N00639.AR.002395
NSA MID SOUTH
5090.3a

INJECTION WELL PERMIT REQUEST FOR SOLID WASTE MANAGEMENT UNIT 14 (SWMU 14) MILLINGTON SUPPACT TN

11/11/2011

QUANTUM ENVIRONMENTAL AND ENGINEERING SERVICES LLC

Quantum Environmental &
Engineering Services, LLC

November 11, 2011

Mr. Greg Parker, Supervisor
Water Quality Branch & Septic Tank Program
Shelby County Health Department
814 Jefferson Avenue
Memphis, Tennessee 38105-5041

Re: Injection Permit Request
SWMU-14 NSA Mid-South, Millington, Tennessee

Dear Mr. Parker

Please find attached an injection well permit application for Solid Waste Management Unit 14 (SWMU-14) at Naval Support Activity (NSA) Mid-South. Quantum Environmental & Engineering Services, LLC (QE^2), on behalf of the Navy, requests to use four previously installed injection wells to deliver a sodium acetate solution (99% sodium acetate and 1% diammonium phosphate) into the aquifer to enhance the degradation of trichloroethylene (TCE) and tetrachloroethylene (PCE). Details of the SWMU-14 injection remedial plan can be found in the previously submitted report (attached), Corrective Action Measures Study SWMU 14/46 (EnSafe, December 2003). The material safety data sheets for sodium acetate and diammonium phosphate are attached.

The sodium acetate solution is proposed to be used in the four previously installed injection wells (well IDs: 014G15LS, 014G16LS, 014G17LS, and 014G18LS). Each injection well was installed approximately 24 feet below ground surface (bgs) and screened from 14-24 feet bgs. Injection activities at SWMU-14 will occur monthly. There are seven monitoring wells located at SWMU-14. Groundwater from four monitoring wells (014G02LS, 014G12LS, 014G13LS, and 014G14LS) will be sampled quarterly to monitor the effectiveness of the monthly substrate injections. Table 1 lists the number of injection wells, quantity of the sodium acetate solution, and the amount of mixing water to be added to each well. The three attached figures show the location of NSA Mid-South property, Site Map of SWMU-14, and the most recent contaminant plume map for SWMU-14.

Table 1
Injection Information for SWMU-14

	SWMU-14
*Number of injection wells	4
Substrate dose of sodium acetate per well	50 lbs
Substrate dose of DAP per well	0.5 lbs
Water added per well (mixed with sodium acetate solution)	100 gallons

* Wells previous installed by EnSafe
DAP – Diammonium phosphate

QE^2, on behalf of the Navy, requests permission from the Shelby County Health Department to proceed with the continuation of sodium acetate solution injections at SWMU-14. The efforts listed above are being requested in order to expedite the ongoing cleanup efforts at NSA Mid-South. If you have any questions or concerns, please give me a call at (865) 689-1395 ext. 4028.

Sincerely,

Matthew Teglas, P.G.
Project Manager

Attachments: Well Application Form
Corrective Action Measures Study SWMU 14/46
MSDS for Sodium Acetate
MSDS for Diammonium Phosphate
Figures

c: Mr. Benjamin Simes, NAVFAC Midwest
Mr. Jim Heide, NSA Mid-South
QE^2 File 500903

Well Application Form

Table 1
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Mr. Jim Heide, NSA Mid-South
QE^2 File 500903

MEMPHIS AND SHELBY COUNTY HEALTH DEPARTMENT
POLLUTION CONTROL SECTION
WATER QUALITY BRANCH
1075 Mullins Station Road
Memphis, Tennessee 38134
(901) 379-7254 and fax (901) 379-7570

WELL APPLICATION FORM

SECTIONS I, II, III AND IX MUST BE COMPLETED BY THE WELL OWNER.
SECTIONS IV THRU VIII MUST BE COMPLETED BY THE WELL DRILLER.
APPLICANT AND DRILLER MUST SIGN THE APPLICATION

I. WELL OWNER

Name of Owner/Establishment NSA Mid-South
Contact Name and Title Jim Heide Name of Company DOD - Navy
Mailing Address 5722 Integrity Drive
City Memphis State Tennessee Zip Code 38054
Business Phone Number (901) 874-5367 Home Phone Number _____

II. WELL LOCATION

Address NSA Mid-South Perimeter Road (southside) Zip Code 38054
Well is Approximately 0.85 Miles (N) S E W Of Paul W. Barrett Memorial Hwy Road/Street/Hwy
Well Identification Number 014G15LS, 014G16LS, 014G17LS, 014G18LS Land Size in Acres _____

III. TYPE OF WELL TO BE INSTALLED

Water Production _____
Dewatering _____
Soil Boring _____
Geoprobe _____
Direct Push _____
Other Injection (wells previously installed)
Specify _____

Monitoring _____
A) Ground Water Quality _____
B) Methane Gas _____
C) Water Level _____
D) Leachate _____
E) Gas Movement _____
F) Chemical Movement _____

IV. WELL DRILLER

Drilling Company EnSafe supervised well installation. See initial Well Application Form for details.
Tennessee Well Drillers License Number _____ Representative _____
Tennessee P.E./R.P.G. Number _____ Representative _____
Mailing Address _____ City _____ State _____ Zip Code _____
Business Phone Number ( ) _____ Fax Number( ) _____

V. TYPE OF WORK

New Well _____
Repair _____
Replacement _____
Other Groundwater remediation

Fill and Abandonment _____
Chemical Treatment _____

VI. WATER WELL CONSTRUCTION INFORMATION

Expected depth of the well _____ in feet
Type of water source used during construction of the well _____
Well casing: Type of Material _____ Diameter _____ Wall Thickness _____

VII. MONITORING WELL INFORMATION

Number of Monitoring Wells to be installed 0; Wells already installed _____ Proposed depth of wells Injection wells are 24 ft bgs
Substance (s) to be analyzed from well a. _____ b. _____ c. _____
Sampling method to be used Bailor _____ Pump _____
How often will the well be sampled? Monthly injection _____

VIII. WATER WELL USAGE INFORMATION

Residential _____	Farm _____	Sprinkler System _____
Commercial _____	Irrigation _____	Water Livestock _____
Industrial _____	Retain lake level _____	Other _____

IX. ADDITIONAL INFORMATION THAT IS REQUIRED

1. How many existing wells are on the property? Active Approx. 185 Inactive _____ None _____
2. The following must accompany any application that is submitted:
   A.) Plot plan that includes all information required as stated in the Regulations
   B.) A $25.00 dollar application processing fee
   C.) When an Emergency Permit is issued for any work an additional $50.00 dollars
   D.) All monitoring well, soil boring or similar applications require an inspection fee of $100.00 dollars, with the exception of water production wells.
   E.) A sketch or diagram of any proposed monitoring well must be enclosed

The applicant as well as the well driller agrees to comply with all regulations outlined in the Shelby County Well Construction Code as they relate to the construction and maintenance of a well in Shelby County. All applicable fees as well as the paperwork submitted are accurate as outlined in the regulations. By signing this application the applicant and well driller agree to comply with all of the regulatory requirements outlined in the Shelby County Well Construction Code.

Signature of Well Owner Jenes Heide Date 11/14/2011

Signature of Well Driller _____ Date _____

Remarks: The Health Department reserves the right to supplement the general requirements by an addendum as may be required. If the application is approved by the Health Department, a Construction Permit will be issued in writing to the selected well driller with a copy to the applicant. No construction is to begin until the permit has been received and the permit shall be kept at the construction site until the well or other work has been completed.

FOR DEPARTMENT USE ONLY

Date Application Received _____ **Approval/Denial Date** _____ **Permit Rejected** _____
Permit Granted _____ **Conditions** _____ **Permit Number** _____
Log Number _____ **Handy Map Page & Section** _____

Departmental Signature _____

Corrective Action Measures Study SWMU 14/46

ENSAFE

ENSAFE INC. ENVIRONMENTAL AND MANAGEMENT CONSULTANTS

5724 Summer Trees Drive • Memphis, Tennessee 38134 • Telephone 901-372-7962 • Facsimile 901-372-2454 • www.ensafe.com

December 22, 2003

Commander
Attn: James Reed/18812JR
NAVFAC EFD SOUTH
2155 Eagle Drive
P.O. Box 190010
North Charleston, SC 29419-9010

Subject: CTO-0146; NSA Mid-South, SWMU 14/46, Millington, Tennessee

Document Transmittal – *Corrective Measures Study Report, Naval Support Activity Mid-South, SWMU 14/46 – Building S-140, Revision 1,* December 22, 2003

Reference: Contract N62467-89-D-0318 (CLEAN II)

Dear Sir:

This letter is provided to document submittal of the *Corrective Measures Study Report, Naval Support Activity Mid-South, SWMU 14/46 – Building S-140, Revision 1,* June 16, 2003. The document has been distributed as shown on the attached NSA Mid-South RFI Distribution List.

If you have any questions or comments of a technical nature, please contact me at 901/372-7962. Comments or questions of a contractual nature should be directed to Scott Nye at 901/386-9344.

Sincerely,

EnSafe Inc.

By: John Stedman, Jr.
Task Order Manager

Enclosures: As Stated

cc: Contracts File: CTO-0146 (w/out enclosure)
Project File: 0146-14-007 (w/out enclosure)
Other: See attached NSA Mid-South Distribution List

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U.S. Envt. Protection Agency Attn: Jennifer Herndon Waste Management Division Federal Facilities Branch 100 Alabama Street, SW Atlanta, GA 30303 (404) 562-8791	Fed Ex 2-day	Jennifer Herndon	1
TDEC–Division of Superfund Memphis Field Office Attn: Jim Morrison Suite E-645, Perimeter Park 2500 Mt. Moriah Memphis, TN 38115-1511 (901) 368-7958	FedEx 2-day	Jim Morrison	
TDEC– Division of Solid Waste Management Attn: Roger Donavan 5th Floor, L & C Annex 401 Church Street Nashville, TN 37243-1538 (615) 532-0859	FedEx 2-day	Roger Donovan	2
U.S. Geological Survey Water Resources Division Attn: Jack Carmichael 640 Grassmere Park, Suite 100 Nashville, TN 37211 (615) 837-4704	FedEx 2-day	Jack Carmichael	1
Memphis and Shelby Co. Health Dept. Attn: Brenda Duggar 814 Jefferson Avenue Memphis, TN 38105 (901) 576-7741	FedEx 2-day	Brenda Duggar (bound copy)	
			8

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CORRECTIVE MEASURES STUDY REPORT
SWMU 14/46

NAVAL SUPPORT ACTIVITY MID-SOUTH
MILLINGTON, TENNESSEE

Revision: 1

Comprehensive Long-Term Environmental Action Navy
Contract Number: N62467-89-D-0318
CTO-0146

Prepared for:

Department of the Navy
Naval Facilities Engineering Command
Southern Division
North Charleston, South Carolina

Prepared by:

5724 Summer Trees Drive
Memphis, Tennessee 38134
(901) 372-7962
www.ensafe.com

The Contractor, EnSafe Inc., certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0318 are complete, accurate, and comply with all requirements of the contract.

Date: December 22, 2003
Signature: Dana Grady
Name: John Stedman, Jr.
Title: Task Order Manager

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Appendix A Quarterly Monitoring Geochemical Tables

List of Acronyms

µg/L	micrograms per liter
µg/kg	micrograms per kilogram
1,1-DCE	1,1-dichloroethene
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethylene
AOC	Area of Concern
BCT	BRAC Cleanup Team
bls	below land surface
BRAC	Base Realignment and Closure
BTEX	benzene, toluene, ethylbenzene, and xylene
CMS	Corrective Measures Study
CO_2	carbon dioxide
COC	chemical of concern
CRP	community relations plan
CSI	confirmatory sampling investigation
cm/sec	centimeter per second
DO	dissolved oxygen
DPT	direct-push technology
DRO	Diesel Range Organics
EPH	Extractable Petroleum Hydrocarbons
gpm	gallon per minute
GRO	Gasoline Range Organics
ICs	institutional controls
LS	lump sum
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
mV	millivolt
NA	not applicable
NAVFACEFD	Naval Facilities Engineering Field Division South
ND	not detected
NS	not sampled
NSA	Naval Support Activity
nM	nanoMolar

O&M	operation and maintenance
ORP	oxidation-reduction potential
OSWER	Office of Solid Waste and Emergency Response
PCE	tetrachloroethene
PPE	personal protective equipment
PRG	preliminary remedial goal
POTW	publicly-owned treatment works
RAB	Restoration Advisory Board
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RGO	remedial goal option
SOB	statement of basis
SWMU	solid waste management unit
TCA	trichloroethane
TCE	trichloroethene
TDEC	Tennessee Department of Environment and Conservation
TOC	total organic carbon
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VC	vinyl chloride
VOC	volatile organic compound
yd^3	cubic yards

1.0 INTRODUCTION

This Corrective Measures Study (CMS) report presents an evaluation of remedial action technologies to mitigate hazards and threats to human health and the environment from groundwater contamination at solid waste management units (SWMU) 14/46, located on the Southside of Naval Support Activity (NSA) Mid-South, Millington, Tennessee. As recommended in the CMS work plan (EnSafe, 2001), a streamlined approach for corrective measures at SWMU 14/46 has been taken.

The CMS is being performed under the Resource Conservation and Recovery Act (RCRA) of 1976. As required by RCRA, the NSA Mid-South Restoration Advisory Board (RAB) provides a focus for community input to the remedial decision-making process. The RAB, which regularly holds open public meetings, consists of community members, state and federal regulators, Southern Division Naval Facilities Engineering Field Division South (NAVFAC EFD SOUTH), and other NSA Mid-South project team representatives.

When the CMS is complete, a Statement of Basis (SOB) will be written to document the CMS process and present the preferred alternative for site remediation. The document will be made available for public comment to ensure that decision-makers are aware of public concerns. The selection of the final remedy for the site could be affected by public input. The primary NSA Mid-South decision-makers are NAVFAC EFD SOUTH, the Tennessee Department of Environment and Conservation (TDEC), and the United States Environmental Protection Agency (USEPA).

The CMS report has been organized according to the format in the Office of Solid Waste and Emergency Response (OSWER) Directive 9902.3-2A, *RCRA Corrective Action Plan* (Final, May 1994), as outlined:

- **Section 1, Introduction:** This section presents the purpose of the report and summarizes the project.

- **Section 2, Site Description:** This section presents the history and background of SWMU 14/46 and the results of previous investigations, including the RCRA Facility Investigation (RFI) and supplemental CMS sampling.

- **Section 3, Remedial Objectives:** To maintain the CMS focus, this section summarizes the chemicals of concern (COCs) to be directly addressed by this CMS and their remedial action objectives. In some cases, this section justifies the inclusion or removal of COCs identified in the RFI based on the contribution of a particular chemical or lack thereof to significant risks, hazards, or other regulatory standards applicable to this site.

- **Section 4, Identification and Screening of Technologies:** This section identifies and screens the remedial technologies that may be used to achieve remedial action objectives.

- **Section 5, Development and Evaluation of Alternatives:** This section develops and evaluates the potential remedial alternative according to the nine evaluation criteria identified in OSWER Directive 9902.3-2A, RCRA *Corrective Action Plan* (Final, May 1994).

- **Section 6, Recommendations:** The section assesses the performance of the alternative and presents recommendations for selection of a final remedy.

- **Section 7, Public Involvement Plan:** This section summarizes the public involvement plan as it relates to the CMS.

- **Section 8, References:** This section lists applicable references used to prepare this report.

- **Section 9, Signatory Requirement:** This section provides the applicable signatory requirements for the CMS report.

2.0 SITE DESCRIPTION AND ENVIRONMENTAL SETTING

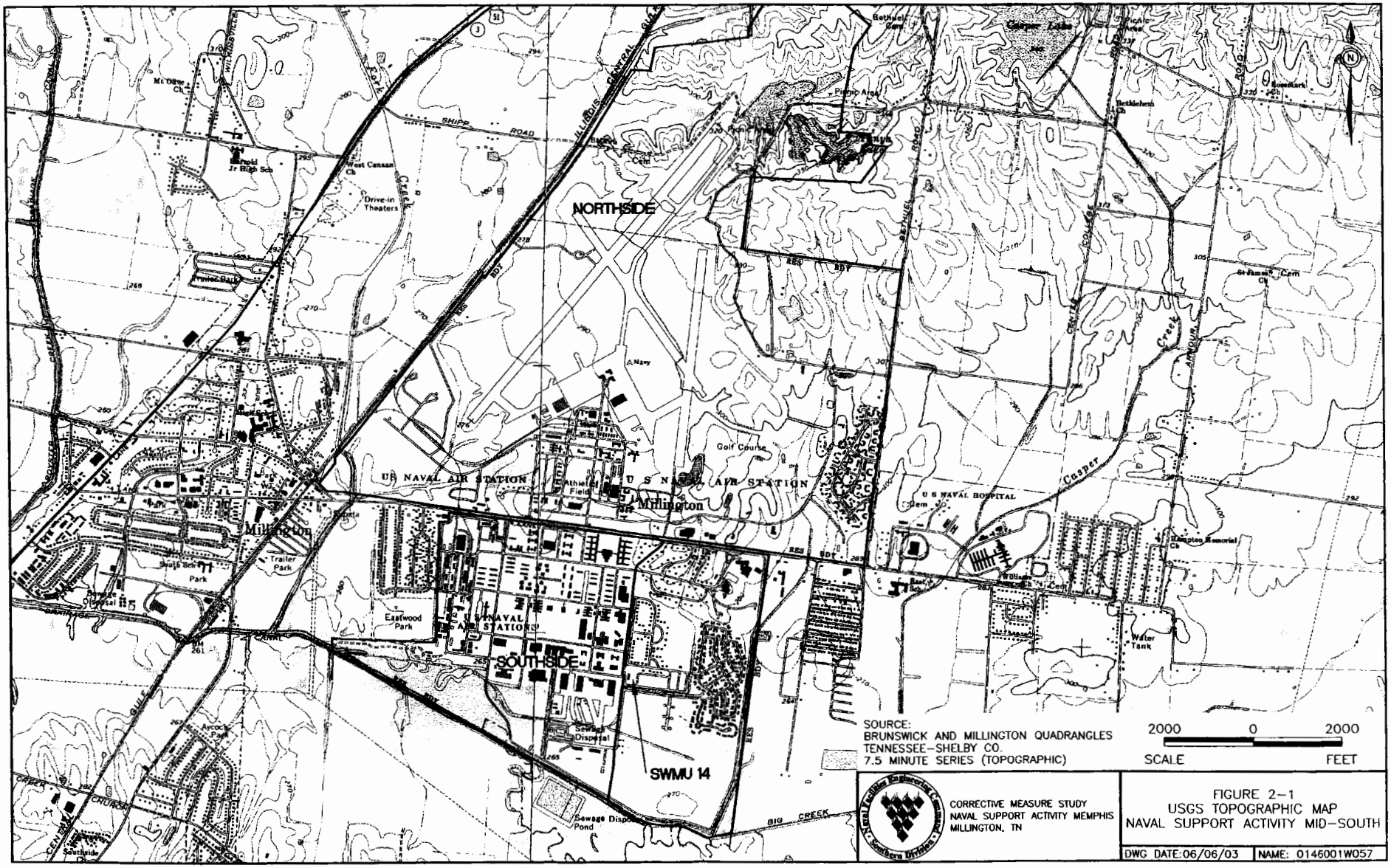
2.1 Site Description

SWMU 14, the former site of Building S-140, is now a flat, grass-covered area located on the Southside of NSA Mid-South, east of Seventh Avenue and north of Polaris Drive. Drainage ditches run along the south and west sides of the site. The site's eastern portion features a small stand of pine trees, several sidewalks, and a large open field once used as a trailer park. Residential property is located at the far east end of this open field. Figure 2-1, a topographic map of the facility and the surrounding area, shows the NSA Mid-South Northside and Southside base boundaries that were in place during the property transfer in January 2000, as well as the location of SWMU 14.

Building S-140, demolished in 1985, housed a paint spray booth, a paint removing area, and a paint wash-down area that the Navy reportedly used from 1943 to 1985 to train personnel in painting-related processes. According to building diagrams, two drainage systems were associated with painting activities at S-140: one was located in the central portion of the building, which housed the paint spray booths and water wash pits, and the other was in the northern portion near the interior wash-down area and work table.

Based on records that document the site, paint-related wastes generated by the paint spray booth and water wash pits apparently collected in two floor drains, which emptied into two 1,885-gallon sump pits. Paint waste and sludge from these sumps were most likely removed as-needed, with any overflow discharged directly to the Seventh Avenue ditch. After 1980, the flow from the paint booth and wash-down area was redirected to a paint separator and sump in the building's mechanical room and the overflow was discharged to the sanitary sewer. The paint waste and sludge likely contained chromium, lead, various hydrocarbons, and paint solvents, including mineral spirits, toluene, and phenols.

Reportedly, wastes generated by the paint wash-down area and work tables were discharged to an drain line exiting the building's east side that has never been located. In 1968, these wastes were diverted to an interceptor-separator beneath the north end of a sidewalk immediately east of the building. According to construction diagrams, this interceptor-separator was 3.5 x 5 feet

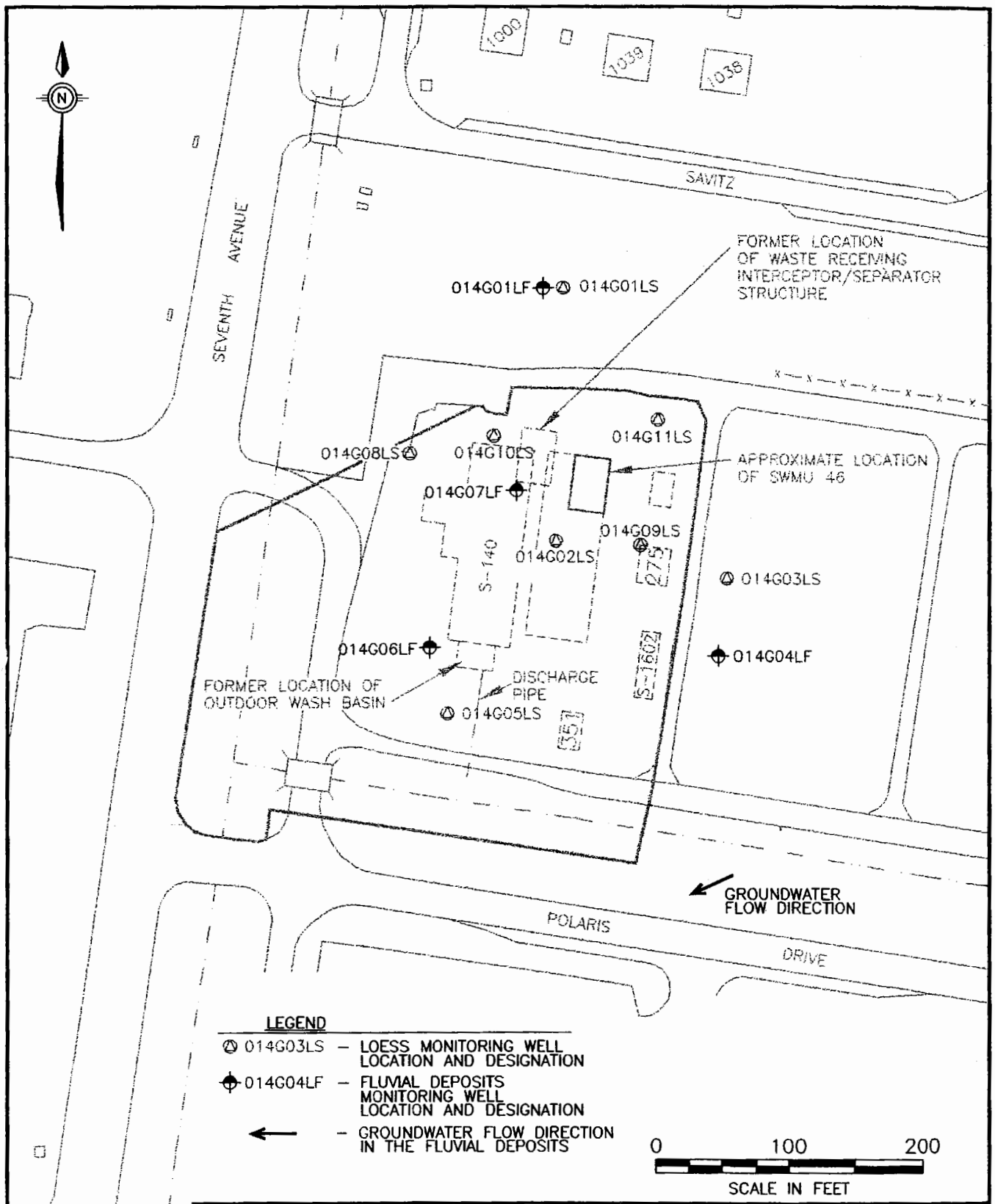

NORTHSIDE
SOUTHSIDE
SWMU 14
U S NAVAL AIR STATION
U S NAVAL AIR STATION
U S NAVAL HOSPITAL
Millington
Millington
Golf Course
Picnic Area
Casper Lake
Drive-in Theaters
Trailer Park
Eastwood Park
Sewage Disposal
Sewage Disposal Pond
Water Tank
Hampton Memorial Ch
Bethlehem Ch
St James Cem Ch
Bethel Cem
West Canaan Ch
McDow Ch
Southside Ch
Bethel Field
Navy
SHIPS ROAD
ILLINOIS CENTRAL GULF
BIG CREEK
CASPER CREEK
BETHEL ROAD
COLLEGE ROAD
SOURCE:
BRUNSWICK AND MILLINGTON QUADRANGLES
TENNESSEE–SHELBY CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
2000 0 2000
SCALE FEET
CORRECTIVE MEASURE STUDY
NAVAL SUPPORT ACTIVITY MEMPHIS
MILLINGTON, TN
FIGURE 2–1
USGS TOPOGRAPHIC MAP
NAVAL SUPPORT ACTIVITY MID–SOUTH
DWG DATE:06/06/03
NAME: 0146001W057

wide and 4.5 feet deep. Interceptor discharge was directed to the sanitary sewer line located to the north.

A former outdoor wash basin located next to Building S-140's south side exterior wall consisted of a 36- by 40-foot concrete slab surrounded by a 6-inch berm. According to sewer modification diagrams, the basin's drain connected to a 12-inch concrete line, which ran beneath Polaris Drive and discharged directly into the southern drainage ditch across Polaris Drive. Reportedly, when the drain line was plugged in 1980, drainage was diverted to the sanitary sewer. Today, there is no evidence of the drain, but the associated outfall (a small discharge pipe) is visible in the Polaris Drive ditch.

According to the building's engineering plans, four smaller structures were also associated with the building. Building S-275, a gear locker located approximately 50 feet east of S-140, reportedly was constructed in 1944 and demolished in 1985. Building S-1602 is reported to have been a temporary structure located along the eastern edge of the site; it was removed in August 1989. Building S-351, which was located 50 feet southeast of S-140, reportedly was a 12-foot by 20-foot, prefabricated metal storage building used as a paint locker prior to its demolition in 1985. Also associated with Building S-140 is SWMU 46, a former hazardous waste accumulation point located at the north end of a paved area east of the building. From 1980 until 1985, SWMU 46 reportedly was used for less-than-90-day storage of drummed hazardous waste, including waste paints and thinners. SWMUs 14 and 46 were investigated together during the RFI. Results of this SWMU 14/46 investigation are presented in the Assembly E RFI (EnSafe, 2000).

The site is relatively flat with no obvious direction for surface-water runoff. However, it is likely that all runoff currently discharges as sheet flow to the Seventh Avenue ditch to the west and the Polaris Drive drainage ditch to the south. These ditches, which ultimately discharge into the Big Creek Drainage Canal, are partially concrete-lined. Figure 2-2 presents a site location map.



SWMU 14/46
CMS
NSA MID-SOUTH
MILLINGTON, TENNESSEE

FIGURE 2-2
SITE LOCATION MAP
SWMU 14 BUILDINGS S-140 AND
SEVENTH AVENUE DRAINAGE DITCH

DWG DATE: 12/11/03 | NAME: 0146001W056

2.2 Site Geology and Hydrogeology

The geology of SWMU 14/46 consists of three major lithologic units, which are listed in descending order (youngest to oldest) (Carmichael et al., 1997):

- Pleistocene-age loess
- Pleistocene- to possibly Pliocene-age fluvial deposits
- Eocene-age Cockfield and Cook Mountain Formations (upper units of the Claiborne Group), which overlie the Memphis Sand of Eocene-age and serve as the upper Claiborne confining unit for the Memphis aquifer

Two principal groundwater units have been the focus of investigations at NSA Mid-South: the alluvial-fluvial deposits aquifer, which is the most prominent surficial aquifer, and the Memphis aquifer, which is the primary drinking water source in the Memphis area. These aquifers are hydraulically separated by the Cockfield and Cook Mountain formations, which individually range from 0 to 185 and 10 to 60 feet think at NSA Mid-South, respectively (Carmichael et al., 1997).

The SWMU 14/46 monitoring and background monitoring wells were screened in either the loess or fluvial deposits. The background wells comparable to SWMU 14/46 are located 1,300 to 5,000 feet north of the Big Creek Drainage Canal.

The loess encountered in soil borings consists of clay, silty clay, clayey silt, and silt from land surface to depths ranging from 30 to 39 feet below land surface (bls). In general, the clay fraction decreases and the silt fraction increases with depth. The loess color ranges from moderate to dark yellowish-brown, brown, brownish-gray, greenish-gray, and light olive gray. Sparse to common dark orangish-yellow or light olive gray mottling was observed in some soil borings, as

was iron staining, iron/manganese nodules, and organic material. Hard, siliceous clayey material or concretions were present in the loess near 27 feet bls in one SWMU 14/46 soil boring.

Loess soil samples collected for geotechnical analysis consisted of one sample from SWMU 14/46 (014S01LF, 8 to 10 feet bls) and one from the United States Geological Survey (USGS) test hole north of SWMU 14/46 (TH-7, 10 to 12 feet bls). The vertical coefficient of permeability for these samples, which was calculated from falling head permeability testing, ranged from 2.83×10^{-7} cm/sec to 5.7×10^{-7} cm/sec. Sieve analyses of these samples indicated a clayey silt or silt classification, with porosities ranging from 0.36 to 0.44 percent. The geotechnical reports are provided in *Assembly E RFI Report* (EnSafe, 2000).

The upper 6 or 7 feet of the loess are typically dry. A moist to wet zone encountered from 10 to 16 feet bls in most SWMU 14/46 soil borings represents the uppermost water-bearing zone here at the site. Depth-to-groundwater measurements in SWMU 14/46 loess monitoring wells have ranged from 4.99 feet to 7.96 feet bls (014G01LS and 014G05LS). Loess groundwater migrates primarily downward, although locally, some water in the loess may discharge to nearby streams, drainage ditches, and other surface-water bodies. The average loess horizontal groundwater velocity calculated from the direct-push technology (DPT) investigation results at SWMU 14/46 was 3.44×10^{-5} cm/sec, or 0.09 feet per day.

The fluvial deposits underlie the loess at SWMU 14/46. The upper portion of the fluvial deposits consists of a silty, clayey, fine- to medium-grained sand; at some locations, it also contained scattered quartz and chert gravel up to three quarters of an inch in diameter. In general, the grain size of sand coarsened with depth. The percentage of gravel and its maximum diameter also generally increased with depth. In most soil borings, the base of the fluvial deposits consisted of a sand-and-gravel mixture, with gravel up to 4 inches in diameter. The percentage of gravel within the sand matrix varied from approximately 10% to 75%, depending on the boring location. The fluvial deposits range from 12 to 20 feet thick at SWMU 14/46 to 33 to 47 feet thick at Southside background well locations.

As shown in Figure 2-3, groundwater elevations in SWMU 14/46 loess monitoring wells measured in March 2003 were used to generate a computer-contoured potentiometric-surface map for the site. The figure indicates a horizontal component of groundwater beneath SWMU 14/46 that generally is to the southwest, toward the Seventh Avenue and Polaris Drive drainage ditches.

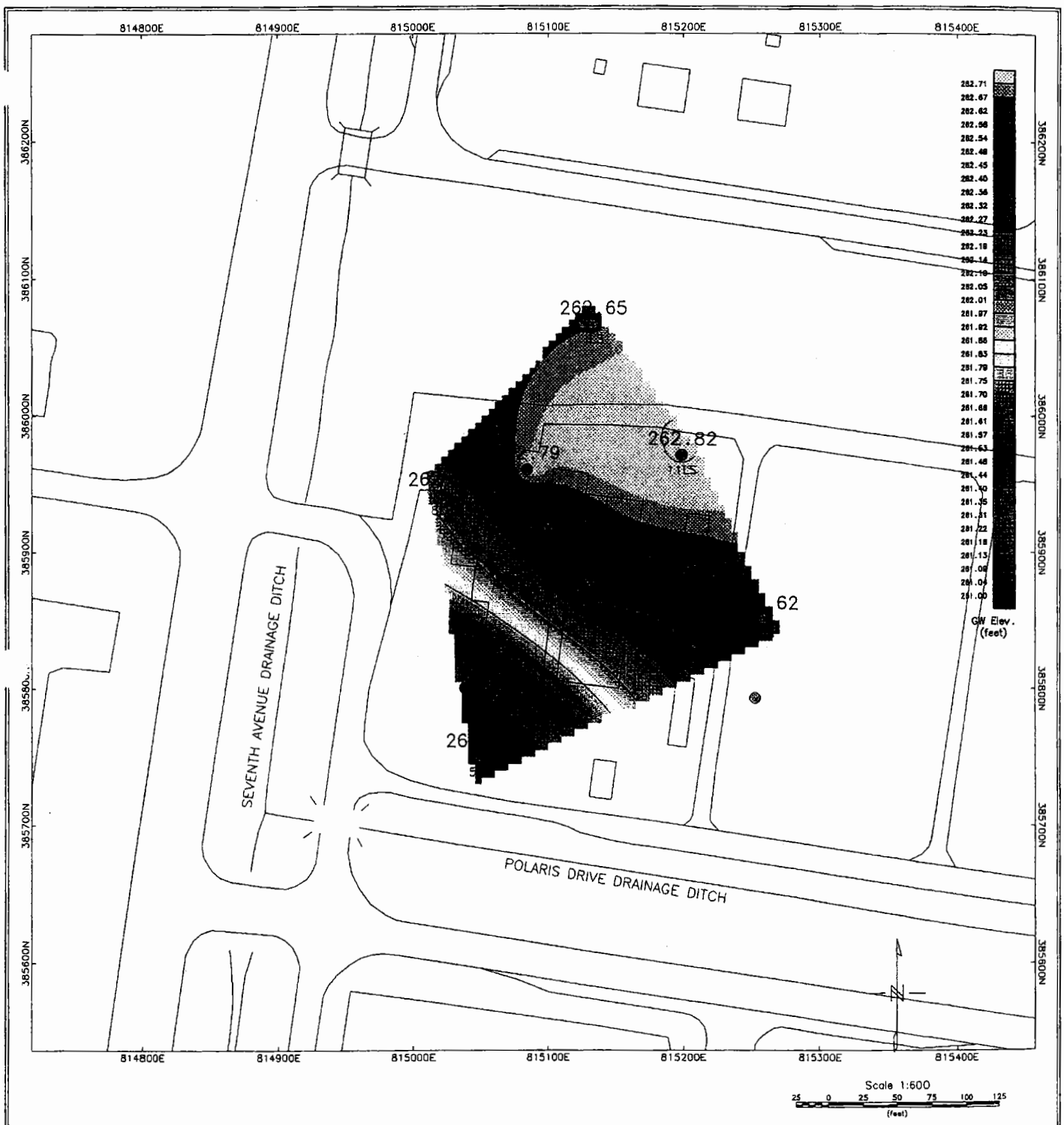
2.3 Aquifer Characterization

The permeability coefficient of the sample collected from the fluvial deposits was found to be 4.0×10^{-7} cm/sec (location 014S01LF). Sieve analyses and porosity testing classified the sample from location 014S01LF as a silty clay containing sand and small gravel with a porosity of 32%. The approximate horizontal gradient of groundwater in the fluvial deposits beneath SWMU 14/46 is 0.005 feet/foot. Based on these data, the horizontal groundwater velocity in the fluvial deposits is 3.98×10^{-5} cm/sec, or 0.11 feet per day. A horizontal groundwater velocity for SWMU 14/46 fluvial deposits also was calculated from specific capacity testing of monitoring well 014G07LF at 0.14 feet per day.

2.4 RFI/CMS Sampling Results

During November 1995, a preliminary DPT screening investigation was conducted at SWMU 14/46 as part of the RFI characterization. Based on the anticipated site contaminants from paint-related activities, volatile organic compounds (VOCs) were chosen as the indicator parameter. Tetrachloroethene (PCE) and trichloroethene (TCE) were detected at concentrations exceeding maximum contaminant levels (MCLs) in groundwater from the loess and fluvial deposits at the DPT locations. The DPT locations and their corresponding results are presented in Figure 2-4. The results of the DPT investigation were then used to define the nature and extent of contamination during the subsequent RFI.

In 1996 and 1997, soil and groundwater samples were collected at nine sample locations for the RFI. Results from this sampling event indicated that past operations in the SWMU 14/46 area had apparently impacted the soil and groundwater. Even though there were various detections in soil, few exceeded regulatory standards. Therefore, the RFI concluded that the soil no longer needed



PLOT SUMMARY
- Groundwater levels obtained from loess wells, March 2003
- Light contours every 0.2 foot, heavy contours every foot
- Labeled wells are loess wells; unlabeled are fluvial deposits wells

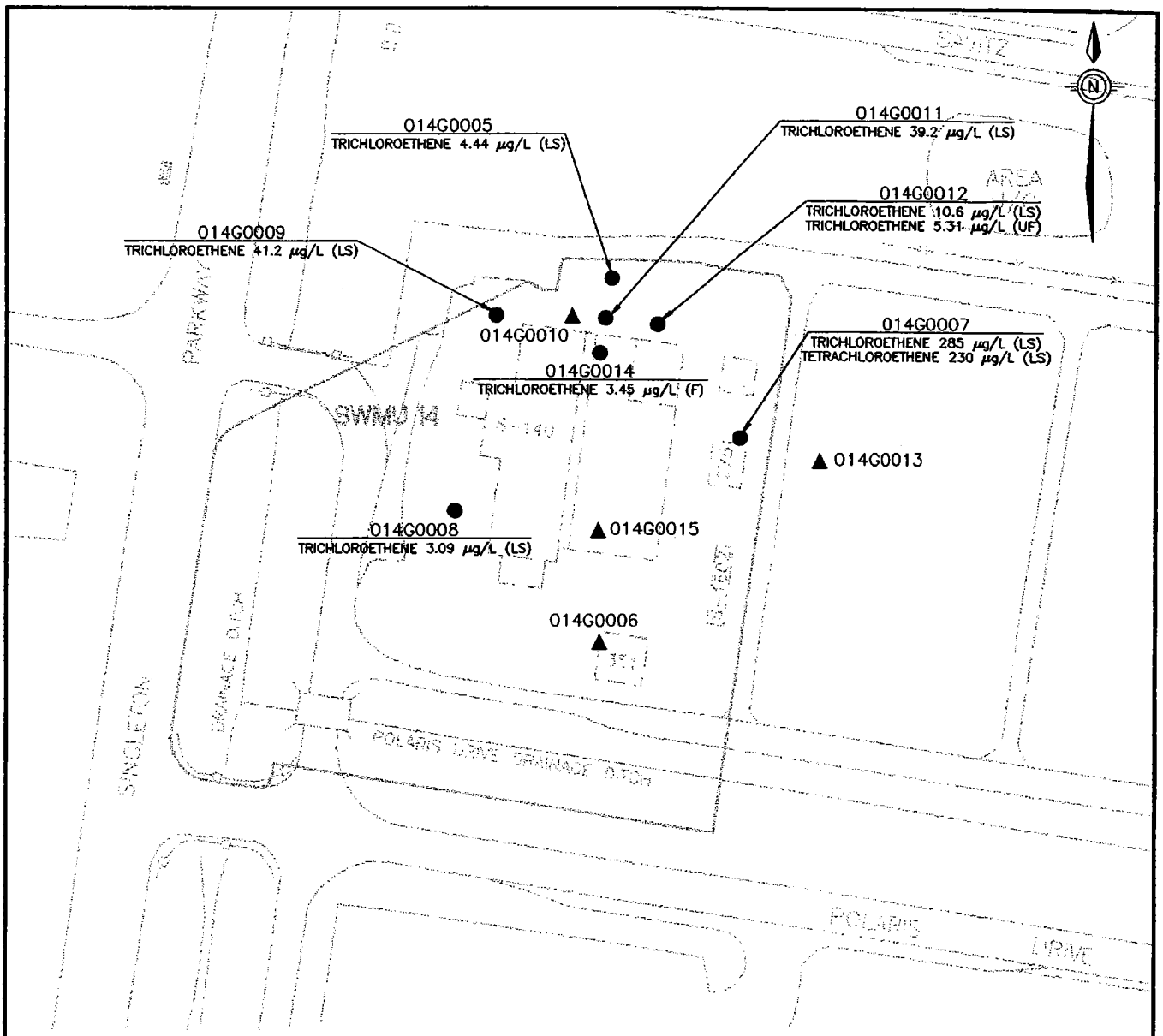
- Drawing file: 0146GEO.DXF
- Plotted via Geosoft 12-08-03
n:\wp51\users\hughes\memphis\north-gw\swmu14\11.P01

Figure 2-3

March 2003 Loess Potentiometric Map
SWMU 14

SWMU 14 Corrective Measures Study Report
NSA Mid-South, Millington, TN

EnSafe Inc.



LEGEND

▲ – NO VOC IN DPT GROUNDWATER SAMPLE EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER.

● – ONE OR MORE VOCs IN DPT GROUNDWATER EXCEEDED THE RBC FOR TAP WATER OR THE MCL FOR DRINKING WATER.

014G0005 – THE LOESS GROUNDWATER SAMPLE FROM DPT SAMPLING LOCATION 014G0005 CONTAINED THE FOLLOWING VOC THAT EXCEEDED THE RBC FOR TAP WATER AND/OR THE MCL FOR DRINKING WATER: 4.4 µg/L TRICHLOROETHENE.
TRICHLOROETHENE 4.4 µg/L (LS)

(LS) – LOESS

(F) – FLUVIAL DEPOSITS

NOTE: DPT GROUNDWATER SAMPLES WERE ANALYZED FOR VOCs ONLY BY THE ONSITE LABORATORY USING METHOD 8021.

100 0 100
SCALE FEET

CORRECTIVE MEASURES STUDY
NSA MID-SOUTH
MILLINGTON, TENNESSEE

FIGURE 2-4
RBC AND/OR MCL EXCEEDANCES FOR VOCs IN DPT GROUNDWATER SAMPLES
SWMU 14 – BUILDING S-140
AND SEVENTH AVENUE DITCH

DWG DATE: 12/11/03 | NAME: 0146001W066

to be investigated. However, the RFI recommended further delineation of chlorinated solvents and total petroleum hydrocarbons (TPH) in the loess and fluvial deposits to complete a CMS evaluation.

In October 2000, the nine groundwater monitoring wells at SWMU 14/46 were sampled as part of recommended continued monitoring. October 2000, RFI, and supplemental VOC and TPH sample results for monitoring wells at SWMU 14/46 are presented in Tables 2-1 and 2-2.

2.4.1 Soil Sampling Results

During the RFI, soil samples were collected from the SWMU 14/46 area. Analytical results indicated a release of chlorinated solvents and petroleum-related compounds. Although VOCs were detected, only acetone exceeded its screening value in one surface soil sample. TPH-Diesel Range Organics (DRO) and TPH-Gasoline Range Organics (GRO) also were detected in many soil samples, however, none exceeded the TDEC cleanup level of 500,000 µg/kg for non-drinking water aquifers. Because minimal contamination was found, the RFI recommended no further action for soil at SWMU 14/46.

2.4.2 Groundwater Sampling Results

Based on the DPT investigation results, five loess and four fluvial deposits monitoring wells were installed in the SWMU 14/46 area. Results from groundwater sampling show *cis*-1,2-dichloroethene (DCE), PCE, and TCE exceeding their respective MCL in loess groundwater. In addition, TPH exceeded TDEC's most stringent action levels in loess and fluvial deposits groundwater samples.

As recommended by the RFI, supplemental groundwater sampling was conducted in all nine groundwater monitoring wells during October 2000. Because loess groundwater likely will never be used as a potable water source at NSA Mid-South because of its low yield and poor aesthetic quality, detected concentrations of TPH in samples collected from loess wells were compared with TDEC's groundwater cleanup level of 1,000 µg/L for non-drinking water aquifers. TPH concentrations found in fluvial deposits monitoring wells are compared to the TDEC's most stringent groundwater cleanup level of 100 µg/L for drinking water aquifers.

Results of the supplemental sampling indicate that PCE and TCE concentrations remain greater than their respective MCLs in loess monitoring well 014G02LS. TPH concentrations were found to be less than the state groundwater cleanup standard of 1,000 µg/L for non-drinking water aquifers in all loess monitoring wells. The CMS work plan concluded that remediation of PCE and TCE in loess groundwater should be evaluated in a streamlined CMS, which should evaluate natural attenuation. Because TPH did not exceed the TDEC action level, the work plan concluded that no further investigation of TPH on loess groundwater was required (EnSafe, 2001).

No VOCs were detected in concentrations greater than their respective MCLs in any fluvial deposits monitoring well. TPH concentrations were less than the state groundwater cleanup standard of 100 µg/L in all fluvial deposits monitoring wells. Based on these findings, the CMS work plan concluded that no further investigation of fluvial deposits groundwater was required (EnSafe, 2001).

Groundwater sample results are presented in Tables 2-1 and 2-2.

Table 2-1
Groundwater Sampling Results in Loess
(results in µg/L)

Well Location	Date	*cis*-1,2-DCE	PCE	TCE	TPH		
					GRO[a]	DRO[b]	EPH[c]
014G01LS	April 1996	10 U[g]	10 U	10 U	NA[h]	100 U	NA
	April/May 1997	5 U	5 U	5 U	36 U	100 U	NA
	November 1997	5 U	5 U	5 U	NA	NA	NA
	February 1999	3 U	3 U	3 U	NA	NA	NA
	October 2000	5 U	5 U	5 U	NA	NA	200 J
014G02LS	April 1996	**13**	**150**	**120**	NA	100 U	NA
	April/May 1997	**31**	**92**	**130**	42	300 J	1300
	November 1997	**30**	**150**	**200**	NA	NA	NA
	February 1999	**37**	**90**	**140**	NA	NA	NA
	October 2000	**62**	**180**	**200**	NA	NA	100 J

Table 2-1
Groundwater Sampling Results in Loess
(results in µg/L)

Well Location	Date	*cis*-1,2-DCE	PCE	TCE	TPH		
					GRO[a]	DRO[b]	EPH[c]
014G03LS	April 1996	10 U	10 U	10 U	NA	100 U	NA
	April/May 1997	5 U	5 U	5 U	36 U	110	NA
	November 1997	5 U	5 U	5 U	NA	NA	NA
	February 1999	3 U	3 U	3 U	NA	NA	NA
	October 2000	5 U	4 J	5 U	NA	NA	400 J
014G05LS	April 1996	10 U	10 U	10 U	NA	100 U	NA
	April/May 1997	5 U	5 U	5 U	36 U	160	NA
	November 1997	5 U	5 U	5 U	NA	NA	NA
	February 1999	3 U	3 U	3 U	NA	NA	NA
	October 2000	5 U	1 J	5 U	NA	NA	290 J
014G08LS	April 1996	10 U	10 U	10 U	NA	100 U	NA
	April/May 1997	5 U	5 U	0.65 J	36 U	100 U	NA
	November 1997	5 U	5 U	5 U	NA	NA	NA
	February 1999	3 U	3 U	3 U	NA	NA	NA
	October 2000	5 U	5 U	5 U	NA	NA	200 J
MCLs [d]		70[e]	5	5	-----		
TDEC Cleanup Level		-----	-----	-----	1000		

Notes:

(a) GRO — Gasoline Range Organics
(b) DRO — Diesel Range Organics
(c) EPH — In May 1998, TDEC replaced the DRO method 8015M with the extractable petroleum hydrocarbon (EPH) by GC/FID method.
(d) Maximum contaminant levels in drinking water were obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).
(e) The MCL for *cis*-1,2 DCE is the most conservative of the 1,2-DCE isomers and was therefore chosen as the MCL for 1,2-DCE (total).
(f) No RBC or SSL exists for TPH; the TDEC groundwater cleanup level of 1 mg/L (1,000 µg/L) total TPH for non-drinking water aquifers has been substituted for the RBC for tap water. Standard obtained from the *Policy Statement for Petroleum-Contaminated Sites* (TDEC, 1997).
(g) U indicates that the material was analyzed but not detected at the listed numerical quantitation limit; J indicates that the associated numerical value is an estimated quantity.
(h) NA denotes indicated analyte was not analyzed during time period indicated.
Bold exceeds MCLs

Table 2-2
Groundwater Sampling Results in Fluvial Deposits
(results in µg/L)

Well Location	Date	benzene	TPH		
			GRO	DRO	EPH
014G01LF	April 1996	10 U[f]	NA[g]	140	NA
	April/May 1997	5 U	36 U	100 U	NA
	November 1997	5 U	NA	NA	NA
	October 2000	5 U	NA	NA	100 UJ
014G04LF	April 1996	10 U	NA	100 U	NA
	April/May 1997	5 U	360 U	180	NA
	November 1997	5 U	NA	NA	NA
	October 2000	5 U	NA	NA	100 UJ
014G06LF	April 1996	10 U	NA	100 U	NA
	April/May 1997	5 U	360 U	100 U	NA
	November 1997	5 U	NA	NA	NA
	October 2000	5 U	NA	NA	100 UJ
014G07LF	April 1996	10 U	NA	100 U	NA
	April/May 1997	5 U	36 U	210	NA
	November 1997	5 U	NA	NA	NA
	October 2000	5 U	NA	NA	100 UJ
MCLs		5[d]	-----		
TDEC Cleanup Level		-----	100[e]		

Notes:

(a) GRO — Gasoline Range Organics
(b) DRO — Diesel Range Organics
(c) EPH — In May 1998, TDEC replaced the DRO method 8015M with the extractable petroleum hydrocarbon (EPH) by GC/FID method.
(d) Maximum contaminant levels in drinking water were obtained from the *Drinking Water Regulations and Health Advisories* (USEPA, 1996c).
(e) No RBC or SSL exists for TPH; the TDEC groundwater cleanup level of 100 µg/L total TPH for drinking water aquifers has been substituted for the RBC for tap water. Standard obtained from the *Policy Statement for Petroleum Contaminated Sites* (TDEC, 1997).
(f) U indicates that the material was analyzed but not detected at the listed numerical quantitation limit; J indicates that the associated numerical value is an estimated quantity.
(g) NA denotes indicated analyte was not analyzed during time period indicated.

2.5 Treatability Study

As discussed in the CMS work plan (*EnSafe, 2001*), monitored natural attenuation (MNA) was identified as the alternative most likely to achieve the remedial goals for SWMU 14/46. An MNA Treatability Study work plan was then developed to monitor the area over time and to verify that natural attenuation is occurring at rates sufficient to attain site-specific remedial goal options (RGOs). Complete information on this program is provided in the *Monitored Natural Attenuation Treatability Study Work Plan — SWMU 14/46 (EnSafe, August 2001).*

To further evaluate the extent of chlorinated solvents in loess groundwater, the monitoring program included the installation of three additional loess monitoring wells at locations north and northwest of 014G02LS. The monitoring program also implemented quarterly groundwater sampling of the three new wells and the other five existing loess wells at SWMU 14/46 for one year. The samples were analyzed for VOCs and geochemical parameters. Quarterly monitoring took place in May, August, and December 2002, and March 2003. VOC results from these sampling events are presented in Table 2-3.

PCE and TCE exceeded their MCLs in each quarterly sample collected from well 014G02LS. No other detections of VOCs exceeded MCLs. Additional samples were collected for geochemical analysis during quarterly monitoring. These results, along with further discussion of the quarterly monitoring results, are presented in Section 5.2.1 and Appendix A.

A graphical computer model was used to visually interpret the loess groundwater data and develop a conceptual model of the contamination at SWMU 14/46. The model-generated plume map showing TCE concentrations detected in NSA Mid-South SWMU 14/46 loess groundwater in March 2003 is presented in this report as Figure 2-5.

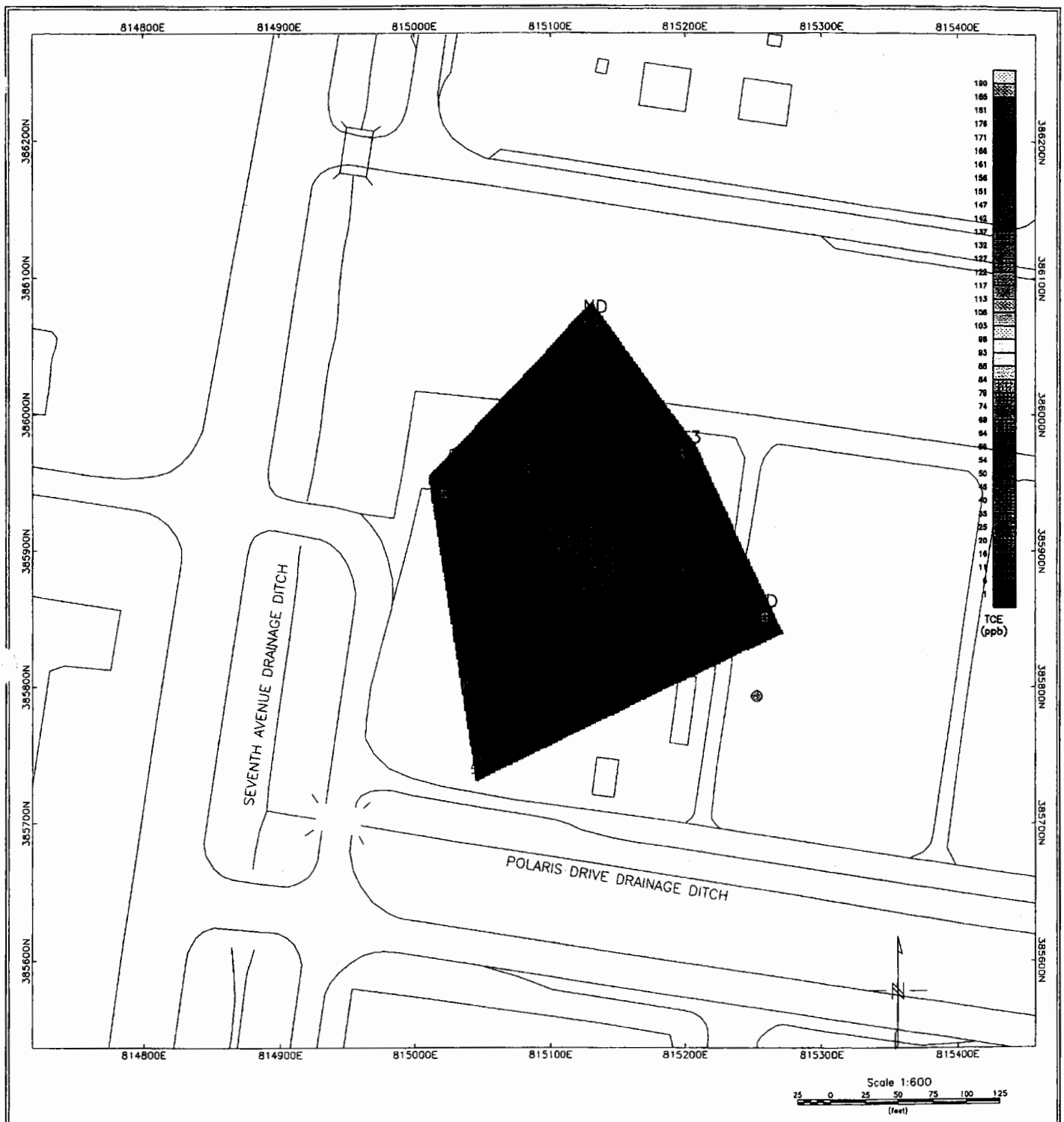
Table 2-3
Quarterly Monitoring
SWMU 14/46 (µg/L)

Well I.D.	Date	Contaminants				
		PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	vinyl chloride
014G01LS	May 2002	ND	ND	ND	ND	ND
	August 2002	ND	ND	ND	ND	ND
	December 2002	ND	ND	ND	ND	ND
	March 2003	ND	ND	ND	ND	ND
014G02LS	May 2002	**120**	**70**	4.4	0.47	ND
	August 2002	**200 D**	**140**	12	1.1	ND
	December 2002	**140**	**100**	5.3	0.57 J	ND
	March 2003	**120**	**75**	7.4	0.67	ND
014G03LS	May 2002	ND	ND	ND	ND	ND
	August 2002	ND	ND	ND	ND	ND
	December 2002	ND	0.37 JB	ND	ND	ND
	March 2003	ND	ND	ND	ND	ND
014G05LS	May 2002	ND	ND	ND	ND	ND
	August 2002	ND	ND	ND	ND	ND
	December 2002	ND	ND	ND	ND	ND
	March 2003	ND	ND	ND	ND	ND
014G08LS	May 2002	ND	ND	ND	ND	ND
	August 2002	ND	ND	ND	ND	ND
	December 2002	ND	ND	ND	ND	ND
	March 2003	ND	ND	ND	ND	ND
014G09LS	May 2002	ND	ND	ND	ND	ND
	August 2002	ND	ND	ND	ND	ND
	December 2002	ND	ND	ND	ND	ND
	March 2003	ND	ND	ND	ND	ND

Table 2-3
Quarterly Monitoring
SWMU 14/46 (µg/L)

Well I.D.	Date	Contaminants				
		PCE	TCE	cis-1,2-DCE	trans-1,2-DCE	vinyl chloride
014G10LS	May 2002	ND	0.44 J	0.62 J	ND	ND
	August 2002	ND	0.53 J	0.90 J	0.32 J	ND
	December 2002	ND	0.41 J	ND	ND	ND
	March 2003	ND	0.6	0.54	ND	ND
014G11LS	May 2002	ND	ND	ND	ND	ND
	August 2002	ND	ND	ND	ND	ND
	December 2002	ND	ND	ND	ND	ND
	March 2003	ND	0.32	ND	ND	ND
MCLs[a]		5	5	70	100	2

Notes:
All concentrations exceeding the MCL are shaded.
µg/L micrograms per liter
J Estimated
D Diluted
a Maximum contaminant levels (MCLs) from the *Drinking Water Regulations and Health Advisory* (USEPA, 2000).
Bold Exceeds MCL



PLOT SUMMARY
- Sampling data obtained from loess monitoring wells only, March 2003
- Potentiometric data for March 2003 (contours)
- Labeled wells are loess wells; unlabeled are fluvial deposits wells

- Drawing file: 0146GEO.DXF
- Plotted via Geosoft 12-08-03
n:\wp51\users\lhughes\memphis\north-gw\swmu14\12.P01

Figure 2-5

March 2003 Loess TCE Concentration Map
SWMU 14

SWMU 14 Corrective Measures Study Report
NSA Mid-South, Millington, TN

EnSafe Inc.

3.0 SWMU 14/46 REMEDIAL OBJECTIVES

This section summarizes the SWMU 14/46 loess groundwater COCs that will be addressed directly by this CMS and presents their remedial action objectives. In some cases, this section justifies the inclusion or removal of COCs from those identified in the RFI and CMS work plan (EnSafe, 2001) based on the chemical's contribution or lack thereof to significant risks, hazards, or other regulatory standards applicable to this site.

3.1 SWMU 14/46 Groundwater Chemicals of Concern

As discussed in Section 2.4, the RFI identified two compounds, PCE and TCE, as COCs for loess groundwater at SWMU 14/46. PCE and TCE will be addressed in this CMS because they are the most prevalent contaminants in the loess groundwater and they are present at concentrations that exceed applicable cleanup standards.

The RFI also identified TPH as a COC in loess groundwater. However, the CMS work plan recommended no further evaluation of this compound in the loess groundwater because none of the samples collected exceeded TDEC action levels for non-drinking water aquifers.

3.2 SWMU 14/46 Groundwater Remedial Goal Options

Based on previous discussions and decisions, the remedial goals for SWMU 14/46 loess groundwater are MCLs. The technology evaluation includes the potential for achieving the 5 µg/L MCL for PCE and TCE.

4.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section describes the initial steps toward remedy selection: identification and screening of applicable technologies, followed by reviewing based on site-specific conditions and waste constraints. From the retained technologies, SWMU 14/46 remedial action technologies will be developed and further evaluated in Section 5.

4.1 Potential Response Actions

Remedial action technologies can be broadly categorized into general response actions for consideration in the CMS. From these general categories, which are summarized below, potentially applicable technologies will be selected. Three technologies were retained for further consideration: institutional controls, monitored natural attenuation, and enhanced biodegradation.

- **Institutional Controls (ICs):** ICs often supplement engineering controls as appropriate for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants. ICs should not substitute for active response measures as the sole remedy, unless active measures are determined to be impractical.

- **MNA:** This term refers to monitoring of decreases in contaminant concentrations via natural processes; such as, biotic and abiotic degradation, contaminant dilution, dispersion, and/or advection. Monitoring must be conducted throughout the process to confirm that degradation proceeds at rates consistent with remedial objectives and to ensure that receptors are not threatened.

- **Treatment:** Where practical, treatment can be used to reduce the toxicity, mobility, or volume of the principal contaminants at a site. It can also be used to treat sources or hot spots as the initial step followed by other response actions such as MNA.

- **Combination:** Appropriate methods can be combined to protect human health and the environment.

4.1.1 Institutional Controls

ICs are required for industrial reuse scenarios and typically include:

- **Governmental controls** such as zoning restrictions, ordinances, statutes, building permits, or other provisions that restrict land or resource use at a site.

- **Proprietary controls**, which involve legal instruments placed in the chain-of-title of the site or property (e.g., easements or covenants).

- **Enforcement and permit tools** with IC components in which orders can be issued or negotiated to compel the land owner (usually the potentially responsible party) to limit certain site activities at both federal and private sites.

- **Informational devices**, such as state registries of contaminated properties, deed notices, and advisories, which provide information or notification that residual or capped contamination may remain on-site.

Because of federal ownership, ICs are applied differently at federal facilities. Some proprietary or governmental controls cannot be applied on active federal facilities. However, for properties being transferred as part of a base closure, the Department of Defense has the authority to restrict property use by retaining a property interest (i.e., easement to ensure the protectiveness of the remedy). For active bases, ICs are commonly addressed through remedy selection documents, base master plans, and separate memorandums of understanding (Fields, 2000). **ICs were retained for further evaluation.**

4.1.2 Monitored Natural Attenuation

MNA of contaminants in groundwater relies on natural processes to reduce concentrations to less than cleanup goals (e.g., MCLs). This technology involves extensive monitoring of site conditions to evaluate the potential for natural processes to achieve cleanup goals. This technology can be applied alone or as a polishing step that accompanies more aggressive technologies. Because it has reduced VOCs, specifically chlorinated hydrocarbons, to detection limits at other sites (USEPA, 1998), **MNA was retained for further evaluation**.

4.1.3 In Situ Biological Treatment Technologies

Chlorinated solvents are known to break down to less-chlorinated daughter products under proper environmental conditions, which may be attained via a variety of engineering means as explained below.

Some forms of enhanced biodegradation use injected materials such as air, nutrients, primary substrates, or cometabolites to stimulate natural degradation of contaminants within the aquifer. In this case, an injected material is generally applied in a grid covering the entire zone targeted for remediation. Applications can be scheduled at different time intervals using different innocuous materials if both anaerobic and aerobic environments are required. This technology can reduce medium to low VOC concentrations to less than cleanup goals. In situ biological treatment or enhanced biodegradation is particularly useful to remediate localized areas of high chlorinated solvent contamination, before initiating actions such as MNA and institutional controls. Furthermore, passive injection of innocuous substrates, an extremely economical and simple application, is all that is required for some sites. Therefore, because of its demonstrated effectiveness at VOC-contaminated sites, **enhanced biodegradation was retained for further evaluation**.

5.0 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

The purpose of the detailed analysis of this alternative is to provide decision-makers with the information needed to evaluate the proposed SWMU 14/46 site remedy. During the detailed analysis, the alternative is assessed against the evaluation criteria described in USEPA OSWER Directive Number 9902.3-2A (USEPA, 1994).

5.1 Evaluation Process

The evaluation process provides decision-makers with the information they need to adequately evaluate each alternative and satisfy RCRA requirements for selecting the remedial action.

Primary Criteria

Four primary evaluation criteria have been developed to address the RCRA requirements and their additional technical and policy considerations. The evaluation criteria with the associated statutory considerations that must be met are:

- Primary Criteria 1: Protection of human health and the environment
- Primary Criteria 2: Attainment of cleanup standards
- Primary Criteria 3: Source control
- Primary Criteria 4: Compliance with applicable waste management standards

Secondary Criteria

Five other general factors are considered. These factors combine technical measures and management controls to address the environmental problems at SWMU 14/46. The remedial alternative is evaluated with respect to the these criteria, as described in the following sections.

- Secondary Criteria 1: Long-term reliability and effectiveness
- Secondary Criteria 2: Reduction in waste toxicity, mobility, or volume
- Secondary Criteria 3: Short-term effectiveness

- Secondary Criteria 4: Implementability
- Secondary Criteria 5: Cost

5.1.1 Protection of Human Health and the Environment

Corrective action remedies must be protective of human health and the environment. The alternative must satisfy this criterion to be eligible for selection. Evaluation of this criterion should provide a final measure to assess whether the alternative adequately protects human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term reliability and effectiveness, short-term effectiveness, and compliance with applicable waste-management standards.

Evaluation of the overall protectiveness of a remedial alternative should gauge whether an alternative achieves adequate protection by eliminating, reducing, or controlling the risks each pathway poses through treatment, engineering, or ICs. This evaluation considers whether an alternative poses any unacceptable short-term or cross-media impacts.

5.1.2 Attainment of Cleanup Standards

Remedies will be required to attain media cleanup standards set by the implementing agency, which may be derived from existing state or federal regulations (e.g., groundwater standards) or other standards. The media cleanup standards for a remedy will often play a large role in determining the extent of the remedy and technical approaches to it. In some cases, certain technical aspects of the remedy, such as the practical capabilities of remedial technologies, may influence to some degree the media cleanup standards that are established.

In addition, this CMS report evaluates whether the potential remedial technology will achieve the remediation objective identified by the implementing agency. The estimated time for the alternative to meet these standards will also be discussed.

5.1.3 Source Control

A critical objective of any remedy must be to stop further environmental degradation by controlling or eliminating further releases that may threaten human health and the environment. Unless source control measures are taken, efforts to clean up releases may be ineffective or, at best, will essentially involve a perpetual cleanup. Therefore, an effective source control program is essential to ensure the long-term effectiveness and protectiveness of the corrective action program.

This CMS report also evaluates whether source control measures are necessary, and if so, the type of actions that would be appropriate. For any proposed source control measure, estimated effectiveness will be discussed based on site conditions and the history of the specific technology.

5.1.4 Compliance with Applicable Waste Management Standards

Corrective action remedies must comply with applicable waste management standards. To be eligible for selection, each alternative must satisfy this criterion, which is used to evaluate whether the alternative will meet federal and state waste management standards identified in previous stages of the remedial process.

5.1.5 Long-Term Reliability and Effectiveness

The evaluation of alternatives under this secondary criterion addresses the results of a remedial action in terms of the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes. Two factors should be addressed for the alternative:

- **Magnitude of Residual Risk:** This factor assesses the residual risk from untreated waste or treatment residuals at the conclusion of remedial activities. This risk may be measured by numerical standards such as cancer risk levels or the volume or concentration of constituents in waste, media, or treatment residuals remaining on-site.

- **Adequacy and Reliability of Controls:** This factor assesses the adequacy and suitability of any controls used to manage treatment residuals or untreated wastes remaining on-site. It may include an assessment of containment systems and ICs to determine if they are sufficient to ensure that any exposure to human and environmental receptors is within protective levels.

5.1.6 Reduction in Waste Toxicity, Mobility, or Volume

This criterion addresses the preference for remedial actions employing treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances. The evaluation should consider the following specific factors:

- The treatment processes, the remedies they will use, and the materials they will treat.
- The amount of hazardous materials that will be destroyed or treated.
- How principal threat(s) will be addressed.
- The degree of expected reduction in toxicity, mobility, or volume, measured as a percentage of reduction (or order of magnitude), when possible.
- The degree to which the treatment will be irreversible.
- The type and quantity of treatment residuals that will remain following treatment.

5.1.7 Short-Term Effectiveness

The short-term effectiveness of a remedial alternative is evaluated relative to its effect on human health and the environment during implementation. Short-term effectiveness is based on four key factors:

- Risks to the community during implementation.
- Risks to workers during implementation.
- Potential for adverse environmental impact as a result of implementation.
- Time until remedial response objectives are achieved.

5.1.8 Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. It involves analysis of the following factors:

Technical Feasibility

- Technical difficulties and unknowns associated with construction and operation.
- Potential technical problems during implementation that may lead to schedule delays.
- Ease of remedial action and potential future activities based on technology performance.
- Ability and ease of monitoring the remedy's effectiveness, including an evaluation of the risks of exposure if monitoring is insufficient to detect a system failure.

Administrative Feasibility

Activities needed to coordinate with other offices and agencies.

Availability of Services and Materials

- Availability of adequate offsite treatment, storage capacity, and disposal services.
- Availability of necessary equipment, specialists, and provisions to ensure any necessary additional resources.
- Potential to obtain competitive bids, which may be particularly important for innovative technologies.
- Availability of prospective technologies.

5.1.9 Cost

A detailed cost estimate for a remedial alternative is based on engineering analyses, suppliers' estimates of necessary technology, and costs for similar actions (such as excavation) at other RCRA sites. The cost estimate for a remedial alternative typically consists of four principal elements: capital cost, annual operation and maintenance (O&M) costs, costs for evaluation reports, and present-worth analysis. Costs are expressed in 2003 dollars.

Capital Costs

- *Direct costs* for equipment, labor, and materials used to develop, construct, and implement a remedial action.

- *Indirect costs* for engineering, financial, and other services that are not actually part of construction, but are required to implement a remedial alternative. The percentage applied to the direct cost varies with the degree of difficulty associated with construction and/or implementation of the alternative. In this CMS, the indirect costs include health and safety items, permitting and legal fees, bid and scope contingencies, engineering design and services, and miscellaneous supplies or costs.

Annual O&M Costs

These are post-construction costs necessary to ensure the continued effectiveness of a remedial action, i.e., long-term power and material (such as the operation of a water treatment facility), equipment replacement, and long-term monitoring.

Evaluation Reports

Those costs are associated with reports that evaluate the results of the selected alternative.

Present-Worth Analysis

This analysis makes it possible to compare remedial alternatives on the basis of a single cost representing an amount that would be sufficient to cover all costs associated with the

remedial action during its planned life, if invested in the base year and disbursed as needed. A performance period appropriate to each alternative is assumed for present-worth analyses. Discount rates of 6% are assumed for base calculations. An increase in the discount rate decreases the present worth of the alternative.

The cost elements for the remedial alternative are summarized in the cost-analysis section. The study estimate cost provided for the alternative is intended to reflect actual costs with an accuracy of minus 30% to plus 50%, in accordance with USEPA guidelines.

5.2 Development and Evaluation of Groundwater Remedial Alternatives

Depending on the potential to achieve remedial objectives and property reuse considerations, the treatment alternative will include some level of ICs and monitoring. Two alternatives have been developed from the technologies described in Section 4.

- Alternative 1: MNA
- Alternative 2: Enhanced Biodegradation with MNA

5.2.1 Alternative 1: MNA

MNA is a site management strategy used where contaminant degradation rates are fast enough to protect human health and the environment under natural conditions.

5.2.1.1 Technology Description

Natural attenuation or MNA is best described as the use of natural biological, physical, and chemical processes to contain the spread of COCs at hazardous waste release sites, reduce their concentrations in the subsurface, and transform them into nontoxic or less toxic end products. It applies to organic wastes such as petroleum compounds and chlorinated solvents, as well as inorganic materials such as metal wastes. MNA is increasingly being used as a remedial alternative at sites contaminated with chlorinated VOCs such as TCE.

Once thought to be persistent in the environment, chlorinated VOCs have been the subject of much research since the mid-1990s. Numerous studies evaluated the degradation mechanisms for chlorinated VOCs under natural conditions. The most common mechanism, described in the USEPA's protocol for MNA (USEPA, 1998a), is reductive dechlorination by sequential anaerobic pathways (such as iron reduction, sulfate reduction, and methanogenesis). Other mechanisms include contaminant dispersion, dilution, adsorption, volatilization, and chemical or biological stabilization. However, if contaminant biodegradation (destruction) is not occurring, these nondestructive mechanisms may require supplemental active remedial technologies to protect human health and the environment.

Common Destructive Pathways

Natural biological attenuation uses naturally occurring microorganisms to breakdown or degrade hazardous substances into less toxic or non-toxic ones. Degradation can occur via several metabolic pathways depending on the chemistry and geochemistry of the site groundwater. These pathways can be broadly classified as being anaerobic, aerobic, or co-metabolic. The most common metabolic pathways for chlorinated solvent degradation are summarized below.

Reductive Dechlorination

Reductive dechlorination is the most important process in chlorinated solvent biodegradation. This process occurs when chlorine atoms in compounds such as PCE, TCE, and trichloroethane (TCA) are substituted with hydrogen to successively transform these compounds into daughter products such as *cis*-1,2-DCE and VC. In this pathway, the chlorinated solvent is the electron acceptor. Reductive dechlorination generally occurs only under reducing conditions, i.e, the aquifer must be reduced or anaerobic in nature (low in dissolved oxygen). An electron donor (carbon source) also is required. Geochemical analysis is generally required to demonstrate reducing conditions. The reductive-dechlorination process could proceed beyond VC to eventually produce innocuous gaseous end-products such as ethene. Though highly reducing conditions are required for complete dechlorination to occur, *cis*-1,2-DCE has been found to degrade to VC under *slightly* anaerobic conditions (USEPA, 1998a). Often, because of the natural reductive

dechlorination process, intermediate biological breakdown products (*cis*-,2-CE and VC) are formed which could also then degrade via different metabolic pathways such as aerobic cometabolism or direct oxidation.

Direct Oxidation

Oxidation also is an important mechanism for the degradation of daughter products such as DCE and VC. In this process, the chlorinated solvents can be used as an electron donor. Direct oxidation can proceed either aerobically (in the presence of oxygen) or anaerobically, where iron or nitrate serve as the electron acceptor to complete the metabolic process. Direct oxidation is often an important step in downgradient sections of a chlorinated VOC plume, which tend to be more oxygenated or contain higher nitrate and oxidized iron concentrations.

The ability of an aquifer to naturally oxidize *cis*-1,2-DCE and VC is particularly important at sites where in situ bioremediation is being implemented to promote reductive dechlorination of TCE. In such a situation, the daughter products DCE and VC could either further dechlorinate, accumulate, or oxidize under the appropriate natural conditions. These conditions include an aerobic environment (oxygen); or the presence of nitrate or oxidized iron in an anaerobic environment that facilitates direct bacterial oxidation of *cis*-1,2-DCE and VC.

Anaerobic Cometabolism

Anaerobic cometabolism of parent chlorinated compounds (PCE, TCE, and TCA) generally occurs when natural methanogenic, acetogenic, and sulfate reducer microorganisms mediate the fortuitous degradation of these compounds. These microorganisms have been found to possess metal-porphyrin-containing co-factors that can mediate the slow, incomplete reductive dechlorination of PCE and TCE to DCE (Gossett and Zinder, 1996). The process is cometabolic in that it happens more or less incidentally as the organisms carry on their normal metabolic functions; that is, they derive no growth or energy-linked benefits from the reductive dechlorination itself. Generally, the microorganisms that mediate such processes are ubiquitous. However, the

process is much slower than reductive dechlorination (Gossett and Zinder, 1996) and is hard to distinguish from direct reductive dechlorination at most sites.

Aerobic Cometabolism

Aerobic cometabolism is similar to anaerobic cometabolism, but occurs in oxygenated conditions. It is a much faster process and is applicable to most chlorinated solvents (USEPA, 1998a). Under conditions that support aerobic metabolism, chlorinated solvents are degraded by cometabolism. Certain aerobic microorganisms generate oxygenase enzymes of broad substrate specificity that oxidize chlorinated solvents (USEPA, 1998a). Several types of microorganisms are capable of carrying on the process. Microorganisms derive no growth-linked or energy-conserving benefit from this fortuitous degradation. The oxygenase enzymes produce a highly reactive chlorinated ethylene epoxide intermediate. These epoxides are very unstable, which leads to their natural transformation to harmless end products. Therefore, DCE and VC are unlikely to be a part of the co-metabolic process.

Chlorinated ethylenes do not induce the production of these oxygenases, therefore a co-substrate is required to stimulate enzyme production. During the cometabolism of chlorinated solvents, other microorganisms derive their energy from organic compounds such as methane, phenol, and toluene (McCarty, 1997). Anthropogenic organic sources such as TPH or BTEX could also be used for energy in the cometabolic process.

Chemical Degradation

This process includes hydrolysis and chemical elimination. It is a much slower process than the reductive/oxidative processes, but may be found to occur when a contaminant exists for long periods of time at a site. The two parent chlorinated solvents which most commonly undergo chemical transformation are 1,1,1-TCA and 1,2-DCA. Generally, the presence of 1,1-DCE at a site is indicative of its chemical breakdown via elimination from 1,1,1-TCA (USEPA, 1998a). Therefore, chemical breakdown mechanisms merit consideration at sites where MNA is being evaluated.

Common Nondestructive Pathways

Other natural attenuation mechanisms commonly include contaminant advection, dispersion, dilution, volatilization, and adsorption.

Advection — Movement of solute by bulk groundwater movement.

Dispersion — Fluid mixing due to groundwater movement and aquifer heterogeneity.

Diffusion — Described by Fick's Law, diffusion refers to the spreading and dilution of a contaminant as it migrates from zones of higher concentrations to those of lower concentrations.

Dilution — Movement of uncontaminated water into a contaminated zone.

Volatilization — Partitioning of dissolved contaminants from the dissolved phase to air.

Adsorption — Reaction between aquifer matrix and solute whereby relatively hydrophobic compounds become sorbed to organic carbon or clay minerals.

The rates of nondestructive mechanisms are relatively slow relative to the biodegradation rates. Nevertheless, these abiotic mechanisms do contribute to overall contaminant reduction, particularly when aquifer geochemistry does not favor biodegradation (e.g., low availability of electron donor or carbon sources).

Geochemistry

Direct evidence of natural attenuation typically involves evaluation of analytical data from the site to determine the relative presence of parent compounds (e.g., TCE) as opposed to degradation (or daughter) products such as 1,2-DCE and VC. If daughter products are identified, some degree of natural attenuation is occurring. If complete degradation is observed between the

source area and the downgradient compliance point, natural attenuation may be effective at degrading site contaminants. Appropriate supporting evidence is necessary to conclude the efficacy of natural attenuation.

The most important factor that governs the potential or feasibility of natural attenuation is the aquifer geochemistry. The USEPA has suggested a list of geochemical parameters for groundwater MNA evaluation (USEPA, 1998a). This data can either be quantified in screening tables or analyzed quantitatively to provide the strength of evidence for MNA occurrence and feasibility. Each parameter bears its own significance in the determination of MNA occurrence. The following outlines the chemical and geochemical parameters and their significance in MNA evaluation of chlorinated solvents.

All of these data combined with the geochemical interpretation can be used to infer whether MNA may be the sole remedy, part of a remedy, or whether biological enhancement is the preferred option.

Dissolved Oxygen

The dissolved oxygen (DO) content of water in an aquifer indicates whether the aquifer is aerobic or anaerobic. Oxygen provides the most thermodynamically favorable respiratory pathway (or electron acceptor) used by microorganisms for biodegradation. DO concentrations are very critical to natural attenuation of chlorinated solvents. Because anaerobic bacteria generally cannot function at DO concentrations greater than 0.5 milligrams per liter (mg/L), reductive dechlorination generally does not proceed effectively when DO concentrations exceed this level. The oxygen needs to be depleted before the bacteria begin utilizing other electron acceptors because most microorganisms prefer to use oxygen for respiration (USEPA, 1998a). Generally, the sequence of electronic acceptor use proceeds from DO to nitrate, followed by ferric iron (Fe [III]), sulfate, and finally carbon dioxide (methanogenesis). Each sequential microbial reaction or geochemical condition renders the aquifer more anaerobic, creating favorable conditions for

complete reductive dechlorination. These biochemical mechanisms can also occur simultaneously, particularly under strongly anaerobic conditions.

As the parent compound is reduced to less chlorinated compounds, aerobic conditions can play a more significant role to further degrade daughter products. This often occurs at the downgradient or leading edge of a plume, resulting in cometabolic or oxidative destruction of compounds such as *cis*-1,2-DCE or VC (USEPA, 1998a).

Oxidation-Reduction Potential

The ORP indicates the relative oxidized or reduced state of groundwater in an aquifer. Biological processes generally occur within a prescribed ORP range (USEPA, 1998a). For instance, an ORP of less than 50 millivolts (mV) indicates reducing conditions (groundwater depleted of DO). ORP levels greater than 50 mV indicate aerobic groundwater conditions that will tend to hinder reductive dechlorination but promote aerobic degradation of lesser chlorinated daughter product such as DCE and VC. ORP levels below -100 mV are ideal for reductive dechlorination.

Though ORP is a useful parameter in MNA evaluation, it is difficult to measure in the field. Groundwater often contains constituents in ionic pairs that are not in a state of equilibrium. Each ionic electrode is sensitive to a specific ion pair. Unless the groundwater is at equilibrium, ORP measurement remains questionable in certain aquifers. Therefore, field-measured ORPs should be used with discretion for evaluation purposes.

Nitrate

Nitrate is the next favored electron acceptor for anaerobic degradation of chlorinated solvents after DO has been used by microorganisms. Nitrate concentrations greater than 1.0 mg/L in the contaminated portion of the aquifer could inhibit natural reductive dechlorination. However, nitrate can also facilitate the anaerobic oxidation of lesser chlorinated compounds such as *cis*-1,2-DCE and VC, particularly at the fringes of plumes.

Total Organic Carbon

TOC concentrations in the aquifer are used to assess the amount and distribution of electron donors that microorganisms require to degrade chlorinated solvents metabolically. TOC may be natural organic carbon or anthropogenic carbon (e.g., BTEX and other petroleum constituents). The USEPA has specified that 20 mg/L is a desirable TOC concentration for biodegradation (USEPA, 1998a). However, 20 mg/L is relative to the amount of chlorinated solvents in the aquifer and the type of TOC present. Additionally, the chemical nature of natural organic carbon could also influence its usefulness. Therefore, TOC utilization involves a qualitative understanding of site degradation characteristics in addition to the USEPA-stipulated criteria. At some sites, TOC at low concentrations of 2 to 5 mg/L could be sufficient to carry out the reductive dechlorination of chlorinated solvents.

Ferrous Iron

Fe(II) can be produced from ferric iron (Fe[III]) by microbial activity. Reduction from Fe(III) to Fe(II) can occur during anaerobic degradation of natural or anthropogenic carbon, or during reductive dechlorination of the lesser chlorinated by-products of PCE and TCE, namely DCE and VC. As such, Fe(II) concentrations in the aquifer indicate the possibility of chlorinated solvent degradation (particularly VC). In addition to Fe(II) measurements, total iron measurements can provide an indication of the amount of iron that is available for iron-mediated biological oxidation.

Sulfate and Sulfide

After microbes have depleted DO, nitrate, and iron, sulfate is likely to be the next preferred electron acceptor. Sulfate reduction results in the production of sulfide. Sulfate concentrations greater than 20 mg/L can reduce the efficiency of reductive dechlorination because sulfate can compete with chlorinated solvents as the preferred electron acceptor. The presence of sulfide in the aquifer indicates that conditions are conducive to the reductive dechlorination process. Sulfide is often hard to detect in groundwater because of its tendency to precipitate with iron and other metals in reduced environments.

Methane

During methanogenesis, carbon dioxide is used as an electron acceptor and is converted to methane. Methanogenesis generally occurs after microorganisms have used the available oxygen, nitrate, and sulfate. The presence of methane in the aquifer indicates strongly reducing conditions (commonly ORP is less than -250 mV). Methane is particularly useful as the groundwater transitions from anaerobic conditions to an aerobic environment and still carries relatively high concentrations of methane to facilitate cometabolic degradation of chlorinated solvents.

Alkalinity

Alkalinity commonly increases when chlorinated VOCs are completely degraded. Therefore, groundwater alkalinity in a plume, relative to background concentrations, could indicate the level of microbial activity and serve as an indirect indicator of chlorinated solvent biodegradation.

Chloride

Chloride produced by reductive dechlorination is generally inert and can serve as a conservative indicator of chlorinated solvent degradation in an aquifer. Reductive dechlorination generally results in chloride concentrations greater than background levels in the contaminated portion of the aquifer, and could therefore be an indirect estimator of microbial activity.

pH and Temperature

pH and temperature are common environmental factors that affect microbial activity. Microorganisms capable of degrading chlorinated solvents generally prefer a pH between 6 and 8 standard units. Groundwater temperature also affects microbial activity, which tends to increase with temperature up to a certain level. Below certain temperatures (generally 10°C), microbial activity decreases until it is negligible at freezing temperatures.

VOCs

Analyses of VOCs are used to determine the type, concentration, and distribution of contaminants and daughter products in the aquifer. The presence and distribution of certain daughter products can indicate the extent of parent-compound degradation. VOC data can be used to infer whether the concentrations of the contaminant or its daughter products are decreasing in the direction of groundwater flow. VOC data collected over time can be used to estimate trends and plan long-term monitoring approaches for MNA verification.

5.2.2 MNA: Application at SWMU 14/46

Four MNA sampling events have been conducted at SWMU 14/46 since May 2002. Geochemical and VOC data collected from targeted wells for each sampling event are summarized in Appendix A. The data were used to estimate the potential for natural biodegradation and evaluate whether this alternative would be reliable and effective. As part of this evaluation, the data were scored based on the USEPA's protocol. Based on the USEPA protocol, SWMU 14/46 groundwater data from area wells indicate that attenuation may be occurring, likely via aerobic cometabolism. However, natural attenuation at the rate at which it is perceived to be occurring, could take a very prolonged period of time before it reduced contaminants to the required levels. SWMU 14/46 wells showed limited or inadequate evidence of natural biological reductive dechlorination of chlorinated solvents. Specific findings include the following:

- The presence of petroleum hydrocarbons serves as a valuable energy source of organic carbon for microorganisms, which able them to mediate the fortuitous degradation of PCE and TCE to its degradation products. This process is called cometabolism, which was discussed in the previous section.

- SWMU 14/46 wells appear to be aerobic, a condition which is more suited to either the direct oxidation of DCE and VC to harmless end products or to the cometabolism of PCE and TCE. DO appears to vary and fluctuate to some extent at the site, but is generally above 1.0 mg/L at most locations. ORP measurements also suggest that a large portion

of the loess groundwater is aerobic. The strong aerobic environment could support limited reductive dechlorination of TCE, but should be conducive to direct bio-oxidation of daughter products *cis*-1,2-DCE and VC. Therefore, neither 1,2-DCE nor VC should accumulate.

- The absence of methane, sulfide, and ferrous iron further confirm the aerobic nature of the aquifer and the unlikelihood of TCE degradation via reductive dechlorination.

- Lack of Receptors — No fluvial deposits drinking-water wells are present at NSA Mid-South and a public water supply is readily available, thereby eliminating any potential receptors for SWMU 14/46 groundwater.

- Sampling results at SWMU 14/46 have shown limited horizontal migration of contaminants, which precludes any threat to cross gradient discharge points, including discharges to surface waters, and other ecosystems.

In summary, the above discussion indicates that some natural TCE bioattenuation (MNA) is occurring in the aquifer. However, geochemical inadequacies (DO, ORP, etc.), may limit the rate of degradation. Because the aquifer is strongly aerobic, it is more conducive to direct oxidation of the lesser-chlorinated daughter products, i.e. *cis*-1,2-DCE and VC. Therefore, the aquifer in its current condition is very likely to support natural attenuation of these daughter products.

To overcome the limitations noted during MNA evaluation, groundwater will likely have to be amended with an organic compound (which it is now lacking) to sustain rapid reductive dechlorination. In other words, the aquifer can be modified to induce sustained reducing conditions and degrade PCE, TCE, and their daughter products via reductive dechlorination.

A pilot study that was conducted at a selected location within Area of Concern A (AOC A) on the Northside of NSA Mid-South proved that enhanced biodegradation was feasible and effective at

treating TCE-contaminated groundwater. An organic food source was added during the study to create an anaerobic environment, which supported the reductive dechlorination of TCE. Reducing conditions (low DO) were created and a 50% reduction in TCE mass in the area was achieved during the pilot study. Enhanced biodegradation is now being implemented at AOC A. A similar approach could be effective to treat TCE in groundwater at SWMU 14/46. Because the loess comprises less permeable soil compared to the fluvial, the time available for reductive dechlorination should be greater. In other words, the contaminants and daughter product biodegradation rates should be faster than their migration rates in groundwater. Furthermore, the concentration of PCE/TCE is an order of magnitude lower compared to those detected in the fluvial deposits at AOC A. Therefore, enhanced bioremediation coupled with MNA is an effective remedial approach at SWMU 14/46.

Institutional Controls

One or more of the following ICs would be implemented as part of this alternative:

- Groundwater-use restriction — would likely include prohibitions on well installation in/through the lower part of the fluvial deposits.

- Easement — provisions in any subsequent property transfer/development agreements that would allow continued groundwater monitoring access.

- Covenant — provisions in any subsequent property transfer/development agreements that would restrict groundwater use.

- Reversionary interest — places a condition on the transferee's right to own and occupy the land; if violated (i.e., groundwater is used), the property could be returned to the Navy.

- Informational devices — tools (e.g., deed notices, state registries of hazardous waste sites, and advisories) which often rely on property-record systems, used to provide public information about risks from contamination.

- Site access controls — would likely include fences, signs, gates, and appropriate site personnel.

Monitoring

Annual sampling would be required to gauge the efficacy of natural attenuation. Four existing loess wells (014G01LS, 014G02LS, 014G03LS, and 014G05LS) would be sampled for the parameters and constituents listed to the right. Additionally, two fluvial deposits groundwater monitoring wells (014G06LF and 014G07LF) will be sampled for VOCs. Sampling would continue for 30 years or until VOC concentrations were consistently less than MCLs (i.e., three consecutive years).

Laboratory Parameters/Analytes	Field Parameters/Analytes
VOCs *(SW8260B)*	DO
TOC (*SW9060)*	ORP
	pH
	temperature

5.2.3 Evaluation of MNA Primary Criteria

Protection of Human Health and the Environment

MNA evaluation results indicate that chlorinated VOCs are not biodegrading at rates sufficient enough to attain MCLs. Therefore, this alternative by itself cannot ensure the protection of human health and the environment. However, MNA could be paired with an active (engineered) remedial technology to address VOC-contaminated groundwater. MNA would serve as the

final polishing step for remedial treatment. Attenuation (as the final polishing step) would likely occur via aerobic biodegradation or iron-reducing of daughter products.

Attainment of Cleanup Standards

MNA does not appear to be attaining cleanup goals. Without another remedial alternative, contaminants would remain at concentrations greater than cleanup standards indefinitely.

Source Control

Based on extensive RFI sampling results, there is no defined VOC "source area" for SWMU 14/46 loess groundwater. Nonetheless, there is insufficient natural attenuation to prevent contaminants from potentially migrating offsite. Lacking another active remedial technology, MNA would not be able to provide adequate source control.

Compliance with Applicable Waste Management Standards

No waste would be managed under this alternative; therefore, waste management standards do not apply.

5.2.1.4 Evaluation of MNA Secondary Criteria

Long-Term Reliability and Effectiveness

As discussed earlier, geochemical data and the scoring/ranking system suggest that MNA is unlikely to be an effective long-term remedy by itself. SWMU 14/46 monitoring wells show inadequate or limited evidence of natural chlorinated VOC reductive dechlorination. Again, aerobic cometabolism which is the MNA degradation identified is unlikely to be completely effective. However, MNA could be paired with an active (engineered) remedial technology to address VOC-contaminated groundwater. MNA would serve as the final polishing step for remedial treatment. As such, an active remedial alternative, ICs, and long-term system monitoring would be required to implement this alternative.

Reduction in Toxicity, Mobility, and Volume

By itself, natural attenuation cannot reduce contaminant toxicity, mobility, and volume at SWMU 14/46. There is marginal evidence of chlorinated VOC biodegradation, which if working, would provide some mass reduction. If implemented as a secondary remedial alternative, MNA could be used to mitigate further VOC migration of daughter compounds DCE and VC produced from enhanced biodegradation of TCE. These compounds could attenuate via aerobic biodegradation or iron-mediated biological oxidation (dilution, dispersion, volatilization, etc.)

Short-Term Effectiveness

MNA implementation would not cause any short-term risks to workers. Appropriate personal protective equipment would be used during scheduled groundwater sampling events to minimize worker risk.

Implementability

MNA is technically and administratively feasible and easily implemented. No construction, operation, or maintenance issues are initially involved with this alternative. MNA would not require offsite treatment services, materials, or innovative engineering technologies. Current access controls, including military security and limited personnel access, have been reliable at NSA Mid-South sites in the past. ICs previously described could be implemented to restrict groundwater use in this area, even if the property is transferred to another owner. Other than ICs, no administrative coordination would be required to implement MNA.

Cost

As shown in Table 5-1, the total cost for this alternative is $396,000. Capital costs are estimated to be $96,000; annual costs would be $21,800. As appropriate, the long-term monitoring program can be shortened with contaminant attenuation and regulatory approval.

Table 5-1
Alternative 1: MNA Costs

Action	Quantity	Unit Cost	Total Cost
Capital Costs			
Engineering design and planning	LS	$25,000	$25,000
Groundwater and solute transport modeling	LS	$25,000	$25,000
Institutional controls	LS	$25,000	$25,000
Sampling equipment	LS	$5,000	$5,000
20% contingency			$16,000
Total capital costs			**$96,000**
Annual Costs			
Field technicians	24 hours	$100/hour	$2,400
Laboratory sampling and analysis	9 samples	$250/sample	$2,250
Field sampling and analysis	LS	$1,000	$1,000
Sampling equipment	LS	$2,500	$2,500
Data review and reporting	100 hours	$100/hour	$10,000
Miscellaneous expenses and travel	LS	20% cost	$3,700
		Subtotal Annual Costs	**$21, 800**
		Present value subtotal at 6% for 30 years	**$300,000**
			Total
		MNA Total	**$396,000**

Note:
LS Lump Sum

5.2.2 Alternative 2: Enhanced Biodegradation with MNA

Enhanced biodegradation comprises subsurface zones where migrating contaminants, such as TCE, are intercepted and permanently immobilized or biodegraded into either lesser chlorinated daughter products, such as DCE or VC, or innocuous end products, such as ethane. Redox manipulation, if applied strategically in plume areas, would be a more aggressive remedial strategy than relying only on natural attenuation/reduction.

MNA, as described in Section 5.2.1, would be used to address the chlorinated daughter products formed from the TCE reduction that do not completely dechlorinate to ethene/ethane.

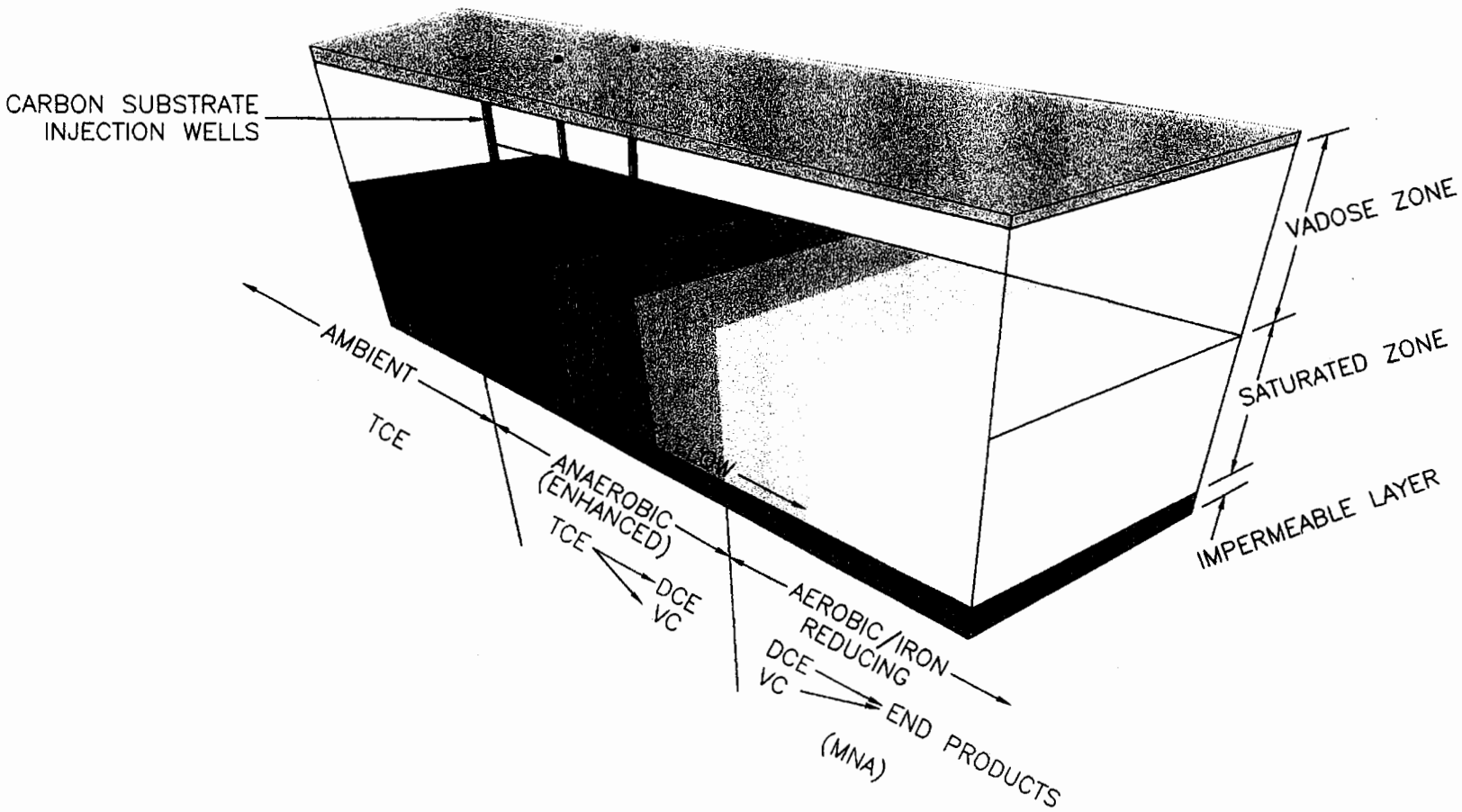
5.2.2.1 Technology Description

Enhanced biodegradation relies on groundwater flowing through created anaerobic zones (Figure 5-1), to treat TCE contamination. The anaerobic zone reduces the highly chlorinated VOCs (PCE/TCE) to lesser chlorinated VOCs (1,2-DCE and VC), which are subsequently degraded to innocuous end products via natural biodegradation.

Carbon (e.g., fructose or acetate) and nutrients (e.g., diammonium phosphate) are injected in designed amounts to the hot spot locations (i.e., locations of the highest concentrations of TCE). The carbon and nutrients provide a food source that stimulates microbial respiration, resulting in DO consumption. This will create an anaerobic zone in the hot spot area. As discussed previously, highly chlorinated solvents such as PCE and TCE are amenable to reductive dechlorination under anaerobic conditions.

Again, reductive dechlorination forms lesser chlorinated daughter products, namely *cis*-1,2-DCE and VC. However, unlike PCE/TCE, these compounds can break down more readily in an aerobic environment. Therefore, the lesser chlorinated daughter products should attenuate naturally in the current aerobic environment that is present at SWMU 14/46. In the unlikely event that it is needed, an aerobic zone may be created downgradient of the injection wells by injecting air into the aquifer using sparging wells connected to an aboveground blower. Sparging rates are based on groundwater DO concentrations in area monitoring wells, and sparging is generally performed intermittently and at low flow rates. Carbon and nutrients can also be added to the air-sparging wells to enhance the aerobic degradation of 1,2-DCE and VC. Aerobic degradation of VC forms innocuous end products such as CO_2, and water.

Without a known VOC source, full-scale treatment using enhanced biodegradation would be as simple as strategically injecting carbon into the loess groundwater to reductively dechlorinate VOCs. With slow groundwater velocities and low VOC concentrations, routine carbon-source injection (as distinguished from one-time applications, e.g., vegetable oil or hydrogen release compounds) using a line of wells would quickly address "hot spots," which could be used to create an aqueous biobarrier or an anaerobic zone perpendicular to groundwater flow (as shown in Figure 5-1).



CMS REPORT
SWMU 14/46
NSA MID-SOUTH
MILLINGTON, TN

FIGURE 5-1
ENHANCHED BIODEGRADATION WITH MNA
CONCEPTUAL DIAGRAM

DWG DATE: 12/22/03 | NAME: 0094001W027

5.2.2.2 Enhanced Biodegradation with MNA: Application at SWMU 14/46

At this time, it appears that a soluble (rather than an insoluble or slowly soluble) organic substrate would be more effective at enhancing aquifer geochemistry to promote relatively rapid biodegradation at SWMU 14/46. Soluble organic amendments would be injected into the loess groundwater to promote PCE/TCE biodegradation, under anaerobic conditions. PCE and TCE would be anaerobically biodegraded to *cis*-1,2-DCE and VC, which would either further dechlorinate under anaerobic conditions or, would degrade naturally to harmless end products in the downgradient aerobic zone. Sparging wells could be installed to introduce additional DO to the second treatment zone if necessary to enhance aerobic degradation of *cis*-1,2-DCE and VC.

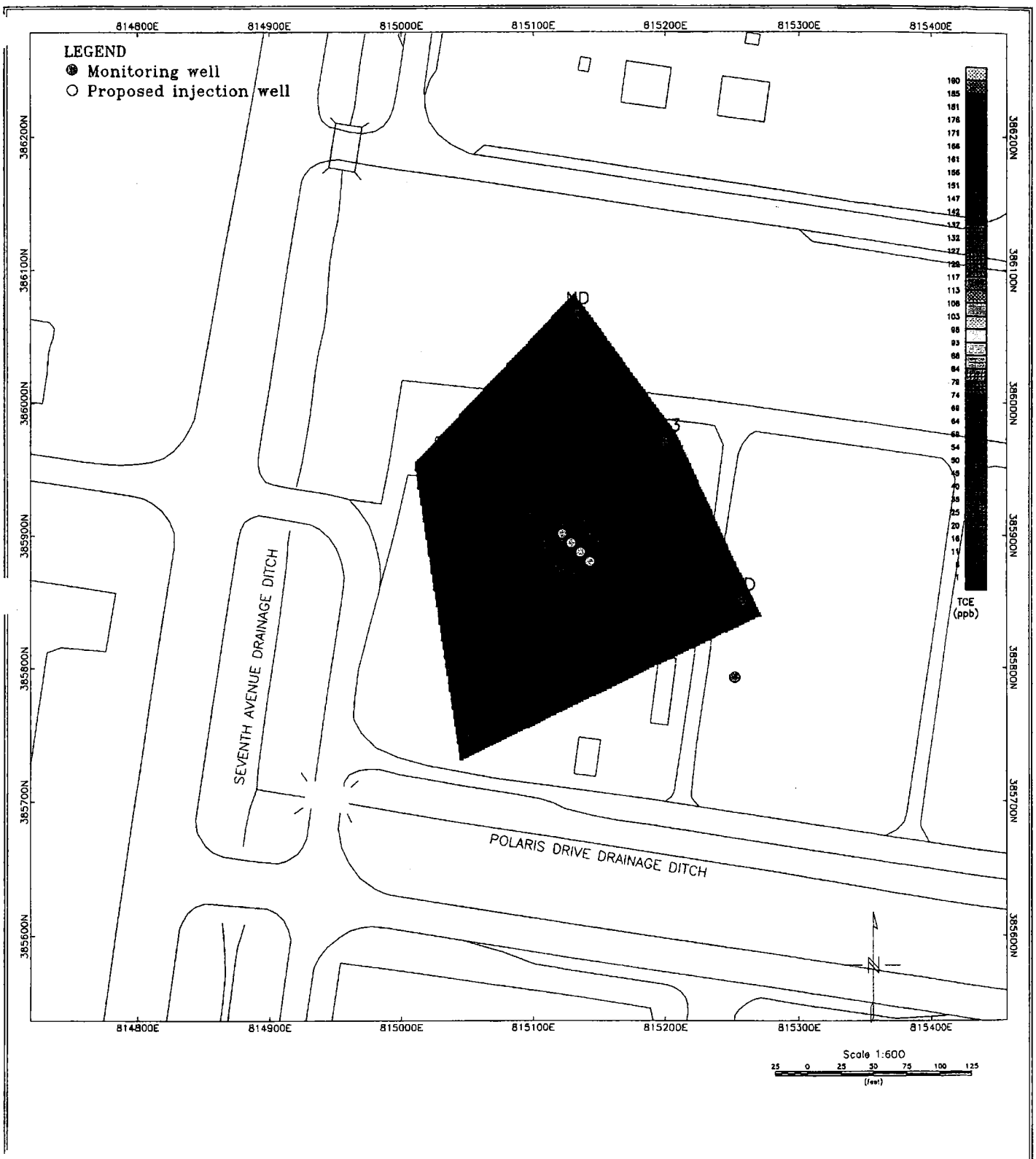
System Design

Wells would be strategically installed to infiltrate or inject a carbon source and nutrient solution in the area of highest PCE/TCE concentrations. The amendment solution would be applied quarterly during the treatment period.

The carbon source would be delivered to the injection points via a mobile application unit (e.g., a truck with a large storage vessel and a pump). As shown on Figure 5-2, a total of four injection points would be strategically located in a single row, upgradient of the area around 014G02LS. The injection wells would be spaced approximately 10 feet apart within the row, which would be approximately 10 feet upgradient of monitoring well 02LS and perpendicular to the direction of groundwater flow. Using this approach, additional injection points could be easily added if effectiveness monitoring indicates that a portion of the plume was not being adequately affected by the amendments. Figure 5-2 shows the well locations with respect to the TCE plume. Figure 5-3 presents a conceptual injection well layout.

Based on the concentration of 120 and 75 ppb for PCE and TCE, respectively, at well 02LS and the biodegradation rate developed for the AOC A pilot study (*EnSafe, 2003*), the time frame for amendment addition is expected to be one to two years.

A sparging system (wells, blower, etc.) would be implemented if aerobic conditions are required to address residual *cis*-1,2-DCE or VC concentrations. However, it is likely that these will be



PLOT SUMMARY
- Sampling data obtained from loess monitoring wells only, March 2003
- Potentiometric data for March 2003 (contours)
- Labeled wells are loess wells; unlabeled are fluvial deposits wells

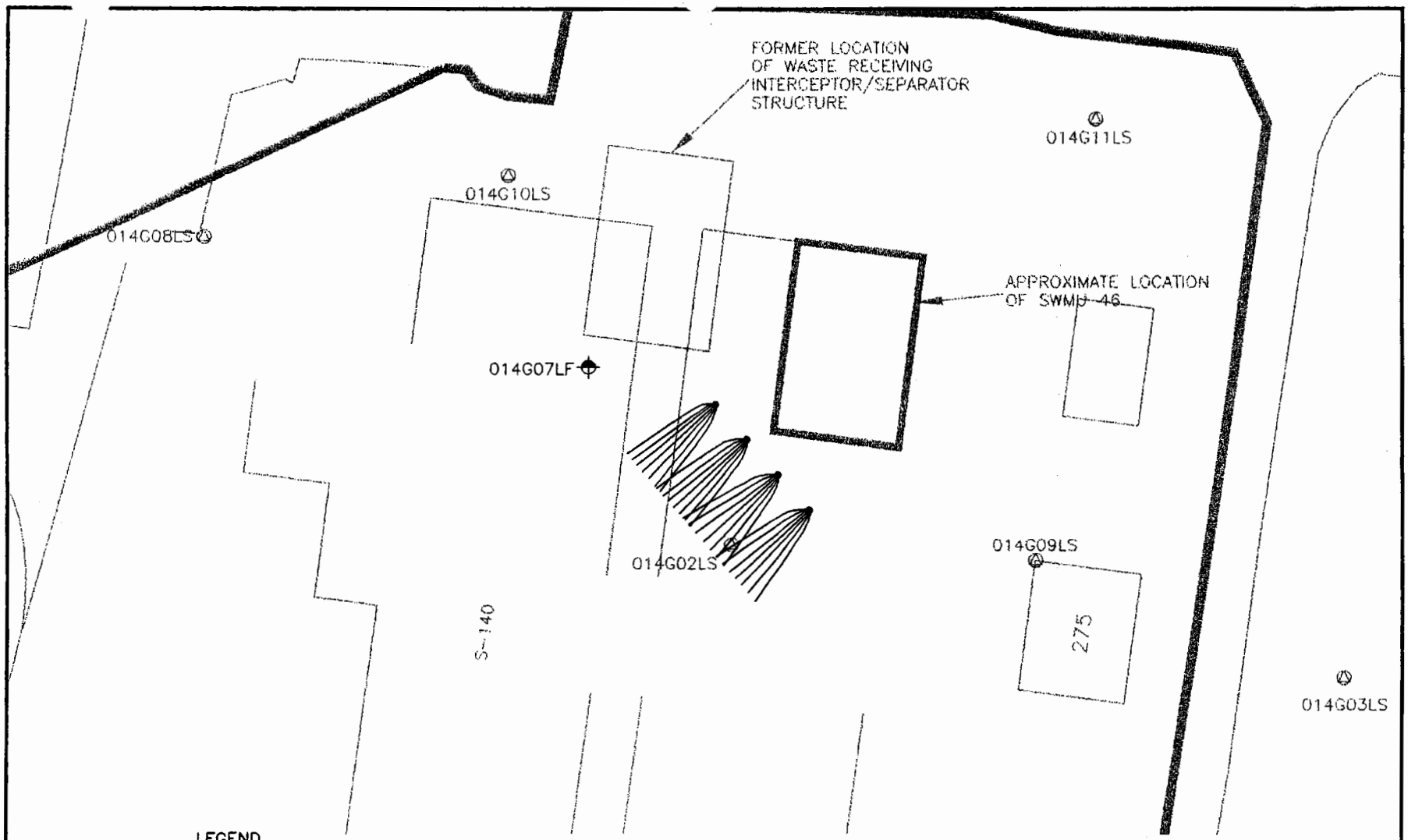
- Drawing file: 0146GEO.DXF
- Plotted via Geosoft 12-08-03
n:\wp51\users\lhughes\memphis\north-gw\swmu14\13.P01

Figure 5-2

Alternative 2: Enhanced Biodegradation with MNA System Layout

SWMU 14 Corrective Measures Study Report
NSA Mid-South, Millington, TN

EnSafe Inc.



LEGEND

- 014G03LS – LOESS MONITORING WELL LOCATION AND DESIGNATION
- 014G04LF – FLUVIAL DEPOSITS MONITORING WELL LOCATION AND DESIGNATION
- • – PROPOSED INJECTION WELL
- ← – GROUNDWATER FLOW DIRECTION
- – APPROXIMATE INJECTION ZONE OF INFLUENCE

Naval Facilities Engineering Command • Southern Division •

SWMU 14/46
CORRECTIVE MEASURES STUDY
NSA MID-SOUTH
MILLINGTON, TENNESSEE

FIGURE 5-3
CONCEPTUAL INJECTION WELL LAYOUT

DWG DATE: 12/15/03 | NAME: 0146001W067

addressed by *natural* aerobic degradation and other natural non-destructive attenuation mechanisms (such as dispersion). Therefore, MNA would be used to address residual VOCs downgradient of the treatment areas and along the perimeter of the plume. As such, in addition to groundwater monitoring, ICs would be included in the alternative to limit exposure pathways.

System Monitoring

Groundwater monitoring would be required to assess enhanced biodegradation with MNA. On-site effectiveness monitoring would include routine chemical and geochemical sampling to gauge remediation effectiveness. Field and laboratory monitoring parameters are listed in Table 5-2. Ideally, wells would be monitored in the targeted area and downgradient of the application; background wells would also be sampled. Samples would be collected and analyzed quarterly using low-flow groundwater collection techniques. Four monitoring wells (014G01LS, 014G02LS, 014G03LS, and 014G05LS) would be sampled for effectiveness monitoring. Additionally, two fluvial deposits groundwater monitoring wells (014G06LF and 014G07LF) would also be sampled for VOCs.

As soon as biodegradation and geochemical trends have been established, the sampling frequency could be reduced to semiannually or annually. Sampling results would be used to estimate the TCE mass reduction and approximate VOC degradation rates. Reductant redosing rates would depend on the plume management strategy, site-specific biodegredation performance, remedial goal options (RGOs), and other technical or regulatory considerations.

Institutional Controls

Because MNA would be used for areas with relatively low VOC concentrations, one or more of the following ICs, which are detailed in Section 5.2.1.2, would be implemented as part of this alternative:

- Groundwater-use restriction
- Easement
- Covenant
- Reversionary interest

- Informational devices
- Site-access controls

Table 5-2
Enhanced In Situ Bioremediation and MNA Sampling Analytes/Parameters

Analyte	Method
Laboratory	
VOCs	SW8260B
hydrogen	AM20GAX
methane, ethane, and ethene	8015MOD
nitrate	353.3
TOC	SW9060
metabolic fatty acids	—
major cations	SW6010
Field	
ferrous iron	potable colorimeter
sulfate and sulfide	potable colorimeter
DO	YSI 55 DO meter calibrated prior to use per manufacturer's instructions
ORP	Orion 250A ORP meter or equivalent calibrated prior to use per manufacturer's instructions
pH	pH meter
temperature	temperature probe
alkalinity	potable colorimeter
chlorides	potable colorimeter
phosphorus and ammonia-nitrogen	potable colorimeter

5.2.2.3 Enhanced Biodegradation with MNA: Primary Criteria

Protection of Human Health and the Environment

Enhanced biodegradation with MNA (Alternative 2) protects human health and the environment by promoting the biodegradation of chlorinated VOCs to relatively harmless end products — ethene and ethane — or completely mineralizing them to carbon dioxide and water. Because enhanced biodegradation is expected to reduce VOCs to concentrations less than MCLs, risk to future site workers or residents and the environment would be greatly minimized. Short-term risks from inhalation and dermal contact during implementation would be minimal and would be

controlled using common engineering techniques and appropriate PPE. This alternative would comply with applicable waste management standards and chemical-specific regulations.

Attainment of Cleanup Standards

Alternative 2 would be expected to meet RGOs in targeted areas within one to two years based on groundwater flow rate and proposed well spacing (cleanup times could be accelerated by increasing the number of carbon-source injection points). As discussed in Section 5.2.2.2, areas with low chlorinated VOC concentrations would be addressed with natural attenuation, which would be monitored for 15 years or until VOC concentrations were consistently less than MCLs (i.e., three consecutive years).

Source Control

Though there is no defined VOC source at SWMU 14/46, Alternative 2 would address areas of highest contamination to minimize or limit continued VOC migration. As discussed in Section 5.2.2.2, the area around monitoring well 02LS would be targeted by the enhanced biodegradation system. The remainder of the VOC plume, which has relatively low concentrations, would be addressed via natural attenuation, groundwater monitoring, and Ics.

Compliance with Applicable Waste Management Standards

No waste would be managed under this alternative; therefore, waste management standards do not apply. However, several permits, which are summarized in Table 5-3, would be required to implement an enhanced biodegradation system.

Table 5-3
Alternative 2 Permit Summary

Task	Permit Required	Agency
Well installation	Well construction permits	MSCHD
Groundwater injection	Injection well permit/variance	MSCHD
	Class V injection well authorization	TDEC, Division of Water Supply

Note:
(1) — Per Section 13 of the Memphis/Shelby County Water Well Regulations, no injection wells of any type shall be allowed in Memphis and Shelby County for the injection of surface or groundwater, or chemically or thermally altered water, or any other fluids into the underground formations. Injection wells for the purpose of improving groundwater quality, however, may be considered under Section 14.02.

5.2.2.4 Enhanced In Situ Biodegradation with MNA: Secondary Criteria

Long-Term Reliability and Effectiveness

Alternative 2 offers long-term reliability and effectiveness once contaminants are biodegraded because this technology is a destructive process (as opposed to containment) and no dense nonaqueous phase liquid (DNAPL) has been detected at SWMU 14/46. Though it is still considered an innovative technology, enhanced biodegradation has already been successfully demonstrated during the pilot studies conducted at another location of NSA Mid-South. This suggests that a strategically implemented full-scale system would effectively address VOC contamination at SWMU 14/46 after treatment.

Based on preliminary estimates, the latest VOC concentrations, experience at other similar sites, and literature degradation rates, the remediation time frame would be one to two years. The time frame depends on injection well density, carbon-source injection rate, how well the aquifer reacts to the enhancement over a long period of time, and other technical or regulatory considerations.

Reduction in Toxicity, Mobility, and Volume

If implemented effectively, this alternative would quickly reduce the toxicity, mobility, and volume of groundwater contamination at SWMU 14/46 by enhancing or hastening biochemical reactions that may be occurring naturally, but at relatively slow rates. Alternative 2 protects human health and the environment by biologically and/or chemically transforming highly chlorinated VOCs to ethene and ethane, which are essentially harmless, or carbon dioxide and water. As discussed in Section 5.2.2.2, residual VOC contamination likely would attenuate naturally via biological and physical mechanisms.

Short-Term Effectiveness

Short-term effectiveness considerations include the health and safety of remediation personnel and site employees (current and/or future). Workers exposed to risks should be trained according to OSHA standards, as required by 29 CFR 1910.120, to protect and mitigate risks during remedial construction. Appropriate PPE is necessary for handling all chemicals (i.e., carbon and nutrient amendments).

Implementability

Implementation of an enhanced biodegradation system at SWMU 14/46 is relatively simple, only requiring the installation of injection wells in targeted areas and establishment of an amendment application plan/methodology. This technology is not connected with a specific vendor; therefore, there are no limitations or constraints based on vendor availability. Though there may be patent issues associated with this technology, the proposed approach has been widely applied by many consulting and remediation firms, and therefore does no violate any patents.

Regulatory acceptance of this alternative is likely. Obtaining the necessary permits (e.g, an underground injection permit) to implement this system on a long-term basis is expected to be possible.

Cost

As shown in Table 5-4, the estimated total cost for Alternative 2 is $486,800. Capital costs are estimated to be $127,200; annual costs would be $147,300 for the first two years and then $21,850 for years three to fifteen. The site would be monitored for a total of fifteen years or until VOC concentrations were consistently less than MCLs (i.e., three consecutive years). As appropriate, the long-term monitoring program can be shortened with contaminant attenuation and regulatory approval, which would result in a significant cost reduction.

Table 5-4
Alternative 2: Enhanced Biodegradation with MNA Costs

	Quantity	Unit Cost	Total Cost
Capital Costs			
Additional aquifer characterization and groundwater and solute-transport modeling	lump sum	$25,000	$25,000
Engineering design and planning	lump sum	$25,000	$25,000
Injection well installation	4	$1,500/well	$6,000
Carbon Substrate Dispensing/Delivery Unit	1	$10,000	$10,000
Contractor oversight, engineering review, and reporting	1 week	$10,000/week	$10,000
Institutional controls	lump sum	$25,000	$25,000
Sampling equipment	lump sum	$5,000	$5,000
		20% contingency	$21,200
		Full-Scale Design and Implementation Subtotal	**$127,200**

Table 5-4
Alternative 2: Enhanced Biodegradation with MNA Costs

	Quantity	Unit Cost	Total Cost
Annual In situ Bioremediation Costs			
Carbon source (and nutrients) (1)	2 tons	$1,500/ton	$3,000
Field technicians (two people two days per quarter)	65 hours	$100/hour	$6,500
Laboratory sampling and analysis (2)	36 samples	$650/sample	$23,400
Field sampling and analysis	lump sum	$4,000	$4,000
Sampling equipment	lump sum	$10,000	$10,000
Engineering review and reporting	200 hours	$100/hour	$20,000
Miscellaneous expenses and travel	lump sum	20% cost	$13,400
		Subtotal	**$80,300**
		Present value subtotal at 6% for 2 years	**$147,300**
Annual MNA Costs			
Field technicians	24 hours	$100/hour	$2,400
Laboratory sampling and analysis	9 samples	$250/sample	$2,250
Field sampling and analysis	lump sum	$1,000	$1,000
Sampling equipment	lump sum	$2,500	$2,500
Data review and reporting	100 hours	$100/hour	$10,000
Miscellaneous expenses and travel	lump sum	20% cost	$3,700
		Subtotal	**$21,850**
		Present value subtotal at 6% for 15 years	**$212,300**
Total			
		In situ Enhanced Bioremediation Total	**$486,800**

Notes:
(1) — approximately 100 pounds per quarter per injection well.
(2) — Average number of samples per year over the two-year treatment period, which includes quarterly sampling of 4 wells for effectiveness monitoring.

6.0 GROUNDWATER REMEDIAL ALTERNATIVE RECOMMENDATION

The recommendation for the SWMU 14/46 loess groundwater remedial alternative is outlined below. Selection of the recommended alternative was based on primary and secondary criteria evaluation and professional judgment. Based on the rationale and decision factors in the previous sections, enhanced biodegradation with MNA was identified as the corrective measures alternative that has the best potential to achieve the remedial goals for this site. The factors that were considered are summarized below:

- Demonstrated pilot-study success at AOC A
- Contaminants are destroyed rather than merely transferred to another medium
- Expected to be the most rapid remedial alternative at reaching RGOs
- Compatible with MNA
- Minimal O & M
- Flexible Technology: More injection points can easily be added if necessary and amendment addition amounts can be varied based on remediation strategy/success
- Cost effective

7.0 PUBLIC INVOLVEMENT PLAN

7.1 General

The following Public Involvement Plan is included as part of this report in accordance with the USEPA guidance on RCRA CMS. This plan reflects and summarizes information prepared and presented in the Navy's Community Relations Plan (CRP), prepared for the NSA Mid-South in 1994.

Under RCRA, there is no required interaction with the community during the CMS process. Public input is required to be solicited only at the beginning of the permitting process, or during certain permit modifications. Therefore, the Navy has outlined a voluntary program of informing local communities throughout the entire RCRA corrective action process. Activities are detailed in the 1994 CRP for this Naval facility.

However, because the CMS process results in a modification to the facility's RCRA permit, certain provisions are made to solicit public input on the preferred alternative (as the reason for the modification). The requirements are identical to those required for a draft RCRA permit.

Two primary objectives are stated in the CRP:

- To initiate and sustain community involvement.
- To provide a mechanism for communicating to the public.

7.2 RFI Public Involvement Plan

To achieve these objectives, the CRP identifies public involvement and outreach activities at each step of the corrective action process. For example, the following activities have been designated for the completion of the RFI. All of these activities have been accomplished to date.

Public Outreach and Involvement Activities

- Update and publicize the information repository.
- Continue to publicize the points of contact.
- Update the mailing list.

- Distribute fact sheets and/or write articles to explain RFI findings.
- Inform community leaders of the RFI completion and results.
- Update and continue to provide presentations for informal community groups.
- Update the community on results of the RFI through a public RAB meeting.

7.3 CMS Public Involvement Plan

During the CMS, the following activities will be carried out as part of the Navy's current and ongoing community involvement program.

- Distribute fact sheets or write articles for publications that report CMS recommendations.
- Continue to update the mailing list.
- Continue to respond to requests for speaking engagements.
- Update the community on the CMS status through a public RAB meeting.

7.4 Statement of Basis Public Involvement Plan

Upon completion of the CMS, when the preferred alternative has been proposed, the following activities are required if a modification to the RCRA permit is required. If a permit modification is not necessary, the Navy may choose to implement all, some, or none of the following actions, depending on the level of public interest or concern:

- A SOB will be prepared, explaining the proposed remedy and the method by which it was chosen.

- A 45-day comment period will be provided to allow community members the opportunity to review and comment on the preferred alternative described in the SOB. The comment period may be as short as 30 days in cases where no permit modification is necessary, but a public comment period is warranted.

- The availability of the comment period and SOB will be announced in a public notice.

- The community will be provided an update on the proposed remedy through the informal and publicized RAB meeting.

In addition, the following activities will be carried out, as identified in the CRP:

- Update and publicize the information repository.
- Publicize the environmental point of contacts.
- Continue to update the mailing list.

7.5 Restoration Advisory Board

The RAB is a key component of this community outreach program. It is through the RAB that the Navy has a regular, scheduled, and publicized forum for interfacing with community members on the progress of the environmental program, including the CMS. In addition, RAB members are key instruments in measuring community interest in specific issues and knowledge of these issues. A Community Relations Subcommittee to the RAB has been tasked with identifying issues and information to be addressed by the Navy.

8.0 REFERENCES

Carmichael, J.K., W.S. Parks, J.A. Kingsbury, and D.E. Ladd. (1997). Hydrology and Groundwater Quality of Naval Support Activity Memphis, Millington, Tennessee. *Water-Resources Investigations Report* 97-4158. USGS: Nashville, Tennessee.

EnSafe Inc. (2000). *RCRA Facility Investigation Report — Assembly E, Naval Support Activity Mid-South,* Revision 2. EnSafe: Memphis, Tennessee. October 6, 2000.

EnSafe Inc. (2001). *Corrective Measures Study Work Plan, Naval Support Activity Mid-South, SWMU 14/46* Revision 1. EnSafe: Memphis, Tennessee. March 30, 2001.

EnSafe, Inc. (2001). *MNA Treatability Study Report — SWMU 14/46, Naval Support Activity Mid-South.* EnSafe: Memphis, Tennessee. August 23, 2001.

Fields Jr., T. (2000). *Institutional Controls: A Site Manager's Guide to Identifying, Evaluating, and Selecting Institutional Controls at Superfund and RCRA Corrective Action Cleanups.* Office of Solid Waste and Emergency Response. September 29, 2000.

McCarty, P.L. (1997). Biotic and Abiotic Transformations of Chlorinated Solvents in Ground Water. *Proceedings of the Symposium on Natural Attenuation of Chlorinated Organics in Ground Water.* May 1997.

USEPA. (1994). *RCRA Corrective Action Plan* (Final), OSWER Directive 9902.3-2A, Office of Waste Programs Enforcement, Office of Solid Waste, May 1994.

USEPA. (1998a). *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water.* EPA 600/R-98/128, Office of Research and Development: Washington D.C., September 1998.

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9.0 SIGNATORY REQUIREMENTS

State of Tennessee Rule 1200-1-11.07(2)(a)8 states: All reports required by permits and other information requested by the Commissioner shall be signed by a person described in part 7 of this paragraph or by a duly authorized representative of that person. The certification reads as follows:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

_____ _____

Name Date
NSA Mid-South
Millington, Tennessee

Appendix A

Quarterly Monitoring Geochemical Tables

Table A-1
MNA Chemical and Geochemical Data
May 2002

Parameters	Units	01LS	02LS	03LS	05LS	08LS	09LS	10LS	11LS
Dissolved Oxygen (DO)*	mg/L	0.79	2.73	4.22	1.21	0.81	4.24	5.94	5.11
Temperature*	°C	18.5	18.3	17.9	18.7	19.3	16.4	17.7	17.8
pH*	pH units	6.09	6.09	6.05	6.15	6.03	5.98	6.31	6.6
Oxidation-Reduction Potential (ORP)*	mV	213	268	305	-62	222	246	460	-59
Chloride*	mg/L	2.3	2	1.8	8.3	5.8	2.8	3	1.6
Alkalinity*	mg/L	400	450	520	410	430	590	420	380
Ferrous Iron (Iron II)*	mg/L	0.02	ND	ND	0.56	0.03	0.03	0.01	0.09
Nitrate*	mg/L	0.16	0.048	0.002	ND	ND	0.021	ND	0.13
Sulfate*	mg/L	27	31	29	37	110	46	64	10.0
Sulfide*	mg/L	ND	ND	ND	ND	ND	ND	ND	ND
Methane	mg/L	0.0003	0.003	ND	0.0	0.003	0.0002	0.0061	0.001
Total Organic Carbon*	mg/L	0.52 B	ND	ND	2.6	0.74B	0.96B	0.76 B	ND
PCE	µg/L	ND	120	ND	ND	ND	ND	ND	ND
TCE	µg/L	ND	70	ND	ND	ND	ND	0.44	ND
cis-1,2-DCE	µg/L	ND	4.4	ND	ND	ND	ND	0.62	ND
trans-1,2-DCE	µg/L	ND	0.47	ND	ND	ND	ND	ND	ND
Vinyl Chloride (VC)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND

Table A-2
MNA Chemical and Geochemical Data
August 2002

Parameters	Units	01LS	02LS	03LS	05LS	08LS	09LS	10LS	11LS
Dissolved Oxygen (DO)*	mg/L	0.5	2.68	1.59	0.8	0.58	0.49	0.72	0.51
Temperature*	°C	24.85	23.35	22.16	23.84	22.60	21.27	22.35	22.99
pH*	pH units	6.82	6.81	6.88	6.7	6.67	6.88	6.71	7.01
Oxidation - Reduction Potential (ORP)*	mV	46	106	76.2	87	58	71.1	69.2	52.2
Chloride*	mg/L	3.0	2.7	2.0	3.5	6.1	2.8	2.7	1.4
Alkalinity (CaCO3)*	mg/L	430	450	500	430	440	460	400	380
Ferrous Iron (Iron II)*	mg/L	0.05	0.09	0.11	1.84	0.05	0.06	0.03	0.05
Nitrate*	mg/L	ND	0.074	ND	ND	ND	ND	0.049	ND
Sulfate*	mg/L	26	24	28	448	110	30	65	9.1
Sulfide*	mg/L	0.011	0.018	0.020	0.065	0.006	0.016	0.011	0.014
Methane	mg/L	0.0005	0.0	0.0	0.0004	ND	0.002	0.031	0.0004
Total Organic Carbon (TOC)*	mg/L	0.69B	1.69B	1.5	0.94B	1.0	1.3	1.7	0.93B
PCE	µg/L	ND	200D	ND	ND	ND	ND	ND	ND
TCE	µg/L	ND	110	ND	ND	ND	ND	0.53J	ND
cis-1,2-DCE	µg/L	ND	12	ND	ND	ND	ND	0.9J	ND
trans-1,2-DCE	µg/L	ND	1.1	ND	ND	ND	ND	0.32J	ND
Vinyl Chloride (VC)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND

Table A-3
MNA Chemical and Geochemical Data
December 2002

Parameters	Units	01LS	02LS	03LS	05LS	08LS	09LS	10LS	11LS
Dissolved Oxygen (DO)*	mg/L	1.22	4.69	7.07	0.75	1.11	1.54	1.98	1.63
Temperature*	°C	16.2	14.8	13.8	16.8	16.5	15.5	15.2	16.8
pH*	pH units	7.08	7.25	7.6	7.14	7.11	6.7	6.44	6.42
Oxidation-Reduction Potential (ORP)*	mV	100.0	153.9	186.5	79.8	114.9	178.9	123.4	170.2
Chloride*	mg/L	2.6	2.1	1.7	2.2	4.8	2.1	3.5	1.3
Alkalinity*	mg/L	420	460	480	240	390	570	410	380
Ferrous Iron (Iron II)*	mg/L	0.02	0.01	0.01	0.79	0.01	0.01	0.01	0.03
Nitrate*	mg/L	0.10	0.064 J	0.14	0.11	0.35	0.014 J	0.038 J	0.082 J
Sulfate*	mg/L	25	22	35	21	83	36	69	10
Sulfide*	mg/L	ND	0.02	0.184	0.015	0.001	0.005	ND	0.004
Methane	mg/L	0.0007	0.0003	0.0002	0.003	0.0	0.0003	0.0002	0.0016
Total Organic Carbon*	mg/L	1.0	0.79 B	1.0 J	2.2	2.0	0.70 B	1.1	0.99 B
PCE	µg/L	ND	140	ND	ND	ND	ND	ND	ND
TCE	µg/L	ND	100 B	0.37 B	ND	ND	ND	0.41 J	ND
cis-1,2-DCE	µg/L	ND	5.3	ND	ND	ND	ND	ND	ND
trans-1,2-DCE	µg/L	ND	0.17 J	ND	ND	ND	ND	ND	ND
Vinyl Chloride (VC)	µg/L	ND	ND	ND	ND	ND	ND	ND	ND

Table A-4
MNA Chemical and Geochemical Data
March 2003

Parameters	Units	01LS	02LS	03LS	05LS	08LS	09LS	10LS	11LS
Dissolved Oxygen (DO)*	mg/L	2.22	3.28	5.67	2.42	1.94	3.13	2.2	3.00
Temperature*	°C	14.93	15.58	16.2	15.96	16.12	14.73	13.92	15.98
pH*	pH units	7.06	7.14	7.16	7.05	7.11	7.06	6.92	7.24
Oxidation-Reduction Potential (ORP)*	mV	106.1	211	162	107.9	134.7	147.2	124.7	145.2
Chloride*	mg/L	2.6	2.2	1.9	3.4	5.8	3.0	3.0	1.9
Alkalinity*	mg/L	450	500	590	460	510	570	430	520
Ferrous Iron (Iron II)*	mg/L	0.01	0.03	0.02	0.03	0.01	0.02	0.00	0.01
Nitrate	mg/L	ND	0.045	ND	0.042	0.025	0.13	0.0287	0.024
Sulfate*	mg/L	22	24	29	70	120	62	94	12
Sulfide*	mg/L	0.002	0.072	0.006	0.001	0.005	0.00	0.00	0.002
Methane	mg/L	0.0006	ND	ND	ND	0.019	0.0003	0.0005	0.0002
Total Organic Carbon	mg/L	ND	ND	ND	ND	ND	ND	0.52	ND
PCE	µg/L	ND	120	ND	ND	ND	ND	ND	ND
TCE	µg/L	ND	75	ND	ND	ND	ND	0.60	0.32
cis-1,2-DCE	µg/L	ND	7.4	ND	ND	ND	ND	0.54	ND
trans-1,2-DCE	µg/L	ND	0.67	ND	ND	ND	ND	ND	ND
Vinyl Chloride (VC)	µg/L	ND	ND	ND	ND	ND	ND	ND	0.14

Sodium Acetate MSDS

Material Safety Data Sheet

Material Name: Sodium Acetate, Anhydrous ID: C1-137

* * * Section 1 - Chemical Product and Company Identification * * *

Chemical Name: Sodium Acetate, Anhydrous
Product Use: For Commercial Use
Synonyms: Acetic acid, sodium salt; Acetate de sodium
Supplier Information

Greenway Products Inc.
4320 Greenway Drive
Knoxville, TN 37918

Phone: (800) 258-5829
Fax: (865) 524-3375
Emergency # (800) 424-9300

General Comments: FOR COMMERCIAL USE ONLY; NOT TO BE USED AS A PESTICIDE.
NOTE: Emergency telephone numbers are to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure, or accident involving chemicals. All non-emergency questions should be directed to customer service.

* * * Section 2 - Composition / Information on Ingredients * * *

CAS #	Component	Percent
127-09-3	Sodium Acetate	> 99%

Component Information/Information on Non-Hazardous Components
This product is considered hazardous under 29 CFR 1910.1200 (Hazard Communication).

* * * Section 3 - Hazards Identification * * *

Emergency Overview
This product is a colorless, crystalline or granular solid. The primary health hazard associated with this product is the potential for slight irritation of the eyes, skin, nose and other tissues which come in contact with dusts or particulates of this product. This material is combustible and may ignite if highly heated. The accumulation of dusts of this product can create a serious hazard of explosion. Thermal decomposition of this product produces irritating vapors and toxic gases (e.g. carbon monoxide, carbon dioxide and oxides of sodium). Emergency responders should wear proper personal protective equipment for the releases to which they are responding.

Hazard Statement
WARNING! MAY FORM COMBUSTIBLE DUST CONCENTRATIONS IN AIR (DURING PROCESSING).
MAY CAUSE IRRITATION TO EYES, SKIN, RESPIRATORY TRACT AND GASTROINTESTINAL SYSTEM. Avoid contact with eyes and skin. Avoid breathing dusts. Wash thoroughly after handling. Keep container closed. Use with adequate ventilation.

Potential Health Effects: Eyes
Exposure to particulates or solution of this product may cause mild irritation of the eyes with symptoms such as stinging, tearing and redness.

Potential Health Effects: Skin
This product can cause slight irritation of the skin, especially after prolonged exposures. Repeated skin contact may lead to dermatitis (red, cracked skin). Symptoms are generally alleviated when exposure ends.

Potential Health Effects: Ingestion
Ingestion of this product (especially in large volumes) can irritate the tissues of the mouth, esophagus, and other tissues of the digestive system. Symptoms of exposure can include vomiting, diarrhea, and nausea. If ingested, this compound breaks down to ethanol in the digestive system, which can cause systemic effects such as motor impairment, if large amounts are ingested.

Potential Health Effects: Inhalation
Breathing dusts or particulates generated by this product can lead to irritation of the nose, throat or respiratory system. Symptoms of such exposure could include coughing and sneezing. Symptoms are generally alleviated when exposure ends.

HMIS Ratings: Health Hazard: 1 **Fire Hazard:** 1 **Physical Hazard:** 0
Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe * = Chronic hazard

* * * Section 4 - First Aid Measures * * *

First Aid: Eyes
In case of contact with eyes, rinse immediately with plenty of water for at least 20 minutes. Seek immediate medical attention if any adverse effect occurs.

First Aid: Skin
Remove all contaminated clothing. For skin contact, wash thoroughly with soap and water for at least 20 minutes. Seek immediate medical attention if irritation develops or persists.

* * * Section 4 - First Aid Measures (Continued) * * *

First Aid: Ingestion

DO NOT INDUCE VOMITING, unless directed by medical personnel. Have victim rinse mouth thoroughly with water, if conscious. Never give anything by mouth to a victim who is unconscious or having convulsions. Contact a physician or poison control center immediately.

First Aid: Inhalation

Remove source of contamination or move victim to fresh air. Apply artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Get immediate medical attention.

First Aid: Notes to Physician

Provide general supportive measures and treat symptomatically.

* * * Section 5 - Fire Fighting Measures * * *

Flash Point: Not determined.
Method Used: Not applicable
Upper Flammable Limit (UEL): Not applicable
Lower Flammable Limit (LEL): Not applicable
Auto Ignition: 600-607°C (1112-1125°F)
Flammability Classification: Not applicable
Rate of Burning: Not applicable

General Fire Hazards

When involved in a fire, this material may decompose and produce irritating vapors, acrid smoke and toxic gases. Large dust clouds of this product have the potential to ignite explosively. Finely divided dusts from this material can form explosive mixtures in air. Large dust clouds from product have the potential to ignite explosively. Refer to NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*, for comprehensive guidance. The minimum ignition temperature for this cloud is 1094 degrees (590°C). The following are data regarding the ignitability of dusts of Sodium Acetate: Minimum Ignition Temperature: 560-590°C (1040-1094°F); Maximum Explosion Pressure: 620 kPa (90 psi); Maximum Rate Of Pressure Rise: 667 kPa/sec (4,600 psi/sec). Also reported as 31,800 kPa/sec (219,229 psi/sec).

Hazardous Combustion Products

Oxides of Sodium, carbon monoxide and carbon dioxide.

Extinguishing Media

Use methods for surrounding fire.

Fire Fighting Equipment/Instructions

Firefighters should wear full protective clothing including self-contained breathing apparatus. If possible control runoff from fire control or dilution water to prevent environmental contamination.

NFPA Ratings: Health: 1 **Fire:** 1 **Reactivity:** 0 **Other:**
Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe

* * * Section 6 - Accidental Release Measures * * *

Containment Procedures

Stop the flow of material, if this can be done without risk. Contain the discharged material. If sweeping of a contaminated area is necessary use a dust suppressant agent, which does not react with product (see Section 10 for incompatibility information).

Clean-Up Procedures

Small releases can be cleaned-up wearing gloves, goggles and suitable body protection. In case of a large spill (in which excessive dusts can be generated), clear the affected area, protect people, and respond with trained personnel. Place all spill residues in an appropriate container and seal. Thoroughly wash the area after a spill or leak clean-up. Prevent spill rinsate from contamination of storm drains, sewers, soil or groundwater.

Evacuation Procedures

Evacuate the area promptly and keep upwind of the spilled material. Isolate the spill area to prevent people from entering. In case of large spills, follow all facility emergency response procedures.

Special Procedures

Remove soiled clothing and launder before reuse. Avoid all skin contact with the spilled material. Have emergency equipment readily available.

* * * Section 7 - Handling and Storage * * *

Handling Procedures

All employees who handle this material should be trained to handle it safely. Do not breathe dust. Avoid all contact with skin and eyes. Wherever dust clouds may be generated, eliminate sparks, flames and other ignition sources. Use this product only with

adequate ventilation. Wash thoroughly after handling. Care should be taken to avoid the accumulation of dusts, which can create a serious dust-explosion hazard. All equipment used in the handling of this material should be electrically grounded. Areas in which this compound is used should be wiped down periodically so that this substance is not allowed to accumulate. Dry powders can build static electricity charges when subjected to the friction of transfer and mixing operations. Provide adequate precautions, such as electrical grounding and bonding, or inert atmospheres.

Storage Procedures

Keep container tightly closed when not in use. Store containers in a cool, dry location, away from direct sunlight, sources of intense heat, or where freezing is possible. Material should be stored in secondary containers or in a diked area, as appropriate. Store containers away from incompatible chemicals (see Section 10, Stability and Reactivity). Storage areas should be made of fire-resistant materials. Post warning and "NO SMOKING" signs in storage and use areas, as appropriate. Refer to NFPA 654, *Prevention of Fire and Dust Explosions from the Manufacturing, Processing and Handling of Combustible Particulate Solids* for additional information on storage. Containers of this material should be separated from oxygen, or other oxidizers, by a minimum distance of 20 ft., or by a barrier of non-combustible material at least 5 ft. high, having a fire-resistance rating of at least 0.5 hours. Additional information can be found the OSHA Safety and Health Information Bulletin: *Combustible Dust in Industry: Preventing and Mitigating the Effects of Fire and Explosions.* Use only appropriately classified electrical equipment and powered industrial trucks. Floors should be sealed to prevent absorption of this material. Inspect all incoming containers before storage, to ensure containers are properly labeled and not damaged. Have appropriate extinguishing equipment in the storage area (i.e., sprinkler system, portable fire extinguishers). Open containers slowly on a stable surface. Containers of this product must be properly labeled. Empty containers may contain residual amounts of this product; therefore, empty containers should be handled with care. Keep this product in an air-tight container. Store containers in a cool, dry location, away from direct sunlight, sources of intense heat, or where freezing is possible. Keep container tightly closed when not in use Never store food, feed, or drinking water in containers that held this product. Keep this material away from food, drink, and animal feed. Do not store this material in open or unlabeled containers.. Limit quantity of material stored.

* * * Section 8 - Exposure Controls / Personal Protection * * *

Exposure Guidelines

A: General Product Information

Follow the applicable exposure limits. Use a non-sparking, grounded, explosion-proof ventilation system separate from other exhaust ventilation systems. Ensure that dust-handling systems (such as exhaust ducts, dust collectors, vessels, and processing equipment) are designed in a manner to prevent the escape of dust into the work area (i.e., there is no leakage from the equipment).

B: Component Exposure Limits

ACGIH, OSHA, and NIOSH have not developed exposure limits for any of this product's components.

The exposure limits given are for Particulates Not Otherwise Classified (PNOC).

OSHA:	15 mg/m^3 TWA (Total dust)
	5 mg/m^3 TWA (Respirable fraction)
DFG MAKs	4 mg/m^3 TWA (Inhalable fraction)
	1.5 mg/m^3 TWA (Respirable fraction)

Engineering Controls

Use engineering methods to control hazardous conditions. This includes exhaust ventilation directly to the outside and using a corrosion-resistant ventilation system separate from other exhaust ventilation systems.

PERSONAL PROTECTIVE EQUIPMENT

The following information on appropriate Personal Protective Equipment is provided to assist employers in complying with OSHA regulations found in 29 CFR Subpart I (beginning at 1910.132). Please reference applicable regulations and standards for relevant details.

Personal Protective Equipment: Eyes/Face

Wear chemical safety goggles. If necessary, refer to U.S. OSHA 29 CFR 1910.133.

Personal Protective Equipment: Skin

Use impervious gloves. Gloves should be tested to determine their suitability for prolonged contact with this material. If necessary, refer to U.S. OSHA 29 CFR 1910.138.

Personal Protective Equipment: Respiratory

None required where adequate ventilation conditions exist. If airborne concentration is high, use an appropriate respirator or dust mask. If airborne concentrations are above the applicable exposure limits, use NIOSH-approved respiratory protection. If respiratory protection is needed, use only protection authorized in the U.S. Federal OSHA Standard (29 CFR 1910.134), applicable U.S. State regulations. Oxygen levels below 19.5% are considered IDLH by OSHA. In such atmospheres, use of a full-facepiece pressure/demand SCBA or a full facepiece, supplied air respirator with auxiliary self-contained air supply is required under OSHA's Respiratory Protection Standard (1910.134-1998).

Personal Protective Equipment: General

Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower.

* * * Section 9 - Physical & Chemical Properties * * *

Physical Properties: Additional Information

The data provided in this section are to be used for product safety handling purposes. Please refer to Product Data Sheets, Certificates of Conformity or Certificates of Analysis for chemical and physical data for determinations of quality and for formulation purposes.

Appearance:	Colorless crystals or granules	**Odor:**	Odorless
Physical State:	Solid	**pH:**	8.9 (0.1M solution)
Vapor Pressure:	Zero	**Vapor Density:**	Not applicable
Boiling Point:	Not applicable	**Freezing/Melting Point:**	324 deg C (615 deg F)
Solubility (H2O):	119 g/100 mL	**Specific Gravity:**	1.53 (H2O = 1)
Softening Point:	Not applicable	**Particle Size:**	Crystals or granules
Molecular Weight:	82.03	**Bulk Density:**	Not available
		Chemical Formula:	CH3COONa

* * * Section 10 - Chemical Stability & Reactivity Information * * *

Chemical Stability

Product is normally stable. Sodium Acetate is hygroscopic; it absorbs moisture from air.

Chemical Stability: Conditions to Avoid

Avoid high temperatures, ignition sources, static discharge, exposure to air and incompatible materials.

Incompatibility

This material is incompatible with strong acids and strong oxidizing agents. There can be a violent reaction with fluorine and potassium nitrate, diketene. Sodium Acetate may be mildly corrosive to most metals in solution or in the presence of moisture.

Hazardous Decomposition

Carbon oxides and sodium oxides, acetic acid from thermal decomposition.

Hazardous Polymerization

Will not occur.

* * * Section 11 - Toxicological Information * * *

Acute and Chronic Toxicity

A: General Product Information

May cause eye, skin, nose, throat and respiratory tract irritation. Skin-Rabbit, adult 500 mg/24 hours: Mild irritation effects; Eye effects-Rabbit, adult 10 mg Mild irritation effects.

Chronic: Long term skin overexposure to this product may lead to dermatitis (red, itchy skin). Excessive long-term inhalation exposures may cause increased mucous flow in the nose and respiratory airways. Rats ingesting 21 mg/kg/day Sodium Acetate for 3 months had significantly decreased body weights and increased thyroid weights. Treated rats had slight changes to thyroid hormone levels in blood.

B: Component Analysis - LD50/LC50

Sodium Acetate:

Oral-Rat LD_{50}: 3530 mg/kg; Oral-Mouse LD_{50}: 6891 mg/kg; Subcutaneous-Mouse LD_{50}: 8000 mg/kg; Subcutaneous-mouse LD_{50}: 3200 mg/kg; Intravenous-Mouse LD_{50}: 335 mg/kg; Inhalation-rat LC50: >30 gm/m^3/1 hour; Skin-rabbit LD_{50}: >10 gm/kg

B: Component Analysis - TDLo/LDLo

Intravenous-mouse LDLo: 1195 mg/kg; Intravenous-Rabbit, adult LDLo: 1300 mg/kg

Carcinogenicity

A: General Product Information

No information available.

B: Component Carcinogenicity

No information available.

Epidemiology

No information available.

Neurotoxicity

No information available.

Mutagenicity

Sodium Acetate did not produce mutations in an in-vitro test (sister chromatid exchange) using human blood cells.

Teratogenicity

No information available.

Other Toxicological Information

No information available.

* * * Section 12 - Ecological Information * * *

Ecotoxicity

A: General Product Information

No information available.

B: Aquatic Toxicity

No information available.

Environmental Fate

No information available.

* * * Section 13 - Disposal Considerations * * *

US EPA Waste Number & Descriptions

A: General Product Information

As shipped, this product is not considered a hazardous waste.

B: Component Waste Numbers

No EPA Waste Numbers are applicable for this product's components.

Disposal Instructions

All wastes must be handled in accordance with local, State and federal regulations or with regulations. This product, if unaltered by use, may be disposed of by treatment at a permitted facility or as advised by your local hazardous waste regulatory authority.

* * * Section 14 - Transportation Information * * *

NOTE: The shipping classification information in this section (Section 14) is meant as a guide to the overall classification of the product. However, transportation classifications may be subject to change with changes in package size. Consult shipper requirements under I.M.O., I.C.A.O. (I.A.T.A.) and 49 CFR to assure regulatory compliance.

US DOT Information

Shipping Name: Not applicable.
Hazard Class: Not applicable
UN/NA #: Not applicable
Packing Group: Not applicable
Required Label(s): Not applicable

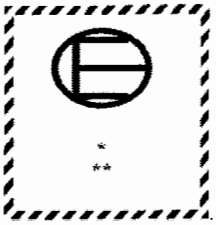
50th Edition International Air Transport Association (IATA):

For Shipments by Air transport: This information applies to air shipments both within the U.S. and for shipments originating in the U.S., but being shipped to a different country.

UN/NA #: UN 3077
Proper Shipping Name: Environmentally Hazardous Substance, solid, n.o.s. (Sodium Acetate)
Hazard Class: 9 (Miscellaneous Dangerous Goods)
Packing Group: III
Passenger & Cargo Aircraft Packing Instruction: 911
Passenger & Cargo Aircraft Maximum Net Quantity: 400 kg
Limited Quantity Packing Instruction (Passenger & Cargo Aircraft): Y911
Limited Quantity Maximum Net Quantity (Passenger & Cargo Aircraft): 30 kg G
Cargo Aircraft Only Packing Instruction: 911
Cargo Aircraft Only Maximum Net Quantity: 400 kg
Excepted Quantities: E1
Special Provisions: A97, A158
ERG Code: 9L

Limited Quantity Shipments: Shipments for air must be marked with the Proper Shipping Name Environmentally Hazardous Substance, solid, n.o.s. (Sodium Acetate) and shall be marked with the UN Number (3077) preceded by the letters "UN", placed within a diamond. The width of the line forming the diamond shall be at least 2 mm; the number shall be at least 6 mm high. The total weight of each outer packaging cannot exceed 30 kg.

Excepted Quantities: The maximum quantity of this material per inner receptacle is limited to 30 g per receptacle and the aggregate quantity of this material per completed package does not exceed 1kg. The inner receptacles must be securely packed in an intermediate packaging with cushioning material to prevent movement in the inner receptacles and packed in a strong outer box with a gross mass not to exceed 29kg. The completed package must meet a drop test. The requirements are found in 2.7.6.1. The package must not be opened or otherwise altered until it is no longer in commerce. For air transportation no shipping paper is required. The package must be legibly marked with the following marking:



NOTE: The "*" must be replaced by the primary hazard class, or when assigned, the division of each of the hazardous materials contained in the package. The "**" must be replaced by the name of the shipper or consignee if not shown elsewhere on the package. The symbol shall be not less than 100 mm x 100 mm and must be durable and clearly visible.

International Maritime Organization (I.M.O.) Classification

Sodium Acetate is not regulated under I.M.D.G./I.M.O. regulations..

* * * Section 15 - Regulatory Information * * *

US Federal Regulations

A: General Product Information

No additional information.

B: Component Analysis

This material contains no chemical required to be identified under SARA Section 302 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65) and/or CERCLA (40 CFR 302.4).

SARA 302 (EHS TPQ) There are no specific Threshold Planning Quantities for Sodium Acetate. The default Federal MSDS submission and inventory requirement filing threshold of 10,000 lbs (4,540 kg) therefore applies, per 40 CFR 370.20.

C: Sara 311/312 Tier II Hazard Ratings:

Component	CAS #	Fire Hazard	Reactivity Hazard	Pressure Hazard	Immediate Health Hazard	Chronic Health Hazard
Sodium Acetate	127-09-3	No	No	No	Yes	No

State Regulations

A: General Product Information

California Proposition 65: Sodium Acetate is not on the California Proposition 65 chemical lists.

B: Component Analysis - State

Sodium Acetate does not appear on any state hazardous substance list.

Component	CAS #	CA	FL	MA	MN	NJ	PA
Sodium Acetate	127-09-3	No	No	No	No	No	No

Other Regulations

A: General Product Information

No other information available.

B: Component Analysis - Inventory

Component	CAS #	TSCA	DSL	EINECS
Sodium Acetate	127-09-3	Yes	Yes	Yes

C: Component Analysis - WHMIS IDL

The following components are identified under the Canadian Hazardous Products Act Ingredient Disclosure List:

Component	CAS #	Minimum Concentration
Sodium Acetate	127-09-3	No disclosure limit.

ANSI LABELING (Z129.1):

CAUTION! MAY FORM COMBUSTIBLE DUST CONCENTRATIONS IN AIR (DURING PROCESSING). MAY CAUSE SKIN AND EYE IRRITATION. Avoid contact with skin, eyes, or clothing. Do not taste or swallow. Avoid breathing dusts and particulates. Use only with adequate ventilation. Keep away from heat or flame. Keep container closed and grounded. Prevent dust accumulations to minimize explosion hazard. Wash thoroughly after handling. Wear gloves, goggles, faceshields, suitable body protection, and NIOSH/MSHA-approved respiratory protection, as appropriate. **FIRST-AID:** In case of contact, immediately flush skin or eyes with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. If inhaled, remove to fresh air. If ingested, do not induce vomiting. Get medical attention. **IN CASE OF FIRE:** Use water fog, dry chemical, CO_2, or "alcohol" foam. **IN CASE OF SPILL:** Absorb spill with inert material. Place residue in suitable container. Consult Material Safety Data Sheet for additional information.

* * * Section 16 - Other Information * * *

NOTICE: The information contained on this Material Safety Data Sheet is considered accurate as of the date of publication. It is not necessarily all inclusive nor fully adequate in every circumstance. The suggestions should not be confused with, nor followed in violation of applicable laws, regulations, rules or insurance requirements. No warranty, express or implied, of merchantability, fitness, accuracy of data, or the results to be obtained from the use thereof is made. The vendor assumes no responsibility for injury or damages resulting from the inappropriate use of this product.

Key/Legend

EPA = Environmental Protection Agency; TSCA = Toxic Substance Control Act; ACGIH = American Conference of Governmental Industrial Hygienists; IARC = International Agency for Research on Cancer; NIOSH = National Institute for Occupational Safety and Health; NTP = National Toxicology Program; OSHA = Occupational Safety and Health Administration

Revision Log

05/31/01 9:31 AM HDF Checked exposure limits; made changes to Sect 9; overall review, add SARA 311/312 Haz Ratings.

09/25/03 12:00 PM HDF General review of entire MSDS. Up-graded Section 3 Health Hazard information, HMIS categories. Addition of dust ignitability data in Section 5. Up-date of PNOC exposure limits to Section 8. Up-date information on incompatibility, Section 10. Addition of current toxicity data to Section 11. Up-Dated Section 14 Transportation Information.
06/22/05 10:09AM SEP Update IATA Section 14
10/19/07 2:11 PM SEP Update IATA Section 14

06/14/10 SEP Update IATA and air/dust explosion hazard per OSHA

This is the end of MSDS # C1-137

For Information Call:

Greenway Products Inc.
1-800-258-5829

Diammonium Phosphate MSDS

CF Industries

Effective Date: June 1, 2010

Material Safety Data Sheet

FOR EMERGENCY CALL CHEMTREC - (800) 424-9300

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product Name: Diammonium Phosphate (DAP)

CAS Number: 7783-28-0

Product Uses

Agricultural Industry: Fertilizer
Industrial Applications: Flame retardant agent. Corrosion inhibitors.

Chemical Name: Ammonium phosphate, dibasic

Chemical Family: Ammonium phosphates

Synonyms and Common Trade Names: Ammonium phosphate; Diammonium hydrogen phosphate; dibasic ammonium phosphate; secondary ammonium phosphate; DAP

Company Identification

Manufacturer: CF Industries, Inc.
Address: 4 Parkway North, Suite 400
Deerfield, Illinois 60015-2590
Telephone: 847-405-2400

2. COMPOSITION/INFORMATION ON INGREDIENTS

Component Name	Weight Percentage	CAS Number
Diammonium phosphate	60-85	7783-28-0
Aluminum ammonium phosphates	4-10	Not applicable
Iron ammonium phosphates	3-5	Not applicable
Ammonium sulfate	4-5	7783-20-2
Fluorides, as F	2-3	Not applicable
Calcium ammonium phosphates	1-2	Not applicable
Water	1-3	7732-18-5
Ammonium Nitrate	<1	6484-52-2
Urea	<1	57-13-6
Miscellaneous metal, ammonium and other compounds	<1 each	Not applicable

3. HAZARDS IDENTIFICATION

Emergency Overview

Caution! Eye and skin irritant. When heated to decomposition Diammonium phosphate may emit toxic fumes of phosphorous oxides, nitrogen oxides, fluorides and ammonia. Do not taste or swallow. Wash thoroughly after handling. Wear appropriate personal protection equipment. Slippery when wet.

Brown to black granules that are odorless or give off a slight ammonia odor.

Potential Health Effects

Eyes: Eye irritant. Contact may cause stinging, watering, redness and swelling.

Skin: Skin irritant. Contact may cause redness, itching, burning and skin damage. Contanct may result in skin absorption but symptoms of toxicity are not anticipated by this route alone under normal conditions of use.

Inhalation: No information available. Studies by other exposure routes suggest a low degree of hazard by skin irritation.

Ingestion: Low to moderate degree of toxicity by ingestion.

Pre-Existing Medical Conditions: Pre-existing skin disorders may be aggravated by exposure to this material.

Signs and Symptoms: Effects of overexposure may include irritation of the nose, throat and digestive tract, nausea, vomiting, diarrhea, coughing and shortness of breath.
Late Toxicities:

Cancer: No data available

Target Organs: No data available.

Developmental and Reproductive System Effects: Inadequate data available.

Other Comments: Inorganic phosphates have been studied extensively due to their use as food additives. High oral doses (1% in the diet) have produced toxic effects on the bones, kidneys and parathyroid glands. The doses and route of exposure in these studies are not considered relevant to occupational settings.

Prolonged or repeated overexposure to fluoride compounds may cause fluorosis. Fluorosis is characterized by skeletal changes, consisting of osteosclerosis (hardening or abnormal density of bone) and osteomalacia (softening of bones) and by mottled discoloration of the enamel of teeth (if exposure occurs during enamel formation.) Symptoms may include bone and joint pain and limited range of motion.

This material contains iron compound(s) of unknown composition. Effects of overexposure to dusts can include irritation of the eyes and respiratory tract, pneumoconiosis (dust congested lungs), pneumonitis (lung inflammation), coughing, vomiting, diarrhea, abdominal pain and jaundice.

4. FIRST AID

Eyes: Hold eyelids open and flush eyes immediately with water for at least 15 minutes. Seek medical attention if necessary.

Skin: Wash affected areas with soap and water. Remove contaminated clothing and shoes. Seek medical attention if necessary. Wash clothing and shoes before reuse.

Inhalation: If respiratory symptoms develop, move victim away from source of exposure and into fresh air. If symptoms persist, seek medical attention. If victim is not breathing, clear airway and immediately begin artificial respiration. If breathing difficulties develop, oxygen should be administered by qualified personnel. Seek immediate medical attention.

Ingestion: If person is conscious, immediately give water or milk (about 4 oz. For adults; too much may cause vomiting). Do not induce vomiting. Seek medical attention immediately. If person is unconscious, do not give anything by mouth.

Notes to Physician: If person has been exposed to concentrated decomposition products, treat symptomatically and watch for delayed symptoms of pulmonary edema. Intubation or tracheostomy may be necessary following severe exposure.

5. FIRE FIGHTING MEASURES

Flammability:	Diammonium phosphate is not flammable or combustible.
Flash Point (test method):	Not applicable
Flammable Limits:	Not applicable
Explosive Limits:	Not applicable
Autoignition Temperature:	Not applicable
Extinguishing Media:	Not applicable
NFPA Fire Rating:	Flammability 0 Health Hazard 1 Reactivity 0 Specific Hazard Not applicable

KEY: Least=0 Slight=1 Moderate=2 High=3 Extreme=4

Special Firefighting Procedures: Firefighters should wear appropriate protective clothing and self-contained breathing apparatus with full-face piece operated in positive pressure mode because toxic gases (ammonia and, possibly, small amounts of phosphorus oxides and nitrogen oxides) can be emitted in fires.

Unusual Fire and Explosive Hazards: DAP can release toxic and/or irritating ammonia and fluorides when subject to temperatures above 310°F in the presence of water or steam. When dry and heated rapidly, above 310°F, DAP will release ammonia.

Hazardous Combustion Products: Phosphorous oxides Nitrogen oxides. Ammonia. Fluorides.

6. ACCIDENTAL RELEASE MEASURES

Recover any reusable product, taking care not to generate excess dust. Dispose of in accordance with federal, state and local regulations.

Neutralizing Chemicals: Not applicable

7. HANDLING AND STORAGE

Handling: The use of respiratory protection is advised when concentrations exceed any established exposure limits (see Section 8). Wash thoroughly after handling. Do not wear contaminated clothing or shoes. Use good personal hygiene practice.

Storage: Store in a cool, dry, ventilated area. Isolate from incompatible substances, particularly alkaline materials, as ammonia gas will be released.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Ventilation: Use process enclosure, general dilution ventilation or local exhaust systems, where necessary, to maintain airborne ammonia and dust concentrations below the OSHA standard or in accordance with applicable regulations.

Preventative Measures / Specific Personal Protective Equipment

Eyes: Safety glasses with side shields are recommended. Maintain eye wash fountain in work area.

Skin: The use of gloves impermeable to the specific material handled (including cotton, etc.) is advised to prevent excessive skin contact.

Respiratory: Protection is not required where ventilation is adequate. Use dust mask or other appropriate respiratory protection when engineering controls are not feasible or during operations that generate airborne concentrations exceeding the relevant standards. In closed areas, wear appropriate respiratory equipment, when necessary, to protect against ammonia fumes. A respiratory protection program that meets OSHA's 29 CFR 1910.134 requirements must be followed whenever workplace conditions warrant a respirator's use.

Other: None

Exposure Guidelines*

Although standards for Diammonium phosphate (DAP) have not been established, the following nuisance dust standards are applicable. The following standards for ammonia are also applicable since DAP gradually emits ammonia when exposed to air or when in contact with high pH or alkaline materials.

ACGIH TLV:	Particulates Not Otherwise Classified (PNOC) : 3 mg/m^3 TWA (respirable); 10 mg/m^3 TWA (inhalable) Ammonia: 25 ppm (17 mg/m^3) TWA; 35 ppm (24 mg/m^3) STEL
OSHA PEL:	Particulates Not Otherwise Classified (PNOC) : 5 mg/m^3 TWA (respirable); 15 mg/m^3 TWA (total) Ammonia: 50 ppm (35 mg/m^3) TWA

* TLV = Threshold Limit Values; PEL = Permissible Exposure Limits;
TWA = 8-hour Time-weighted Average; STEL = 15-minute Short Term Exposure Limit

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Brown to black granules
Odor:	Odorless or slight ammonia odor
Odor Threshold Level:	Not available
Physical State:	Solid
pH:	Approximately 8 (1% aqueous solution)
Vapor Pressure (ammonia released):	<100Pa at 20°C
Vapor Density (Air = 1):	Not applicable
Boiling point:	Not applicable
Melting point:	Decomposes at 155°C (311°F)
Solubility in water:	588 g/L at 20°C (68°F)
Specific gravity (H_20 = 1):	1.619 (heavier than water)
Evaporation rate (butyl acetate = 1):	Not applicable

Percentage volatile by volume (%):	Stable in air
Molecular weight:	132.07
Molecular formula:	$(NH_4)_2HPO_4$
Water/Oil Distribution Coefficient::	Not determined

10. STABILITY AND REACTIVITY

Stability (thermal, light, etc.): Stable under ordinary conditions of use and storage.

Incompatibility (Materials to avoid): Contact with high pH or alkaline materials (e.g., sodium hypochlorite) may cause Diammonium phosphate to emit ammonia.

Hazardous Decomposition Products: Gradually loses ammonia when exposed to air at room temperature. Decomposes to ammonia and monoammonium phosphate at around 70°C (158°F). At 155°C (311°F), DAP emits phosphorus oxides, nitrogen oxides and ammonia.

Hazardous Polymerization: Will not occur.

Conditions to Avoid: Avoid contact with alkaline materials.

Although standards for Diammonium phosphate (DAP) have not been established, the following nuisance dust standards are applicable. The following standards for ammonia are also applicable since DAP gradually emits ammonia when exposed to air or when in contact with high pH or alkaline materials.

ACGIH TLV:	Particulates Not Otherwise Classified (PNOC) : 3 mg/m^3 TWA (respirable); 10 mg/m^3 TWA (inhalable) Ammonia: 25 ppm (17 mg/m^3) TWA; 35 ppm (24 mg/m^3) STEL
OSHA PEL:	Particulates Not Otherwise Classified (PNOC) : 5 mg/m^3 TWA (respirable); 15 mg/m^3 TWA (total) Ammonia: 50 ppm (35 mg/m^3) TWA

* TLV = Threshold Limit Values; PEL = Permissible Exposure Limits;
TWA = 8-hour Time-weighted Average; STEL = 15-minute Short Term Exposure Limit

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Brown to black granules
Odor:	Odorless or slight ammonia odor
Odor Threshold Level:	Not available
Physical State:	Solid
pH:	Approximately 8 (1% aqueous solution)
Vapor Pressure (ammonia released):	<100Pa at 20°C
Vapor Density (Air = 1):	Not applicable
Boiling point:	Not applicable
Melting point:	Decomposes at 155°C (311°F)
Solubility in water:	588 g/L at 20°C (68°F)
Specific gravity (H_20 = 1):	1.619 (heavier than water)
Evaporation rate (butyl acetate = 1):	Not applicable

11. TOXICOLOGICAL INFORMATION

Irritancy: Eye and skin irritant

Acute Oral Effects: Oral LD50 > 2,000 mg/kg (rats)

Acute Dermal Effects: Dermal LD50 > 5,000 mg/kg (rats)

There is no definitive information available on carcinogenicity, mutagenicity, target organs or developmental toxicity for this product.

Sensitization Capability: No data available.

Synergistic Chemicals: No data available.

Genetic Toxicity: Negative results in both gene mutation and chromosomal aberration in-vitro assays.

Human Experience: DAP is affirmed as "generally recognized as safe" (GRAS) for use as a food additive for both human food and ruminant feed according to prescribed conditions.

Chronic Toxicity: No carcinogenicity data available.

Iron Compounds

Target Organ(s): Chronic exposure to high concentrations of iron have been associated with hemosiderosis, hemochromatosis and in severe cases, liver cirrhosis. Typical occupational exposures to iron compounds are not expected to cause these effects. Chronic inhalation can produce "mottling" of the lungs (siderosis). This is considered a benign pneumoconiosis and does not normally lead to fibrosis or cause significant physiologic impairment.

12. ECOLOGICAL INFORMATION

Can be harmful to aquatic life at high concentrations. Large-scale release may lead to eutrophication of waterways. Notify local health and wildlife officials and operators of any nearby water intakes upon contamination.

Ecotoxicity Information:

The acute toxicity of Diammonium phosphate is slightly toxic to practically non-toxic for both freshwater fish and invertebrates. The 96-hour LC_{50} for fathead minnows is 156 mg/L (static and flow-through bioassays), the 96-hour LG_{50} for rainbow trout is 172 mg/L (flow-through bioassay), and the 96-hour LC_{50} for coho salmon is 245 mg/L (static bioassay). The 96-hour LC_{50} for bluegills is 1,500 mg/L (static Bioassay),. The 96-hour LC_{50} for large mouth bass is 1,160-1,500 mg/L (static bioassay). The 96-hour LC_{50} for mature scuds/sideswimmers is 40 mg/L (static bioassay). No toxicity observed in aquatic algae (*Selenastrum*) at concentrations up to 97.1 mg/L. DAP is not toxic to algae but can stimulate algal growth.

Environmental Fate Information:

Diammonium phosphate is considered biodegradable and is taken up as a nutrient by vegetation.

13. DISPOSAL CONSIDERATIONS

Diammonium phosphate is not considered a hazardous waste under Federal Hazardous Waste Regulations 40 CFR 261. Consult local, state or federal environmental regulatory agencies for acceptable disposal procedures and locations. Follow standard disposal procedures.

14. TRANSPORT INFORMATION

Diammonium phosphate is not listed as a hazardous material by the U.S. Department of Transportation (DOT), Transport Canada, the International Maritime Organization (IMO) or the United Nations (UN).

Proper Shipping Name: Chemicals, N.O.S. (non-regulated)

15. REGULATORY INFORMATION

OSHA (Occupational Safety and Health Administration): This material is considered to be hazardous as defined by the OSHA Hazard Communication Standard.

CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act): This product does not contain Reportable Quantity substances.

SARA TITLE III (Superfund Amendment and Reauthorization Act of 1986): No federal requirements. User should contact local and state regulatory agencies for information on additional or more stringent reporting requirements.

User should contact local and state regulatory agencies for information on additional or more stringent reporting requirements.

Sections 311/312: This product has been reviewed according to the USEPA "Hazard Categories" promulgated under Sections 311 and 312 of SARA Title III and is considered, under applicable definitions, to meet the following categories:

Acute: yes Chronic: no Fire: no Reactivity: no

DOT (Department of Transportation): Please refer to Section 14 (Transport Information) for guidance concerning transportation.

This material has not been identified as a carcinogen by NTP, IARC or OSHA.

16. DOCUMENTARY INFORMATION AND DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES

Issue Date: 06/01/10
Previous Issue Date: 07/01/06

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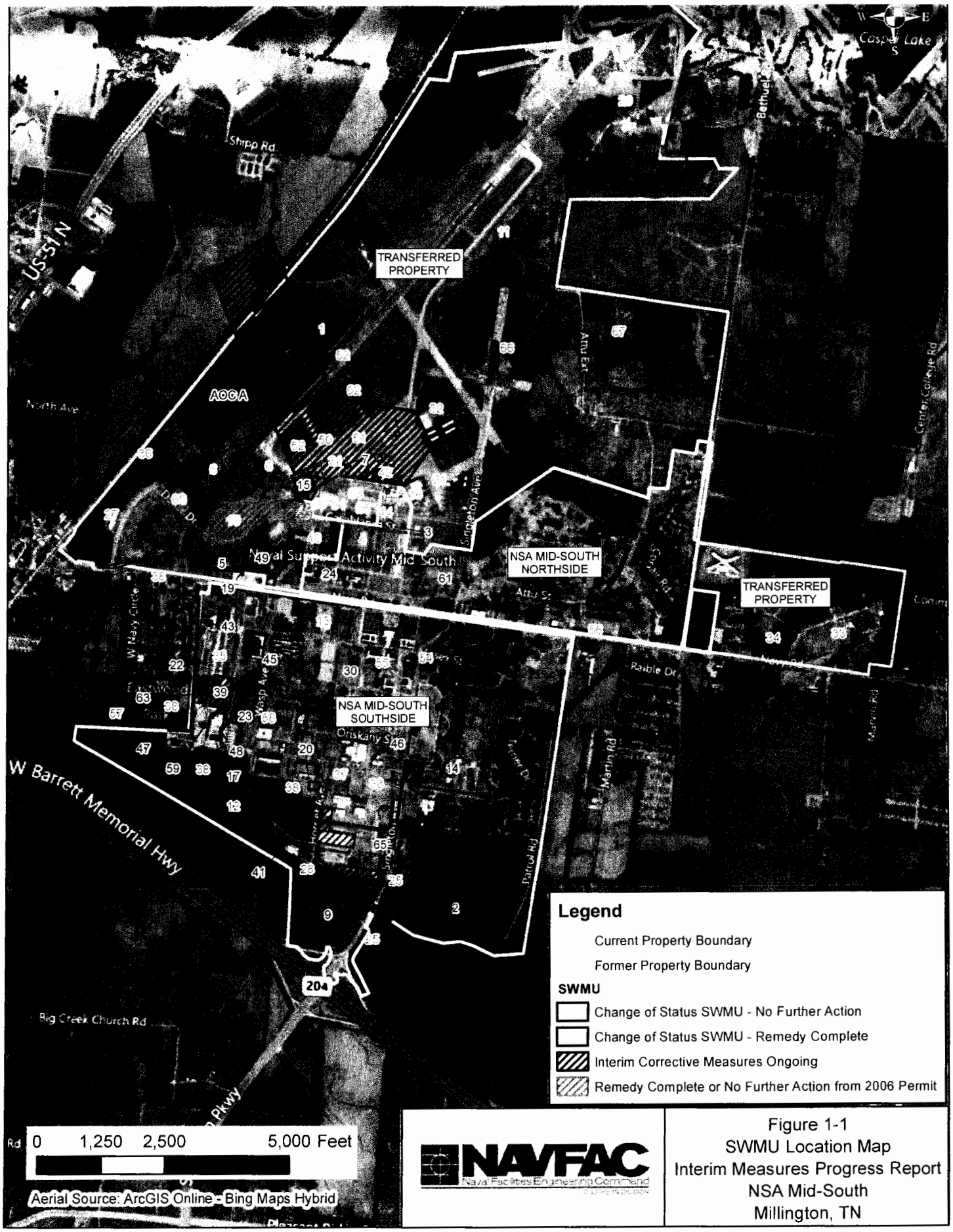
Figures



NAVFAC
Naval Facilities Engineering Command

Figure 1-1
SWMU Location Map
Interim Measures Progress Report
NSA Mid-South
Millington, TN

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Figure 1-2
Monitoring & Injection
Well Locations
Interim Measures Progress Report
SWMU 14/46
NSA Mid-South, Millington, TN

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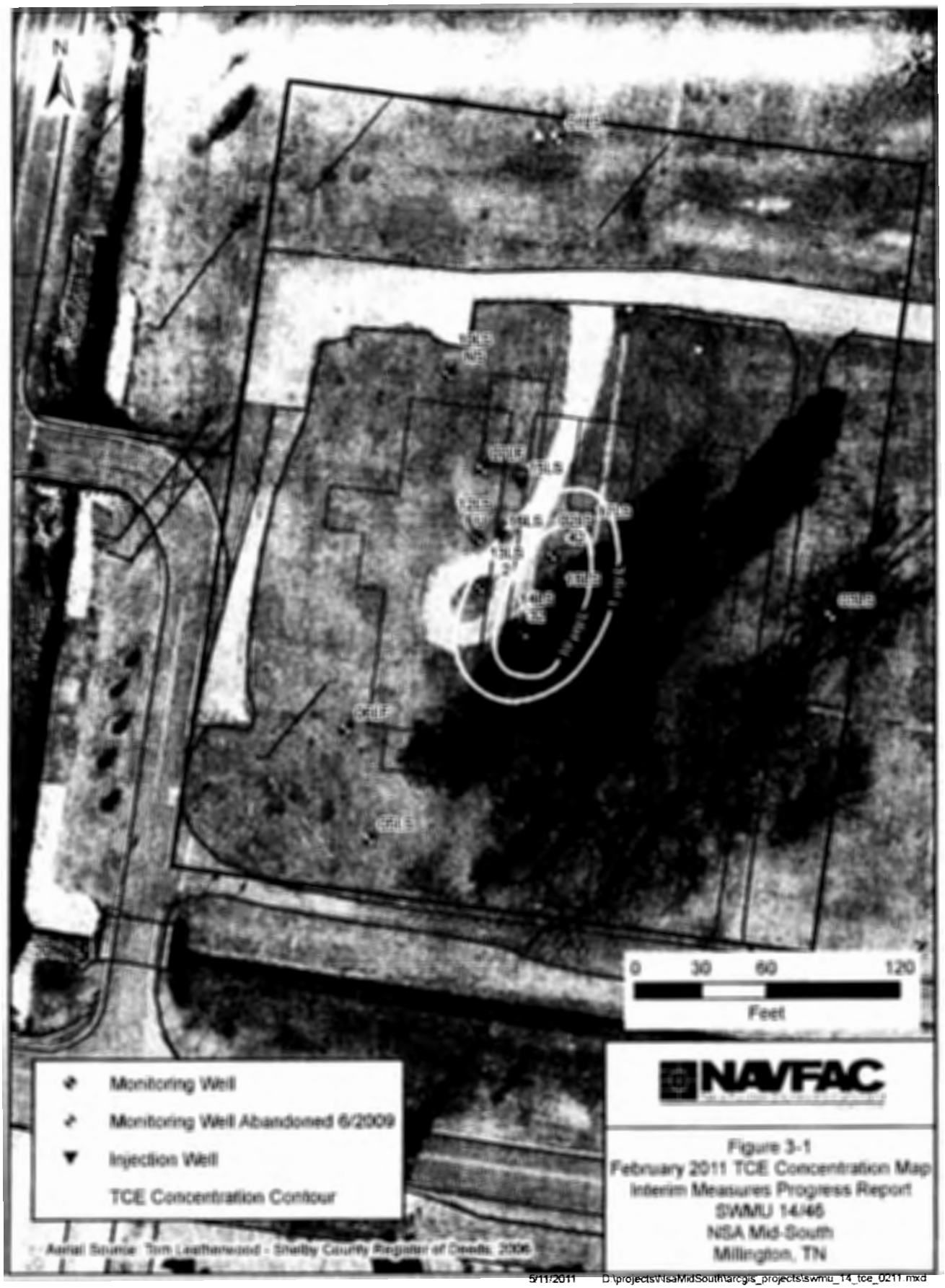

Figure 3-1
February 2011 TCE Concentration Map
Interim Measures Progress Report
SWMU 14/46
NSA Mid-South
Millington, TN

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