-37D	210	0.005	0.106		2	0.21
	TOTALS	0.045	1.000			3
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Cyanide

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		10	3.09
CEF-16-33D	60	0.017	0.371		10	3.71
CEF-16-35S	204	0.005	0.109		10	1.09
CEF-16-36I	210	0.005	0.106		10	1.06
CEF-16-37D	210	0.005	0.106		10	1.06
	TOTALS	0.045	1.000			10
					S.F. =	1.25
					Max. Conc.	13 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Iron

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-33D	60	0.017	0.536		435	233.18
CEF-16-35S	204	0.005	0.158		2460	387.84
CEF-16-36I	210	0.005	0.153		2510	384.41
CEF-16-37D	210	0.005	0.153		299	45.79
	TOTALS	0.031	1.000			1051
					S.F. =	1.25
					Max. Conc.	1314 ug/l

2157 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Lead

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		1	0.31
CEF-16-33D	60	0.017	0.371		1	0.37
CEF-16-35S	204	0.005	0.109		1	0.11
CEF-16-36I	210	0.005	0.106		1	0.11
CEF-16-37D	210	0.005	0.106		1	0.11
	TOTALS	0.045	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Magnesium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		309	95.41
CEF-16-33D	60	0.017	0.371		27200	10078.26
CEF-16-35S	204	0.005	0.109		711	77.48
CEF-16-36I	210	0.005	0.106		480	50.81
CEF-16-37D	210	0.005	0.106		26200	2773.64
	TOTALS	0.045	1.000			13076
					S.F. =	1.25
					Max. Conc.	16345 ug/l

6910 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Manganese

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-33D	60	0.017	0.536		56.8	30.45
CEF-16-35S	204	0.005	0.158		140	22.07
CEF-16-36I	210	0.005	0.153		21.6	3.31
CEF-16-37D	210	0.005	0.153		45.5	6.97
	TOTALS	0.031	1.000			63
					S.F. =	1.25
					Max. Conc.	78 ug/l

33 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Mercury

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		1	0.31
CEF-16-33D	60	0.017	0.371		0.2	0.07
CEF-16-35S	204	0.005	0.109		0.2	0.02
CEF-16-36I	210	0.005	0.106		0.2	0.02
CEF-16-37D	210	0.005	0.106		0.2	0.02
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Nickel

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		0	0.00
CEF-16-33D	60	0.017	0.371		0	0.00
CEF-16-35S	204	0.005	0.109		0	0.00
CEF-16-36I	210	0.005	0.106		0	0.00
CEF-16-37D	210	0.005	0.106		0	0.00
	TOTALS	0.045	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Potassium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		859	265.23
CEF-16-33D	60	0.017	0.371		831	307.91
CEF-16-35S	204	0.005	0.109		260	28.33
CEF-16-36I	210	0.005	0.106		173	18.31
CEF-16-37D	210	0.005	0.106		939	99.41
	TOTALS	0.045	1.000			719
					S.F. =	1.25
					Max. Conc.	899 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Selenium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		4	1.24
CEF-16-33D	60	0.017	0.371		4	1.48
CEF-16-35S	204	0.005	0.109		4	0.44
CEF-16-36I	210	0.005	0.106		4	0.42
CEF-16-37D	210	0.005	0.106		4	0.42
	TOTALS	0.045	1.000			4
					S.F =	1.25
					Max. Conc.	5 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Silver

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		1	0.31
CEF-16-33D	60	0.017	0.371		1	0.37
CEF-16-35S	204	0.005	0.109		1	0.11
CEF-16-36I	210	0.005	0.106		1	0.11
CEF-16-37D	210	0.005	0.106		1	0.11
	TOTALS	0.045	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Sodium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		7030	2170.65
CEF-16-33D	60	0.017	0.371		8020	2971.60
CEF-16-35S	204	0.005	0.109		14600	1591.07
CEF-16-36I	210	0.005	0.106		5570	589.66
CEF-16-37D	210	0.005	0.106		8620	912.55
	TOTALS	0.045	1.000			8236
					S.F. =	1.25
					Max. Conc.	10294 ug/l

8764 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Thallium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		6	1.85
CEF-16-33D	60	0.017	0.371		6	2.22
CEF-16-35S	204	0.005	0.109		6	0.65
CEF-16-36I	210	0.005	0.106		6	0.64
CEF-16-37D	210	0.005	0.106		6	0.64
	TOTALS	0.045	1.000			6
					S.F. =	1.25
					Max. Conc.	8 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Vanadium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		3.5	1.08
CEF-16-33D	60	0.017	0.371		1	0.37
CEF-16-35S	204	0.005	0.109		1.6	0.17
CEF-16-36I	210	0.005	0.106		1	0.11
CEF-16-37D	210	0.005	0.106		1	0.11
	TOTALS	0.045	1.000			2
					S.F. =	1.25
					Max. Conc.	2 ug/l

Location= NAS Cecil Field OU 7 Extraction well 1
Contaminant= Zinc

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-32S	72	0.014	0.309		25.5	7.87
CEF-16-33D	60	0.017	0.371		89.5	33.16
CEF-16-35S	204	0.005	0.109		6.6	0.72
CEF-16-36I	210	0.005	0.106		11.6	1.23
CEF-16-37D	210	0.005	0.106		6.4	0.68
	TOTALS	0.045	1.000			44
					S.F. =	1.25
					Max. Conc.	55 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

INSTRUCTIONS:
1. Input distance from monitoring well to recovery well in feet.
2. Spreadsheet calculates 1/distance.
3. Spreadsheet calculates 1/distance divided by the sum of all 1/distances. Total should equal 1.0.
4. Input contaminant concentration found in each well.
5. Spreadsheet multiplies column D times column F.
6. Spreadsheet totals column G.
7. Spreadsheet multiplies total by a safety factor of 1.25
8. Result is maximum contaminant concentration expected at a treatment unit. Use this number for remidial design purposes.

NOTES:
1. Use this method only if data obtained during a pumping test of the recovery well is unavailable.
2. Modify spreadsheet if using more or less than 5 wells.

w/ 0 as ND for
Barium
Iron
Magnesium
Manganese
Nickel
Sodium

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Aluminum

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		184	86.70
CEF-16-29S	228	0.004	0.273		610	166.41
CEF-16-31DD	243	0.004	0.256		199	50.94
	TOTALS	0.016	1.000			304
					S.F. =	1.25
					Max. Conc.	380 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Antimony

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		2.2	1.04
CEF-16-29S	228	0.004	0.273		2	0.55
CEF-16-31DD	243	0.004	0.256		2	0.51
	TOTALS	0.016	1.000			2
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Arsenic

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		4.7	2.21
CEF-16-29S	228	0.004	0.273		3	0.82
CEF-16-31DD	243	0.004	0.256		3	0.77
	TOTALS	0.016	1.000			4
					S.F. =	1.25
					Max. Conc.	5 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Barium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		6.5	3.06
CEF-16-29S	228	0.004	0.273		4.7	1.28
CEF-16-31DD	243	0.004	0.256		41.8	10.70
	TOTALS	0.016	1.000			15
					S.F. =	1.25
					Max. Conc.	19 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Beryllium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		1	0.47
CEF-16-29S	228	0.004	0.273		1	0.27
CEF-16-31DD	243	0.004	0.256		1	0.26
	TOTALS	0.016	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Cadmium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		1	0.47
CEF-16-29S	228	0.004	0.273		1	0.27
CEF-16-31DD	243	0.004	0.256		1	0.26
	TOTALS	0.016	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Calcium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		1050	494.78
CEF-16-29S	228	0.004	0.273		557	151.96
CEF-16-31DD	243	0.004	0.256		63200	16177.34
	TOTALS	0.016	1.000			16824
					S.F. =	1.25
					Max. Conc.	21030 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Chromium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		2	0.94
CEF-16-29S	228	0.004	0.273		2.1	0.57
CEF-16-31DD	243	0.004	0.256		9.8	2.51
	TOTALS	0.016	1.000			4
					S.F. =	1.25
					Max. Conc.	5 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Cobalt

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		2	0.94
CEF-16-29S	228	0.004	0.273		2	0.55
CEF-16-31DD	243	0.004	0.256		2	0.51
	TOTALS	0.016	1.000			2
					S.F. =	1.25
					Max. Conc.	3 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Copper

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/di..n)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		2	0.94
CEF-16-29S	228	0.004	0.273		2	0.55
CEF-16-31DD	243	0.004	0.256		8.2	2.10
	TOTALS	0.016	1.000			4
					S.F. =	1.25
					Max. Conc.	4 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Cyanide

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		10	4.71
CEF-16-29S	228	0.004	0.273		10	2.73
CEF-16-31DD	243	0.004	0.256		10	2.56
	TOTALS	0.016	1.000			10
					S.F. =	1.25
					Max. Conc.	13 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Iron

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		2050	966.00
CEF-16-29S	228	0.004	0.273		1410	384.66
CEF-16-31DD	243	0.004	0.256		361	92.41
	TOTALS	0.016	1.000			1443
					S.F. =	1.25
					Max. Conc.	1804 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Lead

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		1	0.47
CEF-16-29S	228	0.004	0.273		1	0.27
CEF-16-31DD	243	0.004	0.256		1	0.26
	TOTALS	0.016	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Magnesium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		410	193.20
CEF-16-29S	228	0.004	0.273		286	78.02
CEF-16-31DD	243	0.004	0.256		26600	6808.82
	TOTALS	0.016	1.000			7080
					S.F. =	1.25
					Max. Conc.	8850 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Manganese

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		9.4	4.43
CEF-16-29S	228	0.004	0.273		8.2	2.24
CEF-16-31DD	243	0.004	0.256		53.8	13.77
	TOTALS	0.016	1.000			20
					S.F. =	1.25
					Max. Conc.	26 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Mercury

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0.2	0.09
CEF-16-29S	228	0.004	0.273		0.2	0.05
CEF-16-31DD	243	0.004	0.256		0.2	0.05
	TOTALS	0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Nickel

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		0	0.00
CEF-16-29S	228	0.004	0.273		0	0.00
CEF-16-31DD	243	0.004	0.256		0	0.00
	TOTALS	0.016	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Potassium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		133	62.67
CEF-16-29S	228	0.004	0.273		128	34.92
CEF-16-31DD	243	0.004	0.256		1190	304.61
	TOTALS	0.016	1.000			402
					S.F. =	1.25
					Max. Conc.	503 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Selenium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		4	1.88
CEF-16-29S	228	0.004	0.273		4	1.09
CEF-16-31DD	243	0.004	0.256		4	1.02
	TOTALS	0.016	1.000			4
					S.F. =	1.25
					Max. Conc.	5 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Silver

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		1	0.47
CEF-16-29S	228	0.004	0.273		1	0.27
CEF-16-31DD	243	0.004	0.256		1	0.26
	TOTALS	0.016	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Sodium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		3620	1705.81
CEF-16-29S	228	0.004	0.273		4900	1336.77
CEF-16-31DD	243	0.004	0.256		11600	2969.26
	TOTALS	0.016	1.000			6012
					S.F. =	1.25
					Max. Conc.	7515 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Thallium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		11.7	5.51
CEF-16-29S	228	0.004	0.273		6	1.64
CEF-16-31DD	243	0.004	0.256		6	1.54
	TOTALS	0.016	1.000			9
					S.F. =	1.25
					Max. Conc.	11 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Vanadium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		1	0.47
CEF-16-29S	228	0.004	0.273		1	0.27
CEF-16-31DD	243	0.004	0.256		1	0.26
	TOTALS	0.016	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 2
Contaminant= Zinc

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-27I	132	0.008	0.471		18.4	8.67
CEF-16-29S	228	0.004	0.273		7.2	1.96
CEF-16-31DD	243	0.004	0.256		48.6	12.44
	TOTALS	0.016	1.000			23
					S.F. =	1.25
					Max. Conc.	29 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

INSTRUCTIONS:
1. Input distance from monitoring well to recovery well in feet.
2. Spreadsheet calculates 1/distance.
3. Spreadsheet calculates 1/distance divided by the sum of all 1/distances. Total should equal 1.0.
4. Input contaminant concentration found in each well.
5. Spreadsheet multiplies column D times column F.
6. Spreadsheet totals column G.
7. Spreadsheet multiplies total by a safety factor of 1.25
8. Result is maximum contaminant concentration expected at a treatment unit. Use this number for remidial design purposes.

NOTES:
1. Use this method only if data obtained during a pumping test of the recovery well is unavailable.
2. Modify spreadsheet if using more or less than 5 wells.

W/ 0 as ND for
Barium
Iron
Magnesium
Manganese
Nickel
Sodium

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Aluminum

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		881	271.72
CEF-16-21S	192	0.005	0.342		1400	479.01
CEF-16-22I	188	0.005	0.349		743	259.63
	TOTALS	0.015	1.000			1010
					S.F. =	1.25
					Max. Conc.	1263 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Antimony

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		2	0.62
CEF-16-21S	192	0.005	0.342		2	0.68
CEF-16-22I	188	0.005	0.349		2	0.70
	TOTALS	0.015	1.000			2
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Arsenic

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		3	0.93
CEF-16-21S	192	0.005	0.342		3	1.03
CEF-16-22I	188	0.005	0.349		37.9	13.24
	TOTALS	0.015	1.000			15
					S.F. =	1.25
					Max. Conc.	19 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Barium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		18.9	5.83
CEF-16-21S	192	0.005	0.342		30.3	10.37
CEF-16-22I	188	0.005	0.349		16.1	5.63
	TOTALS	0.015	1.000			22
					S.F. =	1.25
					Max. Conc.	27 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Beryllium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		1	0.31
CEF-16-21S	192	0.005	0.342		1	0.34
CEF-16-22I	188	0.005	0.349		1	0.35
	TOTALS	0.015	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Cadmium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		1	0.31
CEF-16-21S	192	0.005	0.342		1	0.34
CEF-16-22I	188	0.005	0.349		1	0.35
	TOTALS	0.015	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Calcium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		4270	1316.94
CEF-16-21S	192	0.005	0.342		4780	1635.48
CEF-16-22I	188	0.005	0.349		686	239.71
	TOTALS	0.015	1.000			3192
					S.F. =	1.25
					Max. Conc.	3990 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Chromium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		2	0.62
CEF-16-21S	192	0.005	0.342		2	0.68
CEF-16-22I	188	0.005	0.349		2.4	0.84
	TOTALS	0.015	1.000			2
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Cobalt

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		2	0.62
CEF-16-21S	192	0.005	0.342		2	0.68
CEF-16-22I	188	0.005	0.349		5.5	1.92
	TOTALS	0.015	1.000			3
					S.F. =	1.25
					Max. Conc.	4 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Copper

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		2	0.62
CEF-16-21S	192	0.005	0.342		2.1	0.72
CEF-16-22I	188	0.005	0.349		2	0.70
	TOTALS	0.015	1.000			2
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Cyanide

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		10	3.08
CEF-16-21S	192	0.005	0.342		10	3.42
CEF-16-22I	188	0.005	0.349		10	3.49
	TOTALS	0.015	1.000			10
					S.F. =	1.25
					Max. Conc.	13 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Iron

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		1070	330.01
CEF-16-21S	192	0.005	0.342		281	96.14
CEF-16-22I	188	0.005	0.349		1160	405.34
	TOTALS	0.015	1.000			831
					S.F. =	1.25
					Max. Conc.	1039 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Lead

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		1	0.31
CEF-16-21S	192	0.005	0.342		1	0.34
CEF-16-22I	188	0.005	0.349		1	0.35
	TOTALS	0.015	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Magnesium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		584	180.12
CEF-16-21S	192	0.005	0.342		381	130.36
CEF-16-22I	188	0.005	0.349		573	200.22
	TOTALS	0.015	1.000			511
					S.F. =	1.25
					Max. Conc.	638 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Manganese

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		10	3.08
CEF-16-21S	192	0.005	0.342		5.4	1.85
CEF-16-22I	188	0.005	0.349		5.1	1.78
	TOTALS	0.015	1.000			7
					S.F. =	1.25
					Max. Conc.	8 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Mercury

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0.2	0.06
CEF-16-21S	192	0.005	0.342		0.2	0.07
CEF-16-22I	188	0.005	0.349		0.2	0.07
	TOTALS	0.015	1.000			0
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Nickel

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		0	0.00
CEF-16-21S	192	0.005	0.342		0	0.00
CEF-16-22I	188	0.005	0.349		12.5	4.37
	TOTALS	0.015	1.000			4
					S.F. =	1.25
					Max. Conc.	5 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Potassium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		125	38.55
CEF-16-21S	192	0.005	0.342		274	93.75
CEF-16-22I	188	0.005	0.349		177	61.85
	TOTALS	0.015	1.000			194
					S.F. =	1.25
					Max. Conc.	243 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Selenium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		4	1.23
CEF-16-21S	192	0.005	0.342		4	1.37
CEF-16-22I	188	0.005	0.349		4	1.40
	TOTALS	0.015	1.000			4
					S.F. =	1.25
					Max. Conc.	5 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Silver

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		1	0.31
CEF-16-21S	192	0.005	0.342		1	0.34
CEF-16-22I	188	0.005	0.349		1	0.35
	TOTALS	0.015	1.000			1
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Sodium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		3000	925.25
CEF-16-21S	192	0.005	0.342		2600	889.59
CEF-16-22I	188	0.005	0.349		4980	1740.17
	TOTALS	0.015	1.000			3555
					S.F. =	1.25
					Max. Conc.	4444 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Thallium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		6	1.85
CEF-16-21S	192	0.005	0.342		6	2.05
CEF-16-22I	188	0.005	0.349		6	2.10
	TOTALS	0.015	1.000			6
					S.F. =	1.25
					Max. Conc.	8 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Vanadium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0.005	0.308		2.5	0.77
CEF-16-21S	192	0.005	0.342		4.1	1.40
CEF-16-22I	188	0.005	0.349		3.3	1.15
	TOTALS	0.015	1.000			3
					S.F. =	1.25
					Max. Conc.	4 ug/l

Location= NAS Cecil Field OU 7 Extraction well 4
Contaminant= Zinc

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-17S	213	0 005	0.308		12.1	3.73
CEF-16-21S	192	0.005	0.342		17.7	6.06
CEF-16-22I	188	0.005	0.349		13.9	4.86
	TOTALS	0.015	1.000			15
					S.F. =	1.25
					Max. Conc.	18 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

INSTRUCTIONS:
1. Input distance from monitoring well to recovery well in feet.
2. Spreadsheet calculates 1/distance.
3. Spreadsheet calculates 1/distance divided by the sum of all 1/distances. Total should equal 1.0.
4. Input contaminant concentration found in each well.
5. Spreadsheet multiplies column D times column F.
6. Spreadsheet totals column G.
7. Spreadsheet multiplies total by a safety factor of 1.25
8. Result is maximum contaminant concentration expected at a treatment unit. Use this number for remidial design purposes.

NOTES:
1. Use this method only if data obtained during a pumping test of the recovery well is unavailable.
2. Modify spreadsheet if using more or less than 5 wells.

W/ 0 as ND for
Barium
Iron
Magnesium
Manganese
Nickel
Sodium

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Aluminum

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		188	29.16
CEF-16-10S	45	0.022	0.176		4830	849.05
CEF-16-12I	15	0.067	0.527		1170	617.01
CEF-16-13S	255	0.004	0.031		1160	35.98
CEF-16-15S	165	0.006	0.048		112	5.37
CEF-16-19S	126	0.008	0.063		689	43.26
	TOTALS	0.126	1.000			1579.84
					S.F. =	1.25
					Max. Conc.	1975 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Antimony

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		2	0.31
CEF-16-10S	45	0.022	0.176		2	0.35
CEF-16-12I	15	0.067	0.527		2	1.05
CEF-16-13S	255	0.004	0.031		2	0.06
CEF-16-15S	165	0.006	0.048		2	0.10
CEF-16-19S	126	0.008	0.063		2	0.13
	TOTALS	0.126	1.000			2.00
					S.F. =	1.25
					Max. Conc.	3 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Arsenic

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		3	0.47
CEF-16-10S	45	0.022	0.176		3	0.53
CEF-16-12I	15	0.067	0.527		56.2	29.64
CEF-16-13S	255	0.004	0.031		3	0.09
CEF-16-15S	165	0.006	0.048		3	0.14
CEF-16-19S	126	0.008	0.063		3	0.19
	TOTALS	0.126	1.000			31.06
					S.F. =	1.25
					Max. Conc.	39 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Barium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		11	1.71
CEF-16-10S	45	0.022	0.176		23.9	4.20
CEF-16-12I	15	0.067	0.527		20.2	10.65
CEF-16-13S	255	0.004	0.031		24.7	0.77
CEF-16-15S	165	0.006	0.048		8.5	0.41
CEF-16-19S	126	0.008	0.063		29.5	1.85
	TOTALS	0.126	1.000			19.59
					S.F. =	1.25
					Max. Conc.	24 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Beryllium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		1	0.16
CEF-16-10S	45	0.022	0.176		1	0.18
CEF-16-12I	15	0.067	0.527		1	0.53
CEF-16-13S	255	0.004	0.031		1	0.03
CEF-16-15S	165	0.006	0.048		1	0.05
CEF-16-19S	126	0.008	0.063		1	0.06
	TOTALS	0.126	1.000			1.00
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Cadmium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		1	0.16
CEF-16-10S	45	0.022	0.176		2.4	0.42
CEF-16-12I	15	0.067	0.527		1	0.53
CEF-16-13S	255	0.004	0.031		1	0.03
CEF-16-15S	165	0.006	0.048		1	0.05
CEF-16-19S	126	0.008	0.063		1	0.06
	TOTALS	0.126	1.000			1.25
					S.F. =	1.25
					Max. Conc.	2 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Calcium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		16600	2574.77
CEF-16-10S	45	0.022	0.176		31800	5590.04
CEF-16-12I	15	0.067	0.527		1330	701.39
CEF-16-13S	255	0.004	0.031		1390	43.12
CEF-16-15S	165	0.006	0.048		27000	1294.43
CEF-16-19S	126	0.008	0.063		1680	105.47
	TOTALS	0.126	1.000			10309.22
					S.F. =	1.25
					Max. Conc.	12887 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Chromium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		7.9	1.23
CEF-16-10S	45	0.022	0.176		4.3	0.76
CEF-16-12I	15	0.067	0.527		2	1.05
CEF-16-13S	255	0.004	0.031		2	0.06
CEF-16-15S	165	0.006	0.048		2	0.10
CEF-16-19S	126	0.008	0.063		2	0.13
	TOTALS	0.126	1.000			3.32
					S.F. =	1.25
					Max. Conc.	4 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Cobalt

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		2	0.31
CEF-16-10S	45	0.022	0.176		2.3	0.40
CEF-16-12I	15	0.067	0.527		5.9	3.11
CEF-16-13S	255	0.004	0.031		2	0.06
CEF-16-15S	165	0.006	0.048		2	0.10
CEF-16-19S	126	0.008	0.063		2	0.13
	TOTALS	0.126	1.000			4.11
					S.F. =	1.25
					Max. Conc.	5 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Copper

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		2.6	0.40
CEF-16-10S	45	0.022	0.176		4.8	0.84
CEF-16-12I	15	0.067	0.527		5	2.64
CEF-16-13S	255	0.004	0.031		2	0.06
CEF-16-15S	165	0.006	0.048		2.1	0.10
CEF-16-19S	126	0.008	0.063		2	0.13
	TOTALS	0.126	1.000			4.17
					S.F. =	1.25
					Max. Conc.	5 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Cyanide

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		10	1.55
CEF-16-10S	45	0.022	0.176		10	1.76
CEF-16-12I	15	0.067	0.527		10	5.27
CEF-16-13S	255	0.004	0.031		10	0.31
CEF-16-15S	165	0.006	0.048		10	0.48
CEF-16-19S	126	0.008	0.063		10	0.63
	TOTALS	0.126	1.000			10.00
					S.F. =	1.25
					Max. Conc.	13 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Iron

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		420	65.14
CEF-16-10S	45	0.022	0.176		907	159.44
CEF-16-12I	15	0.067	0.527		5960	3143.08
CEF-16-13S	255	0.004	0.031		868	26.93
CEF-16-15S	165	0.006	0.048		476	22.82
CEF-16-19S	126	0.008	0.063		2500	156.95
	TOTALS	0.126	1.000			3574.36
					S.F. =	1.25
					Max. Conc.	4468 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Lead

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		1	0.16
CEF-16-10S	45	0.022	0.176		1	0.18
CEF-16-12I	15	0.067	0.527		1	0.53
CEF-16-13S	255	0.004	0.031		1	0.03
CEF-16-15S	165	0.006	0.048		1	0.05
CEF-16-19S	126	0.008	0.063		1	0.06
	TOTALS	0.126	1.000			1.00
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Magnesium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		1920	297.80
CEF-16-10S	45	0.022	0.176		2730	479.90
CEF-16-12I	15	0.067	0.527		836	440.87
CEF-16-13S	255	0.004	0.031		2230	69.18
CEF-16-15S	165	0.006	0.048		1260	60.41
CEF-16-19S	126	0.008	0.063		1530	96.06
	TOTALS	0.126	1.000			1444.22
					S.F. =	1.25
					Max. Conc.	1805 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Manganese

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0	0.00
CEF-16-10S	45	0.022	0.176		52.9	9.30
CEF-16-12I	15	0.067	0.527		10.4	5.48
CEF-16-13S	255	0.004	0.031		4.7	0.15
CEF-16-15S	165	0.006	0.048		23.9	1.15
CEF-16-19S	126	0.008	0.063		5.5	0.35
	TOTALS	0.126	1.000			16.42
					S.F. =	1.25
					Max. Conc.	21 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Mercury

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0.2	0.03
CEF-16-10S	45	0.022	0.176		0.2	0.04
CEF-16-12I	15	0.067	0.527		0.2	0.11
CEF-16-13S	255	0.004	0.031		0.2	0.01
CEF-16-15S	165	0.006	0.048		0.2	0.01
CEF-16-19S	126	0.008	0.063		0.2	0.01
	TOTALS	0.126	1.000			0.20
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Nickel

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		0	0.00
CEF-16-10S	45	0.022	0.176		0	0.00
CEF-16-12I	15	0.067	0.527		0	0.00
CEF-16-13S	255	0.004	0.031		0	0.00
CEF-16-15S	165	0.006	0.048		0	0.00
CEF-16-19S	126	0.008	0.063		0	0.00
	TOTALS	0.126	1.000			0.00
					S.F. =	1.25
					Max. Conc.	0 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Potassium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		632	98.03
CEF-16-10S	45	0.022	0.176		4210	740.06
CEF-16-12I	15	0.067	0.527		325	171.39
CEF-16-13S	255	0.004	0.031		376	11.66
CEF-16-15S	165	0.006	0.048		292	14.00
CEF-16-19S	126	0.008	0.063		1650	103.59
	TOTALS	0.126	1.000			1138.74
					S.F. =	1.25
					Max. Conc.	1423 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Selenium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		4	0.62
CEF-16-10S	45	0.022	0.176		4	0.70
CEF-16-12I	15	0.067	0.527		4	2.11
CEF-16-13S	255	0.004	0.031		4.2	0.13
CEF-16-15S	165	0.006	0.048		4	0.19
CEF-16-19S	126	0.008	0.063		4	0.25
	TOTALS	0.126	1.000			4.01
					S.F. =	1.25
					Max. Conc.	5 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Silver

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		1	0.16
CEF-16-10S	45	0.022	0.176		1	0.18
CEF-16-12I	15	0.067	0.527		1	0.53
CEF-16-13S	255	0.004	0.031		1	0.03
CEF-16-15S	165	0.006	0.048		1	0.05
CEF-16-19S	126	0.008	0.063		1	0.06
	TOTALS	0.126	1.000			1.00
					S.F. =	1.25
					Max. Conc.	1 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Sodium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		7290	1130.73
CEF-16-10S	45	0.022	0.176		30800	5414.25
CEF-16-12I	15	0.067	0.527		6100	3216.91
CEF-16-13S	255	0.004	0.031		2940	91.20
CEF-16-15S	165	0.006	0.048		3500	167.80
CEF-16-19S	126	0.008	0.063		3510	220.36
	TOTALS	0.126	1.000			10241.24
					S.F. =	1.25
					Max. Conc.	12802 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Thallium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		6	0.93
CEF-16-10S	45	0.022	0.176		6	1.05
CEF-16-12I	15	0.067	0.527		6	3.16
CEF-16-13S	255	0.004	0.031		6	0.19
CEF-16-15S	165	0.006	0.048		6	0.29
CEF-16-19S	126	0.008	0.063		6	0.38
	TOTALS	0.126	1.000			6.00
					S.F. =	1.25
					Max. Conc.	8 ug/l

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Vanadium

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		1.4	0.22
CEF-16-10S	45	0.022	0.176		11.7	2.06
CEF-16-12I	15	0.067	0.527		1.1	0.58
CEF-16-13S	255	0.004	0.031		2.6	0.08
CEF-16-15S	165	0.006	0.048		2.7	0.13
CEF-16-19S	126	0.008	0.063		1.6	0.10
	TOTALS	0.126	1.000			3.16
					S.F. =	1.25
					Max. Conc.	4 ug/l

NAS CECIL FIELD OU 7 MAXIMUM CONTAMINANT CONCENTRATIONS

Location= NAS Cecil Field OU 7 Extraction well 3
Contaminant= Zinc

monitoring well(n)	distance to recovery well (ft)	1/dist	1/dist/ sum(1/dist)	X	conc(n) (ug/l)	=conc
CEF-16-7S	51	0.020	0.155		24.7	3.83
CEF-16-10S	45	0.022	0.176		46	8.21
CEF-16-12I	15	0.067	0.527		34.	18.25
CEF-16-13S	255	0.004	0.031		8.8	0.27
CEF-16-15S	165	0.006	0.048		3	0.14
CEF-16-19S	126	0.008	0.063		27.7	1.74
	TOTALS	0.126	1.000			32.44
					S.F. =	1.25
					Max. Conc.	41 ug/l

APPENDIX D
ATTACHMENT C

ESTIMATED CONCENTRATION OF TCE IN EXTRACTED GROUNDWATER

Average TCE Concentration in Groundwater, Screening Results

SCREENING BOREHOLE	SAMPLING INTERVAL	CONC. OF TCE	AVG. CONC. OF TCE IN BOREHOLE
GS-16-1	11 - 16	6300	
	18 - 22	1100	
	28-32	29	
			2476
GS-16-2	11 - 16	0	
	18 - 22	22	
	28-32	0	
	52 - 56	2	
			6
GS-16-3	11 - 16	0	
	18 - 22	0	
	28-32	3	
			1
GS-16-4	11 - 16	15	
	18 - 22	0	
	28-32	3	
			6
GS-16-6	11 - 16	0	
	18 - 22	0	
	28-32	0	
			0
GS-16-7	11 - 16	0	
	18 - 22	0	
	28-32	0	
	52 - 56	0	
			0
GS-16-8	11 - 16	24	
	18 - 22	96	
	28-32	17	
	52 - 56	36	
	72 - 76	74	
			49
GS-16-9	11 - 16	0	
	18 - 22	0	
			0
GS-16-10	11 - 16	0	
	18 - 22	0	
			0

Average TCE Concentration in Groundwater, Screening Results

SCREENING BOREHOLE	SAMPLING INTERVAL	CONC. OF TCE	AVG. CONC. OF TCE IN BOREHOLE
GS-16-11	11 - 16	0	
	18 - 22	0	
	28-32	0	
			0
GS-16-12	11 - 16	590000	
	18 - 22	110000	
	28-32	1500000	
	52 - 56	6400	
			551600
GS-16-14	11 - 16	130	
	18 - 22	29	
	28-32	2800	
			986
GS-16-15	11 - 16	0	
	18 - 22	0	
	28-32	55	
			18
GS-16-16	11 - 16	0	
	18 - 22	0	
	28-32	0	
			0
GS-16-19	11 - 16	0	
			0
GS-16-20	11 - 16	0	
	18 - 22	0	
	28-32	25	
	52 - 56	0	
	72 - 76	0	
			5
GS-16-21	11 - 16	0	
	18 - 22	0	
	28-32	0	
			0
GS-16-24	11 - 16	0	
	18 - 22	0	
	28-32	0	
	52 - 56	0	
	72 - 76	0	
			0

Average TCE Concentration in Groundwater, Screening Results

SCREENING BOREHOLE	SAMPLING INTERVAL	CONC. OF TCE	AVG. CONC. OF TCE IN BOREHOLE
GS-16-25	11 – 16	0	
	18 – 22	0	
	28–32	0	
	52 – 56	0	
			0
GS-16-26	11 – 16	0	
	18 – 22	190	
	28–32	17	
	52 – 56	0	
			52
GS-16-28	11 – 16	2	
	18 – 22	0	
	28–32	1400	
	52 – 56	36	
			360
GS-16-31	11 – 16	84	
	18 – 22	190	
			137
GS-16-32	11 – 16	0	
	18 – 22	0	
			0
GS-16-33	11 – 16	27	
	18 – 22	0	
			14
GS-16-34	11 – 16	640	
	18 – 22	0	
			320
GS-16-36	11 – 16	0	
	18 – 22	0	
	28–32	0	
			0
GS-16-43	11 – 16	2500	
	18 – 22	21	
	28–32	100	
			874

Average TCE Concentration in Groundwater, Screening Results

SCREENING BOREHOLE	SAMPLING INTERVAL	CONC. OF TCE	AVG. CONC. OF TCE IN BOREHOLE
32S		470	
33D		0	
35S		0	
36I		0	
37D		0	
27I		12	
29S		0	
31DD		0	
7S		500	
10S		630	
12I		0	
13S		0	
15S		0	
19S		0	
17S		0	
21S		0	
22I		15	
			96
AVERAGES		**21804**	**19893**

NOTES:

1) Only screening boreholes within the plume and within the zone of influence of the extraction system were considered.

2) The only data used in this spreadsheet was from sampling intervals where no water was observed in the auger prior to sampling.

3) Average concentrations were calculated two ways: once on the entire data set and once on the average concentration within each screening borehole.

APPENDIX E

EQUIPMENT SIZING AND ESTIMATED COSTS

TABLE OF CONTENTS

Appendix E
Equipment Sizing and Estimated Costs

Feasibility Study, Operable Unit 7
Naval Air Station Cecil Field
Jacksonville, Florida

Table	Title
E-1	Cost Summary Table, Alternative MM-1: No Action
E-2	Cost Summary Table, Alternative MM-2: Natural Attenuation
E-3	Cost Summary Table, Alternative MM-3: Groundwater Extraction, Treatment, and Discharge to Surface Water
E-4	Cost Summary Table, Alternative MM-4: Air Sparging
E-5	Cost Summary Table, Alternative MM-5: Groundwater Extraction, Pretreatment, and Discharge to FOTW

Table E-1 Cost Summary Table Alternative MM-1: No Action	
DIRECT COST	
Groundwater Monitoring Well Installation (2)	$3,000
Groundwater Use Restrictions	$10,000
Total Direct Cost	$13,000
INDIRECT COST	
Health and Safety (20%)	$2,600
Engineering (20%)	$2,600
Direct Cost Contingency (20%)	$2,600
Total Indirect Cost	$7,800
OPERATION AND MAINTENANCE COST (Annual)	
Annual Groundwater Monitoring	$24,000
Five-year Reviews and Five-year Groundwater Monitoring (annualized)	$12,600
Present Worth of O&M (over 30-year period)	$503,000
Total Cost	$524,000

PROJECT	COMP. BY	JOB NO.
Costs for [illegible] No Action Out	[illegible]	[illegible] TKG
	CHK. BY [illegible]	DATE [illegible]

① Five year site reviews – assume 6 (30-year site review)
– LOE for participation w/ preparation & presentation
N-1/2 [illegible]

28 hours/mtg [illegible] × $80/hr = $2520/mtg

3 [illegible] = $2160/mtg

– photocopying, etc for meeting presentation
$250/mtg × [illegible] = $1500/mtg

= travel/mtg is/supplies/travel
$250/mtg × 6 mtg = $1500/mtg
(see also 5yr gwater monitoring task ②)

total 5-yr review = $7680 ≈ $8,000 ✓

② Annual [illegible] monitoring – assume [illegible] per year for 30 years
– Analyze for inserted compounds
Assume 3/4 cost of full suite TCL/TAL
3/4 (1500/sample) × 16 samples = $18,000/yr

– LOE for sampling wells
26 hrs Associate engineer × $60/hr = $1560/yr
30 hrs tech × $45/hr = $1350/yr

ODCs for shipping samples $225/yr
– sampling equipment, supplies, expendables $1500/yr

– LOE for summary data report
4 hrs for mid-level engineer × $60/hr = $240/yr
12 hrs for junior-level engineer × $45/hr = $540/yr
– ODC's for report ≈ 100 pages × 30 copies ($0.1) = $300/yr

Σ GW mon costs/yr $24,000/yr ✓

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PROJECT	COMP. BY	JOB NO.
Cavid	CDP	03570-36-16
	CHK. BY	DATE
	[illegible]	March 27, 1995

(3) Five-year Groundwater monitoring

- Analysis for for TCL/TAL
  $1500 (sample × 16 samples) = $27,000/yr

- LOE for sampling wells
  26 hrs [illegible] × $60/hr = $1500/yr
  30 hrs [illegible] × $45/hr = $1350/yr

ODCs for shipping samples $2250/yr

sampling equipment, supplies, expenses $1500/5yr

- LOE for data [illegible]
  100 hrs for mid-level engineer × $60/hr = $6000/5yr
  20 hrs for jr-level engineer × $45/hr = $900/5yr

- 5-yr report
  evaluate data 4 hrs for mid-level engineer × $60/hr = $240/5yr
  12 hrs for jr engineer × $45/hr = $540/5yr
  Site visit sr engineer 1 dy + ODCs = $1500/5yr
  Review/update FS alternative & comparison (see evaluate data task) = $780/5yr
  Report - 40 hrs mid level eng × $60/hr = $2400/5yr
  40 hrs jr engineer × $45 = $1800/5yr
  Meeting - [illegible] engineer 1 dy + ODCs = $1500/5yr

- ODCs for report
  200 pages × 30 copies (0.10) = $600/5yr

Total 5-yr Monitoring = $44,895 ≅ $45,000 ✓

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ABB Environmental Services, Inc.

PROJECT	COMP. BY	JOB NO.
Cont	LDP	03-70-36-TEG
	CHK BY	DATE
	[illegible]	March 22, 1993

(4) Installation of 2 new wells for monitoring

See attached page [illegible] wells to be used for [illegible]
one well is [illegible] $ [illegible]
[illegible]

(5) [illegible]

Assume $ 0300 [illegible] (legal, and filing fees)

Summary

(1) Direct Costs

Well installation $ [illegible]

Groundwater use monitoring $ 16,000

(2) Annual O&M

Groundwater monitoring $ 24,000 /yr

Present Worth = $P = A(P/A, 6\%, 30)$

$= \$24,000(13.765)$

$= \$330,000$

(3) Five-year O&M

Groundwater monitoring $ 45,000 /5yr

5-year review $ 8,000 [illegible]

Total = $53,000 /5yr

Present Worth = $A' = P(A/P, 6\%, 5)$

$A' = 53,000(0.2374)$

$A' = \$12600/yr$

$P = A'(P/A', 6\%, 30)$

$P = 12600(13.765)$

$P = \$173,000$

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ABB Environmental Services, Inc.

PROJECT	COMP. BY	JOB NO.
Monitoring wells for GW Monitoring Program	SEB	6577-26
	CHK. BY	DATE
	MEC	2/28/95

(1) Wells to include (that currently exist)

CEF-16-13S (upgradient of source area)
CEF-16-12I (source area well)
CEF-16-7S (just downgradient of source, shallow well, plume dips below this well but inside anyway)

CEF-16-22I in plume

CEF-16-27I in plume

CEF-16-32S at leading edge of plume

CEF-16-38S downgradient of 32S - plume would go here next

(2) Install 2 wells at source area (where high aquaprobe pt. were found:

- one shallow (10-15 ft)
- one int (25-35 ft)
- to be located near aquaprobe pt. 65-12

add CEF-16-24S } currently clear and cross-
CEF-16-29S } gradient from plume, but inside
to monitor potential lateral movement of plume over time

add CEF-16-9D - questionable TCE hit

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ABB Environmental Services, Inc.

Table E-2
Cost Summary Table
Alternative MM-2: Enhanced Bioremediation

DIRECT COST	
Site Preparation	$23,000
Treatment System	
Injection Wells (6)	$15,000
Pumps (6), Piping, and Injection Equipment	$107,000
Monitoring Equipment	$30,000
Nutrients (for 12 year treatment duration)	$326,000
Biodegradation Monitoring	$120,000
Treatability Studies	$20,000
Groundwater Monitoring Well Installation (2)	$3,000
Groundwater Use Restrictions	$10,000
Total Direct Cost	$654,000
INDIRECT COST	
Health and Safety (4%)	$26,000
Administration and Permitting (5%)	$33,000
Engineering and Design (10%)	$65,000
Construction Support Services (10%)	$65,000
Direct Cost Contingency (20%)	$131,000
Total Indirect Cost	$320,000
OPERATION AND MAINTENANCE COST (Annual)	
Administrative O&M (30-year period)	
Annual Groundwater Monitoring	$24,000
Biodegradation Monitoring	$6,000
Five-year Reviews and Five-year Groundwater Monitoring (annualized)	$12,600
Present Worth - Admin. O&M (over 30-year period)	$586,000
Treatment System O&M (12-year period)	
System Maintenance	$27,000
Utilities	$56,000
Present Worth - Treatment System O&M (over 12-year period)	$696,000
Total Cost	$2,256,000

PROJECT	COMP. BY	JOB NO.
AH MM-2	MJR	08500-
Exhibit B [illegible] 1/7	CHK. BY LDP	DATE [illegible]

1 of 7

DIRECT COST ESTIMATE

Description — TOTAL COST

1. Site Preparation

- Fencing [illegible] Area (10' x [illegible]) – Trailers (40' x 20') = 340'
  340' x $[illegible] in ft = $3,000 ✓

- Utility Connections $15,500.00
- Trailer – Storage [illegible]
  2 Trailers x 3 mo x $200/mo = $1,200.00 ✓
- Mob/De Mob. 2 mob [illegible] $2,000/mob. = $4,000.00 ✓

TOTAL SITE PREP (round up) $23,000.00 ✓

2. Monitoring Well Installation (2) – see AH MM [illegible] $3,000.00 ✓

3. Treatment System
   - Injection Wells (6) – see next page $15,000.00 ✓
   - 6 pumps x $4,000/pump installed = $24,000.00 ✓
     (1-5 gpm Eimco-Elfos Readi-Flo 4)
   - Piping 6 areas x 40' pipe/area x $20/ft = $4,800.00 ✓
   - Injection piping 2,000 ln ft x $18/ft = $36,000.00 ✓
   - Injection Equipment (6) x $7,000/unit = $42,000.00 ✓
     (Automated dose/feed control)

SUBTOTAL $107,000.00

- Nutrients* (Est. need for trt. duration - 12 yrs)
  - Nitrogen (See page 5) $100,000.00
  - Tripolyphosphate (See page 5) $100,000.00
  - Glucose / Lactic Acid (See page 5) $100,000.00
  - On-site Storage for Nutrients (See page 5) $26,000.00

PROJECT	COMP. BY	JOB NO.
AH MM-2 Enhanced Bioremediation 2/7	[illegible]	[illegible]
	CHK. BY MK	DATE 6 [illegible] 95

2. WELL INSTALLATION

Costs adjusted from [illegible] for similar project site.

Intermediate wells (4, @ 25' depth each)	$30/LF	$ 2800
Shallow wells (2, @ 15' depth each)	$30/LF	$ 600

Other costs:

Mobilization		$2,000
Lodging/PD (assume 5 days)	$60/day/person	$900
Drilling (assume 30 hrs)	$100/hr	$3,000

Misc

(clean wash time, sidepad [illegible] of equipment, etc)	$5,000

Total $14,300 → round to $15,000

PROJECT	COMP. BY	JOB NO.
Air MW-2 Enhanced Bioremediation 3/7	MR	08500-[illegible]
	CHK. BY	DATE
	LDP	3/20/[illegible]

PROJECT COST [illegible]

Treatment System

- Bioventing (see page 6)
  $24,000 yr x 5 years = $ 120,000.00
- Monitoring Equipment
  (temp gauge, [illegible]) $ 30,000.00

TOTAL TREATMENT SYS $ 351,800.00

4. Bench & Pilot Scale Testing
   2 Tests @ $10,000/test $ 20,000.00

5 GW Use Restrictions
   For permits, [illegible] $ 10,000.00

SUMMARY COST ITEMS

	TOTAL COST
1. Site Preparation	$ 23,000.00
2. Monitoring well Installation	$ 3,000.00
3. Treatment System	$ 598,000.00
4. Treatability Testing	$ 20,000.00
5 GW Use Restrictions	$ 10,000.00
TOTAL	$ 654,000.00

PROJECT AH [illegible] Erinnerungsblatt 4/7	COMP. BY [illegible]	JOB NO. [illegible]
	CHK. BY [illegible]	DATE

Treatment Duration

Based on the "batch flush" model for the plume at OU7 and using the RESCO pair [illegible] the treatment time is estimated for [illegible] on.
(See Corporation [illegible] Feb 22, 1995)

For GW flushing, the # of pore volumes ($\forall_p$) required for contaminant reduction

$$\forall_p = -R \ln\left(\frac{c_f}{c_i}\right)$$

where $\forall_p$ = pore volumes
R = retardation coefficient (2.0)
c_i, c_f = initial & final concentration

Given: TCE conc. w/ c_i = 21,000 ppb
c_f = 3 ppb (MCL Goal)

$$\forall_p = -2.0 \ln\left(\frac{3}{21{,}000}\right) = 18.0$$

(∴ 18 flushes with fresh [illegible] reduce c_i = 21,000 to 3 ppb) for extraction treatment.

For biodegradation rate (1/6 $\forall_p$ need)

∴ $\forall_p = \frac{1}{6}(18) = 3$

Based on a total Flow $Q_{recovery}$ = 30 gpm
& capture zones of plume ≈ 4 years to treat entire plume.

Since 3 pore volumes [illegible]

Treatment Duration = 4 years × 3 (pore volumes) = 12 years

PROJECT	COMP. BY	JOB NO.
Alt MW — Enhanced Bioremediation 5/7	MJK	08500-36
	CHK. BY SAB	DATE 3/10/95

Nutrient Costs

- treatment duration (t) = 12 yrs.
- Nutrients – Ammonium Nitrate (Powdered Nitrogen) — C_i = 50 ppm — unit cost $1.25/lb
  - Trisodium Phosphate — 50 ppm — [illegible]
  - Glucose, Lactic Acid — 50 ppm — $1.25/lb
- Flow (Q) = 30 gpm
- Dose (d) = 50 ppm = 50 mg/L × 3.785 L/gal × 1 lb/453.6 g × 1 g/1000 mg = 1.[illegible] lb/gal

Cost = Q · d · unit cost · t

For each nutrient:

$$\text{Cost} = 30\,\frac{gal}{min} \times 1.[illegible]\times10^{-3}\,\frac{lb}{gal} \times \frac{\$1.25}{lb} \times 12\,yrs \times \frac{1440\,min}{day} \times \frac{365\,days}{yr} = \$98,39[illegible]$$

≈ $100,000 / Nutrient

(3) Nutrients = $300,000.00

Size On-site Storage for Nutrients

For each injection area; deter. annual nutrient amts.

$$5\,\frac{gal}{min} \times \frac{1440\,min}{day} \times \frac{365\,days}{yr} \times 4.16\times10^{-4}\,\frac{lb}{gal} \approx 1100\,lbs/yr/\text{Nutrient}$$

(3) Nutrients = 3300 lbs/yr

$$\#\text{drums need} = \frac{3300\,lbs.}{400\,lbs/drum} = 8.25 \approx 9\,\text{drums/injection area}$$

Cost

9 drums/injection area × 6 areas × $40/drum = $2160.00/yr

DRUMS $2160/yr × 12 yrs (duration) = $26,000.00

PROJECT	COMP. BY	JOB NO.
AH. MM-2 Enhanced Bioremediation 6/7	MJR	09500-[illegible]
	CHK. BY	DATE
	LJP	[illegible]

O & M COST (Annual)

TOTAL COST

1. Equipment Maintenance
   - pumps, generators, [illegible]
   - labor 8hrs/wk × 52wk/yr × [illegible]/hr = $10,000.00 / $17,000.00
2. Utilities
   - electricity 70 kW × 24 hr/day × 365 day/yr × $0.05/kW·hr = $30,000.00
   - water (From Fire) 30 gal/min × 60 min/hr × [illegible] × 365 day/yr × $1.35/1000 gal = $2[illegible],000.00
3. GW Sampling/Monitoring [illegible] $13,000.00
4. Five-Year Reviews (See AH. MM-1) $3,000.00
5. Biodegradation Monitoring
   - 11 wells sampled & analyzed quarterly basis (4X/yr)

Description	Qty	Unit Cost	Total Cost
• Labor			
— Scientist	16 hrs/event × 4 events/yr (64 hrs)	$45/hr.	$2,880.00
— Technician	64 hrs	$30/hr	$1,920.00
• ODCs	Lump Sum	$500/yr	$500.00
• Mob/Demob	4 trips/yr.	$200/diem	$800.00
• Report	4 reports	$500/report	$2,000.00
• Analytical	(Samples = 11 wells × 1 sample/well × 4 events/yr = 44 samples/yr)		
— VOCs (TCE, DCE, Vinyl Chlor, Ethane)	44	$140/sample	$6,160.00
— BOD	44	$30/sample	$1,320.00
— TKN, NH_3, NO_3, PO_4	44	$80/sample	$3,520.00
— Sulfide & sulfate	44	$60/sample	$2,640.00
— Iron (Fe – total & dissolved)	44	$20/sample	$880.00
— pH & dissolved O_2 (DO)	44	$30/sample	$1,320.00

5. Biomonitoring Annual Cost (First 5 years) $24,000.00

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ABB Environmental Services, Inc.

PROJECT	COMP. BY	JOB NO.
[illegible] Enhanced [illegible] 7/7	[illegible]	[illegible]
	CHK BY [illegible]	DATE 3/10/95

Present Worth / [illegible] Cost

System O&M — $ (Annual)

1. System [illegible] $ 27,000.00
2. Utilities $ [illegible]

TOTAL $ 83,500.00 = A

$PW = A(P/A, i = 6\%, n = 12 \text{ yrs.})$

$PW = \$83,000 (8.384) = \$696,000.00$

Baseline O&M — Cost (Annual)

1. Annual GW Monitoring $ 24,000.00 ✓
5. Bio Monitoring $ 6,000.00
6. Five-Year Reviews (Annualized) and 5-yr gw monitoring $ 12,600.00 ✓

see MM-1

$ 42,600.00

$PW = A(P/A, i = 6\%, n = 30 \text{ yrs.})$

$PW = \$42,600 (13.765) = \$586,000$ ✓

Table E-3
Cost Summary Table
Alternative MM-3: Groundwater Extraction, Treatment, and Discharge to Surface Water

DIRECT COST	
Site Preparation	$39,000
Groundwater Extraction System	$280,000
pH Adjustment	$18,000
Ultraviolet Oxidation (UV/OX) System	$150,000
Inclined-plate Clarifier	$165,000
Miscellaneous Piping and Equipment	$50,000
Liquid-phase GAC (including regeneration)	$381,800
Groundwater Monitoring Well Installation (2)	$3,000
Groundwater Use Restrictions	$10,000
Total Direct Cost	$1,096,000
INDIRECT COST	
Health and Safety (2%)	$22,000
Administration and Permitting (2%)	$22,000
Engineering and Design (10%)	$110,000
Construction Support Services (10%)	$110,000
Direct Cost Contingency (20%)	$219,000
Total Indirect Cost	$483,000
OPERATION AND MAINTENANCE COST (Annual)	
Administrative O&M (30-year period)	
Annual Groundwater Monitoring	$24,000
Five-year Reviews and Five-year Groundwater Monitoring (annualized)	$12,600
Present Worth - Administrative O&M (over 30-year period)	$503,000
System O&M (30-year period)	
System Maintenance	$190,000
Utilities	$75,000
Present Worth - System O&M (over 30-year period)	$3,650,000
Total Cost	$5,732,000

PROJECT	COMP. BY	JOB NO
Alternative MM-3	SCB	3510-36
	CHK. BY	DATE
	[illegible]	3/21/95

Cost Estimate for MM-3 was based on a design for a site with similar geology, the same contaminants, similar water quality, and similar pumping rates.

The costs presented in the following tables were adapted from this design estimate.

The first set of tables (pgs. 1 thru 4) summarize direct and O&M costs.

The second set of tables (pgs. 5 thru 15) provide backup cost information for MM-3.

PROJECT ALT MM-3 1/4 P&T → SURFACE WATER	COMP. BY MDK	JOB NO. 06500-36
	CHK. BY MJR	DATE 3/10/95

DIRECT COSTS

SITE PREP

Fencing: 1 treatment area for equip/controls (30'x30')
1 trailer area (40'x20')

Total length = 1,700 ft²
Total cost = (1,700)($8/ft²) = $13,600

Utility Hook-up: trailer, mech. equip., controls $20,000

Trailer: 2 for 3 mos @ $200/mo. $1,200

Mob/Demob: 2 @ $2,000/mob. $4,000

TOTAL: $38,800 ✓

GW EXT. SYSTEM

(Attached pages 5 to 6 of 15) TOTAL: $280,000 ✓

pH ADJUSTMENT

(Attached page 7 of 15) TOTAL: $18,000 ✓

$12,000 + $6,000

UV/OX SYSTEM

(Attached page 7 of 15) TOTAL: $150,000 ✓

PROJECT ALT MM-3 2/4 P&T → SURFACE WATER	COMP. BY MAR CHK. BY MSP	JOB NO. 08500-36 DATE 3/10/95

CLARIFIER

(Attached page 8 of 15)

1 Inclined-plate clarifier @ $ 110,000

1 Sludge management system @ $ 55,000

TOTAL = $ 165,000

MISC. EQUIP, PIPING

(Attached page 8 of 15)

TOTAL: $ 50,000

GAC (LIQUID-PHASE)

(Attached pages 9 to 14 of 15)

TOTAL: $ 381,800

includes 2 GAC units and required regeneration over 30 years.

TREATABILITY STUDIES

Lump Sum Estimate TOTAL: $ 20,000

ADMIN COSTS

(Same as MM-1)

2 new wells $3,000

gw use rest. $10,000

TOTAL: $ 13,000

TOTAL DIRECT COST: $ 1,117,000

PROJECT ALT MM-3 3/4 P&T → SURFACE WATER	COMP. BY NDR CHK BY SAB	JOB NO. 08530-36 DATE 3/10/95

0 of 5

O&M COSTS

ADMIN O&M

(same as MM-1)

GW monitoring $24,000/yr

5-yr reviews $12,600/yr (annualized)

Present Worth (30-year) TOTAL: $503,000

SYSTEM O&M

(see attached page 15 of 15)

$190,000/yr = $190,000/yr

UTILITIES O&M – TREATMENT SYSTEM

(see attached system cost, page 15 of 15)

$31,000/yr

UTILITIES O&M – GW EXT SYSTEM

elec: (100 kW)(24 hrs/day)(365 days/yr)(0.05 dollars/kW/hr)

= $44,000/yr

UTILITIES TOTAL: $75,000/yr

TOTAL SYSTEM O&M $265,000/yr

PROJECT ALT MM-3 4/4 P&T → SURFACE WATER	COMP. BY MDA CHK. BY SGB	JOB NO. 08500-36 DATE 3/10/95

PRESENT WORTH OF SYSTEM O&M (30 yrs.)

$$P = A(P/A, 6\%, 30)$$

$$P = 265{,}000(13.765) = \underline{\underline{3{,}650{,}000}}$$

TOTAL O&M (PRESENT WORTH)

503,000
3,650,000
\# 4,153,000

PROJECT	COMP. BY	JOB NO.
Gilmanton MW 3 [illegible]	LDP	08536-36
Pump [illegible]	CHK. BY [illegible]	DATE 2/[illegible]/95

Summary of Extraction System

The extraction system consists of 6 wells fitted with pumps at 2 to 15 gpm each for approximately 30 years. Three wells may be converted to injection wells and the extraction/injection system will operate for approximately 5 more years.

Well materials

240 feet stainless steel 6 in ID riser each
120 feet stainless steel 6 in ID screen, 10 slot each
6 pumps for extraction, capable of handling 2 to 15 gpm
3 pumps for injection, capable of handling 2 to 15 gpm

piping to treatment facility
500 feet capable of 15 gpm
500 feet capable of 30 gpm
1100 feet capable of 45 gpm

piping for injection well water
2000 feet capable of 15 gpm

electrical to pumps
3500 feet

miscellaneous - gauges, valves, controls

Costs

Extraction system

Well and pump	6 each × 20,000 =	$ 120,000
Piping	1½" ϕ 500 LF × 17.00 =	$ 8,500
	2" ϕ 500 LF × 18.00 =	$ 9,000
	2" ϕ 1100 LF × 20.00 =	$ 22,000
Injection pumps	3 each × $2000/pa =	$ 6000
Injection piping	2000 LF × 18.00 =	$ 36,000

PROJECT	COMP. BY	JOB NO.
Alternative [illegible]	LDP	[illegible]
Pump [illegible]	CHK. BY	DATE
	[illegible]	3/22/95

Electrical - pump 350 LF [illegible] = [illegible]

MISC - gages, [illegible] 6 wells @ 2500 = [illegible]

Misc $28,500

$280,000

PROJECT	COMP. BY	JOB NO.
MM-3	PRM	8500-36
	CHK. BY	DATE
	ACL	3-6-95

TREATMENT - BASED ON SERVALL (KWD OF)

EQUAL. TANK (1000 GAL)	$2500
→ pH ADJ. TANK	2500
H_2SO_4 - BY BARRELL BY VENDOR	0
MIXER	1500
FEED PUMP	1000
BBL / PUMP SPT	500
CARTRIDGE FILTER	3000
MISC	1,000
	$12,000 ✓

UV/OX

H_2O_2 TANK BBL BY VENDOR	$0
FEED PUMP & SUPPORT	1500
TEMP GA - INCL WITH PIPING	0
FLOW METER - INCL WITH ER & INST	0
SAMPLING PORT - INCL WITH PIPING	0
UV/OX CONTACTOR	135000
PIPING & VALVES - INCL W PIPING	0
CONTROL PANEL - INCL WITH CONTACTOR	0
TEMP GA - INCL WITH PIPING	0
MISC	13,500
	$150,000 ✓

pH ADJ

$KMnO_4$ TANK - BBL BY VENDOR	$0
pH MIXING TANK	2500
MIXER	1500
METERING PUMP & SUPPORT	1500
MISC	500
	$6,000

PROJECT	COMP. BY	JOB NO.
MM-3	PRM	8500-36
	CHK. BY RCL	DATE 3-6-95

CLARIFIER

POLYMER - BDL BY VENDOR	$0
METERING PUMP & SPT	1500
CLARIFIER	100,000
SLUDGE PUMP	1000
MISC	7500
	$110,000 ✓

SLUDGE HANDLING

SLUDGE THICKENER	$12500
DAY TANK	2500
MIXER	1000
SLUDGE PRESS	30,000
FEED PUMP	1100
SLUDGE TANK PLATFORMS	2500
MISC	5400
	$55,000 ✓

~~GAC TREATMENT~~ superseded - see attached GAC

~~FEED PUMP~~	~~$1500~~
~~PIPING & VALVES - INCL IN PIPING costs~~	~~0~~
~~SAMPLING PORT - INCL IN PIPING~~	
~~GAC CANISTER~~	~~2000~~
~~MISC~~	~~500~~
	~~$4000~~

~~DISCHARGE~~ not needed

~~CARTRIDGE FILTER~~	~~$3000~~

PIPING, FITTINGS, VALVES	$50,000 ✓

PROJECT OU7 Cost Info Alternative Mills Cost Info	COMP. BY LOP	JOB NO. [illegible]
	CHK. BY MAZ	DATE 5/8/97

Liquid Phase Carbon Costs [30 yr extraction system]

UV/OX, clarifier reduces effluent to ~ 13,000 ppb TCE
19.5 ppb DCE

need to reduce concentrations to 20.7 ppb TCE
3.2 ppb DCE

Our GAC usage rate is ~ 50 lb/day [based on the adsorption isotherm data, notes at]

Use the L-1600 model (1600 lb carbon) 2 in series (see attached figure)

$= \frac{1600 \text{ lbs}}{50 \text{ lb/day}} = 32$ days to spent 1 unit of L-1600

After 30 days, rotate canisters, and send #1 GAC canister to be recycled. [continue for 1st ten years]

See Attached for cost information.

First ten years: capital costs = 2-1600 lb units = (\$4600) · 2 = \$9200

O&M costs = (10 yrs)(12 mos/yr)(1 unit/mos)

= 120 1600-lb replacements

= 120 (\$1350 regen + \$200 transport)

= \$186,000

Assumption: Contaminant decrease will require less carbon as treatment continues.

Assume subsequent period only requires 60-day change-out

Next 20 years: O&M costs = (20 yrs)(12 mos/yr)(1 unit/2 mos) = 120 replacements

= 120 (\$1350 regen + \$200 transport)

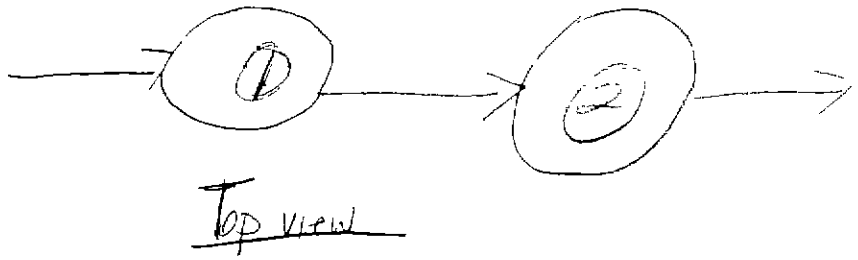
= \$186,000

PROJECT 047 [illegible] FS	COMP. BY LDP	JOB NO. [illegible]
Alternative HM-3 [illegible]	CHK. BY MDA	DATE 2/8/94

Disposal (again) for each unit on last use (b/c not [illegible])
= 2 units × $300 [illegible] = $600

Total [illegible] cost for 30 years $381,800

This cost includes [illegible] and between units



Top view

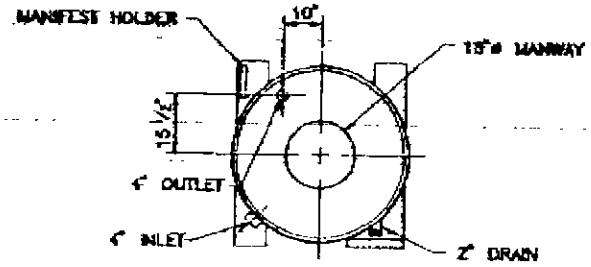
Barnebey & Sutcliffe Corp.
Technical Department
Liquid Phase Consumption Calculation
Activated Carbon Type 207A

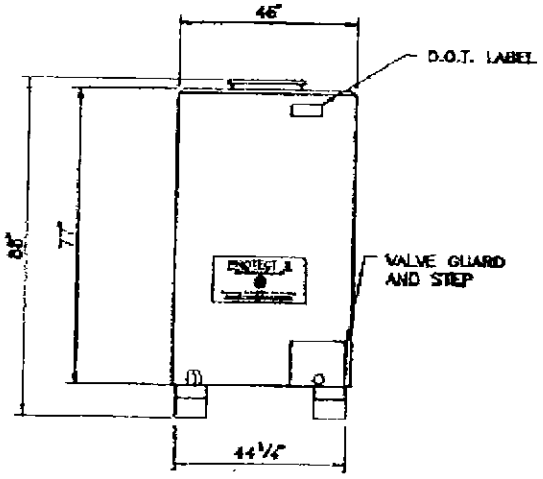
System Conditions	
WATER FLOW RATE (gpm) :	30
WATER TEMPERATURE oF :	70

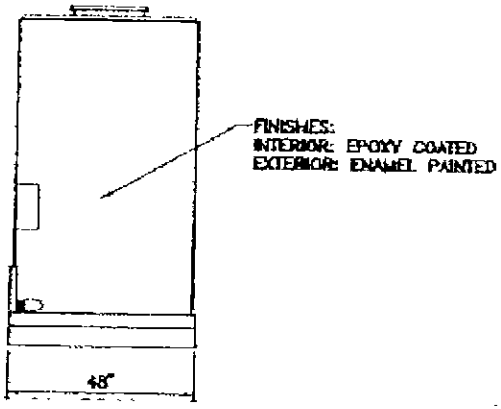
Design for : ABB Environmental

08-Mar-95

Compound	Inlet Concentration (ugm/l)	Carbon Usage (lb GAC/ 1000 gal H2O)	Carbon Usage Corrected For TOC (lb GAC/ 1000 gal H2O)	Carbon Usage Rate (lb gac/ lb/24 hrs)
Alachlor	0.0000	0.000000	0.0000	0.000
Aldicarb	0.0000	0.000000	0.0000	0.000
Atrazine	0.0000	0.000000	0.0000	0.000
Benzene	0.0000	0.000000	0.0000	0.000
Bromodichloromethane	0.0000	0.000000	0.0000	0.000
Bromoform	0.0000	0.000000	0.0000	0.000
Carbofuran	0.0000	0.000000	0.0000	0.000
Carbon tetrachloride	0.0000	0.000000	0.0000	0.000
Chlorobenzene	0.0000	0.000000	0.0000	0.000
Chloroform	0.0000	0.000000	0.0000	0.000
Dibromochloromethane	0.0000	0.000000	0.0000	0.000
Dibromomethane-1,2	0.0000	0.000000	0.0000	0.000
Dibromo-1,2-chloropropane-3	0.0000	0.000000	0.0000	0.000
Dichlorobenzene-o	0.0000	0.000000	0.0000	0.000
Dichlorobenzene-p	0.0000	0.000000	0.0000	0.000
Dichloroethane-1,1	0.0000	0.000000	0.0000	0.000
Dichloroethane-1,2	0.0000	0.000000	0.0000	0.000
Dichloroethene-1,2 cis	0.0000	0.000000	0.0000	0.000
Dichloroethene-1,2 trans	0.0000	0.000000	0.0000	0.000
Dichloropropane-1,2	0.0000	0.000000	0.0000	0.000
Dichloroethene-1,1	19.5000	0.074917	0.3119	13.474
Dinoseb	0.0000	0.000000	0.0000	0.000
Ethyl Benzene	0.0000	0.000000	0.0000	0.000
Lindane	0.0000	0.000000	0.0000	0.000
Methylene chloride	0.0000	0.000000	0.0000	0.000
Pentachlorophenol	0.0000	0.000000	0.0000	0.000
Pichloram	0.0000	0.000000	0.0000	0.000
Simazine	0.0000	0.000000	0.0000	0.000
Styrene	0.0000	0.000000	0.0000	0.000
Tetrachloroethene	0.0000	0.000000	0.0000	0.000
Toluene	0.0000	0.000000	0.0000	0.000
Trichlorobenzene-1,3,5	0.0000	0.000000	0.0000	0.000
Trichloroethane-1,1,1	0.0000	0.000000	0.0000	0.000
Trichloroethane-1,1,2	0.0000	0.000000	0.0000	0.000
Trichloroethene	13000.0000	0.563643	0.7955	34.367
Trichloropropane	0.0000	0.000000	0.0000	0.000
Xylene-m	0.0000	0.000000	0.0000	0.000
Xylene-o	0.0000	0.000000	0.0000	0.000
Xylene-p	0.0000	0.000000	0.0000	0.000
TOTAL	13019.500	0.639	1.107	47.841







GENERAL SPECIFICATIONS	
LIQUID FLOW	MAX 50 GPM
PRESSURE	MAX 10 PSIG
TEMPERATURE	MAX 110° F
FACE VELOCITY	4.35 GPM/sqft
RESIDENCE TIME	8.4 MIN
CARBON BED DEPTH	60"
CARBON CAPACITY	56.5 cu.ft.
SHIPPING WEIGHT	2100 LBS
CONNECTION SIZE	4" FPT
PRESSURE DROP (sys)	~3.2 PSI.
MATERIAL	CARBON STEEL

REVISION	DATE	DWN	CHK	APPV	DESCRIPTION
C	2-92	DLB			CHANGED PRESSURE DROP TO PSI
B	1-92	DLB			REDRAWN, CHANGED CONN. SZ. TO 4", & P.D. TO 90
A	4-91	ART		SMT	REDRAWN

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FILE: 23283 | PLOT: 14.7.97 | ORIGIN: 0,0 | FACTOR: 1=37

DRAWN	Richlo5-08-90
CHECKED	
APPROVED	
RELEASE DATE	
TAG:	
TOLERANCES	
FRACTIONAL	±1/4"
ANGULAR	±3/4"

BARNEBEY & SUTCLIFFE CORP
Activated Carbon & Air Purification Equipment

CUSTOMER: | REG. NO.

TITLE: PROTECT II
MODEL L1600 – LIQUID PHASE

SCALE	SIZE	DRAWING NUMBER	REV.
3/8 SIZE	B	23283	C

SHEET 1 of 1

12 of 5

Product Information

BARNEBEY & SUTCLIFFE CORP.
P.O. Box 2526
Columbus, OH 43216
Facsimile: 614-258-3464
Telephone: 614-258-9501

LIQUID PHASE

PROTECT Line
Installation and Start Up Instructions

Protect II is designed for easy installation. Final installation requires appropriate size piping or flexible hose for connection of the PROTECT to the process outlet. The following steps are recommended prior to start up.

a. Position the PROTECT on a level area close to the source. The area should be flat, accessible, and must be able to support the weight of the adsorber when it is saturated.

b. Check and make sure all safety labels are visible. Remove the inlet/outlet plugs.

c. Fill the adsorber with water and allow the carbon to soak (if possible for 24 hours).

d. Backflushing the system is recommended at a rate of 5-10 gpm for a period of 10-15 minutes. At a minimum, the entrapped air pockets within the carbon bed must be allowed to escape through a pressure relief valve.

e. Pressure relief valves are not provided by the factory, but can be furnished if requested.

f. The inlet of the PROTECT should be connected to the source. The adsorber is now operational.

WARNING
Your PROTECT II is designed to operate up to a maximum pressure. Refer to Table I for the corresponding maximum pressure rating.

CONNECTION SIZES
Refer to Table I for connection sizes and locations.

OPERATION CONDITIONS
Table I illustrates the operating conditions for each PROTECT model.

RECOMMENDED ARRANGEMENT

Refer to Drawing #24346 for recommended arrangement.

T-1209
G/IC

14 5

TABLE I

Model Number	L-170	L-500	L-1000	L-1600
Maximum Pressure (psig)	8	8	10	10
Inlet Size (FNPT)	2"	4"	4"	4"
Inlet Location	bottom	bottom	bottom	bottom
Outlet Size (FNPT)	2"	4"	4"	4"
Outlet Location	top	top	top	top
Maximum Flow (gpm)	10	25	50	60
Maximum Temperature (deg	110	110	110	110
Influent pH	3-11	3-11	3-11	3-11
System Pressure Drop (psi)	1.5	2.1	2.5	3.3

Liquid unit L-1600

capital costs $4600 recycle $1350 dispose $300

Vapor unit vapor L-2000

capital costs $4800 recycle $1600 dispose $300

T-1209
G/IC

PROJECT	COMP. BY	JOB NO.
MM-3	PRM	8500-36
	CHK. BY	DATE
	RCL	3-6-95

5-15

O & M COSTS – MONTHLY

UV/OX EQ.		
ELEC., H2O2, ACID, BASE	SENVALL x 50%	$5500/mon
MAINTENANCE		3000
POLYMER	SENVALL x 30%	600
EQUIP MAINT	SENVALL x 100%	370
~~CARTRIDGE FILTERS~~	~~SENVALL x 50%~~ not needed	~~400~~
~~ELECTRICITY~~	~~= SENVALL x 50% + 25% for ELEC HVAC~~ not needed	~~1100~~
LABOR	SENVALL	6067
SLUDGE DISPOSAL	SENVALL x 50%	250
~~NATURAL GAS~~	~~= 0 USE ELEC HEAT~~ not needed	~~0~~
~~ANALYTICAL~~	not needed	~~1500~~
~~MISC~~	not needed	~~2213~~
		~~$21,000/mon~~
		~~x 12 mon~~
		~~$252,000/yr~~

supplanted

EQUIP O&M

(15,800/mo.)(12 mos/yr) = 190,000/yr

UTILITY

Treatment System: (2,600/mo)(12 mos/yr) = 31,000/yr

GW Ext: (calculated)

Table E-4
Cost Summary Table
Alternative MM-4: Sparging of Groundwater

DIRECT COST	
Site Preparation	$33,000
Treatment System	
Compressors (2)	$20,000
Blowers (2)	$15,000
Generators (4)	$30,000
Misc Flow Equipment	$102,000
Pipes, Valves, and Misc materials	$150,000
Well Installation (for air sparging and SVE)	$30,000
Vapor Phase Carbon (includes regeneration over treatment duration)	$23,000
Treatability Studies	$20,000
Groundwater Monitoring Well Installation (2)	$3,000
Groundwater Use Restrictions	$10,000
Total Direct Cost	$436,000
INDIRECT COST	
Health and Safety (5%)	$22,000
Administration and Permitting (5%)	$22,000
Engineering and Design (15%)	$65,000
Construction Support Services (15%)	$65,000
Direct Cost Contingency (20%)	$87,000
Total Indirect Cost	$261,000
OPERATION AND MAINTENANCE COST (Annual)	
Administrative O&M (30-year period)	
Annual Groundwater Monitoring	$24,000
Five-year reviews and Five-year Groundwater Monitoring (annualized)	$12,600
Present Worth-Administrative O&M (over 30-year period)	$503,000
Treatment System O&M (12-year period)	
System maintenance	$44,000
Utilities	$31,000
Present Worth - System O&M (over 12-year period)	$629,000
Total Cost	$1,797,000

&A

Evaluation of Air Sparging Effectiveness – Time Estimation

Design values:

a (sft)	30000	Plume area
f	0.80	Fraction of plume within sparging wells' radius of influence
d	0.75	Fraction of a 24–hour day that sparge wells operate
D (m2/sec)	0.000000001	Diffusion coefficient
L (m)	1.0E–03	Diffusive distance around a bubble
S/V	3000	Bubble surface area to volume ratio
H (ft)	65	Height of sparging zone
v (m/s)	0.25	Rise velocity of the bubble
Q (CFM)	20	Vapor flow rate
Vs	23418.71927	Volume of water in the contaminant plume
Roi (ft)	45	Radius of influence of sparging well
r	1.0E–03	Average radius of bubbles
k	10	Number of sparging wells
n	0.2	Porosity
B	0.0000000575	Coefficient of decay

Estimation of time required to remediate:

EXISTING GW CONC. C(0) (mg/l)	DESIRED GW CONC. C(t) (mg/l)	TIME REQUIRED (t) (seconds)	
6.3	0.003	133065765.49428	seconds
		1540.11303	days
		4.21949	years

Governing equations:

B=fd(D/L)(S/V)(H/v)(Q/Vs)

t=ln(C(t)/C(0))/–B

Calculations based on:
Sellers, Katharine L. and Schreiber, Robert P., "Air Sparging Model for Predicting Groundwater Cleanup Rate", in Proceedings of the 1992 Conference on Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Detection, and Restoration. National Ground Water Association, Nov. 4–6, 1992.

Because of uncertainties associated with modelling in-situ processes, a safety factor of 3.0 was applied to the modelled treatment duration.

4 x 3 = 12 yrs.

PROJECT	COMP. BY	JOB NO
alternative MM 4 Cost Info other cost items	DP	08550-[illegible]
	CHK. BY SAB	DATE 3/10/95

Description

1. Site Preparation

- Fencing two treatment areas (10'x10') + Trailers (40'x20') = 1000'
  1000' × $8/ln ft = $8000 ✓

- Utility connection to pumps and trailers = $20,000 ✓

- Trailer - Storage and Office
  2 trailers × 3 mo. × $200/mo. = $1200 ✓

- Mob/Demob 2 mob(s) × $2,500/mob = $4,000 ✓

Total Site Prep ~~$34,200~~ $33,200 SAB 3/14/95

2. Utilites (annual)
   - electricity: 70 kW × 24 hr/dy × 365 dy/yr × 0.05 $/kW/hr = $30,660 ✓

3. Install 2 Monitoring wells for Groundwater Monitoring Program (from AH. MM-1) = $3,000 ✓

4. Groundwater Use Restrictions = $10,000 (from AH. MM-1) ✓

5. Five-year site reviews (annualized cost) and 5-yr groundwater monitoring = $12,600 (from AH MM-1)

6. Groundwater Monitoring (annual) = $24,000 (from AH MM-1)

PROJECT	COMP. BY	JOB NO.
Cost items, Alternative 1-4 Air Injection	[illegible]	[illegible]
	CHK. BY SCB	DATE 6 Mar 95

★ Items / quantities for a pilot-scale system to be installed at a similar project site in Florida, with similar geology, similar contaminants, and similar water quality (see page 8)

Air Injection

wells = 10 — 5 in source area of plume; 5 in downgradient area of plume

Compressors — 1 for source area wells (5 wells)
+ 1 for downgradient area wells (5 wells)
2.

→ Each must be able to induce flow of 20-30 cfm to each well

compressors	2	Unit Cost = $10,000/ea	= $20,000 total
Generators (enough to power one compressor each)	2	$7500/ea	= $15,000
flow meters (for air flow measurement)	10	$1500/ea	= $15,000
pressure gauges	10	$250/ea	= $2500
pressure relief valves	10	$2000/ea	= $20,000
temp. gauges	10	$500/ea	= $5,000
pipes, valving, misc materials for manifolding	[illegible]	$7500	

$ = 42,5

PROJECT	COMP. BY	JOB NO.
Cost items, alternative #4 Soil vapor extraction	DKS	8500-36
	CHK. BY SEB	DATE 6 Mar 95

Vapor Extraction

wells = 14

Blowers = 1 for [illegible] wells (7)
+ 1 [illegible] (7)
2

→ Each [illegible] to induce flow of 30 cfm to each well

blowers	2	Unit Cost =	7500/ea =$15,000 total
Generators (enough to power 1 blower each)	2		7500/ea =$
flow meters (for air flow measurement)	14		1500/ea = $21,000
pressure gauges	14		250/ea - $3500
pressure relief valves	14		2000/ea - $28,000
temp. gauges	14		500/ea - $7000
pipes, valves, misc. materials for assembly	[illegible]		75000 LS

PROJECT	COMP. BY	JOB NO.
Drilling costs, alternative MM-4 for new well	MAS	5500-36
	CHK. BY SAB	DATE 6 Mar 15

Costs expected from invoice dates 2012 for similar project site.

Trench wells (2 @ 60' depth each)	$10/LF	$1,200 ✓
Intermediate wells (8 @ 45' depth each)	$9/LF	$3240 ✓
SVE wells (14 @ 20' depth each)	$8/LF	$1,120 ✓

Other costs

Mob/demob	(2)	$4,000 ✓
Lodging / PD (assume 15 days 2 people)	$60/day/person	$2,700 ✓
Decon (assume 100 hrs)	$100/hr	$10,000 ✓
Misc (decon equipt time, setups, leasing of equipment, etc.)	(assume)	$7,500 ✓

Total $29,760 → round to $30,000

PROJECT Out of FS MM-4 Carbon Costs	COMP BY LDP	JOB NO. 0852-50
	CHK BY MDR	DATE 3/8/95

MM-4 vapor phase carbon after SVE (~ 12 yrs)

* Cost Estimate provided by Barneby & Sutcliffe Corp L models

Concentration of Tce contaminants in gw

TCE	630	ppb
TCA	3000	ppb
DCE	12,800	ppb

Contaminants will partition into gas phase and be adsorbed into carbon.

Our GAC usage rate is ~ 3.53 lb/dy (see page 9)

Use the L-2000 model (2000 lb carbon) 2 in series (see page 10)

$= \frac{2000}{3.53 \text{ lb/dy}} = \underline{566}$ days to spend 1 unit of L-2000

$\underline{1.55}$ years

After 566 days, rotate canisters, and send #1 GAC canister to be recycled.

For 12 years: capital costs = 2-2000 lb units = (\$4800)(2 units) = \$9600

O&M cost = $(12 \text{ yrs})\left(\frac{365 \text{ dys}}{\text{yr}}\right)\left(\frac{1 \text{ unit}}{566 \text{ dys}}\right)$ = 7.7 times * = recycle 7 times

* It is cheaper to recycle the L-2000 model than to order a smaller size.

O&M costs = 7 (1,600 recycle + 200 transport) = \$12,600

Disposal for each unit on last use (because not being recycled again).

= 2 units x \$300 ea = \$600

Total Carbon Cost for MM-4 = \$22,800

PROJECT	COMP BY	JOB NO.
Cost Estimate for Alt MM-4 other cost Items (continued)	LDP	3570-22
	CHK BY SAB	DATE 3/13/95

10, 10

Monthly Maintenance over 12-yr Period

SVE/Sparging maint	$1000
Equipment (supplies)	$200
Labor	$2000
Electricity	$500
	$3,700
Total O&M per year	$44,400

PW costs:

PW = System maint + utilities

44,000 + 31,000 = $75,000

PW = 75,000 (1A, 6%, 12 yrs) = $629,000

8.384

[3] From: Phil Martin at USEVS03 3/9/95 1:14PM (2085 bytes: 47 ln)
To: Shannon Buckley at USEVS06
Subject: MM-4 COST ITEMS
---------- Message Contents ----------

SHANNON,

HERE IS THE LIST OF ITEMS YOU SENT ME AND THEIR COSTS

AIR INJECTION	
BLOWER	$10000/EA
GENERATOR	$ 7500/EA
FLOW METER	$ 1500/EA
PRESSURE GAUGES	$ 250/EA
PRESSURE RELIEF VALVES	$ 2000/EA
TEMPERATURE GAUGES	$ 500/EA
PIPES, VALVES, MISC	$75000/LS
VAPOR EXTRACTION	
BLOWER	$ 7500/EA
GENERATOR	$ 7500/EA
FLOW METER	$ 1500/EA
PRESSURE GAUGE	$ 250/EA
PRESSURE RELIEF VALVE	$ 2000/EA
TEMPERATURE GAUGE	$ 500/EA
PIPES, VALVES, MISC	$75000/LS

from cost estimator

PLEASE NOTE:

THIS DOES NOT INCLUDE A BUILDING TO HOUSE THE EQUIPMENT, IF REQUIRED

THIS DOES NOT INCLUDE ANY SYSTEM CONTROLS, IF REQUIRED

THIS DOES NOT INCLUDE ANY UTILITIES, IF REQUIRED

GENERATORS ARE THE MOST COSTLY ELECTRICITY COST YOU CAN GET. UNLESS THIS IS A VERY SHORT TERM JOB POWER SHOULD BE PERMANENTLY BROUGHT TO THE SITE.

IF BOTH GENERATORS ARE LOCATED IN THE SAME PLACE ONLY ONE IS REQUIRED FOR EACH PROCESS

THE COST FOR THE GENERATORS ARE PURCHASE AND INSTALLATION COSTS ONLY. THIS DOES NOT INCLUDE DIESEL FUEL COSTS.

ANY QUESTIONS GIVE ME A CALL

PHIL
X3645

9 of 10

Barnebey & Sutcliffe Corp.
Technical Department
Vapor Phase Adsorption Model
Activated Carbon Consumption Calculation

System Conditions	
System Temperature (oF)	77
Flow Rate (cfm)	20
System Pressure (mmHg)	760
System Operation (hrs/day)	24

Design For :

Rev 2 (2-94)
08-Mar-95

Component	Inlet Concentration ppm	Adsorption Capacity AC % (w/w)	Carbon Usage GAC AC lb/day	Adsorption Capacity 207E4 % (w/w)	Carbon Usage GAC 207E4 lb/day
Acetaldehyde	0.0000	0.00	0.00	0.00	0.00
Acetone	0.0000	0.00	0.00	0.00	0.00
Acrylonitrile	0.0000	0.00	0.00	0.00	0.00
Allyl Chloride	0.0000	0.00	0.00	0.00	0.00
Aniline	0.0000	0.00	0.00	0.00	0.00
Benzene	0.0000	0.00	0.00	0.00	0.00
Butane	0.0000	0.00	0.00	0.00	0.00
Butanol	0.0000	0.00	0.00	0.00	0.00
Butyl Acetate	0.0000	0.00	0.00	0.00	0.00
Carbon Tetrachloride	0.0000	0.00	0.00	0.00	0.00
Chloroform	0.0000	0.00	0.00	0.00	0.00
Cumene	0.0000	0.00	0.00	0.00	0.00
Cyclohexane	0.0000	0.00	0.00	0.00	0.00
Dichlorobenzene-1,4	0.0000	0.00	0.00	0.00	0.00
Dichloroethane-1,2	0.0000	0.00	0.00	0.00	0.00
Dichloroethylene	12.8000	9.45	1.05	3.19	3.12
Dichloromethane	0.0000	0.00	0.00	0.00	0.00
Dimethyl Pentane-2,2	0.0000	0.00	0.00	0.00	0.00
Ethanol	0.0000	0.00	0.00	0.00	0.00
Ethyl Benzene	0.0000	0.00	0.00	0.00	0.00
Ethyl Acetate	0.0000	0.00	0.00	0.00	0.00
Heptane	0.0000	0.00	0.00	0.00	0.00
Hexane	0.0000	0.00	0.00	0.00	0.00
Isopropyl Alcohol	0.0000	0.00	0.00	0.00	0.00
Isoprene	0.0000	0.00	0.00	0.00	0.00
Isopropyl Acetate	0.0000	0.00	0.00	0.00	0.00
Methanol	0.0000	0.00	0.00	0.00	0.00
Methyl Acrylate	0.0000	0.00	0.00	0.00	0.00
Methyl Methacrylate	0.0000	0.00	0.00	0.00	0.00
Methylene Chloride	0.0000	0.00	0.00	0.00	0.00
Methyl Ethyl Ketone	0.0000	0.00	0.00	0.00	0.00
Methyl Isobutyl Ketone	0.0000	0.00	0.00	0.00	0.00
Octane	0.0000	0.00	0.00	0.00	0.00
Pentane	0.0000	0.00	0.00	0.00	0.00
Perchloroethylene	0.0000	0.00	0.00	0.00	0.00
Phenol	0.0000	0.00	0.00	0.00	0.00
Propane	0.0000	0.00	0.00	0.00	0.00
Styrene	0.0000	0.00	0.00	0.00	0.00
Trichloroethane	3.0000	22.69	0.14	12.67	0.25
Trichloroethylene	0.6000	11.42	0.06	3.83	0.16
FREON 113	0.0000	0.00	0.00	0.00	0.00
Tetrahydrofuran	0.0000	0.00	0.00	0.00	0.00
Toluene	0.0000	0.00	0.00	0.00	0.00
xylene	0.0000	0.00	0.00	0.00	0.00
Total Usage			1.25		3.53

The Adsorption Capacity Is Estimated Using The Polanyi Adsorption Theory And Toluene As The Reference Component

TABLE I

Model Number	L-170	L-500	L-1000	L-1600
Maximum Pressure (psig)	8	8	10	10
Inlet Size (FNPT)	2"	4"	4"	4"
Inlet Location	bottom	bottom	bottom	bottom
Outlet Size (FNPT)	2"	4"	4"	4"
Outlet Location	top	top	top	top
Maximum Flow (gpm)	10	25	50	50
Maximum Temperature (deg	110	110	110	110
Influent pH	3-11	3-11	3-11	3-11
System Pressure Drop (psi)	1.5	2.1	2.5	3.3

Liquid unit L-1600

capital costs $4600 . recycle $1350 dispose $300

Vapor unit vapor L-2000

Capital costs $4800 recycle $1600 dispose $300

T-1209
G/IC

Table E-5
Cost Summary Table
Alternative MM-5: Groundwater Extraction, Pretreatment, and Discharge to FOTW

DIRECT COST	
Site Preparation	$69,000
Treatment System	
Extraction Wells and Pumps (6)	$126,000
Piping for Injection Well Water and Piping to Treatment Facility	$76,000
Misc pumping materials	$78,000
Air Stripper and Vapor Phase Carbon Unit (includes regeneration or replacement over treatment duration)	$41,000
pH Adjustment	$12,000
Groundwater Monitoring Well Installation (2)	$3,000
Groundwater Use Restrictions	$10,000
Total Direct Cost	$415,000
INDIRECT COST	
Health and Safety (5%)	$21,000
Administration and Permitting (5%)	$21,000
Engineering and Design (15%)	$62,000
Construction Support Services (15%)	$62,000
Direct Cost Contingency (20%)	$83,000
Total Indirect Cost	$249,000
OPERATION AND MAINTENANCE COST (Annual)	
Administrative O&M (30-year period)	
Annual Groundwater monitoring	$24,000
Five-year reviews and Five-year Groundwater Monitoring (annualized)	$12,600
Present Worth - Administrative O&M (over 30-year period)	$503,000
Treatment System O&M (30-year period)	
System maintenance	$134,000
Utilities	$48,000
Present Worth - System O&M (over 30-year period)	$2,505,000
Total Costs	$3,672,000

PROJECT	COMP. BY	JOB NO.
alternative MM-5 cost Est	LDP	08500-36
	CHK. BY	DATE
	MDL	3/10/95

Description

1. Site Preparation

- Fencing one treatment area (30'x30') + trailers (40'x20') = 1700'
  1700' x $8/lin ft = $13,600

- Utility Connections - hookup to trailer and pumps
  pumps 3500 lb x 10% = $35,000
  trailer $15,000

- Trailer - Storage and Office
  2 trailers x 3 mo. x $200/mo = $1,200

- Mob / Demob 2 mob(s) x $2000/mob = $4,000

Total site prep $68,800

2. Utilities (annual)

- electricity: 110 kw x 24 hr/dy x 365 dy/yr x 0.05 kw/hr = $48,180 annual

3. Treatability Study = $20,000

4. Install 2 Monitoring wells for Gwater Monitoring Program (from Alt MM-1) = $3,000

5. Groundwater Use Restrictions = $10,000 (from Alt MM-1)

6. Groundwater Extraction System (from MM-3) $280,000

7. pH Adjustment (from MM-3) $12,000

PROJECT	COMP. BY	JOB NO.
Alt 1M-5	MDR	02500 [illegible]
	CHK. BY	DATE
	[illegible]	3/8/85

Based on tower design calculations (see pages 6 to 10) and anticipated influent/effluent concentrations, a vendor-supplied model was selected (see pages 11 to 14)

Literature Design:		Vendor-Supplied Tower:		
diam:	2 ft	diam:	1.5 ft	✓
height: (packing)	17 ft	height: (packing)	19 ft	✓

Thus, assuming variations in air flow rates and packing material characteristics, the vendor-supplied tower satisfies the calculated design criteria.

PROJECT alternative MM-5 Air Stripping Costs	COMP. BY LDP	JOB NO. 08560-36
	CHK. BY	DATE 3/10/95

3 of 15

Air Stripping Costs

(see page 11 to 14)

The air stripper designed by Delta Cooling Towers is 1.5 foot in diameter and has 19 foot packing and 19 feet height.

ABB-ES's calculations show a 2 foot diameter stripper with a 16.8 foot height.

These two strippers are comparable and the costs from Delta Cooling Towers can be used in the cost estimate for MM-5.

Total Material Costs = $ 31,550

Add $ 9,800 for each additional carbon unit

- add one additional carbon unit at $9800 (so this track two)

Total air stripping unit = $ 41,350

PROJECT	COMP. BY LCF	JOB NO.
	CHK. BY SAB	DATE

Monthly system O&M

Air stripper maint	$3000
Equipment (supplies)	$400
Labor	$6000
packing material	$400
Electrical	$1000
	$10,800/mo ✓
TOTAL O&M per year	~ $130,000 ✓
Carbon change-out/yr	$4000 ✓
	$134,000 ✓

UTILITIES: (From P. 1) $48,000 ✓

PW costs

System maintenance + utilities

134,000 + 48,000 = 182,000/yr ✓

PW = 182,000 (P/A, 6%, 30yr) = $2,505,000 ✓

13.765

From MM-1

Baseline O&M	Cost (annual)
GW Monitoring	$24,000
Five-year site review (annualized)	$12,600

PROJECT	COMP. BY	JOB NO.
ALT [illegible] - 5	[illegible]	[illegible]
[illegible] -- [illegible]	CHK. BY	DATE

Present Worth Calculations

$P = A(P/A, 6\%, 30)$ % System O&M

$P = (13[illegible] - [illegible])(13.765) = \$2,505,000$

PROJECT Alternative MW-5 Air Stripping Design 1/5	COMP. BY MJR	JOB NO. 08500-36
	CHK. BY MJR	DATE 3/3/95

Calculate Height of Stripper required based on the following assumptions:

- GW contaminated w/ TCE
- initial (max) concentration C_i = 21,000 µg/L (ppb)
- Final Concentration (goal) C_f = 300 µg/L (ppb)
- 98% removal required
- 6 WELLS @ Flow Q = 5 gpm ea.

  Total Q = 30 gpm
- Vol of GW = 1.5 MG
- Area of plume ≈ 30,000 ft²
- Packed Tower Design based on info. in Water Quality and Treatment, AWWA, 4
- GW Temp T = 20°C

Calculations

Column Height (H) = HTU x NTU (Eq. 5.31)

- HTU = height of transfer units
- NTU = # of Transfer units

Eq. 5.32) $HTU = \frac{L}{K_L a}$ where L = Liquid Flux (Flow/Cross Sec Area of Stripper)

$K_L a$ = mass transfer coefficient

- To find HTU:

Step 1. $A_{cs} = \frac{\pi d^2}{4}$ (Assume Column Dia = $2.0 ft \times \frac{1 m}{3.28 ft} = .61 m$

$A_{cs} = \frac{\pi (.61 m)^2}{4} = .292 \ m^2$

Step 2 Mass Flow Rate ($\dot{m}$) = $\frac{30 gal}{min} \times \frac{8.34 lb.}{1 gal} \times \frac{1 kg}{2.2 lb} \times \frac{60 min}{1 hr} = 6,824 \ kg/hr$

Step 3: Liquid Flux (L) = $\frac{\dot{m}}{A_{cs}} = \frac{6,824 kg/hr}{.292} = 23,370 \ kg/hr \cdot m^2$

PROJECT	COMP. BY	JOB NO.
Alternative 1W-5 Air Stripping Design 2/5	MJR	08500-36
	CHK. BY	DATE
	MJL	3/8/95

Step 4: Convert Liquid Flux ($kg/hr \cdot m^2$) to Liquid Velocity (m/hr)

$$= 23,375 \frac{kg}{hr \cdot m^2} \times \frac{1 kmol\ H_2O}{18 kg\ H_2O} \times \frac{1 m^3}{55.5 kmol} = 23.4 m/hr$$

Step 5: $HTU = \frac{L}{K_L a}$ (assume $K_L a = 30 hr^{-1}$ Eq. 5.35)

$$HTU = \frac{23.4 m/hr}{30 hr^{-1}} = 0.78 m \times \frac{3.28 ft}{1 m} = \boxed{2.56 ft}$$

Calculate $NTU = \frac{R}{R-1} \ln\left[\frac{(C_i/C_f)(R-1)+1}{R}\right]$ Eq. 5.33

where R = stripping factor = $H'\left(\frac{Q_A}{Q_W}\right)$

Step 1: $H' = \frac{H}{R_g T}$

$T = 20°C = 293 K$

H = Henry's law const

$H(T = 20°C) = 9.89 \times 10^{-3} \frac{atm \cdot m^3}{mol}$ (Table 5.1)

R_g = Gas constant = $8.205 \times 10^{-5} \frac{m^3 \cdot atm}{mol \cdot K}$

$$H' = \frac{9.89 \times 10^{-3} atm\ m^3/mol}{(8.205 \times 10^{-5} m^3\ atm/mol \cdot K)(293 K)} = 0.411$$

Step 2: $\frac{Q_A}{Q_W}$ = Air Flow : water Flow = 40 : 1 Assumed

Step 3: Calculate $R = 0.411\left(\frac{40}{1}\right) = 16.44$

Step 4: Calculate NTU where $C_i = 21,000$ ppb & $C_f = 300$ ppb

$$NTU = \frac{16.44}{(16.44-1)} \ln\left[\frac{\left(\frac{21,000}{300}\right)(16.44-1)+1}{16.44}\right] = \boxed{4.45}$$

Calculate Stripper Height (Z)

$Z = HTU \times NTU$

$$\boxed{Z = 2.56 ft \times 4.45 = 11.4 ft \simeq 12 ft \text{ height} \ \& \ 2.0 ft \text{ dia}}$$

PROJECT Alt MM-5	COMP. BY MJR	JOB NO. 08500-316
Air Stripping Design 2.5	CHK. BY MJR	DATE 3/8/95

Add 10% safety factor to account for other VOC constituents

$$Z = 1.4(12\ ft) = 16.8\ ft \quad \text{Stripper height}$$

- This stripping tower is designed for 2" dia Tri-pak packaging or 2" dia Raschig rings (see Table 5.6)
- Calculate Pressure drop through stripping tower:

Based on graph of generalized pressure drop curve of mass where:

$$X\ axis = \left(\frac{L}{G}\right)\left(\frac{\rho_{air}}{\rho_{water}}\right)^{1/2}$$

$$y\ axis = \frac{G^2 F}{\rho_{air}(\rho_{water})g_c}$$

$$slope = \frac{\Delta P}{Z}$$

L = liquid loading rate = $lb/ft^2 \cdot sec$
G = air loading rate = $lb/ft^2 \cdot sec$
F = Packing factor
ρ_A = density of air (lb/ft^3)
ρ_w = density of water (lb/ft^3)
g = gravity ($32.2\ ft/s^2$)
ΔP = inches of water / ft of height

- Step 1: Convert L ($kg/hr \cdot m^2$) to $lb/ft^2 \cdot sec$

$$L = 23{,}370\ kg/hr\ m^2 \times \frac{2.2\ lb}{1\ kg} \times \frac{1\ hr}{3600\ sec} \times \left(\frac{1\ m}{3.28\ ft}\right)^2 = 1.33\ lb/ft^2 \cdot sec$$

Step 2: $G = \dfrac{Q_a \rho_a}{A_{cs}}$ where $Q_a = Q_w\left(\dfrac{Q_A}{Q_w}\right) = Q_w\left(\dfrac{40}{1}\right)$ ← assumed

$$Q_a = \underbrace{\left[30\frac{gal}{min} \times \frac{1\ ft^3}{7.48\ gal} \times \frac{1\ min}{60\ sec}\right]}_{Q_w} 40$$

$$Q_A = 2.67\ ft^3/sec$$

$$\therefore G = \frac{(2.67\ ft^3/sec)(.075\ lb/ft^3)}{\pi\left(\frac{2.0\ ft}{4}\right)^2} = 0.0637\ lb/ft^2 \cdot sec$$

PROJECT	COMP. BY	JOB NO.
AH. MM-5 Air Stripping [illegible] 4/5	[illegible]	[illegible]
	CHK BY [illegible]	DATE 3/8/95

Step 2. $X_{axis} = \left(\frac{L}{G}\right)\left(\frac{\rho_{air}}{\rho_{water}}\right)^{1/2} = \frac{1.33\ lb/s}{0.0637\ lb/ft^2} \left(\frac{.075\ lb/ft^3}{62.4\ lb/ft^3}\right)^{1/2}$

$X_{axis} = 0.484$

Step 3 $Y_{axis} = \frac{g^2 F}{\rho_{air} \rho_{water}}$ where F = 16 for 2" dia. Tripper

$Y_{axis} = \frac{(0.0637\ lb/ft^2)^2 \cdot 16}{(.075\ lb/ft^3)(62.4\ lb/ft^3)(32.2\ ft/sec^2)} = 0.00023$

Step 4. $\frac{\Delta P}{Z} \cong 1.03 \frac{\text{inches } H_2O}{ft. \text{ of } Z}$ From Graph (X, Y) Fig 9-5 (next page)

Step 5: Therefore [illegible] ΔP

$\Delta P = \frac{0.03\ \text{inches } H_2O}{ft\ of\ Z} \times Z = \frac{0.03}{ft\ of\ Z} \times 16.3\ ft$

$\Delta P = 0.5$ inches of water

(Pressure drop through stripper)

Summary Table

STRIPPING TOWER

	Z	DIA	ΔP
Column Height	16.3 ft		
Column Diameter		2.0 ft	
Pressure Drop			0.5 inches

alternative MM-5 [illegible]

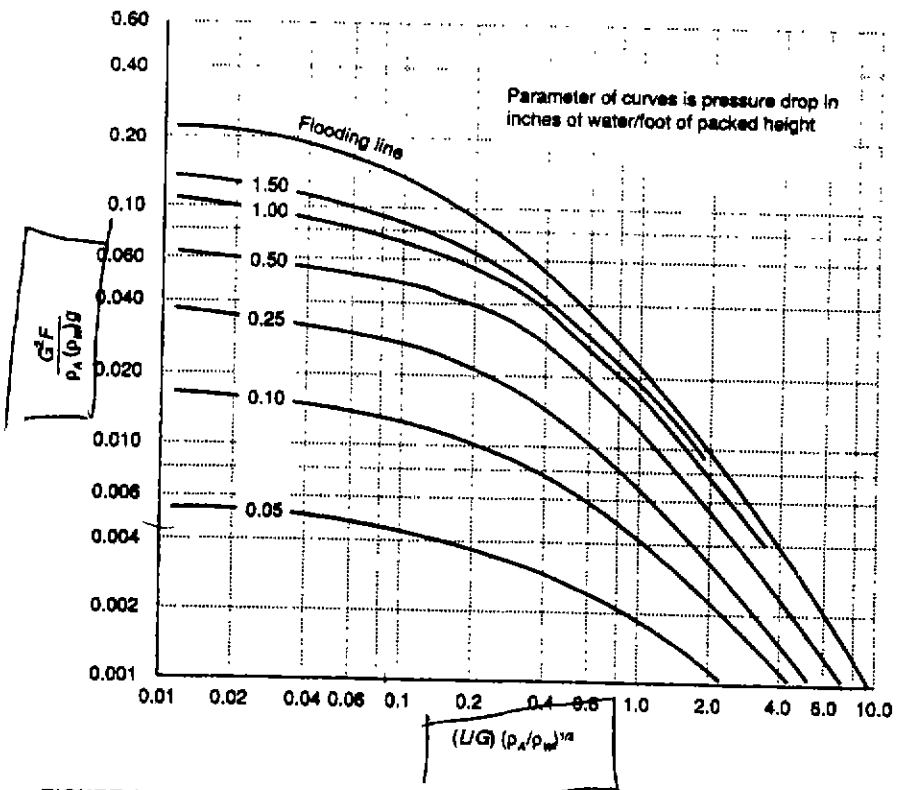

FIGURE 9-5
Generalized pressure drop correlations.[8]

$$G = \frac{Q_A \rho_A}{A_{cs}}$$

where G = air loading rate ($lb/ft^2 \cdot s$)
L = liq. loading rate ($lb/ft^2 \cdot s$)
F = Packing factor (see previous page)
ρ_A = density of air (lb/ft^3)
ρ_w = " of water (lb/ft^3)
g = grav. const ($32.2\ ft/s^2$)

-15

QUOTATION NO: _____

Delta Cooling Towers, Inc.

P.O. Box 952
Fairfield, New Jersey 07004-2970
PHONE: 201/227-0300
FAX: 201/227-0458

VANGUARD® AIR STRIPPER

PAGE 1 of 4

CUSTOMER: ABB ENVIRONMENTAL SERVICES
ARLINGTON VIRGINIA

DATE: 3/9/95

PROJECT: _____

ATTN: LESLIE PANEK

REF. NO.: _____

PHONE NO.: (703) 769 8134

SITE LOCATION: _____

FAX NO.: (703) 769 8182

REMARKS: _____

DESIGN CONDITIONS

Water Flow: Normal 30 gpm., Max./Design 30 gpm.
Influent Temp.: Min. 55 °F., Max. _____ °F.
Destination of treated water: ☐ Drinking ☐ Other _____
Operation is: ☒ Continuous, year round ☐ Other _____
Minimum ambient winter temperature is _____ °F.
Water discharge from system: ☒ Gravity flow. ☐ To transfer pump suction.
Mode of Treatment: ☒ once-through ☐ discrete batch circulation
☐ Other _____

MAJOR CONTAMINANTS AND REMOVAL REQUIREMENTS:

Chemical	Infl. conc.	Unit	Effl. conc.	Unit	% Removal
1. TCE	21,000	ppb	300	ppb	
2.					
3.					
4.					
5.					
6.					
7.					
TOTAL					

Other performance or operational requirements, if any: _____

SELECTION

Model AS-1.5-190R Counterflow type, ☒ Forced Draft ☐ Induced Draft
Fan motor: 1.5 HP, ☒ TEFC 230 or 460/3/60 ☐ Other _____
Number of Strippers: One, in ☐ Series ☐ Parallel
The proposed Strippers are ☒ Delta Standard Design ☐ Custom Engineered

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QUOTATION NO: _____

Delta Cooling Towers, Inc.

P.O. Box 952
Fairfield, New Jersey 07004-2970
PHONE: 201/227-0300
FAX: 201/227-0458

VANGUARD® AIR STRIPPER

STANDARD DESIGN FEATURES

Delta Vanguard® Air Strippers are provided with an FRP Column, an integral treated water collection sump including access and inspection port, Type PVC high-performance Delta-Pak2 structured packing preassembled in Column, a PVC water distribution system, and required connections and fittings, Type AB mist eliminator, Fan with motor and drives, and Type 304 SS fasteners and hardware.

CUSTOM DESIGN FEATURES

Delta Custom Air Strippers are provided as described above except:
RANDOM PACKING USED TO REDUCE AIR FLOW - 160 SCFM

SCOPE OF SUPPLY

Including optional items and accessories.

Item	Component Description	Incl'd	Qty.	Not Incl'd	Remarks
1.	**VANGUARD® AIR STRIPPER WITH FAN, MOTOR AND DRIVE.**	☒	1	☐	
	A. Guywire Package Available in galvanized or stainless steel.	☐		☒	
	B. Free Standing Design An alternate to guywire requirement.	☐		☒	
2.	**SKID MOUNTING.** Factory pre-assembled, prepacked Stripper and components provided on a mounting platform. (Modular column extensions as applicable, are installed in the field.)	☒	1	☐	
3.	**BLOWER COATING OPTIONS.**				
	MASTIC COATING. The housing and wheel are coated and a stainless steel shaft offers additional protection against exposure to the elements.	☐		☒	
	PREMIUM CORROSION PROTECTION PVC plastisol encapsulation of blower housing, wheel and frame, stainless steel shaft and additional protective coating of sheaves, bearing housing and motor shaft. An economical alternative to fiberglass or stainless steel.	☐		☒	
4.	**ACCESS LADDER WITH SAFETY CAGE.** With step-through landing platform, railing and ladder attachments. Pre-assembled, "fold-out" construction for easy installation. Aluminum construction.	☐		☒	

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5

QUOTATION NO: _____

Delta Cooling Towers, Inc.

P.O. Box 952
Fairfield, New Jersey 07004-2970
PHONE: 201/227-0300
FAX: 201/227-0458

VANGUARD® AIR STRIPPER

Item	Component Description	Incl'd	Qty.	Not Incl'd	Remarks
5.	**AIR FLOW SWITCH.** Signals reduction or loss of airflow to indicate fouling of packing, loose belts, motor failure, etc.	☐		☒	
6.	**A. DIFFERENTIAL PRESSURE GAUGE.** Indicates pressure differential between sump and atmosphere	☐		☒	
	B. DIFFERENTIAL PRESSURE SWITCH GAUGE.	☒	1	☐	
7.	**VIBRATION CUT-OUT SWITCH.** Contact closure will shut down blower due to excessive vibrations.	☐		☒	
8.	**HIGH SUMP LEVEL SWITCH.** Signals excess water level in sump of Air Stripper.	☒	1	☐	
9.	**LIQUID LEVEL CONTROL PACKAGE.** For Stripper sump, tanks, etc. with back up controls. Used with two-stage stripping systems and when stripper outlet is connected to pump suction. Primary mechanical system maintains non-oscillating, preset water level over a span of varying flow rates. Two (2) controllers are provided; one for auto-start/stop of transfer pump, and the other for emergency Hi level monitoring and control. Consult Factory for specifications.	☐		☒	
10.	**ANTI-FREEZE OPTIONS.**				
	A. DRAIN VALUE ACTUATOR. Automatically drains stripper sump when freezing condition exists during system shutdown.	☐		☒	
	B. BLOWER AIR PRE-HEATER. Heats inlet air to a wet bulb temperature above 32° F. Required for certain low flow, cold weather operating conditions.	☐		☒	
11.	**TRANSFER PUMP PACKAGE.** For 2nd stage stripper supply or pumped system discharge. Includes two (2) PVC valves for proper function of the above **"liquid level control package."**	☒	1	☐	Feed to stripper
12.	**PREMOUNTING OF TRANSFER PUMP.** Skid mounting option (4) required.	☒	1	☐	
13.	**FLOW METER TOTALIZER.**	☒	1	☐	
14.	**DISTRIBUTION NOZZLE.**	☒	1	☐	
15.	**STORAGE TANK.**	☐		☒	
16.	**WELL PUMP.** Stainless steel with teflon seals for maximum resistance to contaminated water..	☐		☒	
17.	**WELL LIQUID LEVEL CONTROLS.** Intrinsically safe open style controller; conductivity actuated.	☐		☒	
18.	**CONTROL PANEL.**	☒	1	☐	

NEMA 4 enclosure. (Electrical drawing provided after order.)

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QUOTATION NO: _____

Delta Cooling Towers, Inc.

P.O. Box 952
Fairfield, New Jersey 07004-2970
PHONE: 201/227-0300
FAX: 201/227-0458

VANGUARD® AIR STRIPPER

Item	Component Description	Incl'd	Qty.	Not Incl'd	Remarks
19.	PREMOUNTING & PREWIRING OF CONTROL PANEL.	☒	1	☐	
20.	TELEMETRY REMOTE TERMINAL SYSTEM.	☐		☒	
21.	CHEMICAL CLEANING SYSTEM.	☐		☒	
22.	IRON REMOVAL SYSTEM.	☐		☒	
23.	SOIL VENTING SYSTEM.	☐		☒	
24.	CARBON ABSORPTION SYSTEMS.				
	A. VAPOR PHASE w/ 1.5 KW XP Dehumidifier	☒	1	☐	1200 # carbon supply
	B. LIQUID PHASE	☐		☒	
	ADDITIONAL ITEMS.				
25.		☐		☐	
26.		☐		☐	
27.		☐		☐	

TOTAL MATERIAL COST IS $ 31,550 Add $9800. for each additinal carbon unit

THIS QUOTATION IS ☒ FIRM for 30 days and is subject to review thereafter.

THIS QUOTATION IS ☐ FOR BUDGET PURPOSES ONLY.

Price quoted is F.O.B. Fairfield, N.J. and is based on shipment within 90 days after receipt of formal purchase order. Shipment can be made approximately 5-7 weeks after receipt of purchase order, or approval of drawings, if applicable. Terms of payment are net 30 days after date of invoice.

We trust this proposal is complete and satisfies your request.
If we can be of further assistance, please do not hesitate to contact us.

Keith Kay
Sales Engineer
Very truly yours,
Delta Cooling Towers, Inc.

This quotation is submitted on behalf of Delta Cooling Towers, Inc. and is subject to formal review prior to acceptance. All attachments including the standard Conditions of Sale and Warranty, constitute our complete proposal.

Represented by:
(Company) Ensons Inc
(Address) 9508 Ironmaster Drive
(City, State, Zip) Burke, VA 22015
(Telephone No.) 703 913 0704
(Signature) _____

Ram Nagrani

enc. ☐ — List Attached.
cc: ☐ — Delta, Fairfield.

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PROJECT	COMP BY	JOB NO.
OU7 FS [illegible] (MM-5)	LDP	[illegible]
	CHK. BY NDR	DATE [illegible]

Dilution calculations for [illegible]

[illegible]	[illegible]
Iron	[illegible]
TCE	[illegible]

- [illegible] which is likely to be [illegible] in the influent to the FOTW w/ dilution of the existing waste streams.

  Flow of FOTW: 0.6 MGD

  w/ TCE System: 30 gpm

- Dilution IRON

$$\frac{(0.6\ MGD)(38\ ppb) + (30\ gpm)\left(\frac{MG}{10^6\ gal}\right)\left(\frac{60\ min}{hr}\right)\left(\frac{24\ hr}{day}\right)(1{,}877\ ppb)}{\left[0.6 + 30\left(\frac{1}{10^6}\right)(60)(24)\right]}$$

$$= \underline{483\ ppb}$$

% removal in FOTW $483(1 - 0.753) = \underline{119\ ppb\ w/\ dilution}$

$< 300\ ppb$ OK

no pretreatment necessary

- No background value for TCE - must pretreat and treat

Thus, treatment system selected for TCE only.

APPENDIX F

GROUNDWATER EXTRACTION SYSTEM

GROUNDWATER EXTRACTION SYSTEM

1.0 INTRODUCTION. This appendix presents the proposed extraction system for ex situ remedial alternatives for surficial aquifer groundwater at OU 7. First, the U.S. Geological Survey (USGS) developed an extraction system. This system is discussed in Section 2.0. Next, an alternate groundwater extraction system was developed and this system is presented in Section 3.0. Section 4.0 presents the estimated length of time for the extraction system to operate at OU 7.

2.0 GROUNDWATER EXTRACTION SYSTEM DEVELOPED BY THE USGS. The groundwater extraction system developed by the USGS for OU 7 is presented in Attachment A to this appendix. This proposed system consists of 4 groundwater extraction wells with water table drawdowns of approximately 20 feet at a pumping rate of 5 gallons per minute (gpm) for each well.

3.0 ALTERNATE GROUNDWATER EXTRACTION SYSTEM. An alternate extraction system to the one developed by the USGS was prepared. The discussion and calculations contained in this section for this alternate extraction system include a presentation of results for groundwater pathlines for plume capture followed by a discussion of the application of the "batch flush" model that was used to predict the number of pore volumes of flushing to reach action levels in groundwater at OU 7.

The figures presented in Attachment B of this appendix were prepared from the RESSQ Pathline Model (i.e, the main sub-code within the WHPA software package). RESSQ is a two-dimensional model of the flow to (or from) wells pumping (or recharging) in an otherwise uniform regional groundwater flow.

3.1 Capture Zone Flow Patterns The first two figures in Attachment B show groundwater flow lines and water table elevation contours for six recovery wells that are spaced uniformly along the OU7 plume, and are pumping at various flow rates. For this analysis, aquifer transmissivity was taken to be 250 ft^2/day, aquifer thickness was taken to be 80 ft, aquifer porosity was assumed to be 0.25, and the non-pumping water table gradient was taken to be 0.00275 toward the southeast (-45°). The length of the pathlines toward each well is for a five year travel time. In the first figure, the total flow to all six wells is 50 gpm, and in the second figure, the total flow is to all six wells is 26 gpm. It can be seen that the entire plume is flushed - at least once - in the five years when the well pumping rate is 26 gpm. An exception to this is the "stagnation" zones midway between each adjacent pair of wells. These stagnation zones could be flushed by converting the 2nd, 4th and 6th wells to recharging rather than discharging wells. This flow pattern, shown in the third figure, would flush these stagnation zones and would do so rapidly; the flow time between a recharge-discharge well pair would be less than one year.

In summary, six recovery wells would be used to extract groundwater until the plume has been drawn into a narrow band along the line of the wells; perhaps to the point where contaminated water only exists in the stagnation zones. At this point, the alternate wells would be converted to recharge wells where clean water would be used to flush out the remaining contamination.

3.2 Batch Flush Model for TCE For TCE, the contaminant that defines the plume at OU 7, the octanol-carbon partitioning coefficient is about 120 ml/gm. The fraction of organic carbon in the soils of the water table aquifer at OU7 is about 0.0012, the bulk density of the aquifer soils is about 1.7 gm/cc, and the porosity of the aquifer is assumed to be 0.25. With these values, a retardation coefficient of 2.0 is calculated. Using this retardation coefficient, and the batch flush model:

$$PV = -R \ln\left(\frac{C_f}{C_i}\right)$$

Where:

PV = the number of pore volumes of flushing necessary to reduce the groundwater concentration from some initial concentration (c_i)

c_f = the final concentration of TCE

R = the soil retardation factor

the following number of pore volumes of flushing will result in the contaminant reduction indicated:

4.6 PVs will cause a 10 times reduction
3.2 PVs will cause a 5 times reduction
1.4 PVs will cause a 2 times reduction

Table F-1 shows the number of PVs needed to reduce the TCE plume to 5 μg/l given the various starting concentrations.

Table F-1

Feasibility Study, Operable Unit 7
NAS Cecil Field, Jacksonville, Florida

Initial Concentration (μg/l)	Pore Volumes to get to 5 μg/l
50	4.6
100	6
500	9.2
1000	10.6
5000	13.8
50000	18.4
500000	23.0

Now, given the measured plume and the capture pathlines, it can be determined how many years are required to flush the contamination from the aquifer.

4.0 ESTIMATED LENGTH OF TIME FOR EXTRACTION SYSTEM TO OPERATE. This section discusses the assumptions and calculations used to estimate the length of time that an extraction system would to operate OU 7 in order to extract all groundwater above action levels at the OU. The methods used for this analysis were described above, and the following assumptions were made:

- The 6-well, 26 gpm system discussed above would be used at the site.
- The action level for TCE in groundwater is 3 $\mu g/\ell$.
- The highest concentration of dissolved TCE in the plume is 6,300 $\mu g/\ell$ (Aquaprobe boring GS-16-1). Higher concentrations of TCE were detected in samples from GS-16-12 at the source area; however, the rapid decrease in TCE concentrations downgradient from the source area indicate that these high concentrations do not represent dissolved TCE.
- The retardation factor for TCE is 2.0 (as described above).

Using the batch flush model as described above:

$$PV = -2.0 \ln\left(\frac{3ug/L}{6,300ug/L}\right) = 15.3$$

Therefore, at least 15.3 pore volumes would be required to reduce the highest concentrations of TCE in the plume to 3 $\mu g/\ell$. However, the distance to the pumping well also should be considered in this calculation because the contaminated water needs to be removed from the aquifer. Based on the configuration discussed above, it would take approximately 4 years for the water from GS-16-1 to reach extraction well No. 2. Therefore, the extraction system would have to operate for approximately 60 years (15.3 times 4 years).

The alternate extraction system presented above is a rough design that was developed to be used as an aid to costing extraction alternatives in the FS. The extraction system was designed to capture all the water within the OU 7 plume and was not intended to take into account the distribution of contaminants. Therefore, if a pumping system is designed, the well placement and pumping rates will be adjusted to minimize pumping time. Because the extent of the plume used to develop an extraction system for OU 7 was wider than that predicted in the RI, the assumption was made for calculating a timeframe of extraction that the No. 2 extraction well could be moved to the west far enough so that it would only take 2 years for water from GS-16-1 to reach the well. This would reduce the pumping time to 30 years.

As discussed above, some extraction wells could be converted to injection wells to flush out stagnation zones that would form between the pumping wells. It is difficult to estimate how long it would take to flush the stagnation zone because the eventual concentrations in these stagnations zones are unknown. It was assumed that it would take an additional 5 years to flush out the stagnation zones.

The pumping durations presented in this appendix are estimates. There are many adjustments that could be made during the design phase to optimize the system including:

- adding wells
- adjusting pumping rates
- repositioning wells
- building in variable pumping rates designed to flush out stagnation zones

These may significantly reduce the time required to reach the action levels. However, the extraction system presented in the FS and discussed in this Appendix is considered appropriate for cost estimating purposes.

APPENDIX F
ATTACHMENT A

GROUNDWATER EXTRACTION SYSTEM DEVELOPED BY THE U.S. GEOLOGIC SURVEY

904

United States Department of the Interior

GEOLOGICAL SURVEY

WATER RESOURCES DIVISION
224 West Central Parkway, Suite 1006
Altamonte Springs, Florida 32714
(407) 865-7575

MEMORANDUM

January 30, 1995

To: Eric Blomberg, Geologist, ABB, Tallahassee, FL

From: Keith J. Halford, Hydrologist, WRD, Altamonte Springs, FL

Through: Charles H. Tibbals, Hydrologist, WRD, Altamonte Springs, FL

Subject: Site 16 pump and treat remedial alternatives

The calibrated GW flow model of the shallow aquifer system at NAS Cecil Field was used as the basis for answering your questions. The areal and vertical extent of the model is shown by the figures in Packet 1. The model was calibrated to water-level measurements collected during times of low, 5"/yr, and high, 7"/yr, effective recharge rates. The resulting potentiometric surfaces for model layers 1-5 are shown in figure packets 2 and 3 (May '94 and October '94). The postings on the figures are water-level residuals, $r = h_c - h_m$, where h_c is the calculated water level and h_m is the measured water level. A residual of 0.5 indicates the model calculated water level was 0.5 ft higher than the measured value. Likewise, a residual of -0.2 indicates the model calculated water level was 0.2 ft lower than the measured value. The hydraulic properties used for head and pathline computations are listed in Table 1.

Table 1: Aquifer and confining unit properties used in calibrated model.

AQUIFER / CONFINING UNIT (Model Layer)	K_{xy}, ft/d	K_z, ft/d	n_e
Surficial (1-3)	3.	0.04	0.2
Blue Marl (4)	0.01	0.009	0.2
Upper Rock (5)	40.	NA	0.2
Gray Marl	NA	0.005	0.2
Lower Rock (6)	20.	NA	0.2

A model with a finer grid near site 16 (Packet 4) and with the hydraulic properties shown in Table 1 was constructed, since the grid used to develop the calibrated model was too coarse near site 16 to properly evaluate the pump-and-treat remediation alternatives. The smallest model elements are 5 ft on a side and are located at potential extraction well sites. All extraction wells were assumed to be screened from water table to about 60 ft BLS and would produce at 5 gpm. The wells were simulated as extraction points in layer 2 with a high leakance value between layers 1 and 2 above the extraction points. Drawdowns in individual wells were estimated by adding $\Delta s = \frac{ln\left(\frac{r_e}{r_w}\right)q}{2\pi Kb}$ to model simulated drawdowns at a node. r_e is the effective radius of a finite difference block and is equal to

$0.14\sqrt{\Delta x \Delta y}$., where Δx and Δy are the width and length of a model block. The expected drawdowns in the extraction wells are about 20 ft at pumping rates of 5 gpm and assuming 50% well efficiencies.

Four scenarios were considered for remediation, do-nothing, install-1-well, install-3-wells, and install-4-wells. The travel times and capture area are shown in plan and section packets 5-8. The travel times calculated are based on an assumed effective porosity of 20%. The travel times can be checked and improved by comparing those in packet 5 to what is known to have occurred. If the 50 yr travel times, actually took 25 yrs, the times in all packets should be adjusted to half of what is shown. Beware, The travel times are based on advective transport ONLY, not on diffusive or dispersive effects so small concentrations are expected ahead of the plume shown in packet 5.

I think reinjection of the treated water is not feasible in the Surficial aquifer due to its low hydraulic conductivity.

A-ha, I remembered. I can present a given remediation scheme more clearly, if needed, for the RABid committee. If you have questions please call at (407) 865-7575

Sincerely,

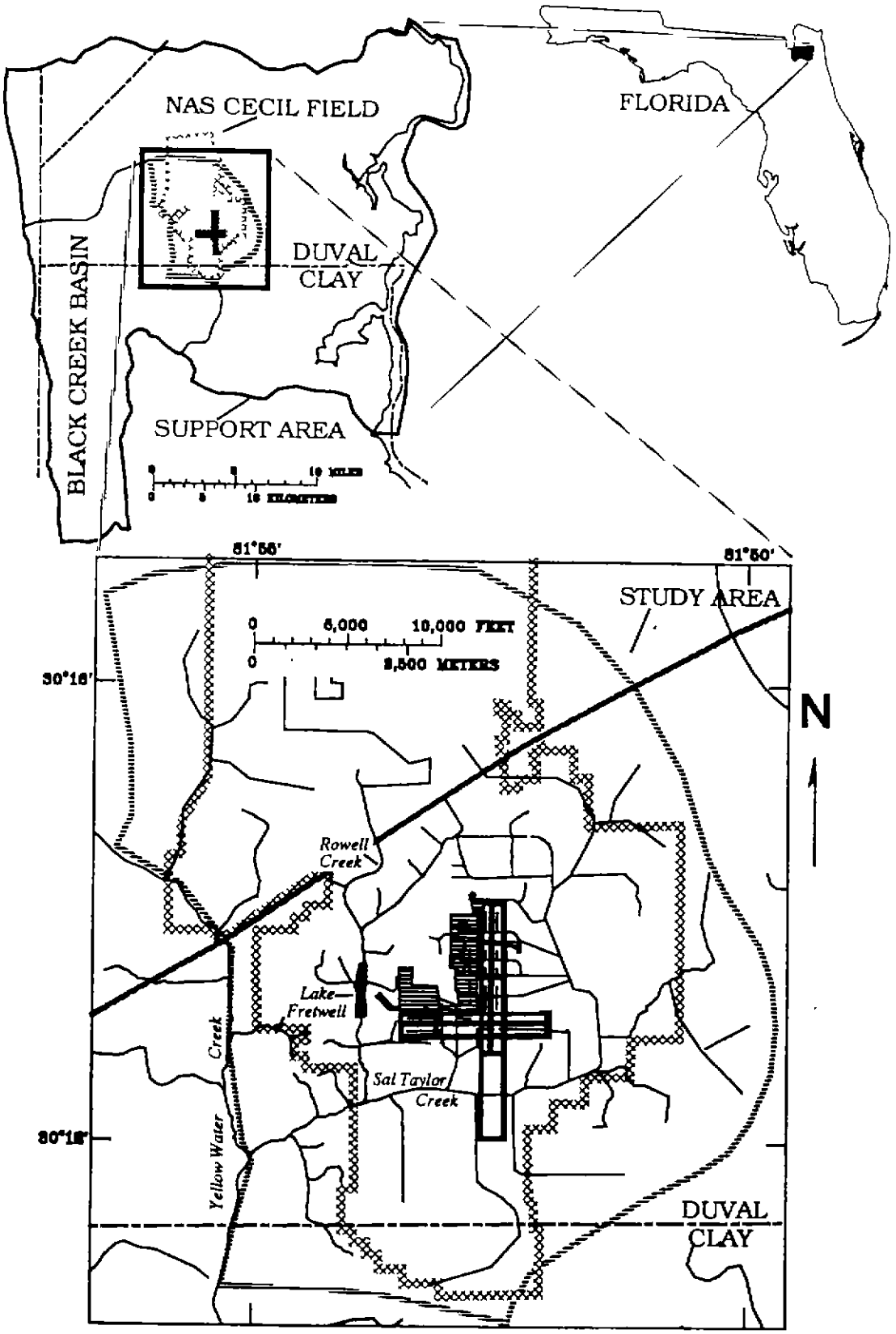
Keith J. Halford

Keith J. Halford

LIST OF PACKETS

1. Summary of base wide model lateral and vertical discretization and extent.
2. Calibrated potentiometric surfaces around site 16 in model layers 1-5 (Upper, Middle, and Lower Surficial, Blue Marl, and the Upper Rock) on May 6, 1994 with residuals posted.
3. Calibrated potentiometric surfaces around site 16 in model layers 1-5 (Upper, Middle, and Lower Surficial, Blue Marl, and the Upper Rock) on October 19, 1994 with residuals posted.
4. Portion of 70 column by 71 row grid used to evaluate pump-and-treat options at site 16.
5. Forward-tracked particle paths from site 16 assuming a steady recharge rate of 6"/yr and no remediation.
6. Backward-tracked particle paths and capture zones from 1 remediation well screened across the Upper and Middle Surficial and produced at 5 gpm.
7. Backward-tracked particle paths and capture zones from 3 remediation wells screened across the Upper and Middle Surficial and produced at 5 gpm.
8. Backward-tracked particle paths and capture zones from 4 remediation wells screened across the Upper and Middle Surficial and produced at 5 gpm.

Summary of Base wide model properties.



Packet 1

Fig. 1

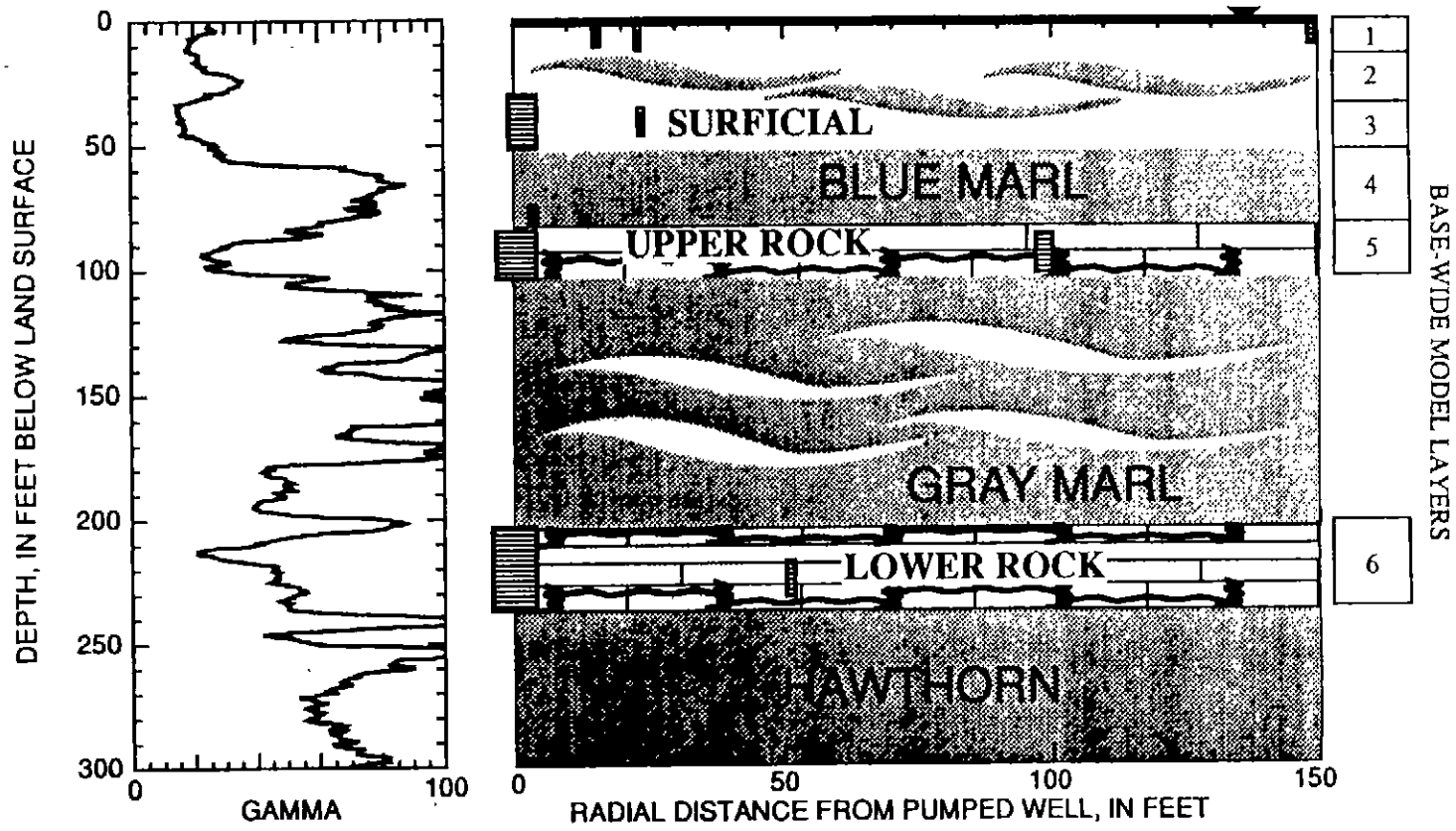


Figure 2.–Cross-section showing well placement for aquifer tests at NAS Cecil Field.

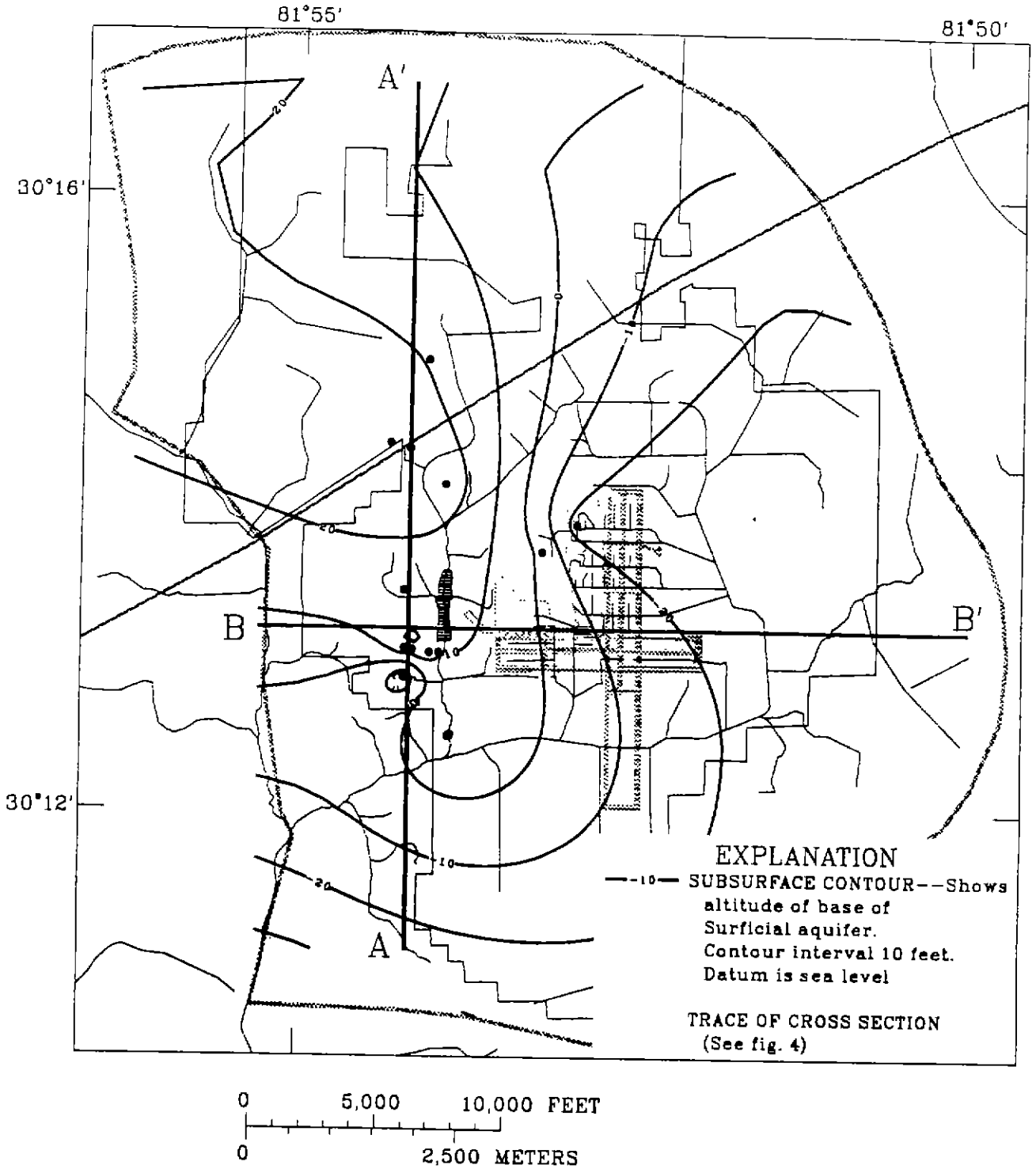


Figure 3.--Altitude of base of the Surficial aquifer in the study area.

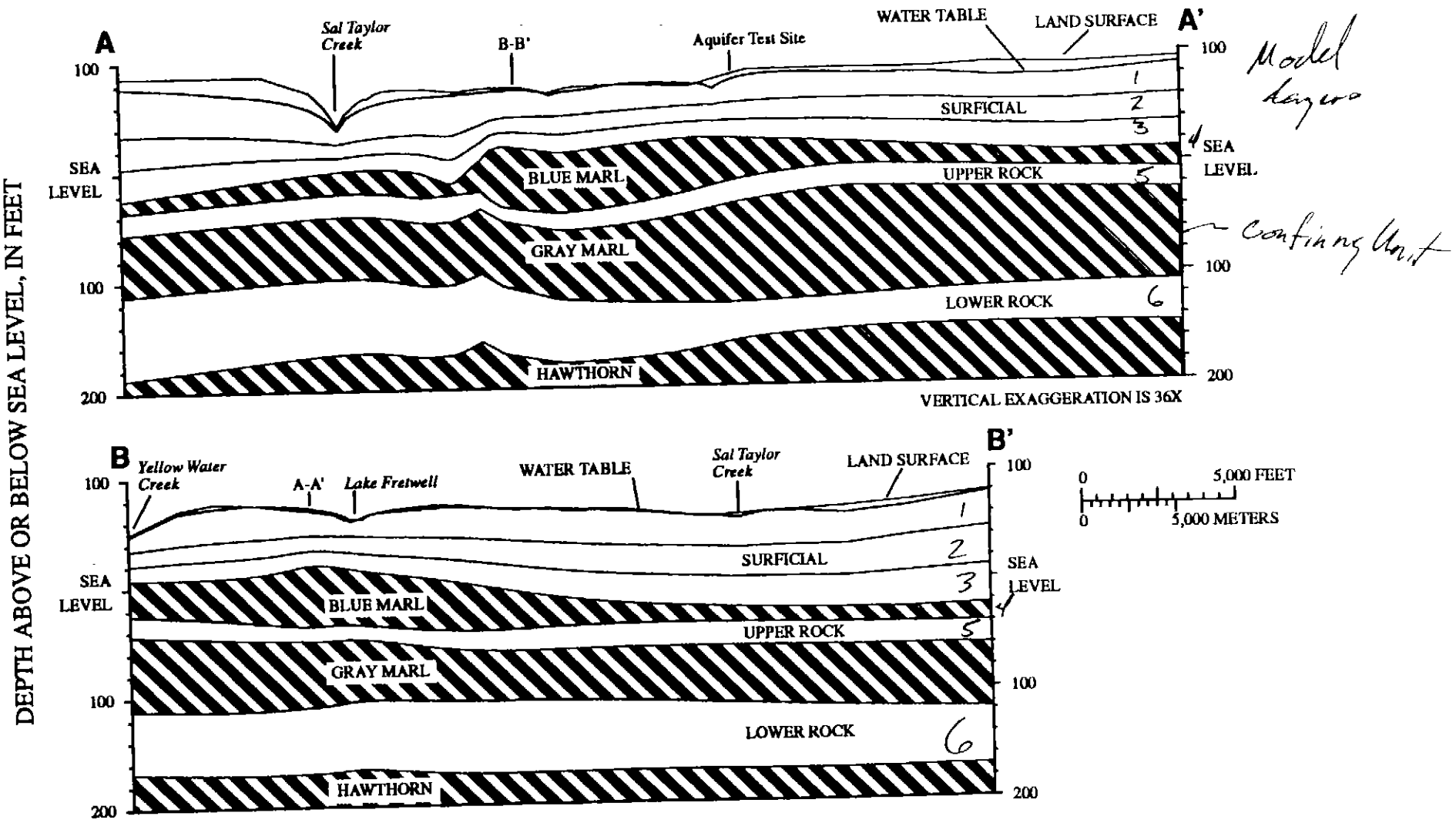
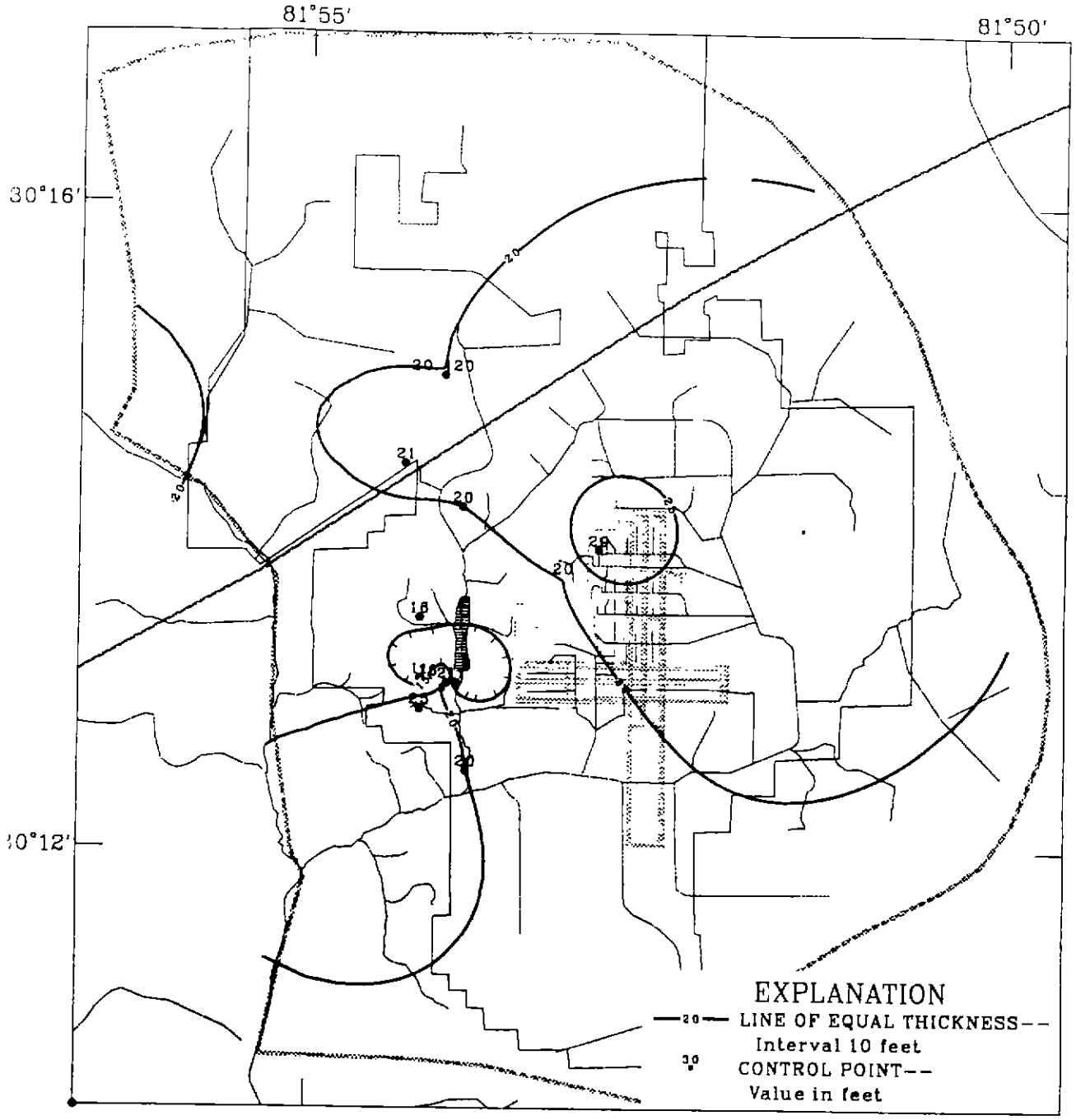


Figure 4.--Diagrammatic sections A-A' and B-B' in the study area.


81°55'
81°50'
30°16'
30°12'
20
30
21
18
EXPLANATION
20 LINE OF EQUAL THICKNESS--
Interval 10 feet
30 CONTROL POINT--
Value in feet

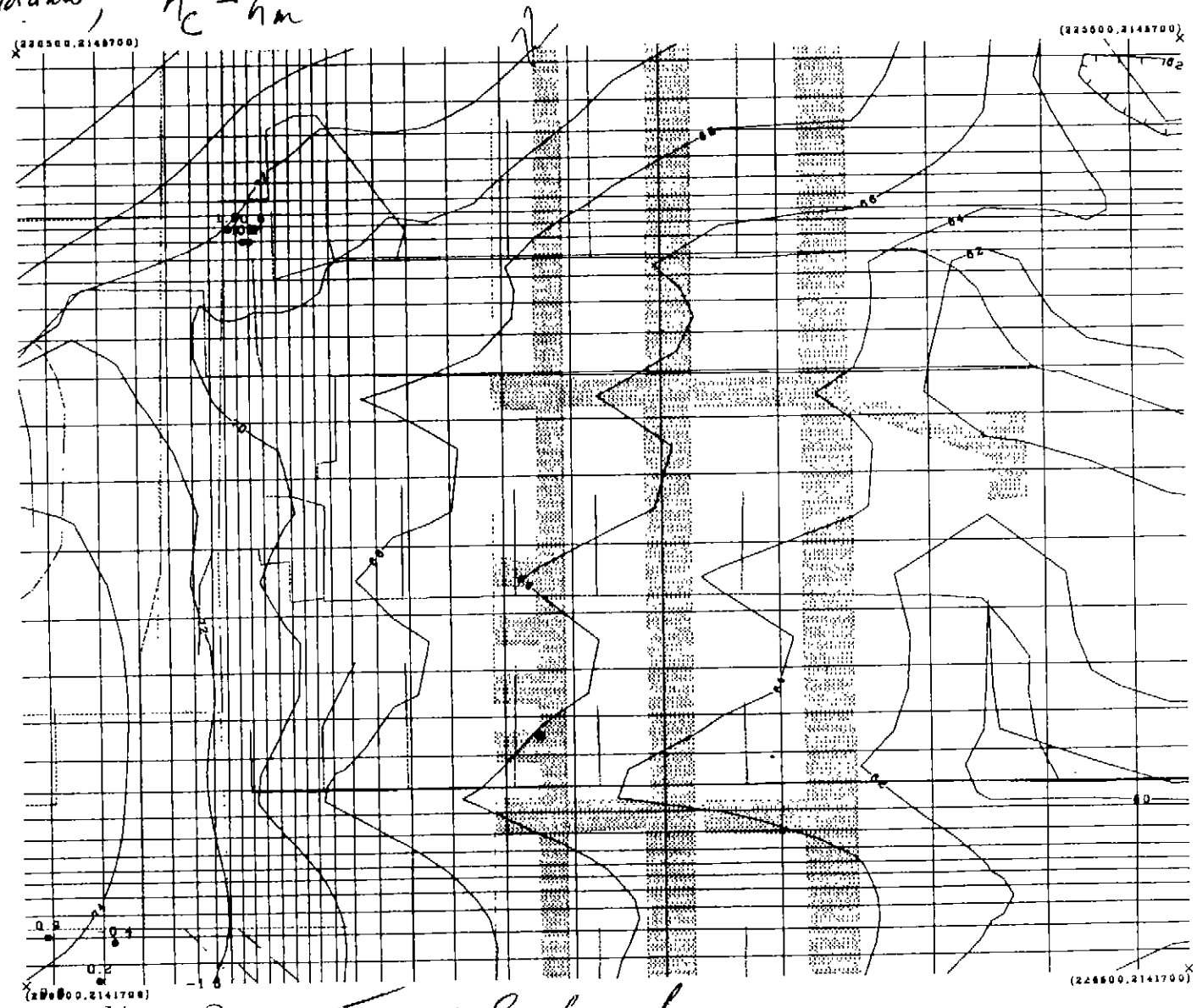
From calibrated, model

May '94

.0 - Residuals, $h_c - h_m$

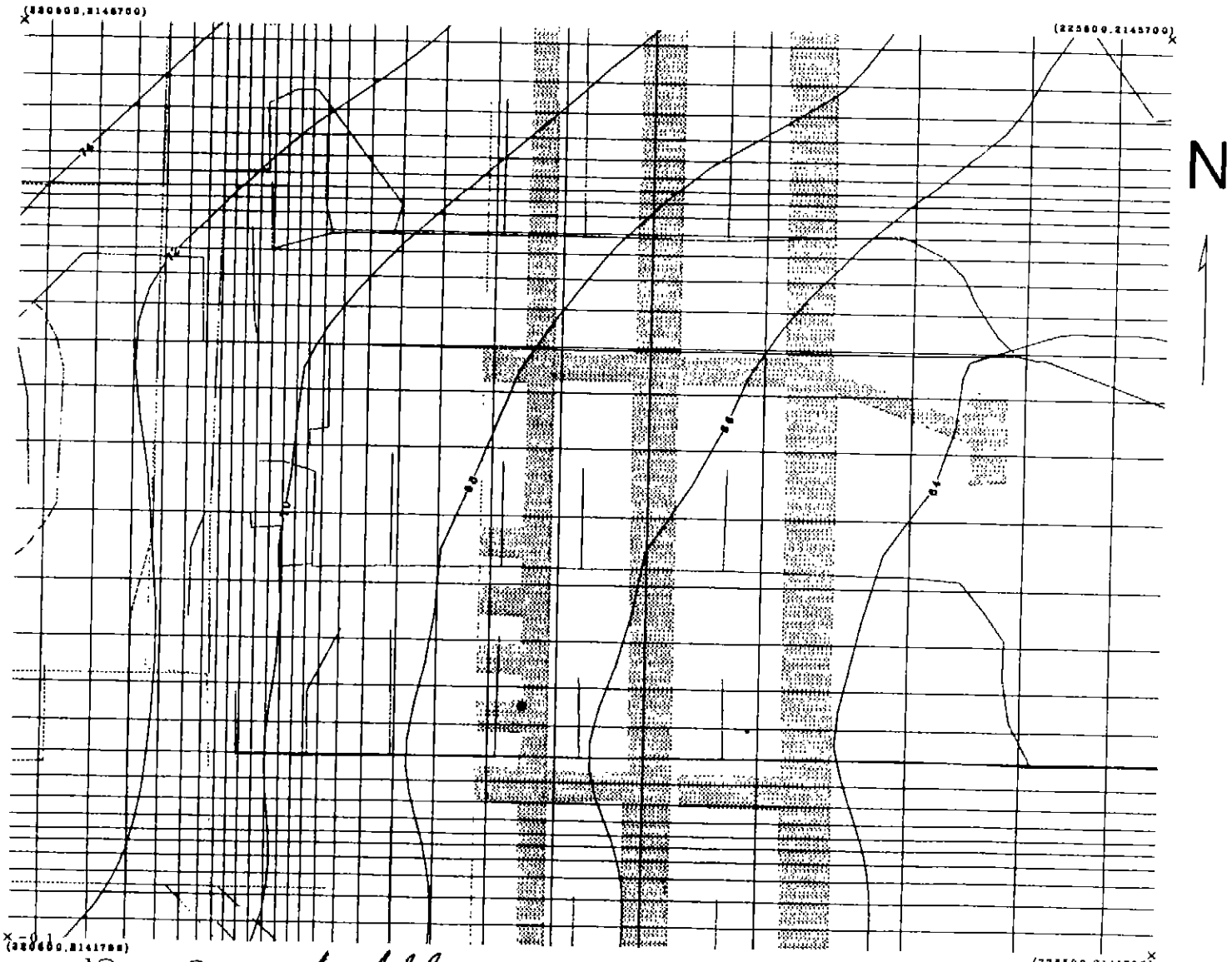
~5"/yr

Recharge



H_sp2res Top of Surficial

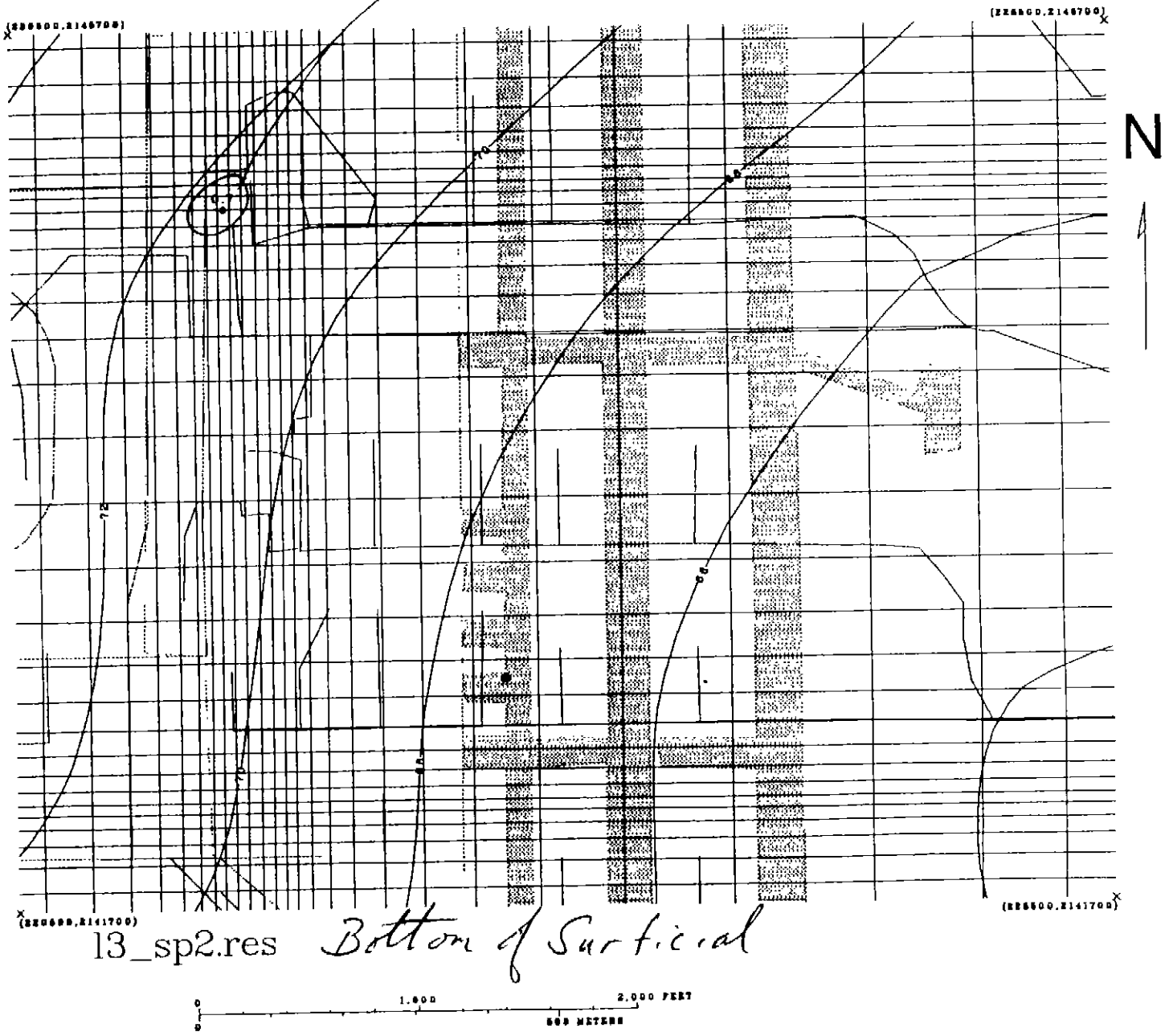
Plot 2



12_sp2.res Middle of Surficial

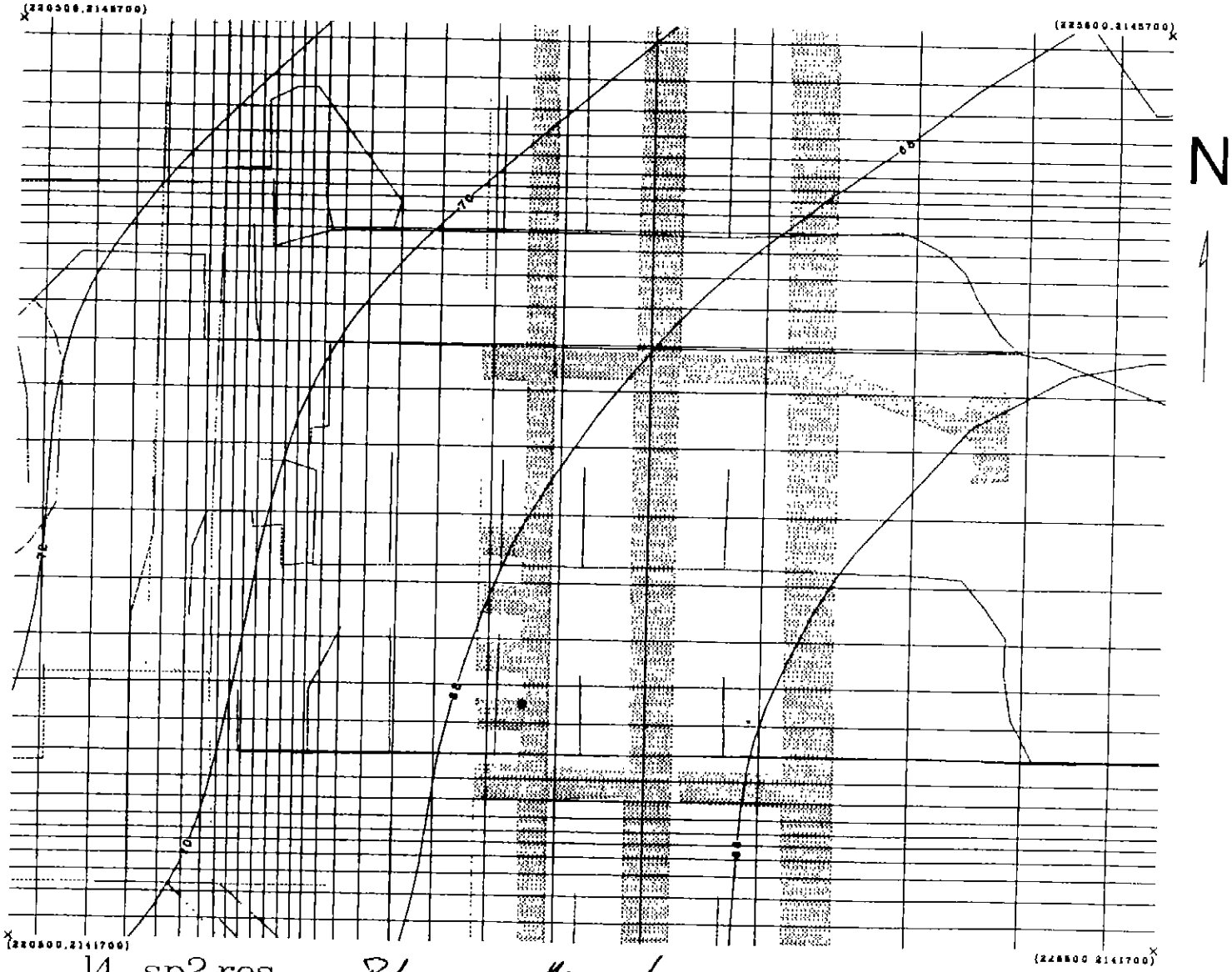
-1 0 0 1,000 2,000 FEET
0 500 METERS

model head is 0.7' higher than what was measured



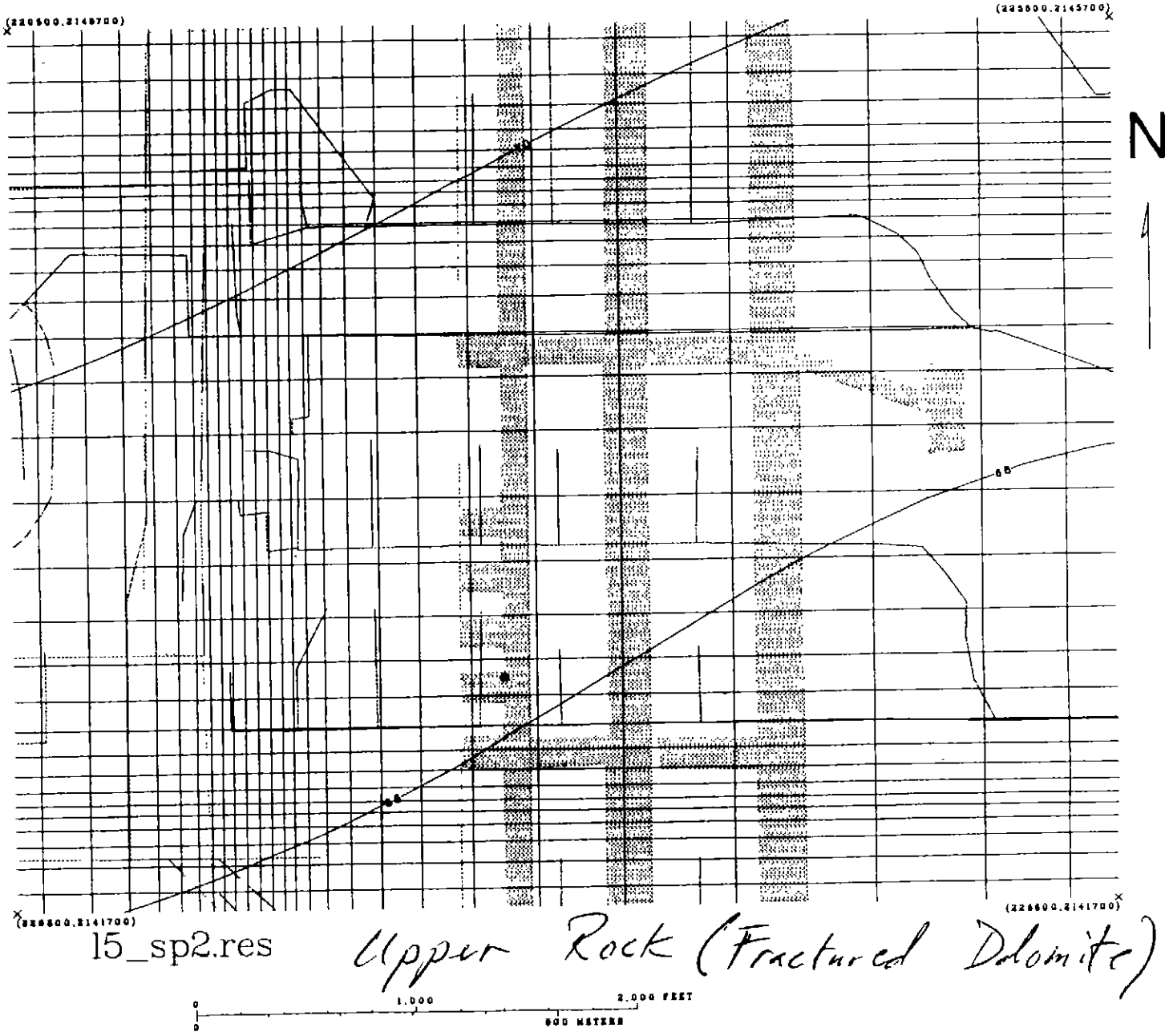
13_sp2.res Bottom of Surficial

0 1,000 2,000 FEET
0 500 METERS



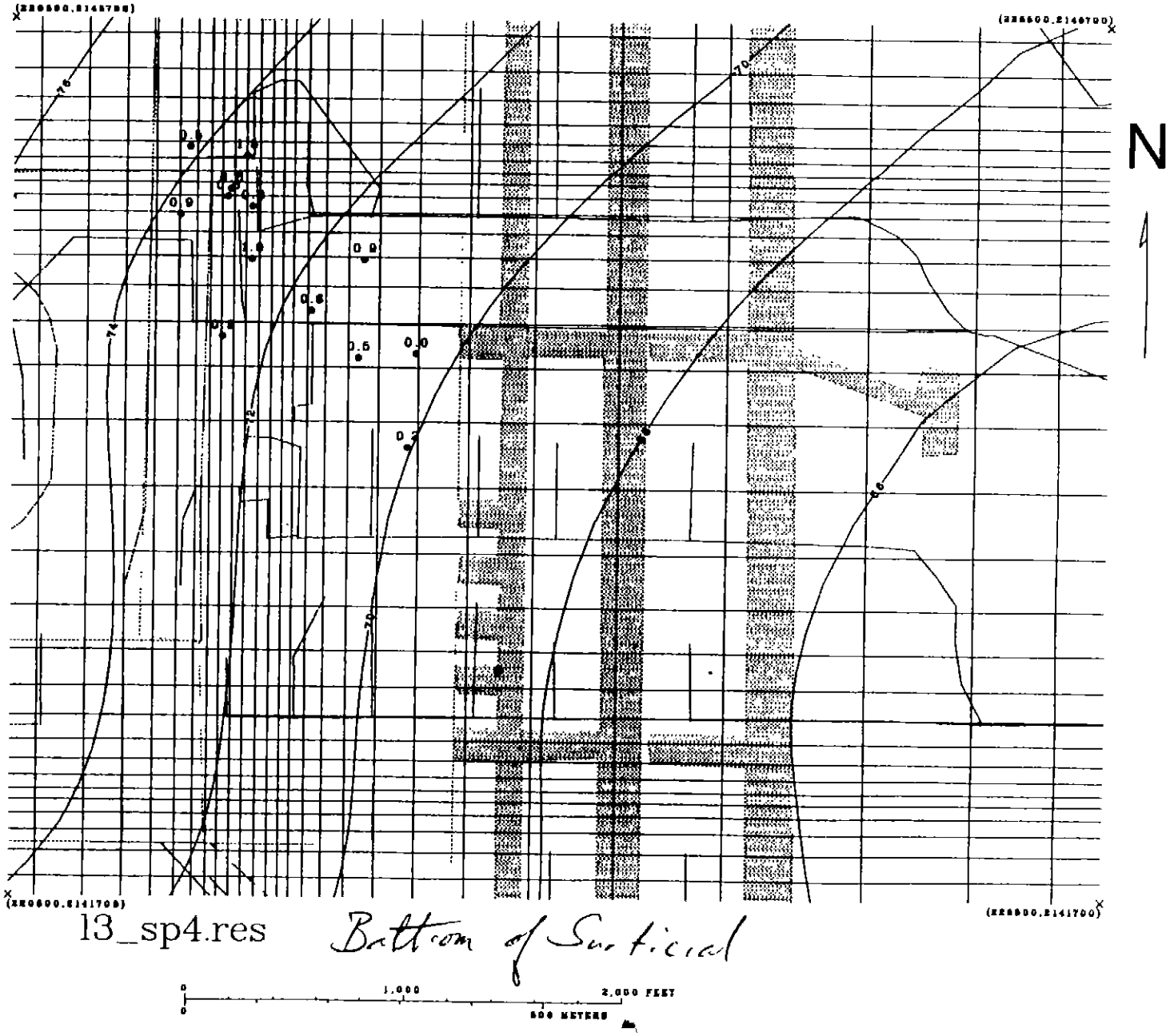
14_sp2.res Blue Marl

0 1,000 2,000 FEET
0 500 METERS

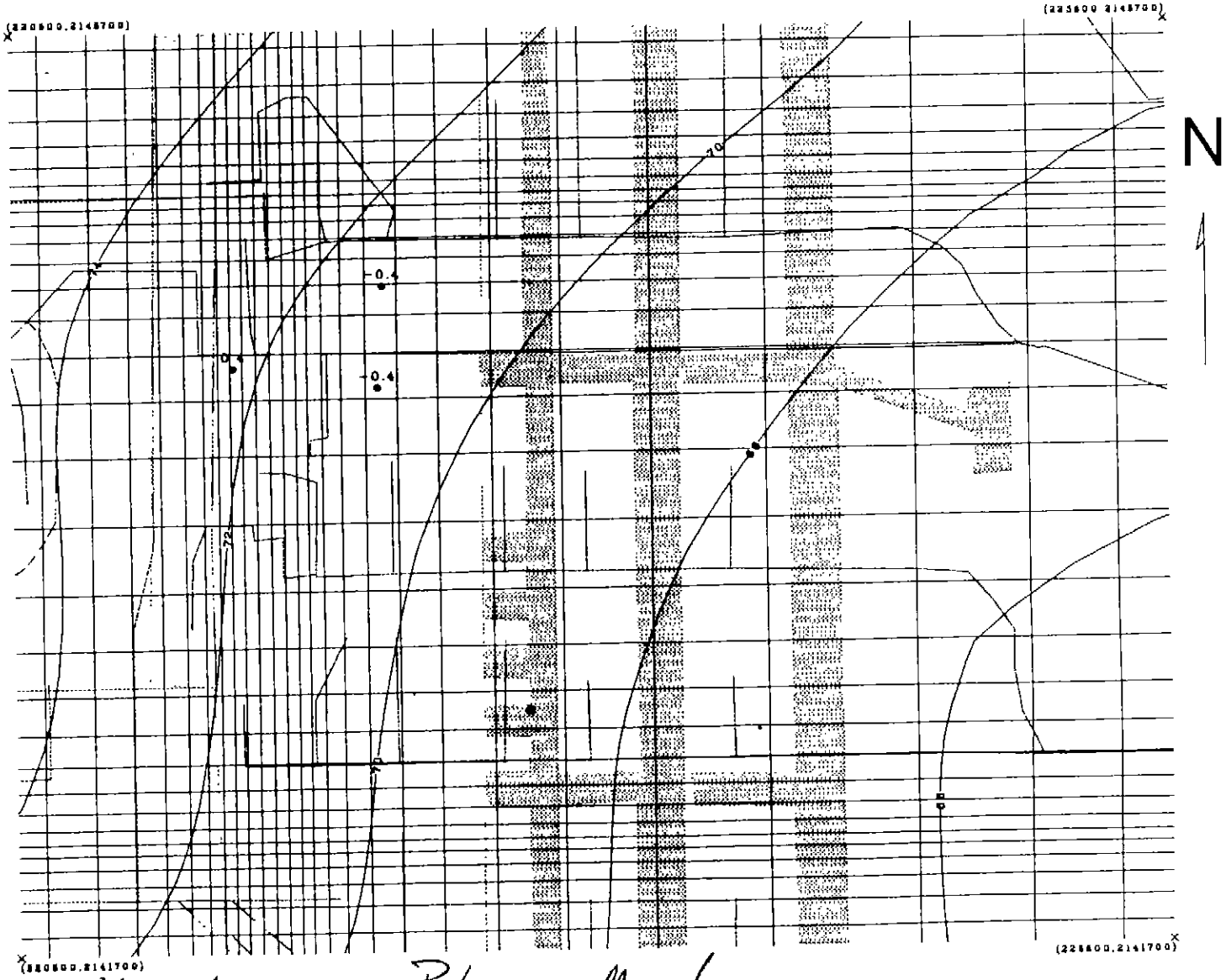


15_sp2.res

Upper Rock (Fractured Dolomite)

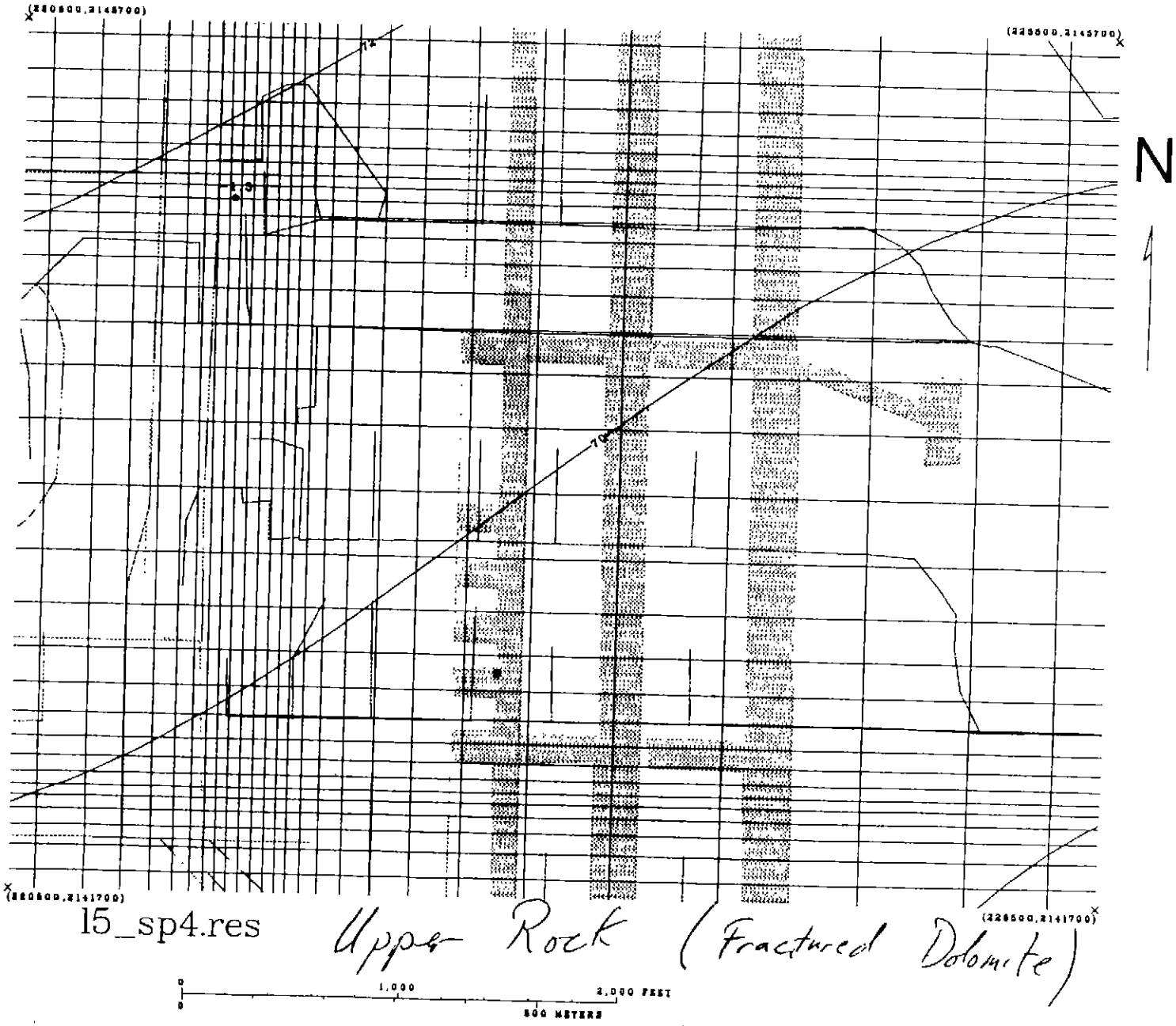


13_sp4.res Bottom of Surficial

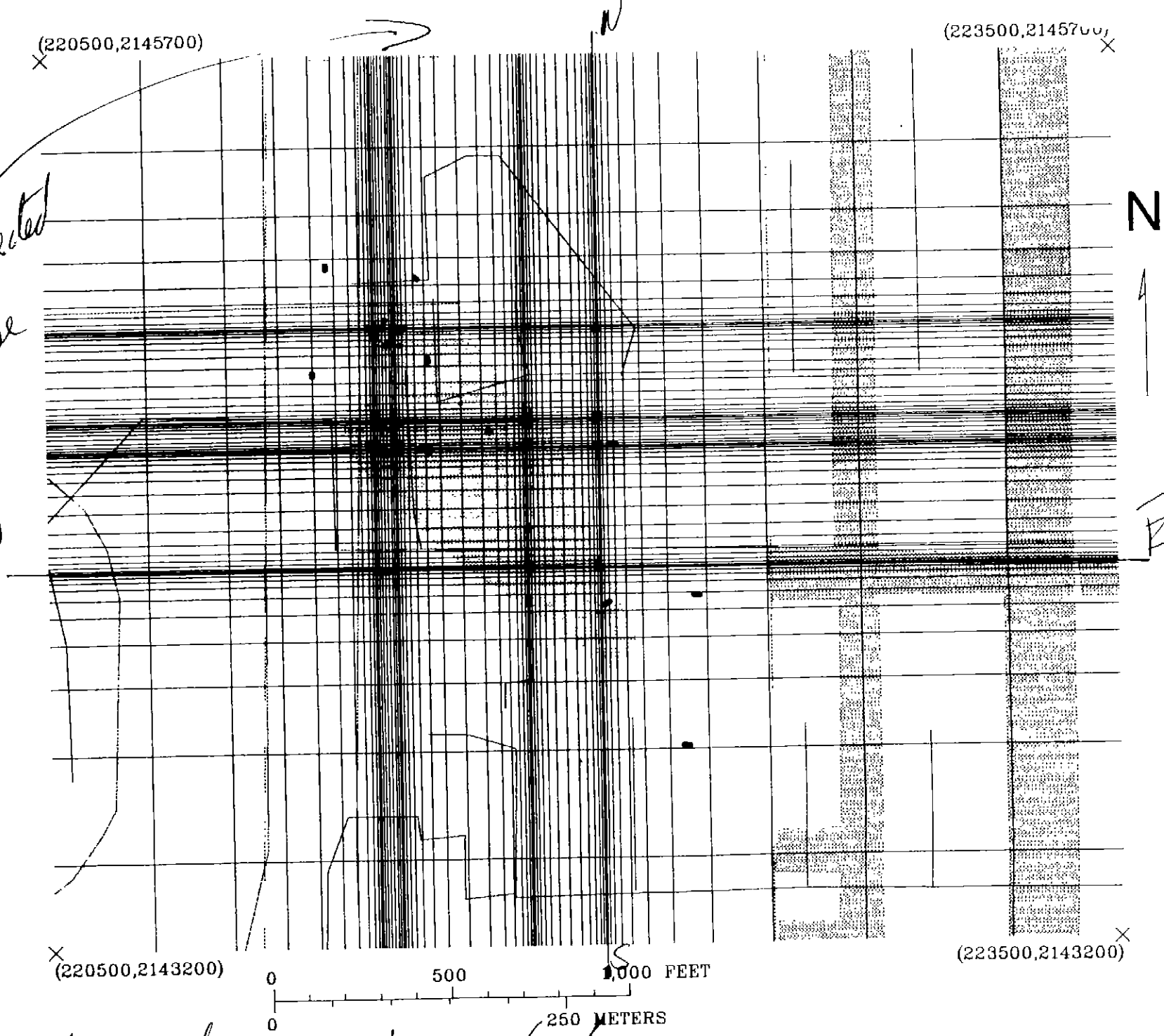


14_sp4.res Blue Marl

0 1,000 2,000 FEET
0 500 METERS



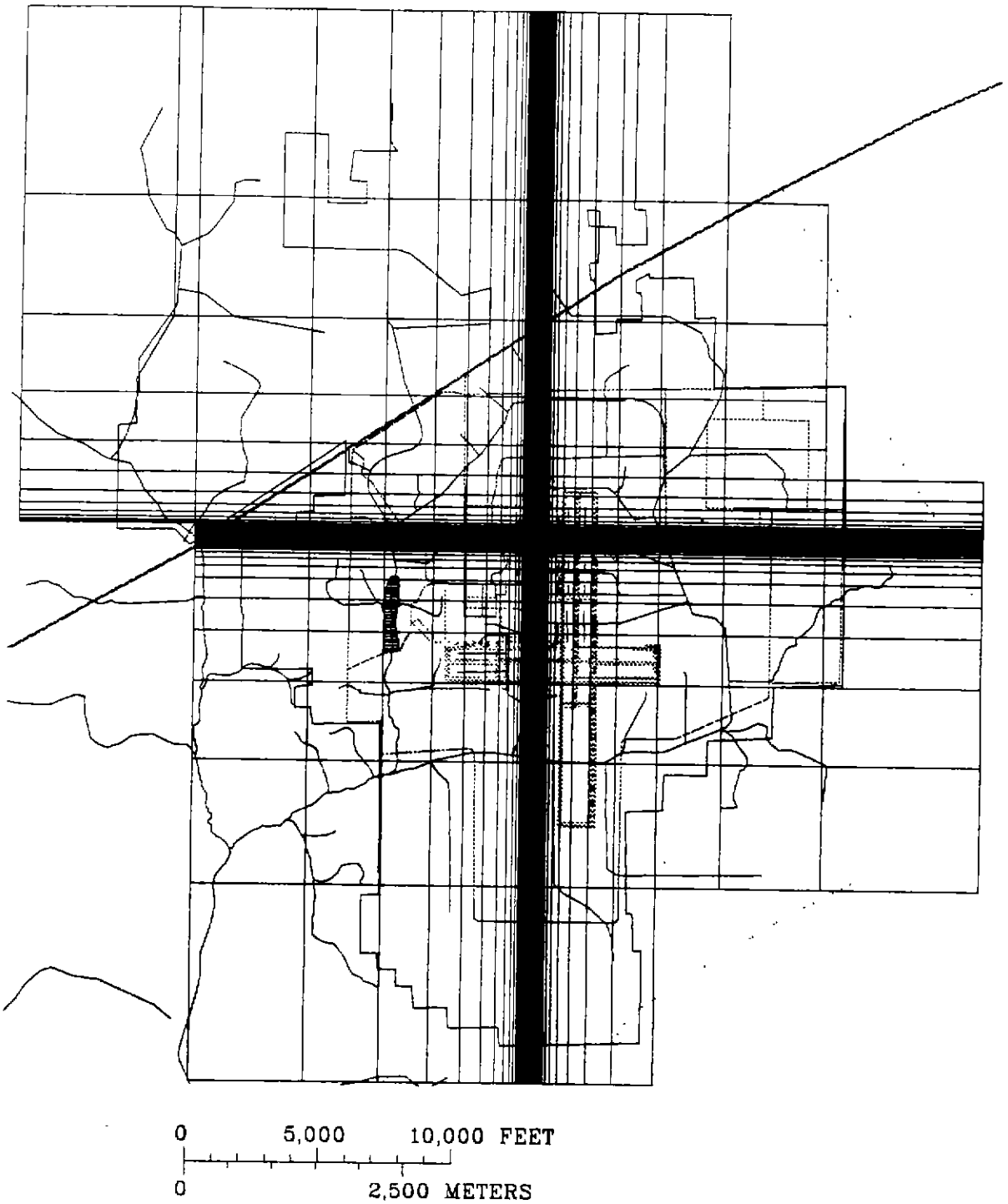
15_sp4.res Upper Rock (Fractured Dolomite)



Sections are projected on to these slices

Grid used for site evaluation

Figure 17 - Grid for site evaluation


0
5,000
10,000 FEET
0
2,500 METERS

6" per/yr

compare pot surface to, & 2, middle Surficial. Maps in Packets 2 & 3

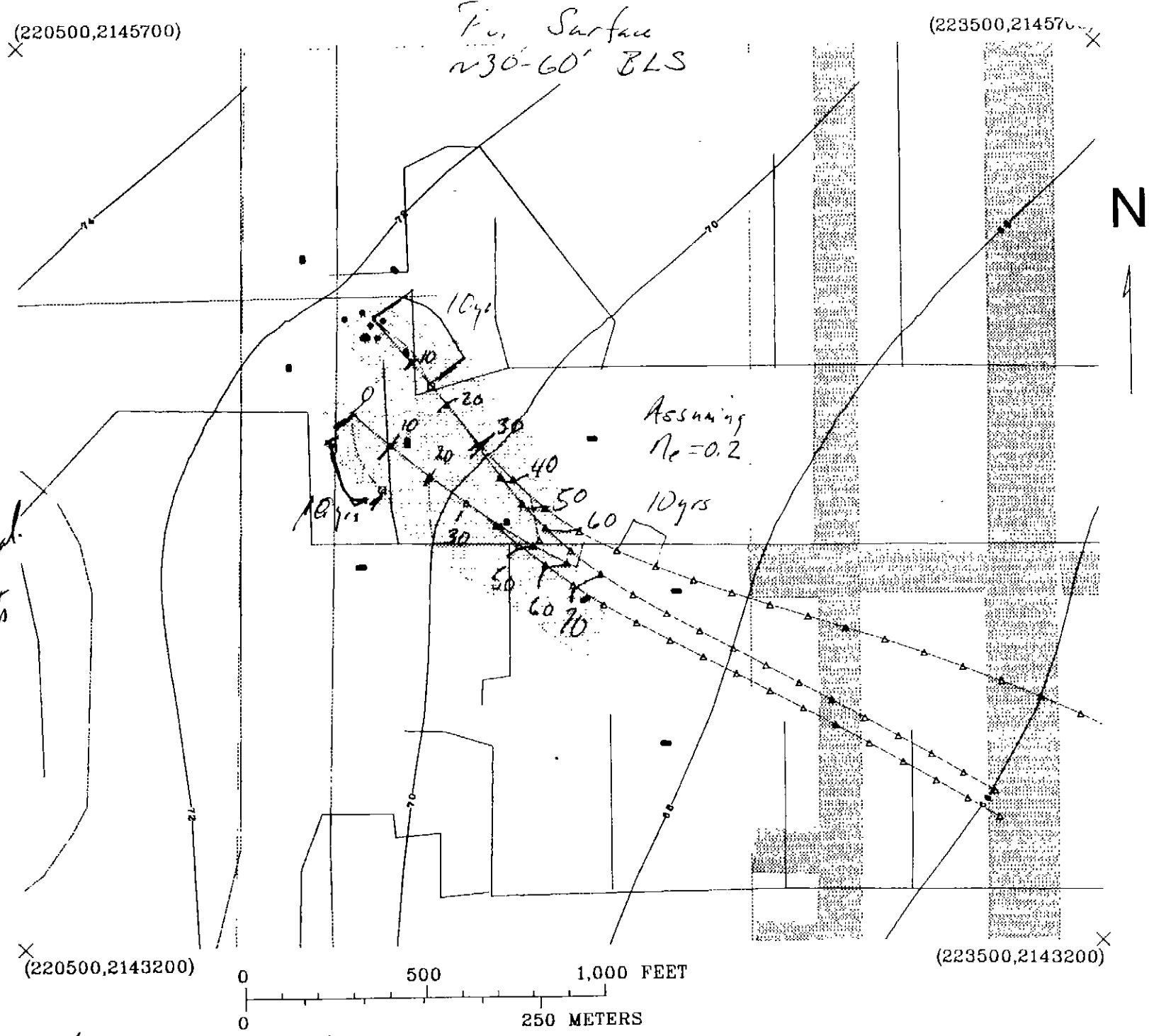
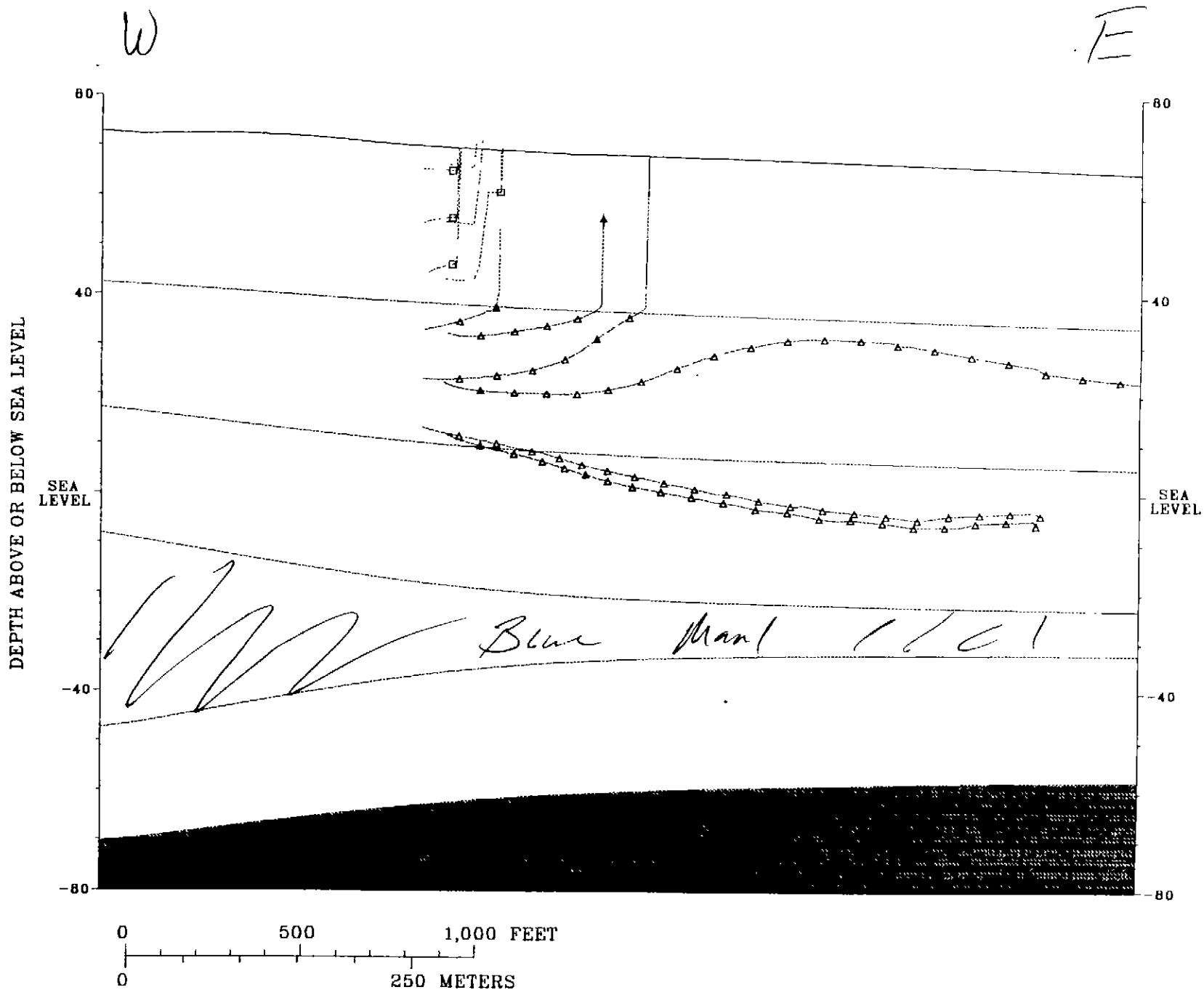
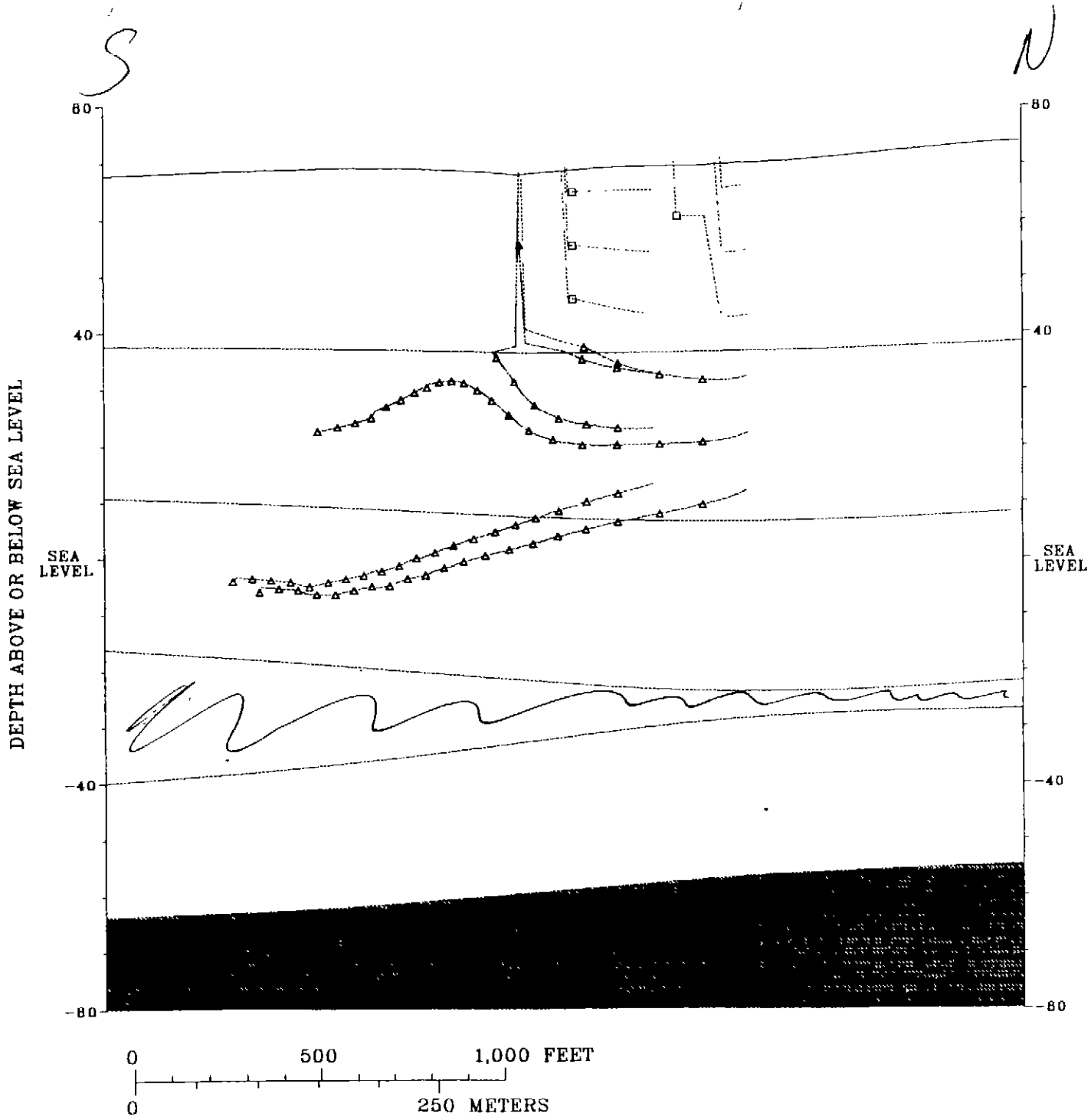
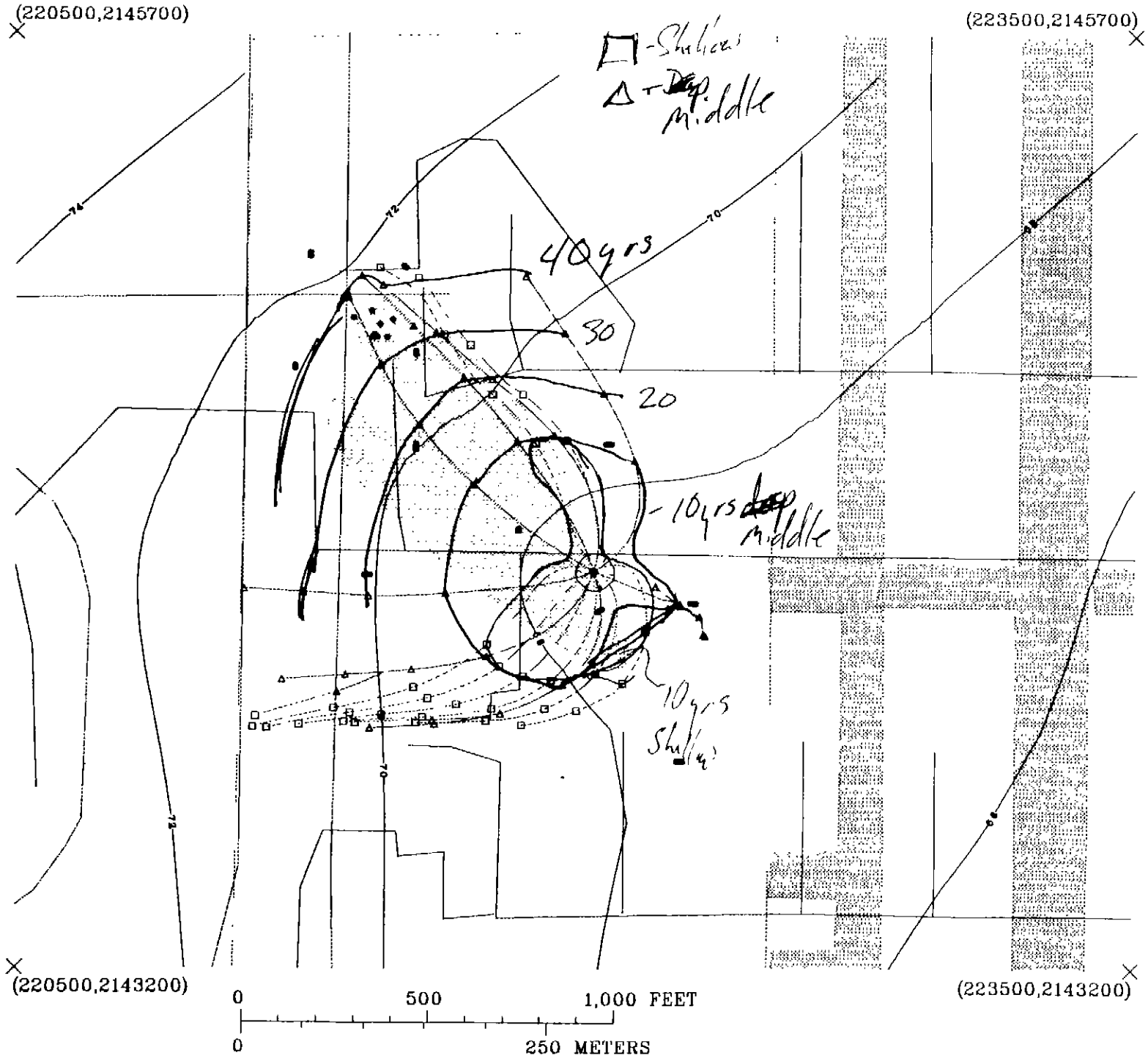


Fig 1 -- Do Nothing

Packet 5 - Fig 1 Nothing

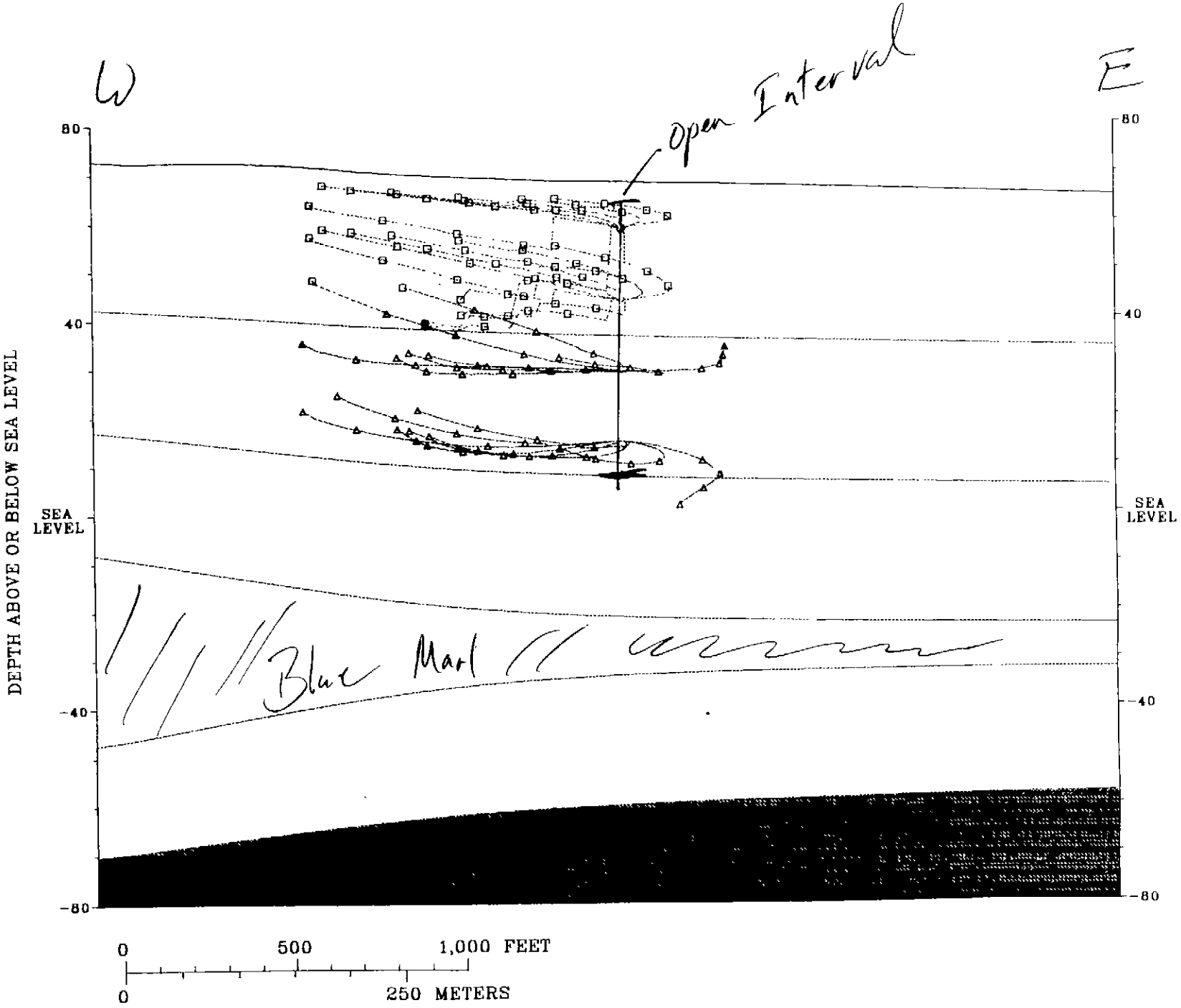

W
E
80
40
SEA LEVEL
-40
-80
DEPTH ABOVE OR BELOW SEA LEVEL
Blue Marl
0
500
1,000 FEET
0
250 METERS

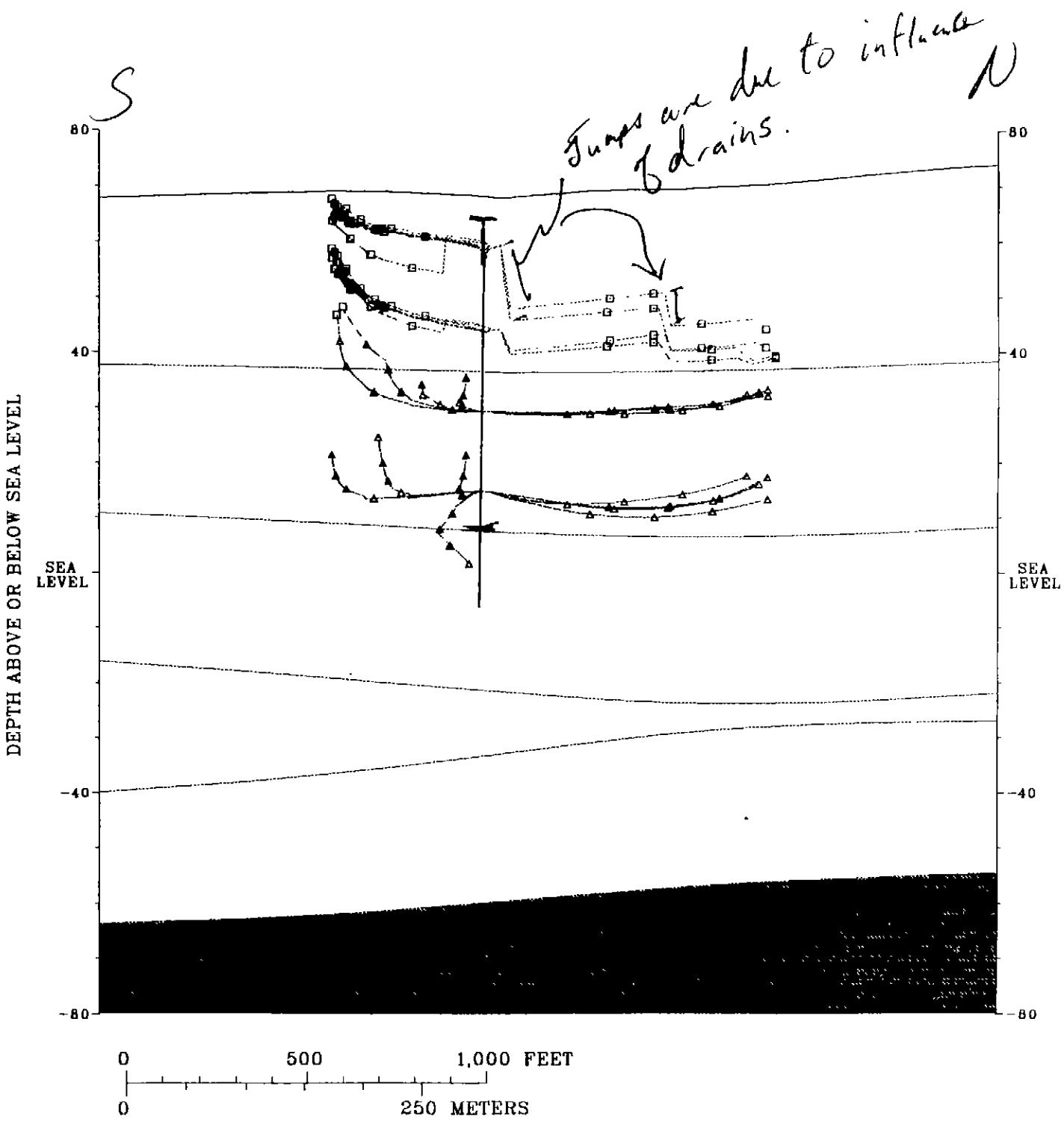

S
N
80
40
SEA LEVEL
-40
-80
DEPTH ABOVE OR BELOW SEA LEVEL
0
500
1,000 FEET
0
250 METERS

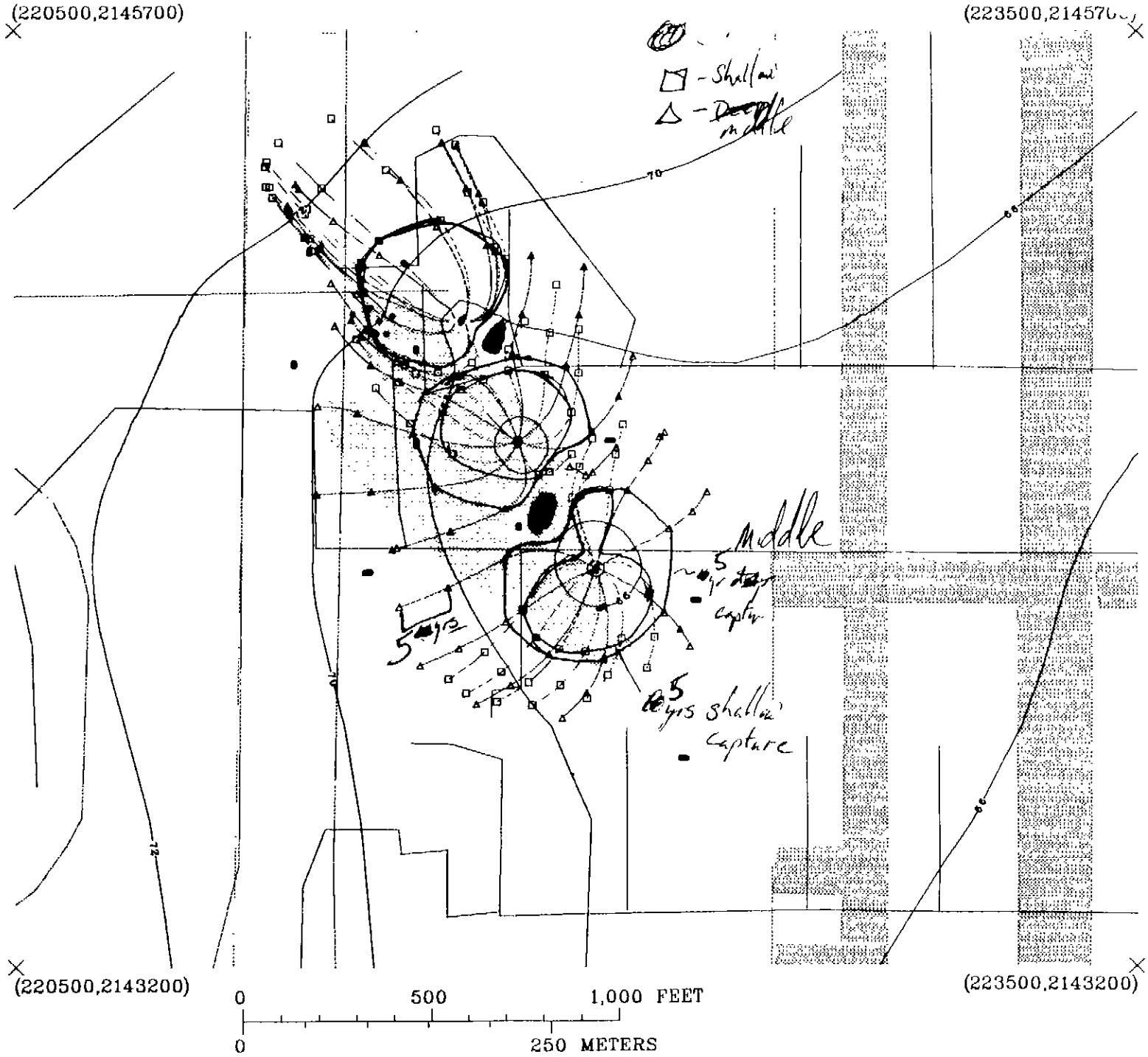


Packet G - 1 well

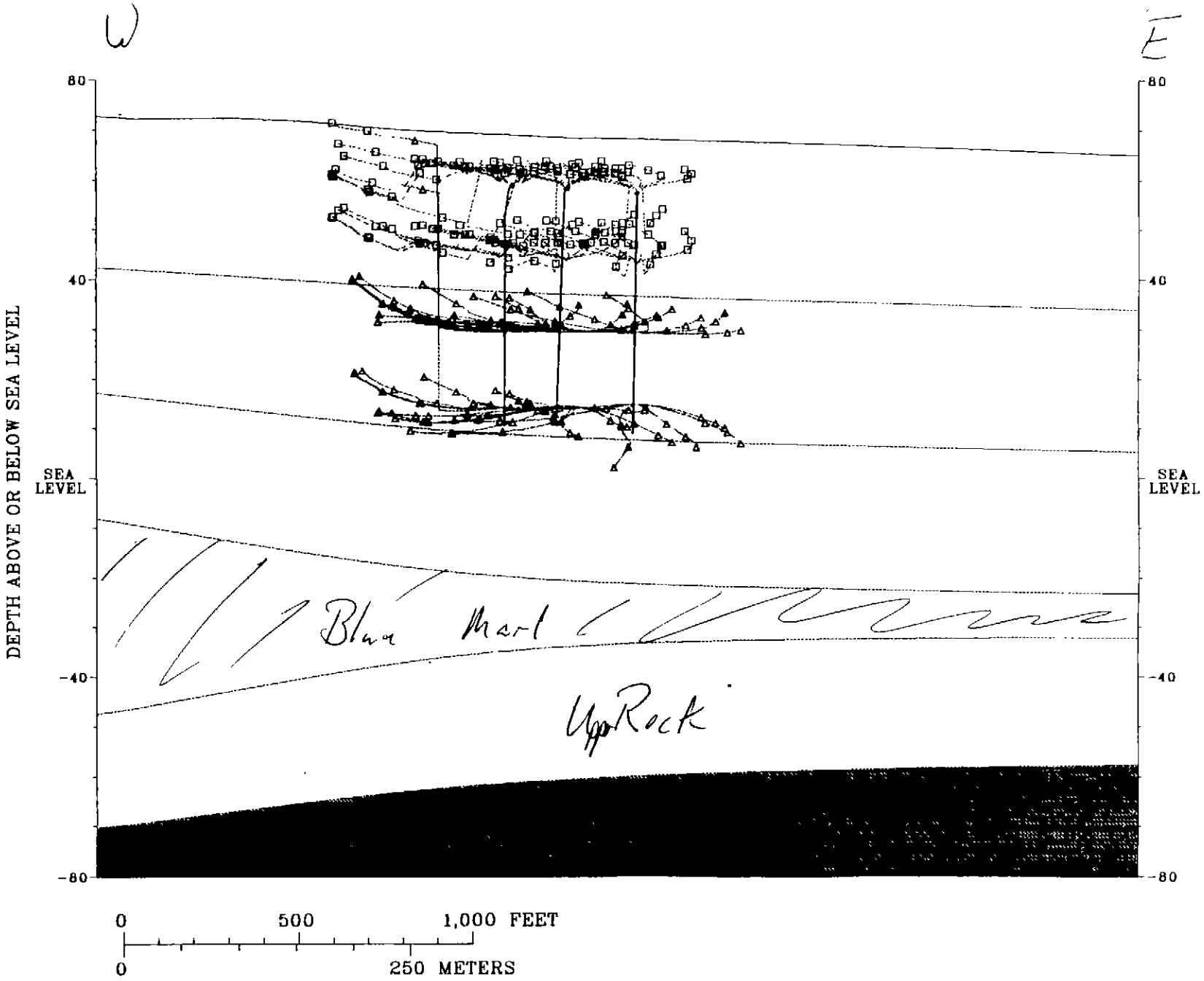
1 well pumping at 5 gpm

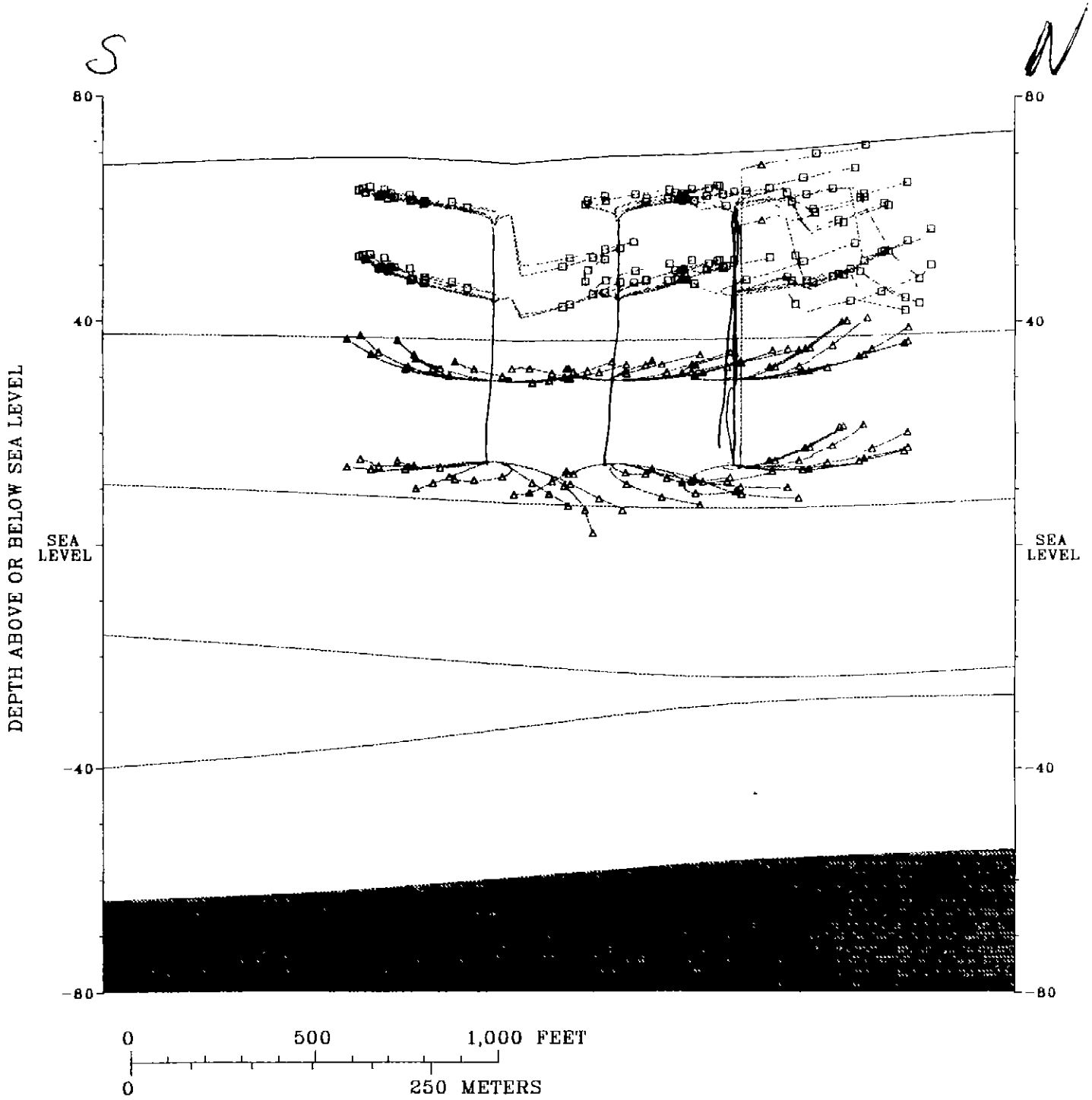

W
E
Open Interval
80
40
SEA LEVEL
-40
-80
DEPTH ABOVE OR BELOW SEA LEVEL
Blue Marl
0
500
1,000 FEET
0
250 METERS

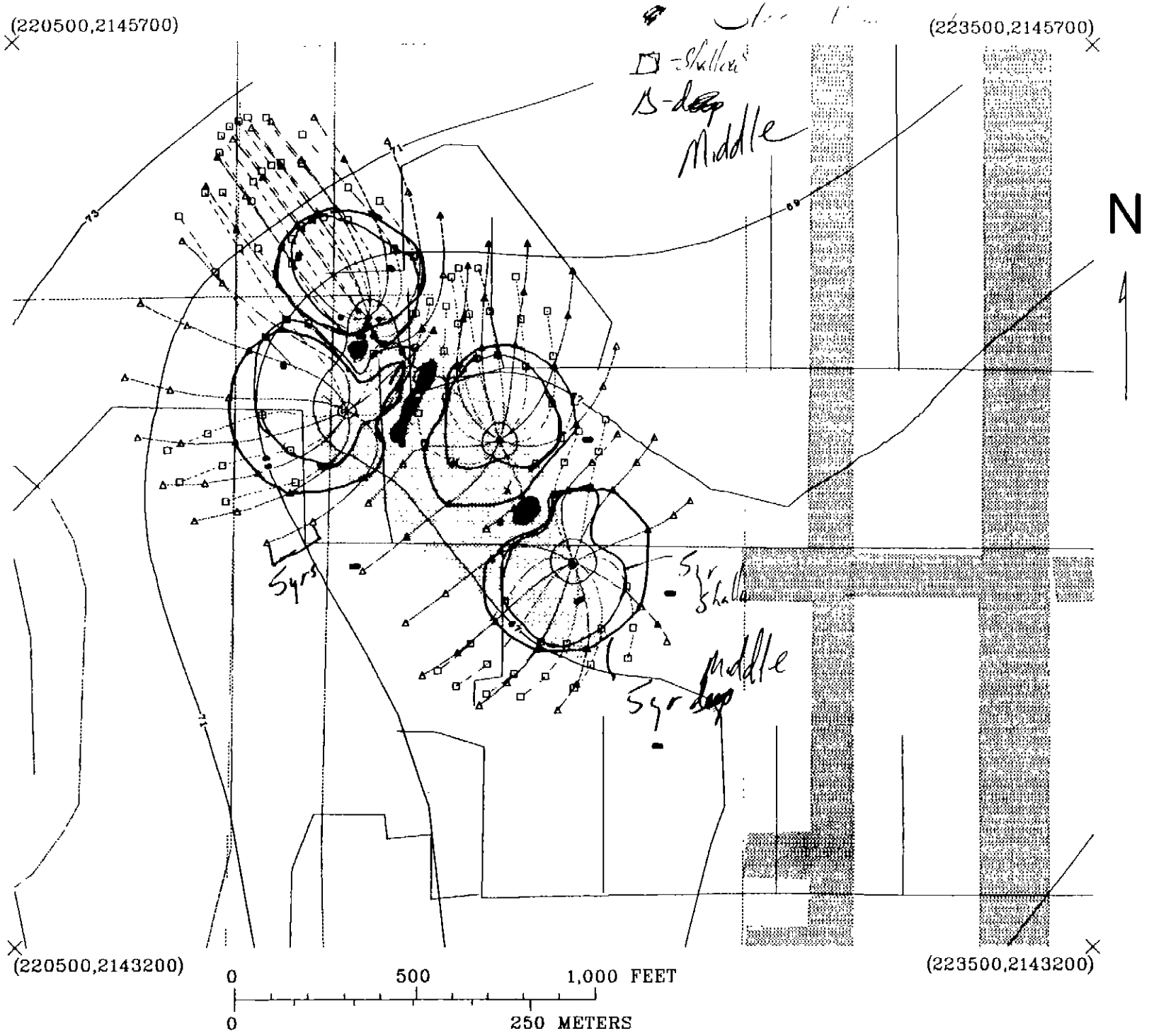

S
N
Jumps are due to influence of drains.
80
40
SEA LEVEL
-40
-80
DEPTH ABOVE OR BELOW SEA LEVEL
0
500
1,000 FEET
0
250 METERS



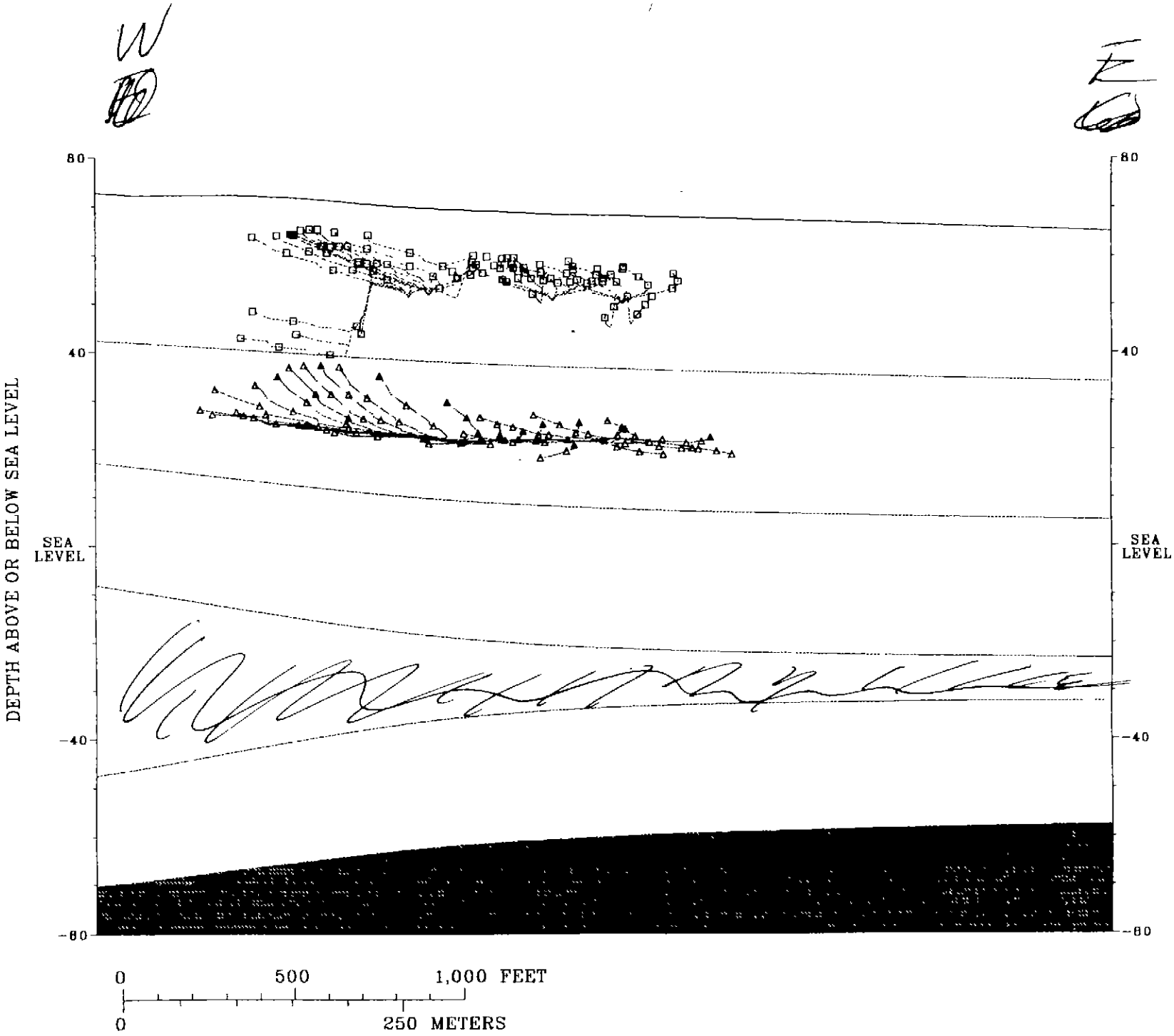
Packet 7 - 3 wells

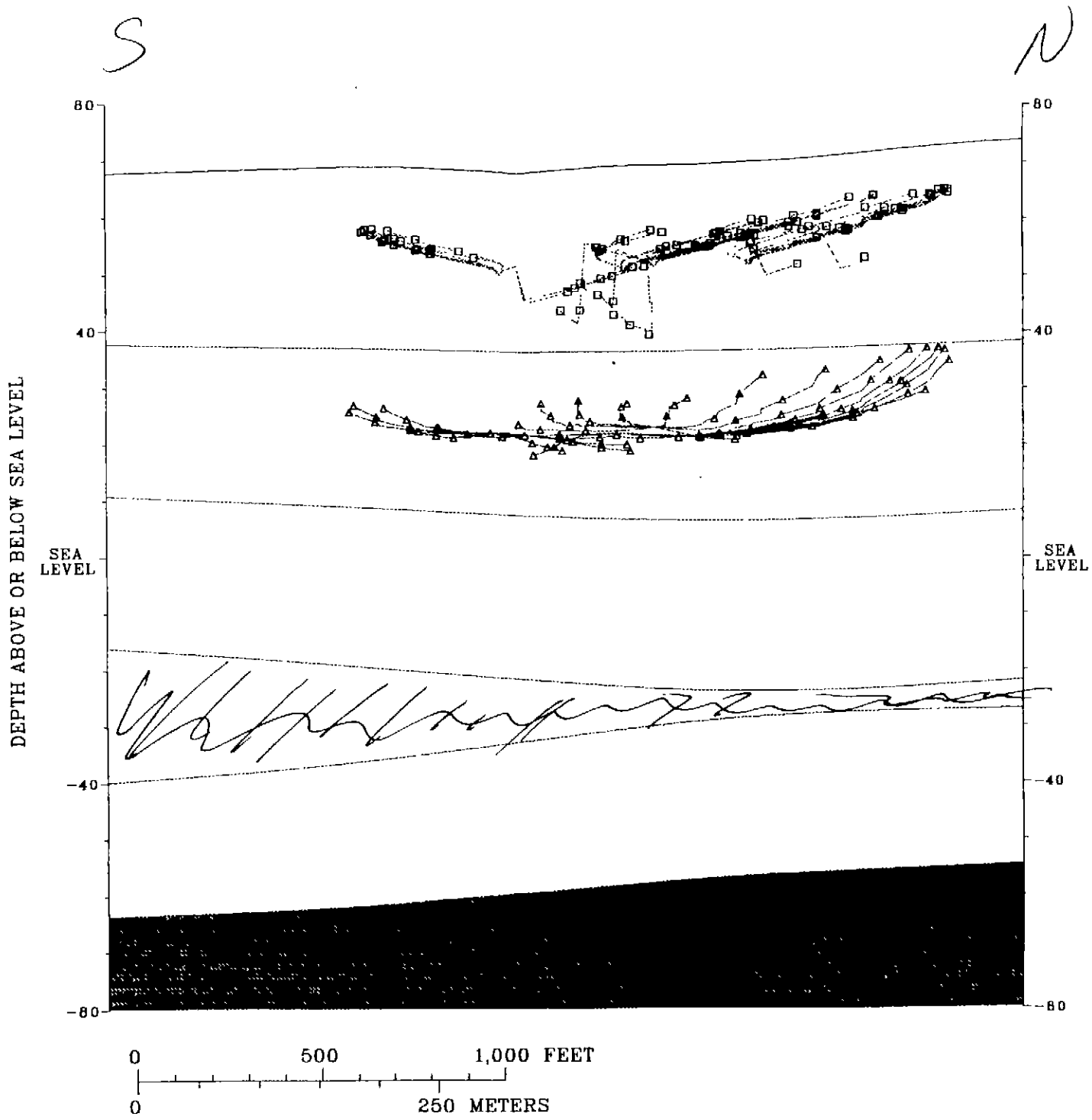

W
E
80
40
SEA LEVEL
-40
-80
DEPTH ABOVE OR BELOW SEA LEVEL
Blue Marl
Up Rock
0
500
1,000 FEET
0
250 METERS


S
N
80
40
SEA LEVEL
-40
-80
DEPTH ABOVE OR BELOW SEA LEVEL
0
500
1,000 FEET
0
250 METERS



Packet 8 - 4 wells


W
E
80
40
SEA LEVEL
-40
-80
DEPTH ABOVE OR BELOW SEA LEVEL
0
500
1,000 FEET
0
250 METERS

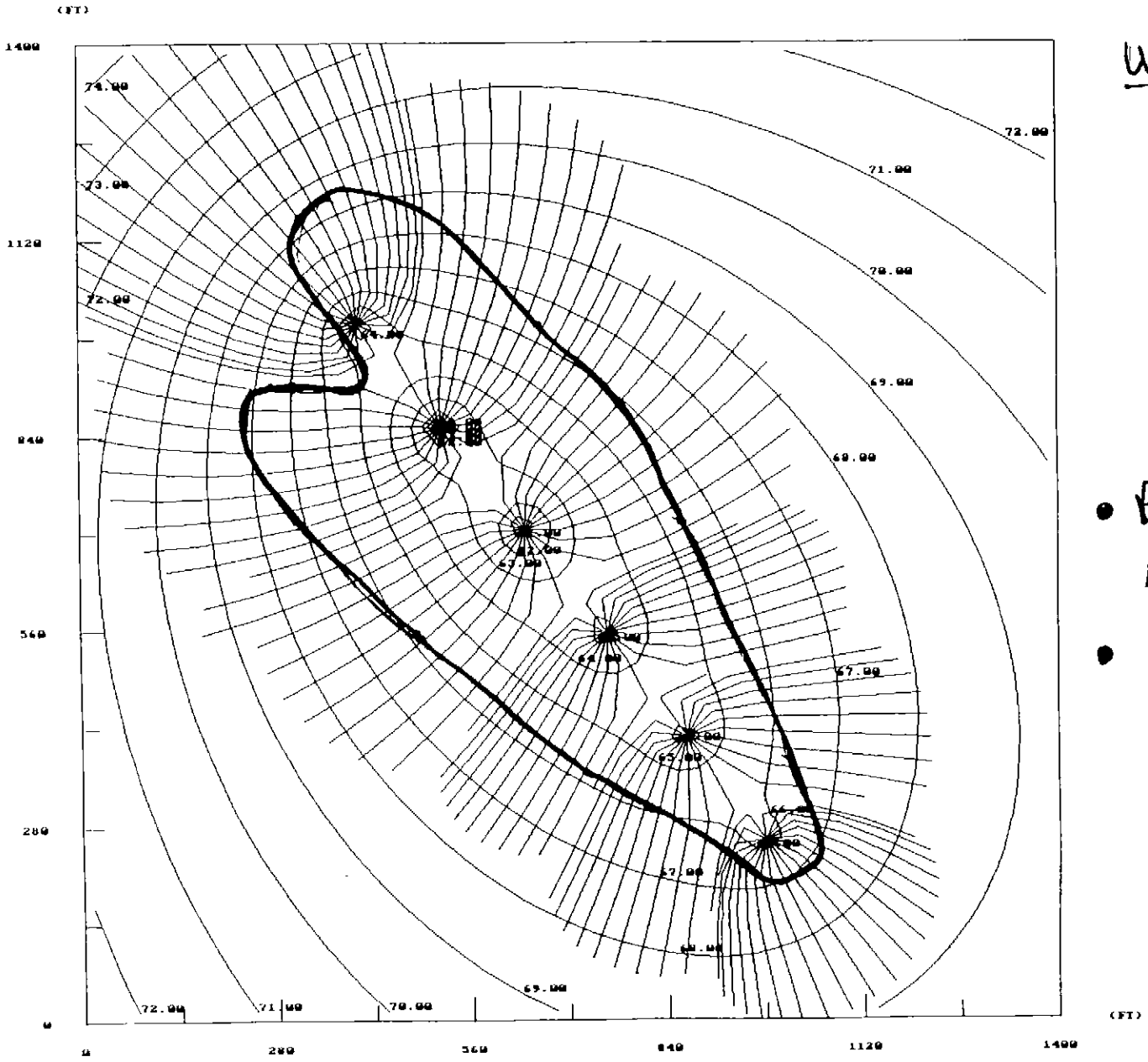

S
N
80
40
SEA LEVEL
-40
-80
DEPTH ABOVE OR BELOW SEA LEVEL
0
500
1,000 FEET
0
250 METERS

APPENDIX F
ATTACHMENT B

FIGURES FOR ALTERNATE GROUNDWATER EXTRACTION SYSTEM

CF OUT.PM4

(1)

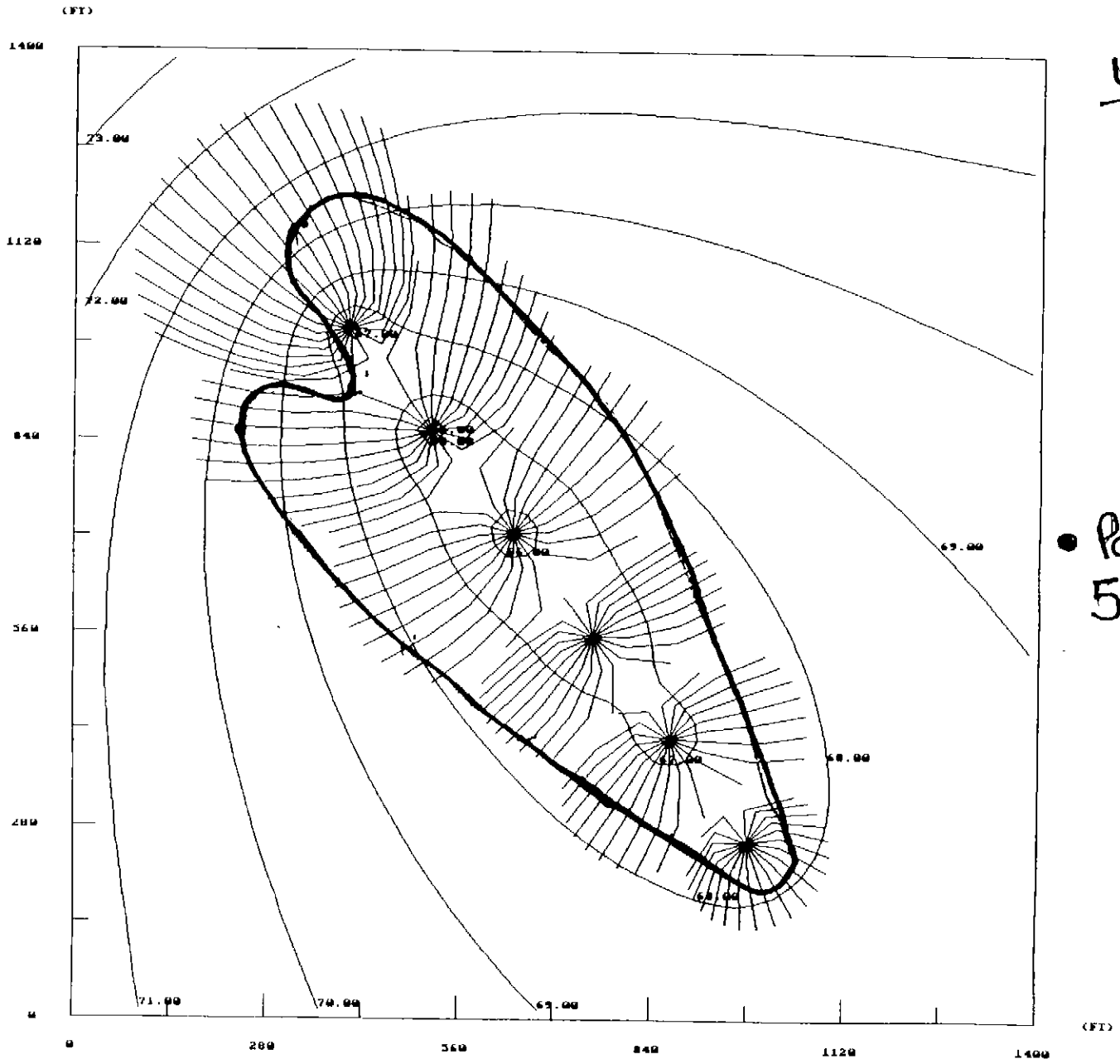


Well	Flow
1	10 gpm
2	12
3	12
4	6
5	6
6	4
	50 gpm

- Pathlines are 5 yrs long
-

CF 0U7.P16

(2)

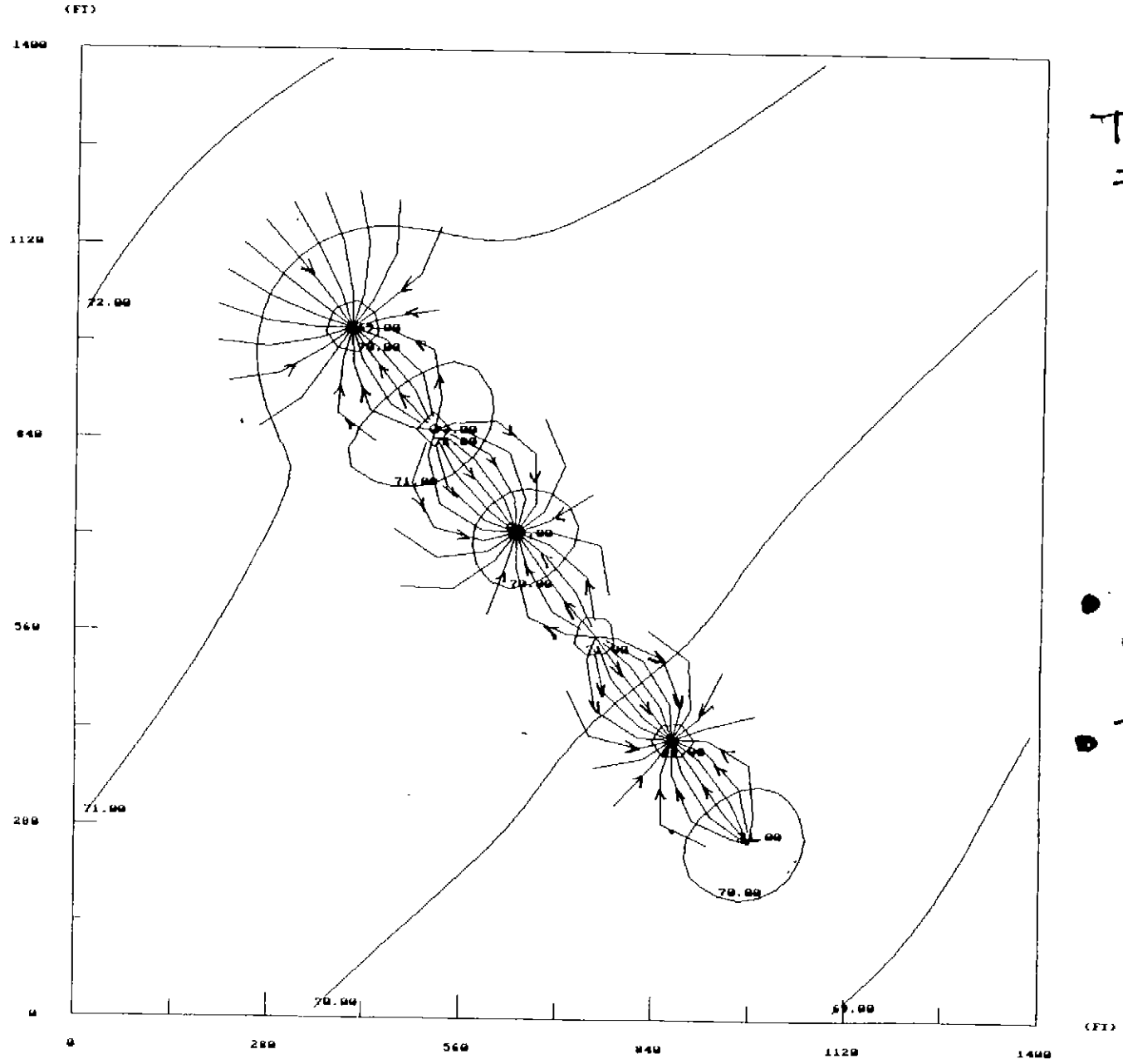


Well	Flow
1	6 gpm
2	6
3	6
4	3
5	3
6	2
	26 gpm

- Pathlines are 5 yrs long

CFOU7.PT7

3



To Flush Stagnation Zones

Well	Flow
1	6 gpm
2	−6 gpm
3	6 gpm
4	−5 gpm
5	5 gpm
6	−5 gpm

- Pathlines are 5 yrs long
- Time between a discharge-recharge well pair is < 1 yr

APPENDIX G

SENSITIVITY ANALYSES

PROJECT Sensitivity Analysis for MM Alternatives 1/2	COMP. BY MJR	JOB NO. 08500-36
	CHK. BY MDL	DATE 3/15/95

- Admin O&M

Sensitivity of Treatment Duration

Alt.	Treatment Duration	PW[1] (30-Year Admin O&M)	PW[2] (Admin O&M to Trt. Duration)	% Change PW
MM-1	160*	$503K	$610K	+21%
MM-2	12	$586K	$357K	-39%
MM-3	30	$503K	$503K	0%
MM-4	12	$503K	$307K	-39%
MM-5	30	$503K	$503K	0%

* Length of time estimated for plume to reach drainage ditch and reduce TCE concentration to 5.0 ppb (see Sec 2.3.1.2)

1 PW cost data taken from Tables D-1, 2, 3, 4, 5

2 PW calcs based on:

$$PW = A(P/A, i=6\%, n) \quad \text{where } A = \$36{,}600/\text{yr.}$$

(Annual cost of Admin O&M)

$$P/A = \frac{(1+i)^n - 1}{i(1+i)^n}$$

ex, $$P/A = \frac{(1+.06)^{160} - 1}{.06(1.06)^{160}} = 16.6665$$

$$PW = \$36{,}600\,(16.6665) = \$610K$$

total cost of Alt to trmt Duration:

MM-1: $630,800
MM-2: $2,027,000
MM-3: $5,732,000
MM-4: $1,633,000
MM-5: $3,672,000

PROJECT	COMP. BY	JOB NO.
Sensitivity Analysis 2/2	MJR	08500-36
	CHK. BY MDL	DATE 3/15/95

recalculated = LDP 3/21/95
rechecked = SEB 3/22/

Sensitivity of Treatment Duration

- Treatment System O&M

Alt.	Treatment Duration *	PW' Admin & Trt Sys. O&M (based on trt. duration)	TOTAL COST	% Change from Alt. Total Cost
MM-1	N/A	—	—	—
MM-2	8-20	$780K – $1,441K	$1,754K – $2,415K	20% decrease to 7% increase
MM-3	25-35	$3,855K – $4,373K	$5,434K – $5,952K	45% decrease to 47% inc
MM-4	8-20	$693K – $1,280K	$1,390K – $1,977K	23% decrease to 10% increase
MM-5	25-35	$2,794K – $3,170K	$3,458K – $3,833K	6% decr. to 44% incr.

* A treatment duration range is applied to each alternative to determine impact on Total Cost.

' PW calcs: $PW = A(P/A)$ $i = 6\%$ n = trt. duration
A = Annual O&M Cost (Admin & Trt.

MM-2 PW(8 yrs.) = $125,600 (6.210) = $780,000 ✓
PW(20 yrs.) = $125,600 (11.470) = $1,441,000K

MM-3 PW(25 yrs.) = $301,600 (12.783) = $3,855,000 ✓
PW(35 yrs.) = $301,600 (14.498) = $4,373,000 ✓

MM-4 PW(8 yrs) = $111,600 (6.210) = $693,000 ✓
PW(20 yrs) = $111,600 (11.470) = $1,280,000 ✓

MM-5 PW(25 yrs) = $218,600 (12.783) = $2,794,000 ✓
PW(35 yrs) = $218,600 (14.498) = $3,169,000 ✓