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EXPEDITED INTERIM STABILIZATION MEASURES CONCEPTUAL PLAN CNC CHARLESTON SC
10/6/1997
CNC CHARLESTON

NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

EXPEDITED INTERIM STABILIZATION MEASURES

CONCEPTUAL PLAN

(October 6, 1997)

To: smtp[lbowers@ensafe.com]
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Cc: Daryle L Fontenot@Code 18,Eugene R Batten@Code 18,
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Subject: EISM comments
Attachment:
Date: 9/22/97 1:45 PM

Here are my comments, I have had the luxury of reviewing some of the other comments therefore I will provide my opinion on these as well.

General;

Larry and I spoke last Thursday afternoon about the EISM's proposed. I wanted Ensafe and everyone else involved to understand that we are not looking for EISMs that are specifically chosen because of predetermined Detachment capabilities nor are we looking for any particular technologies that Bechtel specializes at. The EISM's chosen at the site should be a remedy that is consistent with the long term remedy at the site given the existing information we have. We are not targeting any specific amount of money, even though I may have insinuated this at the August Project Team meeting and at the meeting on the 25th. We want to do the smart thing, the Navy is willing to take risks associated with taking on remedial actions prior to having the benefit of a CMS as long as we know what these risks are. I expect Ensafe to explore some innovative solutions instead of relying on the typical Interim Measures which are historically not cost effective.

Specific;

VMU 2

We need to propose a cleanup standard, this was briefly discussed in the 8/25 meeting and I understood that the difference in the area that is greater than 400 ppm Pb and that greater than 1300 ppm Pb is not much. The Navy is interested in relieving itself of any institutional controls if possible so if this difference is not signficant then we would be interested in pursuing the more stringent standard.

Task 3 - This is the same proposal that was made in the 8/26 meeting, we should have done some evaluation between then and now. Make a proposal. What appears to be the most cost efficient and long term effective for addressing the soil? Let's address the soil problem and leave the groundwater for the study.

2. SWMU 39

Cliff Casey feels like more evaluation should be done at this site for several reasons. First there are a number of factors working in our favor for natural attenuation at this site even with the off site migration. As many of the reviewers noted, we don't want to do anything with groundwater that may oxygenate the aquifer and disturb biodegradation in progress. The source doesn't look that serious meaning the concentrations are such that steady state conditions (i.e. accumulation of contaminant begins to approach zero) may exist. The presence of the Hess contaminants may actually benefit the degradation of the chlorinated compounds in the zone that both are present. The Navy will be dealing with Hess probably sometime in the near future and it may be best to delay any action as long as possible. The important information needed at this site now is whether the contaminant plume is at steady state and this will require continued monitoring.

Task 1 - SOUTHDIV has a protocol developed by USGS for assessing natural attenuation of chlorinated ethenes. We prefer this protocol over the AFCEE document.

Task 5 - Air sparging and SVE may cause water bubbling above ground. This urred at a site in Beaufort which caused great alarm among the DHEC ks. We may have to reassess use of this technology.

3. SWMU 8

Task -1 I agree with Mac's comment concerning the depth of sampling, the first 4 to 5 feet are overburden fill material that shouldn't be contaminated. We are interested in the "impoundment zone" which evidently lies somewhere above the watertable to at least 3 feet below it. Forget TPH, don't even mention that parameter again. Use PAHs, (BTEX, RCRA metals weren't present on site)

Task - 7 The RFI is done for all practical purposes, all we have done is sample to confirm earlier sampling. Use of a steam system to thermally enhance the removal of waste oil is a good idea especially since the use of the steam is at no cost (except for distribution lines obviously). We need to pursue removal of as much of the free product waste oil and sludge as possible and then deal with the dissolved residual in the study. The alternative or part of the treatment train is bioslurping or similar product recovery system. The steam should accelerate the removal and get to property transfer sooner.

AOC 607

Task 1- Again use the SOUTHDIV protocal for natural attenaution of chlorinated ethenes.

Task 2 - Disagree with the rehabilitation of the sewer line first. The iltration of chlorinated compounds has not been verified and in fact has oss the base been shown to be infiltration (Zone L results). I understood that we would investigate the use of SVE or air sparging well network which would provide treatment of plume once the sewer system infiltration was fixed.

Task 3 - We haven't seen any TPH or BTEX issues in prior sampling, what are we looking at this UST for?

Task 4 - Before we start talking about the need for the building removal let's collect a few samples in the footprint to determine whether we missed something. I thought it was apparent in the soil samples collected that the soil on the Southwest side of the building was contaminated and this was the most probable source. Why are we looking for more source areas? This is information that should be research prior to submittal of this conceptual plan.

Task 5 - This is an example of an action that shouldn't be done and the Navy is not interested in doing it. Pump and treat simply to lower the water table so that the contaminant doesn't enter at a concentration that isn't affecting anything to our knowledge doesn't make sense. We need a more comprehensive, cost effective and long term approach.

SWMU 166

Task 1 - See use of SOUTHDIV protocal for natural attenaution of chlorinated ethenes.

Task 3 - This plume is probably not at steady state and is continuing to migrate offsite and as we discovered recently into the storm sewer system ng the interstate. We probably will not make a convincing argument on ıral attenauation until we have reached steady state conditions therefore we need to take the steps to address this. We may not need to do something as exotic as a reactive wall but we certainly should be considering air sparging along the property boundary.

SWMU 17
Task 3 - Recover trench is appropriate and adequate for DNAPL removal.

NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

EXPEDITED INTERIM STABILIZATION MEASURES

CONCEPTUAL PLAN
(October 6, 1997)

BACKGROUND

A Naval Base Charleston Project Team meeting was held in Charleston, South Carolina on August 25, 1997, to discuss sites for potential expedited interim stabilization measures (EISMs). On the following day, representatives of the Southern Division Naval Facilities Engineering Command, the U.S. Navy Charleston Naval Complex Environmental Detachment, EnSafe Inc. (U.S. Navy CLEAN contractor), and Bechtel Inc. (U.S. Navy response action contractor) met to select sites for EISMs and to identify potential remedial alternatives. Based on the results of this meeting, an EISM conceptual plan (dated September 15, 1997) was developed for six sites.

The initial draft of the conceptual plan was peer-reviewed between September 15 and 23, 1997. The conceptual plan, as presented in this document, results from the comments/suggestions generated during the peer review process and subsequent discussions.

WHAT A CONCEPTUAL PLAN IS NOT

This conceptual plan is not a design plan, a work plan or a performance criteria document. The intent of the conceptual plan is to present conceptualized alternatives for fast-track remediation of the six selected sites. The viability of some of the conceptualized ideas, in particular for AOC 607 and SWMU 166, can only be determined though actual pilot testing of the remedial system at the site. Work plans, design and performance specification documents will follow the conceptual plan, as required.

EISM SITE SELECTION CRITERIA

Sites were selected for EISMs based on one or more of the following criteria:

1) The site contained obvious and well-defined contaminant source zones, or

2) The site was suitable for quick source zone remedial action based on existing RFI information, or

3) The types of conceptualized site-specific remedial alternatives are limited in number and/or technical complexity, or

4) Interim remedial action at the site was assumed to be beneficial to human health and/or the environment, or

5) Significant contaminant mass, mobility, or toxicity reduction is possible through the initiation of an interim remedial action, or

6) The site was targeted for EISMs by the Navy, state or federal regulators.

EISM AND CMS RELATIONSHIP

It is important to note that the four organizations' representatives developed the conceptual EISM plan based on the presumption that any EISM identified for any site would be compatible with the likely site-specific and long-term remedy to be finalized in the corrective measures study (CMS). However, the completion of the RFI and CMS is essential in order to propose the final remedy. It is possible that the EISM could become the final remedy, or part of the final remedy, as identified in the CMS.

SELECTED EISM SITES

Based on the selection criteria, the following sites were identified as viable candidates for EISMs.

SWMU 2

- Zone A
- Lead-impacted soil
- Potential reuse is industrial (per RDA, September 1997)

SWMU 39

- Zone A
- Chlorinated solvent-impacted groundwater
- Petroleum hydrocarbon-impacted groundwater (offsite source)
- Potential reuse is industrial (per RDA, September 1997)

SWMU 8

- Zone F
- Petroleum hydrocarbon-impacted soil and groundwater
- Potential reuse is industrial (per RDA, September 1997)

AOC 607

- Zone F
- Chlorinated solvent-impacted groundwater
- Potential reuse is recreation (per RDA, September 1997)

SWMU 166

- Zone K
- Chlorinated solvent-impacted soil and groundwater
- Chlorinated solvent-impacted groundwater (offsite source)
- Potential reuse is light industrial or commercial based on parcel location within Naval Annex (per RDA, September 1997)

SWMU 17

- Zone H
- PCB-impacted soil, SVOC-impacted groundwater, and petroleum hydrocarbon-impacted soil and groundwater
- Potential reuse is for governmental offices and a training campus; i.e., commercial (per RDA, September 1997)

SITE-SPECIFIC CONCEPTUAL PLAN DESCRIPTIONS

SWMU 2 - Summary of Applicable RFI Data

SWMU 2 consists of salvage bin No. 3 and the adjacent paved ground surface in the Zone A former DRMO area. The area was used to store recovered lead from lead-acid submarine batteries from the mid-1960s until 1984. Electrodes and associated internal metallic components were removed from the battery jars in the battery electrolyte treatment area, SWMU 5 in Zone E. Recovered materials were then placed on a railcar and transferred to the DRMO area for storage and eventual sale to a salvage contractor.

Lead was detected in 64 of 65 surface soil samples collected at the site since 1993. Concentrations range from 1.0 - 89,000 ppm with a mean concentration of 1,660 ppm. The lead background concentration for the surface interval in Zone A is 140 ppm. Lead was detected in 54 of 57 subsurface samples collected during the same time frame. Concentrations range from 1.4 to 1,120 ppm with a mean concentration of 35.6 ppm. Background for the lower interval is 22 ppm. Medium values of lead contaminated soil, as expected, are substantially less than the mean (or average) concentrations stated above.

Lead was detected in groundwater above the USEPA TTAL of 15 μg/L at monitoring well CNSY-002-05. This well was located within the perimeter of the lead storage bin. The maximum concentration reported was 639 μg/L however, turbidity levels were high. Later samples collected after the well was redeveloped yielded a maximum concentration of 18.9 μg/L. The well in question was later damaged by site operations and had to be permanently abandoned.

Contributors to hazard and risk at the site consist solely of inorganics. The primary contributors were arsenic and beryllium. Hazard and risk for lead were not calculated due to a lack of available risk information but 12 surface samples contained concentrations which exceeded both background and the USEPA residential cleanup level of 400 ppm.

SWMU 2 – EISM Conceptual Plan

Objective

Eliminate and/or reduce exposure of lead-contaminated surface soil to current and future site populations.

Task 1

Obtain additional surface soil samples (0 to 1 foot interval on approximately 10 foot grid spacing) in areas at SWMU 2 that are known to contain elevated levels of lead in the surface soil. The trigger for establishing a starting point for the additional surface soil delineation is the USEPA residential soil lead level of 400 ppm. Delineation will start from known sample points with lead contamination equal or greater than 400 ppm. Surface soils are to be analyzed for "total lead."

Purpose

To refine the extent of surface soil contamination exceeding 400 ppm total lead.

Task 2

Re-analyze approximately 10% of the highest lead hits obtained from Task 1 via USEPA TCLP method.

Purpose

The results of a TCLP analysis will aid in determining appropriate soil disposal options (should offsite disposal of impacted soil be selected).

Task 3

Calculate volume of impacted soil exceeding 400 ppm lead and 1300 ppm lead. The latter concentration is the USEPA industrial surface soil cleanup level.

Purpose

To determine magnitude of volume differential as a first step in establishing the most appropriate cleanup level. If volume differential is insignificant, as determined by the Navy, it would be more appropriate to focus the cleanup on the more stringent level of 400 ppm. The following tasks would also aid in this decision process.

Task 4

Conduct a comparative cost and feasibility analysis between three potential remedial alternatives (in-situ stabilization via mixing, ex-situ stabilization onsite via mobile pug mill, and excavation/disposal) and two cleanup levels. A cost range and a feasibility determination should be developed for six scenarios.

Purpose

Self explained.

Task 5

Determine the restrictions (ie, tangible and intangible burdens) placed on the site should a cleanup to 1300 ppm be completed. As an example, what is the cost (real or perceived) of being burdened with institutional controls and deed restrictions should a cleanup to 1300 ppm occur?

Purpose

This task, in addition to Task 4, will produce critical information that will aid in selecting the appropriate cleanup level.

Task 6

Select best remedial alternative based primarily on cost, technical feasibility and site re-use considerations.

Purpose

Self explained.

End Point

Treat or excavate surface soil exceeding cleanup criteria as determined through Tasks 3, 4, and 5.

SWMU 2

REMEDIAL TECHNOLOGY PROFILES

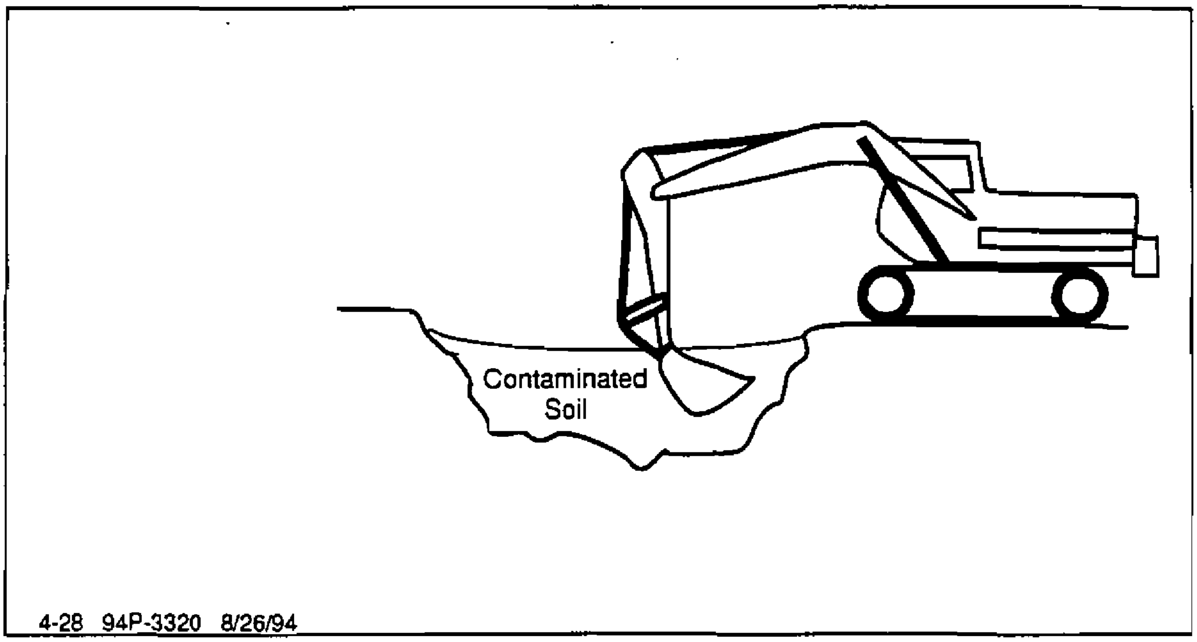
Excavation, Retrieval, and Offsite Disposal

Solidification/Stabilization (in-situ)

Solidification/Stabilization (ex-situ)

4.28 EXCAVATION, RETRIEVAL, AND OFF-SITE DISPOSAL

Description: Contaminated material is removed and transported to permitted off-site treatment and/or disposal facilities. Some pretreatment of the contaminated media usually is required in order to meet land disposal restrictions.



4-28 TYPICAL CONTAMINATED SOIL EXCAVATION DIAGRAM

Applicability: Excavation and off-site disposal is applicable to the complete range of contaminant groups with no particular target group. Although excavation and off-site disposal alleviates the contaminant problem at the site, it does not treat the contaminants.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Generation of fugitive emissions may be a problem during operations.
- The distance from the contaminated site to the nearest disposal facility will affect cost.
- Depth and composition of the media requiring excavation must be considered.
- Transportation of the soil through populated areas may affect community acceptability.
- Disposal options for certain waste (e.g., mixed waste or transuranic waste) may be limited. There is currently only one licensed disposal facility for radioactive and mixed waste in the United States.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge).

The type of contaminant and its concentration will impact off-site disposal requirements. Soil characterization as dictated by land disposal restrictions (LDRs) are required. Most hazardous wastes must be treated to meet either RCRA or non-RCRA treatment standards prior to land disposal. Radioactive wastes would have to meet disposal facility waste form requirements based on waste classification.

Performance Data: Excavation and off-site disposal is a well proven and readily implementable technology. Prior to 1984, excavation and off-site disposal was the most common method for cleaning up hazardous waste sites. Excavation is the initial component in all ex situ treatments. As a consequence, the remediation consulting community is very familiar with this option.

The excavation of 18,200 metric tons (20,000 tons) of contaminated soil would require about 2 months. Disposal of the contaminated media is dependent upon the availability of adequate containers to transport the hazardous waste to a RCRA-permitted facility.

CERCLA includes a statutory preference for treatment of contaminants, and excavation and off-site disposal is now less acceptable than in the past. The disposal of hazardous wastes is governed by RCRA (40 CFR Parts 261-265), and the U.S. Department of Transportation (DOT) regulates the transport of hazardous materials (49 CFR Parts 172-179, 49 CFR Part 1387, and DOT-E 8876).

DOE has demonstrated a cryogenic retrieval of buried waste system, which uses liquid nitrogen (LN_2) to freeze soil and buried waste to reduce the spread of contamination while the buried material is retrieved with a series of remotely operated tools. Other excavation/retrieval systems that DOE is currently developing include a remote excavation system, a hydraulic impact end effector, and a high pressure waterjet dislodging and conveyance end effector using confined sluicing.

Cost: Cost estimates for excavation and disposal range from $300 to $510 per metric ton ($270 to $460 per ton) depending on the nature of hazardous materials and methods of excavation. These estimates include excavation/removal, transportation, and disposal at a RCRA permitted facility. Excavation and off-site disposal is a relatively simple process, with proven procedures. It is a labor-intensive practice with little potential for further automation. Additional costs may include soil characterization and treatment to meet land ban requirements.

References:

Church, H.K., 1981. *Excavation Handbook*, McGraw Hill Book Co., New York, NY.

EPA, 1991. *Survey of Materials-Handling Technologies Used at Hazardous Waste Sites*. EPA, ORD, Washington, DC, EPA/540/2-91/010.

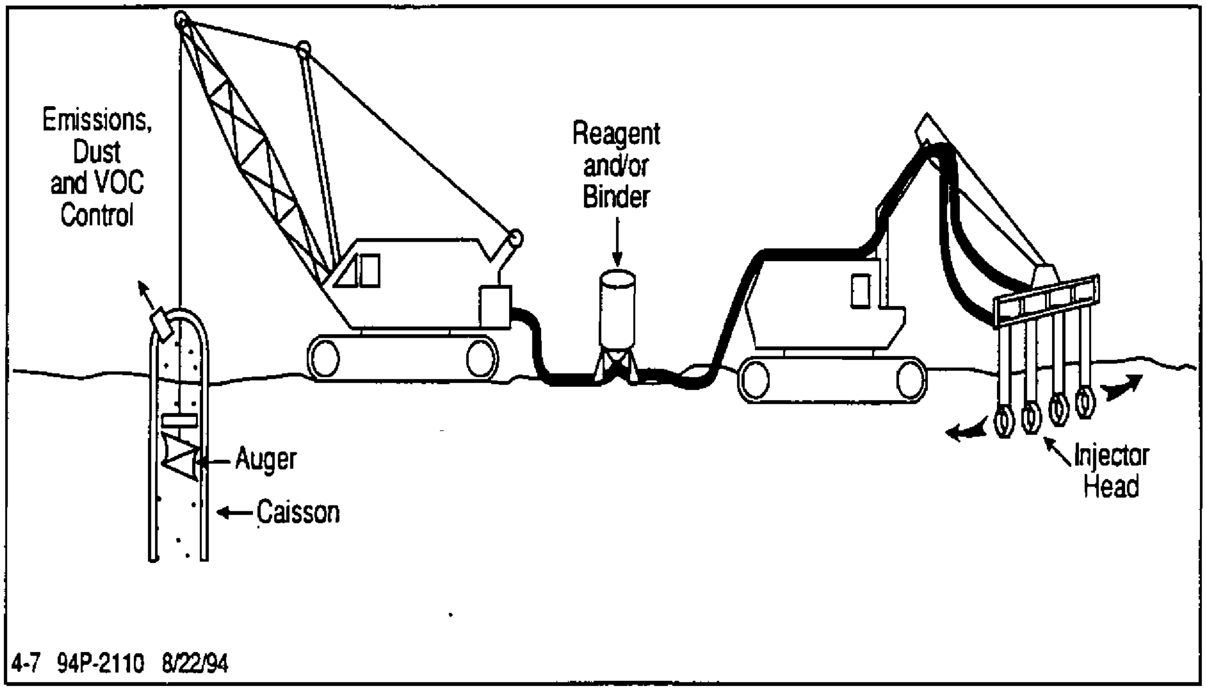
EPA, 1992. *McColl Superfund Site — Demonstration of a Trial Excavation*, EPA RREL, series include Technology Evaluation EPA/S40/R-92/015, PB92-226448; Applications Analysis, EPA/540/AR-92/015; and Technology Demonstration. Summary, EPA/540/SR/-92/015.

Points of Contact:

Contact	Government Agency	Phone	Location
Jaffer Mohiuddin	DOE Program Manager	(301) 903-7965	EM-552, Trevion II Washington, DC 20585
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

4.7 SOLIDIFICATION/STABILIZATION (IN SITU)

Description: Solidification/stabilization (S/S) reduces the mobility of hazardous substances and contaminants in the environment through both physical and chemical means. Unlike other remedial technologies, S/S seeks to trap or immobilize contaminants within their "host" medium (i.e., the soil, sand, and/or building materials that contain them), instead of removing them through chemical or physical treatment. Leachability testing is typically performed to measure the immobilization of contaminants. In situ S/S techniques use auger/caisson systems and injector head systems to apply S/S agents to in situ soils.



4-7 TYPICAL AUGER/CAISSON AND REAGENT/INJECTOR HEAD IN SITU SOLIDIFICATION/STABILIZATION SYSTEMS

S/S techniques can be used alone or combined with other treatment and disposal methods to yield a product or material suitable for land disposal or, in other cases, that can be applied to beneficial use. These techniques have been used as both final and interim remedial measures.

Applicability: The target contaminant group for in situ S/S is inorganics (including radionuclides). The technology has limited effectiveness against SVOCs and pesticides and no expected effectiveness against VOCs; however, systems designed to be more effective in treating organics are being developed and tested.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Depth of contaminants may limit some types of application processes.

- Future usage of the site may "weather" the materials and affect ability to maintain immobilization of contaminants.
- Some processes result in a significant increase in volume (up to double the original volume).
- Certain wastes are incompatible with variations of this process. Treatability studies are generally required.
- Reagent delivery and effective mixing are more difficult than for ex situ applications.
- Like all in situ treatments, confirmatory sampling can be more difficult than for ex situ treatments.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Data needs include particle size, Atterberg limits, moisture content, metal concentrations, sulfate content, organic content, density, permeability, unconfined compressive strength, leachability, pH, and microstructure analysis.

Performance Data: S/S technologies are well demonstrated, can be applied to the most common site and waste types, require conventional materials handling equipment, and are available competitively from a number of vendors. Most reagents and additives are also widely available and relatively inexpensive industrial commodities.

In situ S/S processes have demonstrated the capability to reduce the mobility of contaminated waste by greater than 95%.The effects, over the long term, of weathering (e.g., freeze-thaw cycles, acid precipitation, and wind erosion), groundwater infiltration, and physical disturbance associated with uncontrolled future land use can significantly affect the integrity of the stabilized mass and contaminant mobility in ways that cannot be predicted by laboratory tests.

Cost: Costs for cement-based stabilization techniques vary widely according to materials or reagents used, their availability, project size, and chemical nature of contaminants (e.g., types and concentration levels for shallow applications). The in situ soil mixing/auger techniques average $50 to $80 per cubic meter ($40 to $60 per cubic yard) for the shallow applications and $190 to $330 per cubic meter ($150 to $250 per cubic yard) for the deeper applications.

The shallow soil mixing technique processes 36 to 72 metric tons (40 to 80 tons) per hour on average, and the deep soil mixing technique averages 18 to 45 metric tons (20 to 50 tons) per hour.

The major factor driving the selection process beyond basic waste compatibility is the availability of suitable reagents. S/S processes require that potentially large volumes of bulk reagents and additives be transported to project sites. Transportation costs can dominate project economics and can quickly become uneconomical in cases where local or regional material sources are unavailable.

References:

EPA, 1989. *Chemfix Technologies, Inc. — Chemical Fixation/Stabilization*. EPA RREL, series includes Technology Evaluation, Vol. I, EPA/540/5-89/011a, PB91-127696, and Technology Evaluation, Vol. II, EPA/540/5-89/011b, PB90-274127.

EPA, 1989. *Hazcon — Solidification*, EPA RREL, series includes Technology Evaluation, Vol. I, EPA/540/5-89/001a, PB89-158810; Technology Evaluation, Vol. II, EPA/540/5-89/001b, PB89-158828; Applications Analysis, EPA/540/A5-89/001; and Technology Demonstration Summary, EPA/540/S5-89/001.

EPA, 1989. *IWT/GeoCon In-Situ Stabilization*, EPA RREL, series includes Technology Evaluation, Vol. I, EPA/540/5-89/004a; Technology Evaluation, Vol. II, EPA/540/5-89/004b, PB89-194179; Technology Evaluation, Vol. III, EPA/540/5-89/004c, PB90-269069; Technology Evaluation, Vol. IV, EPA/540/5-89/004d, PB90-269077; Applications Analysis, EPA/540/A5-89/004; Technology Demonstration Summary, EPA/540/S5-89/004; Technology Demonstration Summary — Update Report, EPA/540/S5-89/004a; and Demonstration Bulletin, EPA/540/M5-89/004.

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EPA, 1989. *Soliditech, Inc. — Solidification*, EPA RREL, series includes Technology Evaluation, Vol. I, EPA/540/5-89/005a; Technology Evaluation, Vol. II, EPA/540/5-89/005b, PB90-191768; Applications Analysis, EPA/540/A5-89/005; Technology Demonstration Summary, EPA/540/S5-89/005; and Demonstration Bulletin, EPA/540/M5-89/005.

EPA, 1989. *Stabilization/Solidification of CERCLA and RCRA Wastes: Physical Tests, Chemical Testing Procedures, Technology Screening, and Field Activities*, EPA, CERL, Cincinnati, OH, EPA/625/6-89/022.

EPA, 1990. *International Waste Technologies/Geo-Con In Situ Stabilization/ Solidification*, Applications Report, EPA, ORD, Washington, DC, EPA/540/A5-89/004.

EPA, 1993. *Solidification/Stabilization and Its Application to Waste Materials*, Technical Resource Document, EPA, ORD, Washington, DC, EPA/530/R-93/012.

EPA, 1993. *Solidification/Stabilization of Organics and Inorganics*, Engineering Bulletin, EPA, ORD, Cincinnati, OH, EPA/540/S-92/015.

Wiles, C.C., 1991. *Treatment of Hazardous Waste with Solidification/ Stabilization*, EPA Report EPA/600/D-91/061.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Hialeah, FL	Jeff Newton International Waste Technologies 150 North Main Street, Suite 910 Wichita, KS 67202 (316) 269-2660 Geo-Con Dave Miller (817) 383-1400	Deep soil mixing using drive auger to inject additive slurry and water into in-place soil.	NA	NA	$111-$194/ton

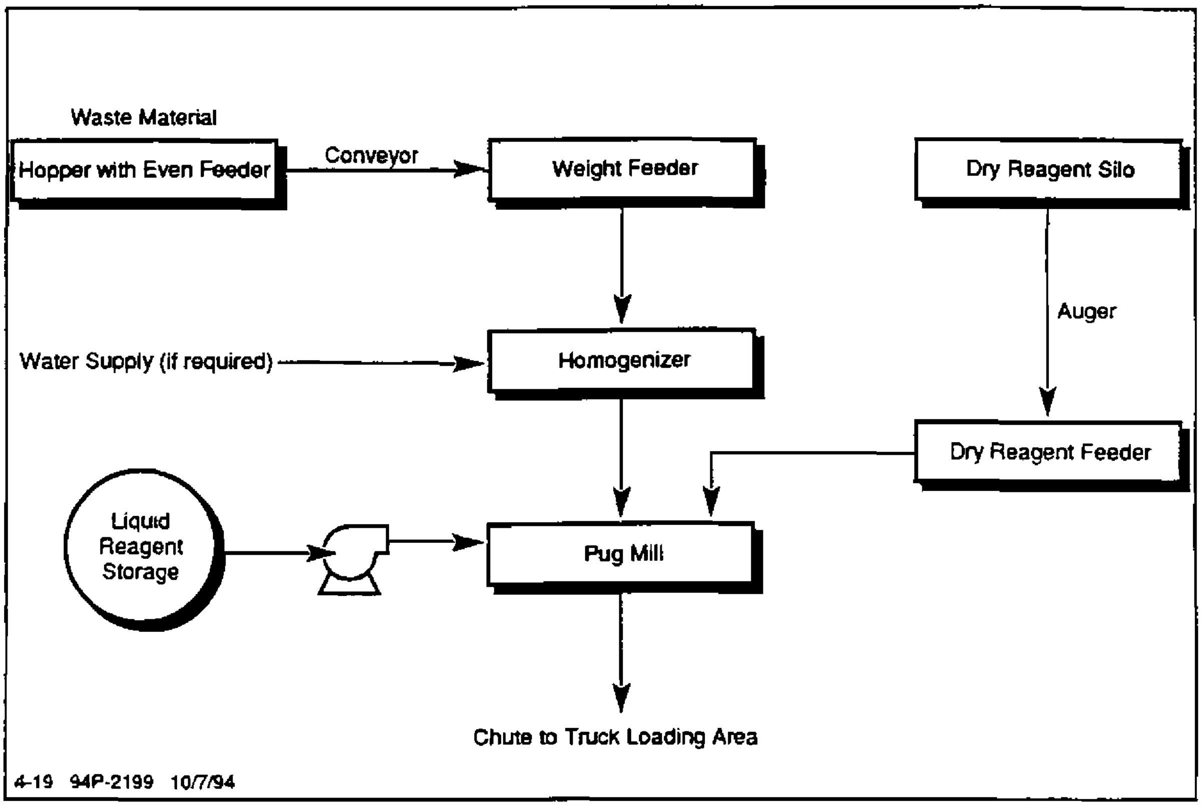
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Mary K. Stinson	EPA RREL	(908) 321-6683 Fax: (908) 321-6640	2890 Woodbridge Avenue (MS-104) Edison, NJ 08837-3679
Patricia M. Erikson	EPA RREL	(513) 569-7884 Fax: (513) 569-7676	26 West M.L. King Drive Cincinnati, OH 45268
Edward R. Bates	EPA RREL	(513) 569-7774 Fax: (513) 569-7676	26 West M.L. King Drive Cincinnati, OH 45268
John Cullinane	USAE-WES	(601) 636-3111	ATTN: LEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

4.19 SOLIDIFICATION/STABILIZATION (EX SITU)

Description: As for in situ solidification/stabilization (S/S) (see Technology Profile No. 4.7), ex situ S/S contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). Ex situ S/S, however, typically requires disposal of the resultant materials.



4-19 TYPICAL EX SITU SOLIDIFICATION/STABILIZATION PROCESS FLOW DIAGRAM

Applicability: The target contaminant group for ex situ S/S is inorganics, including radionuclides. The technology has limited effectiveness against SVOCs and pesticides; however, systems designed to be more effective against organic contaminants are being developed and tested.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Environmental conditions may affect the long-term immobilization of contaminants.
- Some processes result in a significant increase in volume (up to double the original volume).
- Certain wastes are incompatible with different processes. Treatability studies are generally required.
- VOCs are generally not immobilized.

- Long-term effectiveness has not been demonstrated for many contaminant/process combinations.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Soil parameters that must be determined include particle size, Atterberg limits, moisture content, metal concentrations, sulfate content, organic content, density, permeability, unconfined compressive strength, leachability, microstructure analysis, and physical and chemical durability.

Performance Data: Depending upon the original contaminants and the chemical reactions that take place in the ex situ S/S process, the resultant stabilized mass may have to be handled as a hazardous waste. For certain types of radioactive waste, the stabilized product must be capable of meeting stringent waste form requirements for disposal (e.g., Class B or Class C low level materials). Remediation of a site consisting of 18,200 metric tons (20,000 tons) could require less than 1 month, depending on equipment size and type and soil properties (e.g., percent solids and particle size).

DOE has demonstrated the Polyethylene Encapsulation of Radionuclides and Heavy Metals (PERM) process at the bench scale. The process is a waste treatment and stabilization technology for high-level mixed waste. Specific targeted contaminants include radionuclides (e.g., cesium, strontium, and cobalt), and toxic metals (e.g., chromium, lead, and cadmium). The process should be ready for implementation in FY95.

Cost: Ex situ solidification/stabilization processes are among the most mature remediation technologies. Representative overall costs from more than a dozen vendors indicate an approximate cost of under $110 per metric ton ($100 per ton), including excavation.

References:

Bricka, R.M., et al., 1988. *An Evaluation of Stabilization/Solidification of Fluidized Bed Incineration Ash (K048 and K051)*, USAE-WES Technical Report EL-88-24.

EPA, 1989. *Chemfix Technologies, Inc.—Chemical Fixation/Stabilization*, EPA RREL, Technology Evaluation Vol. I, EPA/540/5-89/011a, PB91-127696; and Technology Evaluation Vol. II, EPA/540/5-89/011b, PB90-274127.

EPA, 1989. *Harcon—Solidification*, EPA RREL, series includes Technology Evaluation Vol. I, EPA/540/5-89/001a, PB89-158810; Technology Evaluation Vol. II, EPA/540/5-89/001b, PB89-158828; Applications Analysis, EPA/540/A5-89/001; and Technology Demonstration Summary, EPA/540/S5-89/001.

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EPA, 1993. *Solidification/Stabilization and Its Application to Waste Materials,* Technical Resource Document, EPA, ORD, Washington, DC, EPA/530/R-93/012.

EPA, 1993. *Solidification/Stabilization of Organics and Inorganics,* Engineering Bulletin, EPA, ORD, Cincinnati, OH, EPA/540/S-92/015.

DOE, 1993. *Technology Name: Polyethylene Encapsulation,* Technology Information Profile (Rev. 2) for ProTech, DOE ProTech Database, TTP Reference No. BH-321201.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Portable Equipment Salvage Clackamas, OK	Edwin Barth - EPA CERI	Dry alumina, calcium, and silica blended in reaction vessel.	NA	93.2 to >99.9% reduction of Cu, Pb, and Zn TCLP levels	$80/metric ton ($73/ton)
Naval Construction Battalion Center Port Hueneme, CA	NFESC Code 411 Port Hueneme, CA 93043 (614) 424-5442	Spent blasting abrasives screened and mixed with portland cement and soluble silicates.	NA	<5 ppm TCLP	$94/metric ton ($85/ton)
Robins AFB Macon, GA	Terry Lyons EPA RREL 26 West M.L. King Dr. Cincinnati, OH 45268 (513) 569-7589	Addition of pozzolonic cementitious materials.	NA	NA	NA

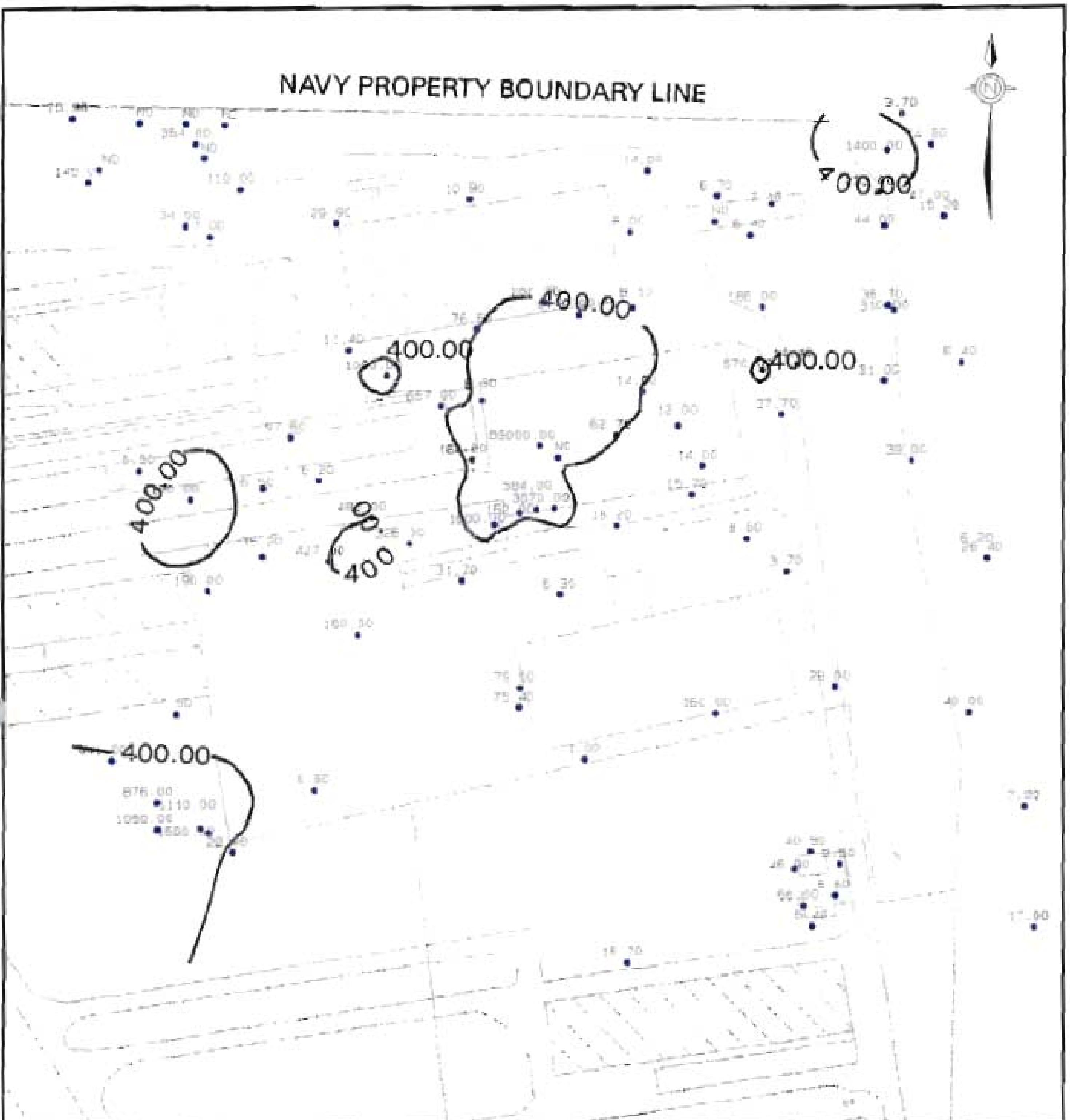
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Edwin Barth	EPA CERI	(513) 569-7669 Fax: (513) 569-7585	26 West M.L. King Dr. Cincinnati, OH 45268
Mark Bricka	USAE-WES	(601) 634-3700	CEWES-EE-S 3909 Halls Ferry Road Vicksburg, MS 39180-6199
Patricia M. Erikson	EPA RREL	(513) 569-7884 Fax: (513) 569-7676	26 West M.L. King Dr. Cincinnati, OH 45268
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401
Sherry Gibson	DOE	(301) 903-7258	EM-552, Trevion II Washington, DC 20585

SWMU 2

SITE FIGURES



LEGEND

NOTE: This contour map assumes homogeneous characteristics in soil

< 400 (ppm)

> 400 (ppm)

0 feet 300

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 11
SWMU 2
LEAD IN
SURFACE SOIL

SWMU 39 - Summary of Applicable RFI Data

SWMU 39 in Zone A is the site of a former storage area for petroleum, oil, and lubricant (POL) drums north of Building 1604. This asphalt-paved area is near the northern boundary of the base. The Hess Oil tank farm is adjacent this boundary.

A total of 21 COCs that contributed to a residential (child) hazard quotient of 14 and a residential ILCR of 8E-04 were identified in groundwater. Primary contributors to risk were benzene, chlorinated solvents, and arsenic. LNAPL has been confirmed to be migrating onsite from a non-Navy source (e.g., Hess Oil Company). The LNAPL was detected in one monitoring well (No. 11). Hess has been cooperating with DHEC and it has been reported that possibly several feet of product has been identified in Hess groundwater. A well has been installed on Navy property by Hess as part of their investigative effort.

A total of 7 COCs that contributed to a residential risk of 4E-05 were identified in soil. Primary contributors to risk were arsenic and benzo(a)pyrene equivalents.

A multi-layer aquifer system exists across most of the site. Groundwater contamination has been detected in the shallow and intermediate levels, and only marginally in the deep interval. Groundwater contamination is migrating off Navy property.

A small layer of DNAPL was observed in well No. 05 during the first round of sampling. Subsequent sampling did not produce evidence of DNAPL in this or other wells at SWMU 39.

SWMU 39 - EISM Conceptual Plan

Objective

First, to demonstrate that monitored natural attenuation is a viable remedial alternative. Second, reduction of LNAPL mass.

Task 1

Sample existing site wells and analyze groundwater for monitored natural attenuation parameters. Complete this task in accordance with monitored natural attenuation guidelines currently established by the USGS for SDIV. Also incorporate any other previous and site- or area-specific groundwater sampling event information containing monitored natural attenuation parameters.

Purpose

To establish a base line, as well as an initial line of evidence to demonstrate monitored natural attenuation of chlorinated solvents.

Task 2

Develop an operational plan (if applicable) to monitor, measure, and remove L NAPL from area wells. Do not use a product recovery device capable of adversely affecting groundwater movement (i.e., high flow and large volume groundwater extraction system). Hand bailing should suffice for anticipated volumes of LNAPL. Coordinate site LNAPL removal with concurrent Hess Oil Company LNAPL investigation and/or removal activities.

Purpose

LNAPL reduction.

Task 3

Demonstrate effectiveness of monitored natural attenuation in the reduction of risk to offsite inhabitants. That is, demonstrate plume stabilization, contaminant reduction, the presence of favorable indicator compounds, etc.

Purpose

To address offsite migration issue.

End Point

Continue LNAPL recovery, if applicable, and demonstrate the effectiveness of monitored natural attenuation parameters until the CMS process is completed and a final remedy is selected.

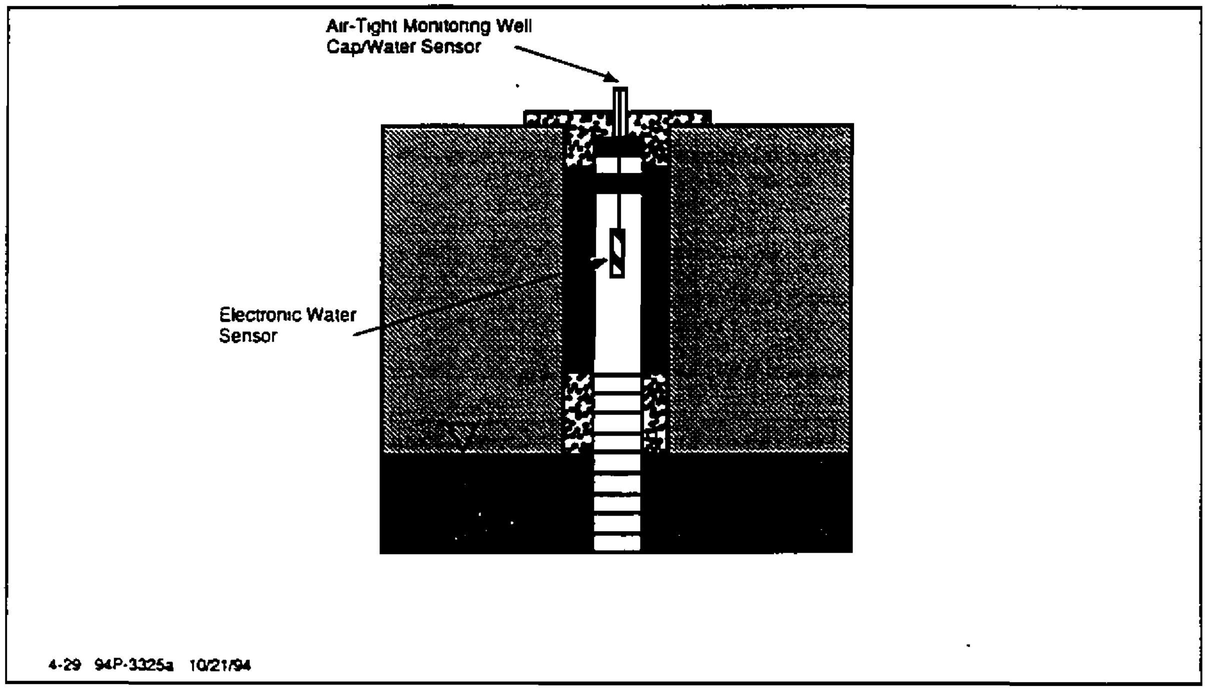
SWMU 39

REMEDIAL TECHNOLOGY PROFILES

Natural Attenuation

4.29 NATURAL ATTENUATION

Description: For natural attenuation, natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels. Natural attenuation is not a "technology" per se, and there is significant debate among technical experts about its use at hazardous waste sites. Consideration of this option requires modeling and evaluation of contaminant degradation rates and pathways. The primary objective of site modeling is to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards before potential exposure pathways are completed. In addition, sampling and sample analysis must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.



4-29 TYPICAL MONITORING WELL CONSTRUCTION DIAGRAM

Natural attenuation is not the same as "no action," although it often is perceived as such. CERCLA requires evaluation of a "no action" alternative but does not require evaluation of natural attenuation. Natural attenuation is considered in the Superfund program on a case-by-case basis, and guidance on its use is still evolving. It has been selected at Superfund sites where, for example, PCBs are strongly sorbed to deep subsurface soils and are not migrating; where removal of DNAPLs has been determined to be technically impracticable [Superfund is developing technical impracticability (TI) guidance]; and where it has been determined that active remedial measures would be unable to significantly speed remediation time frames. Where contaminants are expected to remain in place over long periods of time, as in the first two examples, TI waivers must be obtained. In all cases, extensive site characterization is required.

The attitude toward natural attenuation varies among agencies. USAF carefully evaluates the potential for use of natural attenuation at its sites; however, EPA accepts its use only in certain special cases.

Applicability: Target contaminants for natural attenuation are nonhalogenated VOCs, SVOCs, and fuel hydrocarbons. Halogenated VOCs and SVOCs and pesticides may be less responsive to natural attenuation.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Data must be collected to determine model input parameters.
- Although commercial services for evaluating natural attenuation are widely available, the quality of these services varies widely among the many potential suppliers. Highly skilled modelers are required.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation should be used only where there are no impacts on potential receptors.
- Contaminants may migrate before they are degraded.
- The site may have to be fenced and may not be available for re-use until contaminant levels are reduced.
- If source material exists, it may have to be removed.
- Some inorganics can be immobilized, such as mercury, but they will not be degraded.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge).

Many potential suppliers can perform the modeling, sampling, and sample analysis required for justifying and monitoring natural attenuation. The extent of contaminant degradation depends on a variety of parameters, such as contaminant types and concentrations, temperature, moisture, and availability of nutrients/electron acceptors (e.g., oxygen and nitrate).

When available, information to be obtained during data review includes:

- Soil and groundwater quality data:
  - Three-dimensional distribution of residual-, free-, and dissolved-phase contaminants. The distribution of residual- and free-phase contaminants will be used to define the dissolved-phase plume source area.

- Groundwater and soil geochemical data.
- Chemical and physical characteristics of the contaminants.
- Potential for biodegradation of the contaminants.

- Geologic and hydrogeologic data:
    - Lithology and stratigraphic relationships.
    - Grain-size distribution (sand vs. silt vs. clay).
    - Flow gradient.
    - Preferential flow paths.
    - Interaction between groundwater and surface water.
    - Location of potential receptors: groundwater, wells, and surface water discharge points.

Performance Data: Natural attenuation has been selected by AFCEE for remediation at 45 USAF sites.

Cost: There are costs for modeling contamination degradation rates to determine whether natural attenuation is a feasible remedial alternative. Additional costs are for subsurface sampling and sample analysis (potentially extensive) to determine the extent of contamination and confirm contaminant degradation rates and cleanup status. Skilled labor hours are required to conduct the modeling, sampling, and analysis. O&M costs would be required for monitoring to confirm that contaminant migration has not occurred.

References:

Scovazzo, P.E., D. Good, and D.S. Jackson, 1992. "Soil Attenuation: In Situ Remediation of Inorganics," in *Proceedings of the HMC/Superfund 1992*, HMCRI, Greenbelt, MD.

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Wiedemeier, T.H., D.C. Downey, J.T. Wilson, D.H. Kampbell, R.N. Miller, and J.E. Hansen. 1994. *Technical Protocol for Implementing the Intrinsic Remediation (Natural Attenuation) with Long-Term Monitoring Option for Dissolved-Phase Fuel Contamination in Ground Water*, Brooks Air Force Base, San Antonio, TX.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Hill AFB, UT	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA
Eglin AFB, FL	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA
Elmendorf AFB, AL	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA

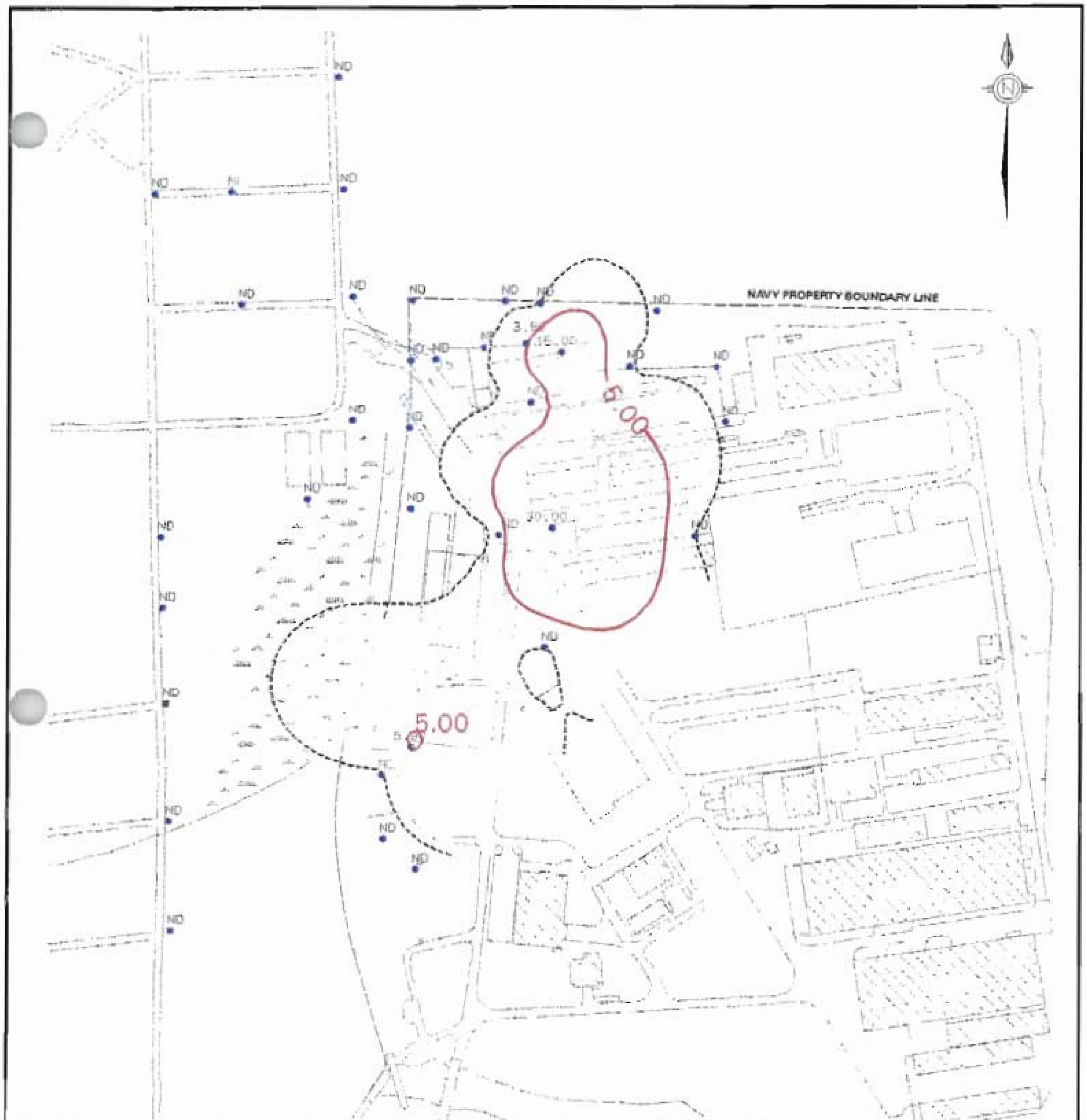
Note: NA = Not available.

Points of Contact:

Contact	Government Agency	Phone	Location
Capt. Tom Venoge	USAF	(904) 283-6205	AL-EQW Tyndall AFB, FL 32403
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

SWMU 39

SITE FIGURES



LEGEND

Approximate extent of PCE based upon computer generated contours

ND

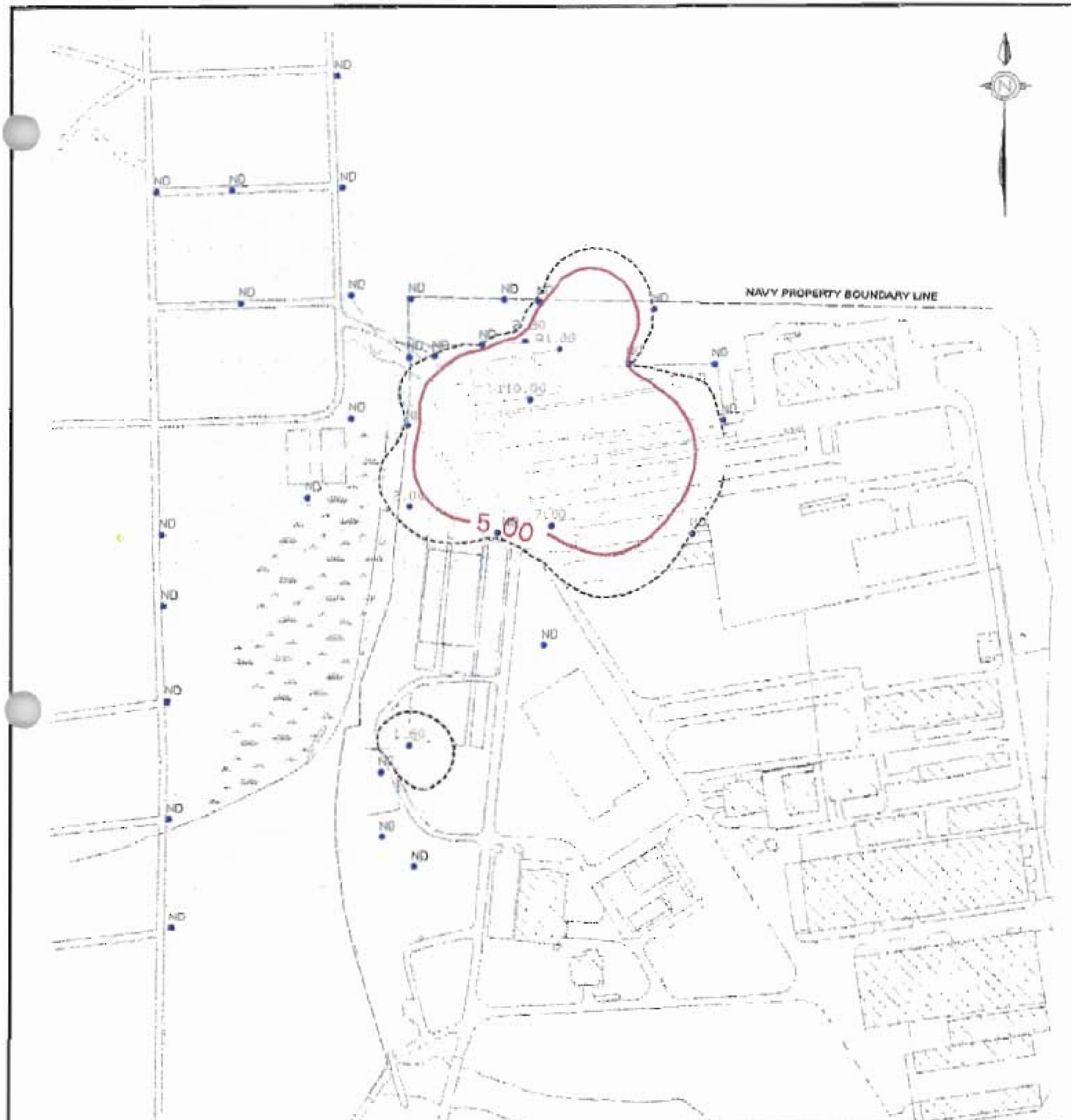
ND - MCL (5 ppb)

> MCL (5 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 1
SWMU 39
PCE IN
SHALLOW GROUNDWATER



LEGEND

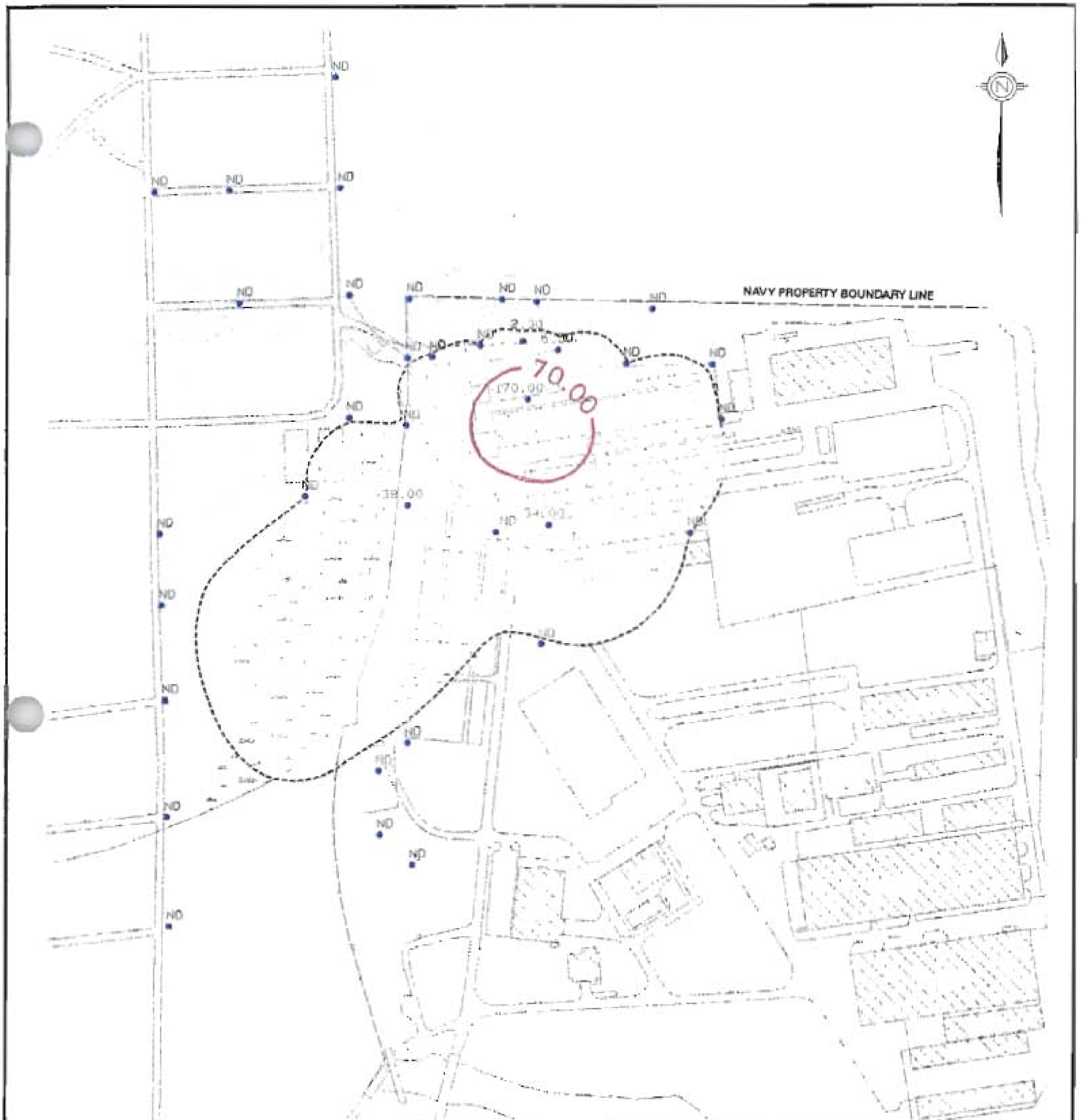
Approximate extent of TCE based upon computer generated contours

- ND
- ND - MCL (5 ppb)
- > MCL (5 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 2
SWMU 39
TCE IN
SHALLOW GROUNDWATER



LEGEND

Approximate extent of CIS-1,2-DCE based upon computer generated contours

ND

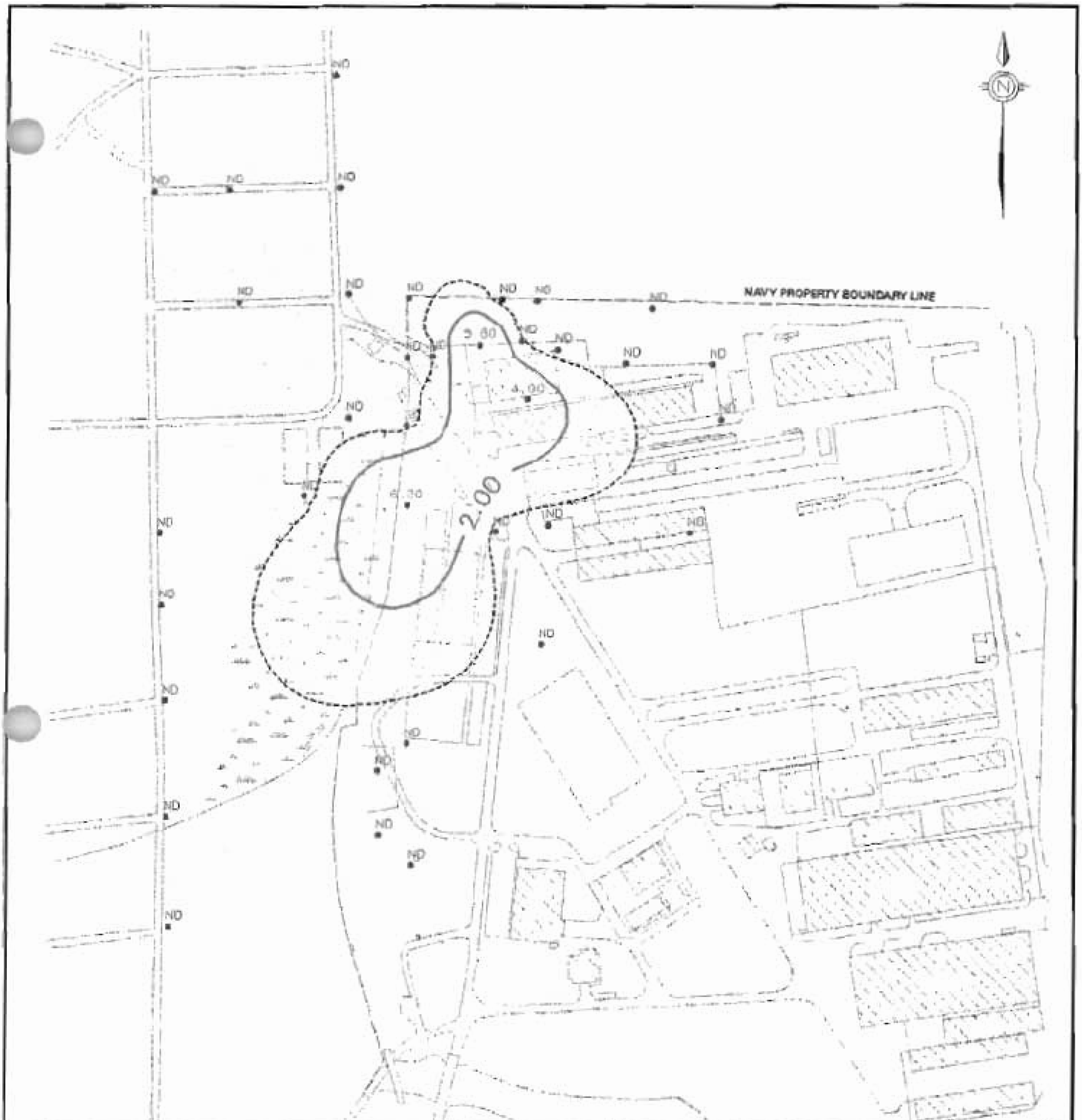
ND - MCL (70 ppb)

> MCL (70 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 3
SWMU 39
CIS-1,2-DCE IN
SHALLOW GROUNDWATER



LEGEND

Approximate extent of VINYL CHLORIDE based upon computer generated contours

ND

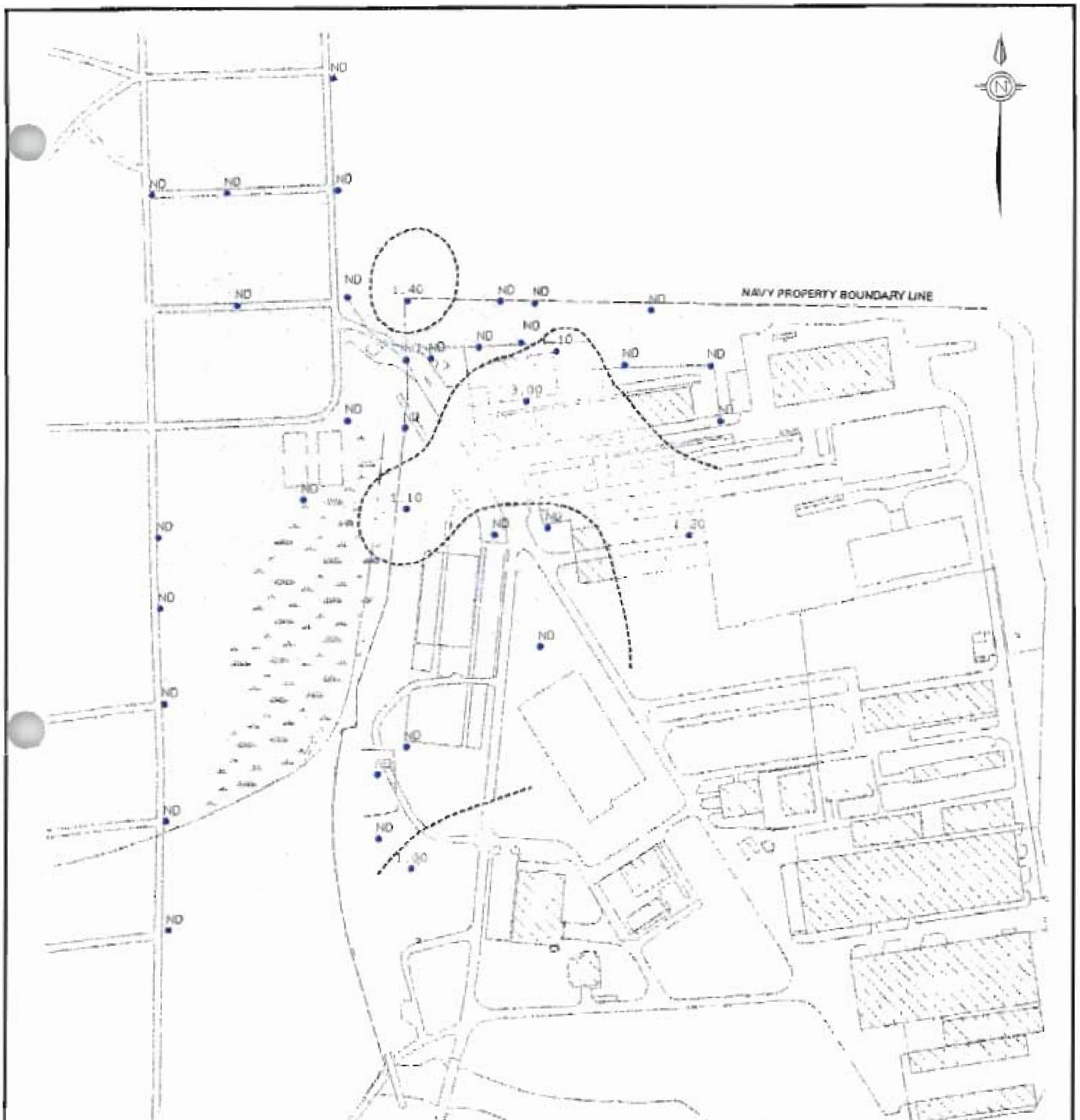
ND - MCL (2 ppb)

> MCL (2 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 4
SWMU 39
VINYL CHLORIDE IN SHALLOW GROUNDWATER



LEGEND

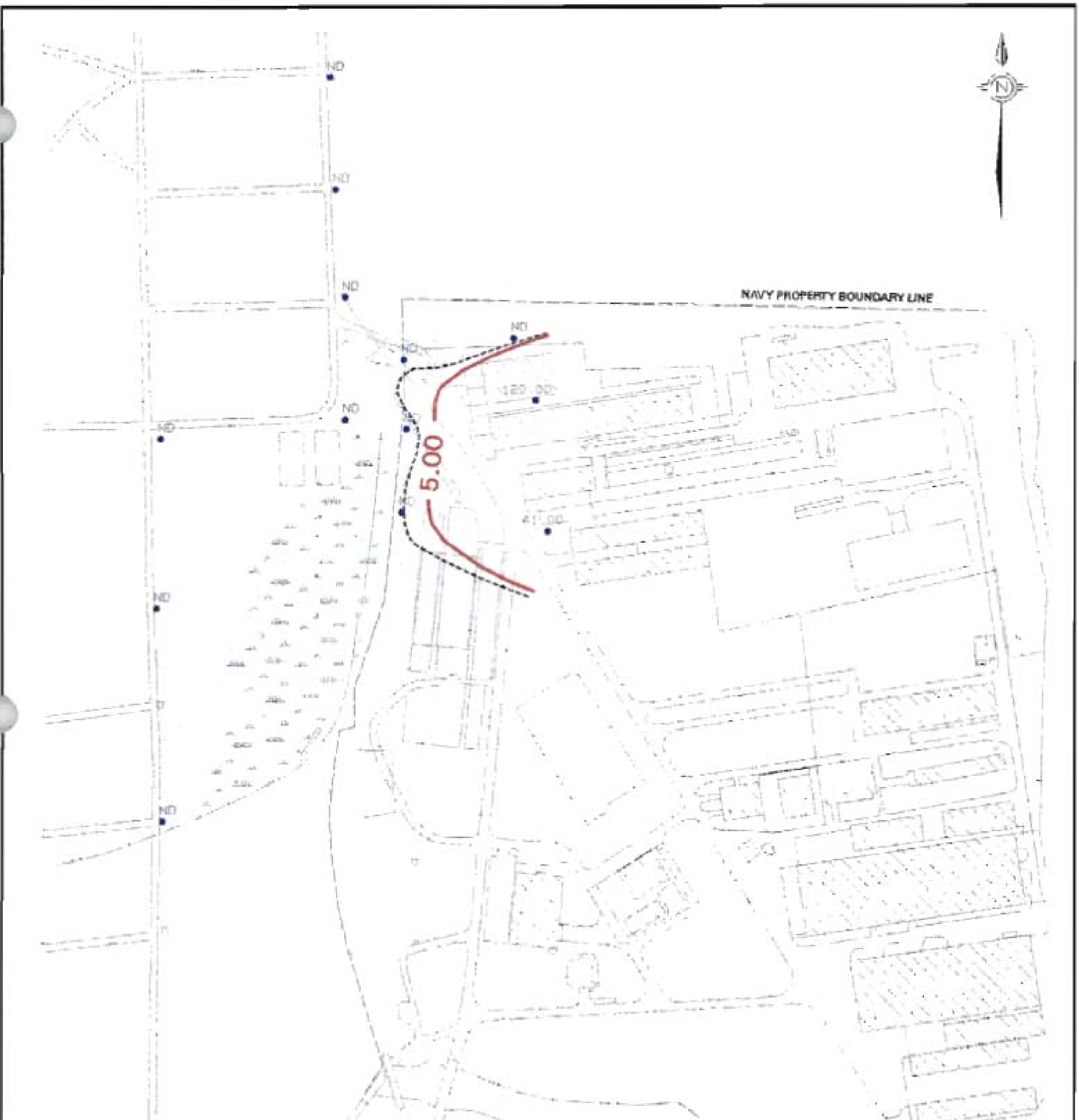
Approximate extent of 1,1-DCE based upon computer generated contours

- ND
- ND - MCL (7 ppb)
- > MCL (7 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 5
SWMU 39
1,1-DCE IN
SHALLOW GROUNDWATER



LEGEND

Approximate extent of TCE based upon computer generated contours

ND

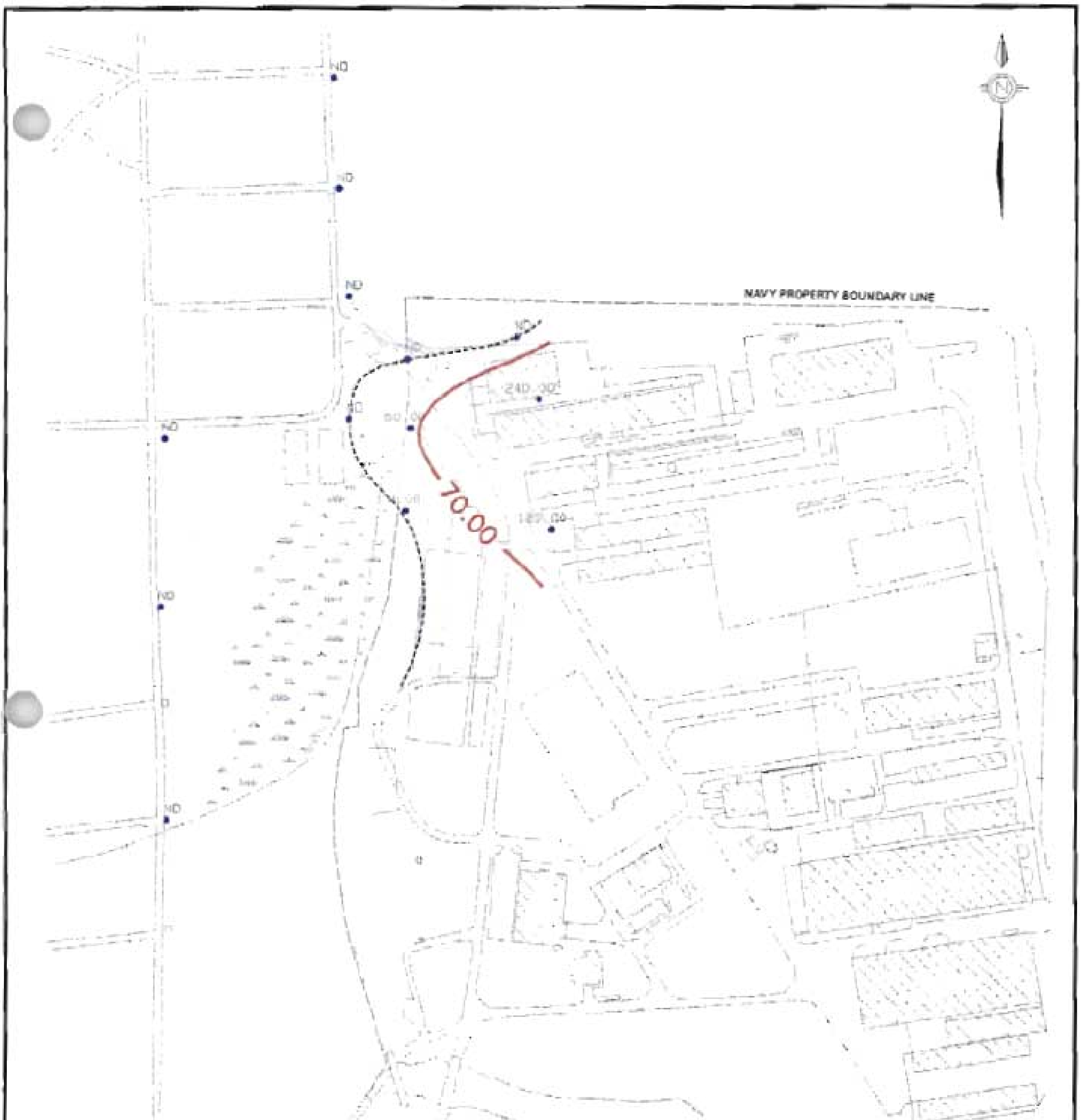
ND - MCL (5 ppb)

> MCL (5 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 6
SWMU 39
TCE IN
INTERMEDIATE GROUNDWATER



LEGEND

Approximate extent of CIS-1,2-DCE based upon computer generated contours

ND

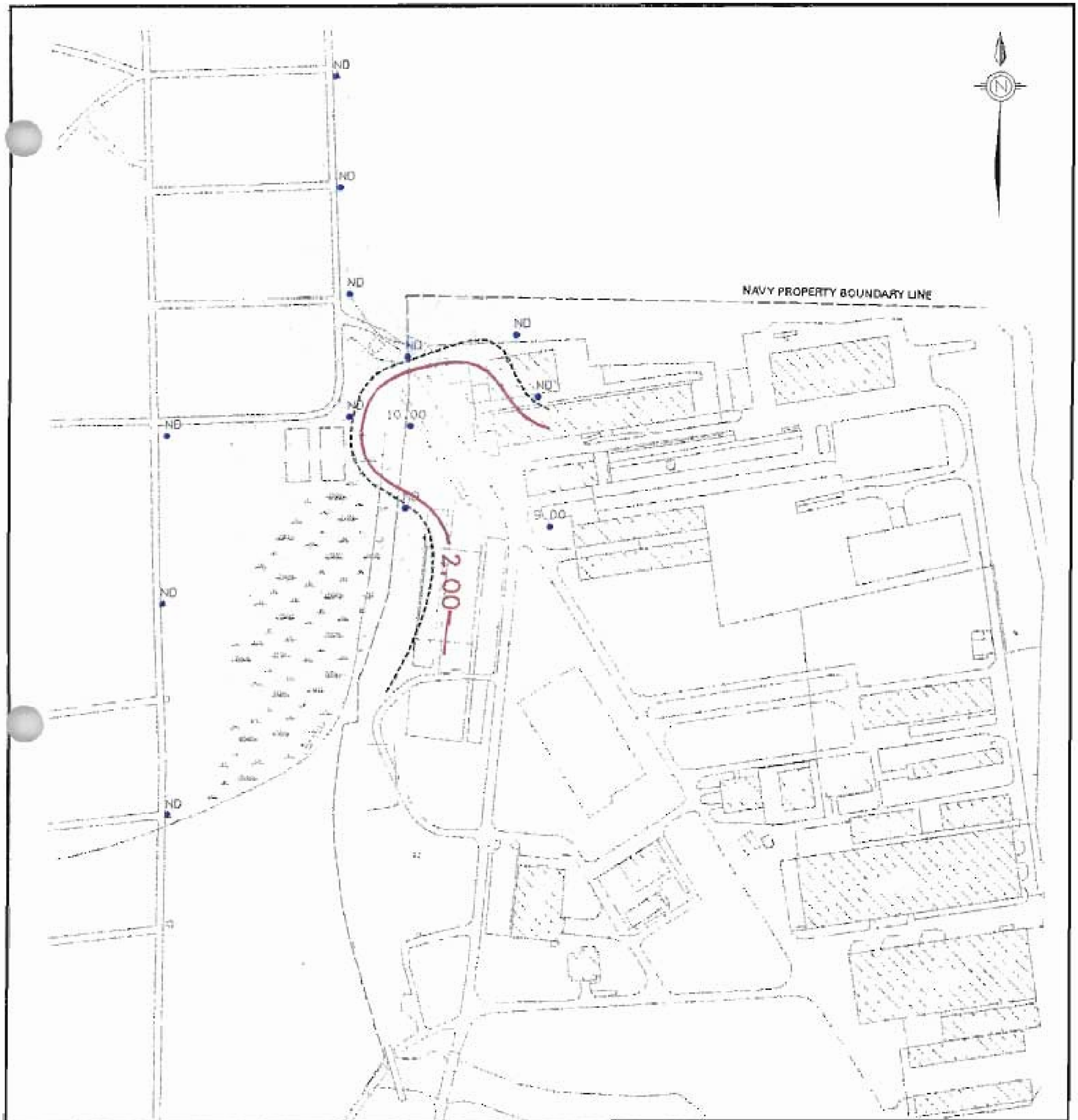
ND - MCL (70 ppb)

> MCL (70 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 7
SWMU 39
CIS-1,2-DCE IN
INTERMEDIATE GROUNDWATER



LEGEND

Approximate extent of VINYL CHLORIDE based upon computer generated contours

ND

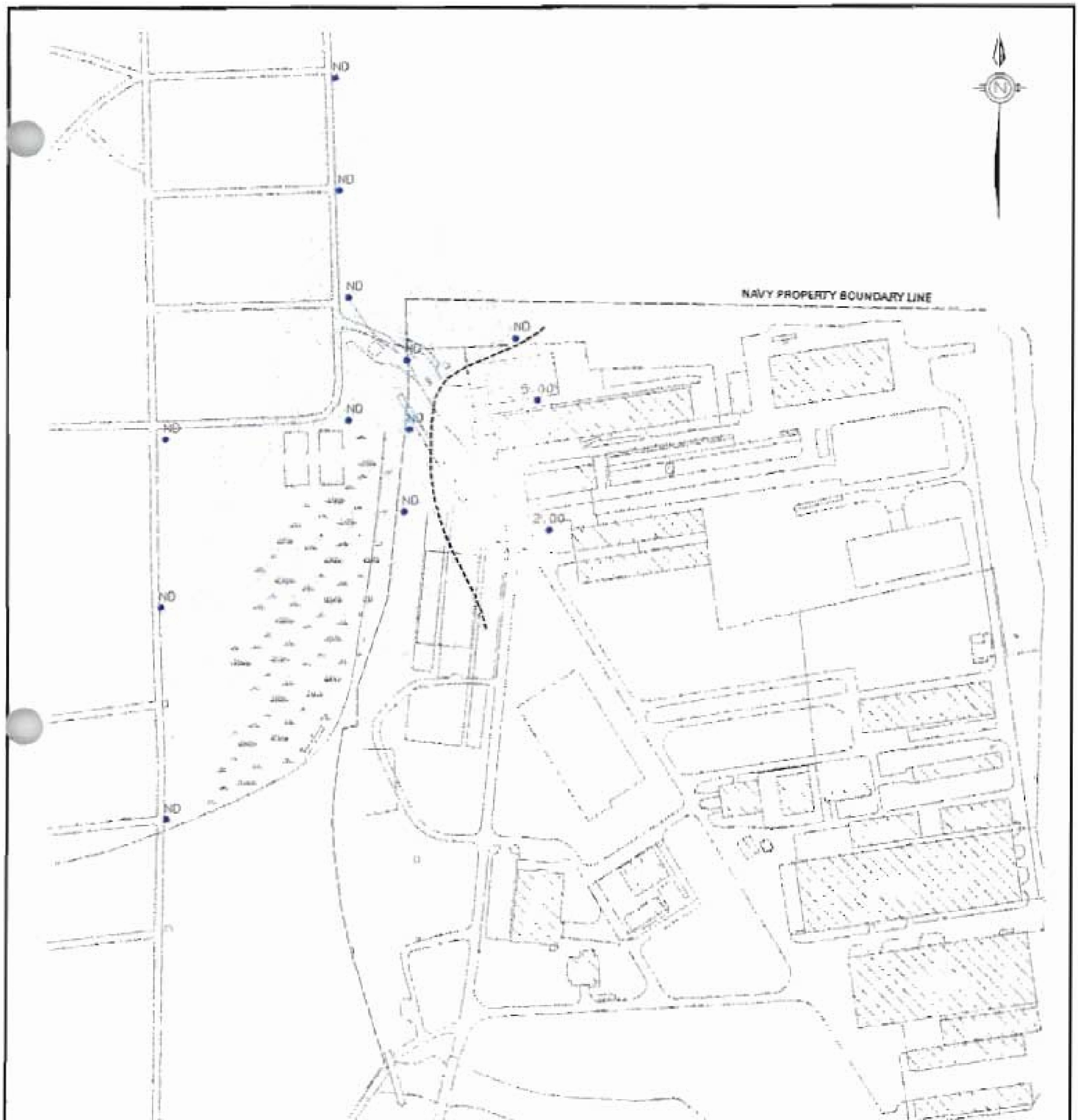
ND - MCL (2 ppb)

> MCL (2 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 8
SWMU 39
VINYL CHLORIDE IN INTERMEDIATE GROUNDWATER



LEGEND

Approximate extent of 1,1-DCE based upon computer generated contours

ND

ND - MCL (7 ppb)

> MCL (7 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 9
SWMU 39
1,1-DCE IN
INTERMEDIATE GROUNDWATER

LEGEND

Approximate extent of CIS-1,2-DCE based upon computer generated contours

ND

ND - MCL (70 ppb)

> MCL (70 ppb)

0 feet 700

ZONE A - RCRA FACILITY INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10
SWMU 39
CIS-1,2-DCE IN
DEEP GROUNDWATER

SWMU 8 - Summary of Applicable RFI Data

At the Navy base pit area, oil sludge was disposed of in three unlined pits from 1944 to 1977. Two pits were filled with sludge before 1955. The remaining pit was filled in 1977. Previous investigations at SWMU 8 detected free-floating oil, particularly in the southwestern portion of the area overlying one of the pits. The thickness of the free-floating oil ranged from 2 to 4 inches over the unit and decreased rapidly with distance.

SWMU 8 is currently undergoing an interim measure to remove sludge material and free product. To date, 10,000 gallons of product has been recovered. Upon completion of the scope of the current IM, it is anticipated that some free product will remain along with a significant amount of dissolved phase contamination in the shallow aquifer.

SWMU 8 - EISM Conceptual Plan

Objective

Removal of soil and sediment source material from site. Installation of product recovery trench and LNAPL removal. It is not the intent of this EISM to dissolved phase contamination. Though in an indirect way, groundwater contamination would be beneficially influenced.

Task 1

Obtain additional subsurface soil samples on an approximate 20 to 30 foot grid throughout the entire SWMU 8 area. The soil samples should be obtained from the "impoundment zone" which is believed to lie from slightly above the groundwater table to about three feet below it. The grid is intended to provide coverage to both known and unknown areas of petroleum contamination. As a first pass delineation effort, soils can be visually inspected for the presence of petroleum product and/or field screened with an OVA/FID or bioassay kit.

Purpose

To refine the extent of elevated petroleum sludge contamination for subsequent hot spot excavation.

Task 2

With the exception of the existing product recovery trench, excavate the significantly impacted areas identified in Task 1. This soil should be stockpiled, covered, and then removed from the site at the completion of Task 3 (overexcavation of existing product recovery trench). Obtain appropriate number and type of confirmation samples from excavation boundary. Soil should be removed from the site by the same process currently in use by the DET. Backfill excavated areas with clean soil.

Purpose

To remove soil source material from identified hot spots.

Purpose

Area 2 of SWMU 8, as defined by the DET, currently consists of an open product recovery trench, approximately 500 feet by 15 feet by 5 feet deep. This trench was dug by the DET in an area suspected of being a disposal trench for ship- and base-generated petroleum sludges. Floating product is occasionally skimmed and collected from the water's surface within the open trench. Task 3 consists of the additional removal, by overexcavation, of sludge and debris from the disposal trench. A clamshell-type bucket and crane is proposed to further excavate the existing ditch to approximately 10 feet below ground surface. If possible, segregate clean top soil from observed sludge-contaminated soil. Clean soil will be stockpiled onsite for eventual reuse. Contaminated soil should be placed along the edge of excavated trench to allow water from the saturated soil to flow back into the ditch over several days. Obtain appropriate number and type of confirmation samples from excavation boundary.

Purpose

To remove obvious contaminated material source from site and to prepare trench for backfill and installation of a product recovery system.

Task 4

As described in Task 2, remove overexcavation-generated contaminated soil from site via DET method.

Purpose

To remove source material obtained during trench overexcavation.

Task 5

Skim obvious LNAPL product from newly constructed trench. Containerize product and transport offsite to a treatment/recovery facility. Do this over an approximate one week period. Properly cordon off ditch and provide ample safety warning signage throughout the time the ditch remains open.

Purpose

To remove first flow LNAPL material from trench prior to installation of product recovery system.

Task 6

Install a vertical pipe recovery system in trench. Conceptual design of recovery system consists of vertical piping segments, approximately 10- to 16-inch diameter and 15-foot length, PVC material, perforated with slots (approx. 0.20 inch) or holes (approximately 0.25 inch) from the bottom of the pipe along its length to within 2 feet of the estimated surface interface point, capped on bottom, and placed centered and along length of trench at approximate 50 feet intervals. Top of exposed pipe should rise above surrounding grade by about 3 feet. Support vertical pipes to keep them upright during trench backfill operation and backfill ditch with pea gravel (of mean diameter approximately three times larger than pipe screening perforations or holes). Fill ditch with gravel up to existing grade elevation minus about two feet. Install impermeable membrane sheeting on top of gravel. Place clean stockpiled overburden material obtained during Task 3 on top of membrane sheeting and grade to produce a crown originating at the center of the trench along its longitudinal axis. Crown should consist of a 2% grade at a minimum.

Purpose

Recovery trench construction.

Task 7

Visually monitor pipes in recovery trench and perform a manual product recovery test. Recovery test consists of gauging and manually bailing vertical pipes to determine approximate rates and quantities of recoverable product. Then implement appropriate product recovery method (i.e., hand bailing, automatic oil skimmer, high viscosity and low flow pump system). Collect and containerize product for transportation to an offsite treatment/recovery facility

Purpose

Reduction of LNAPL.

End Point

Continue product recovery through appropriate means and at appropriate frequency until the CMS process is completed and a final remedy is selected.

SWMU 8

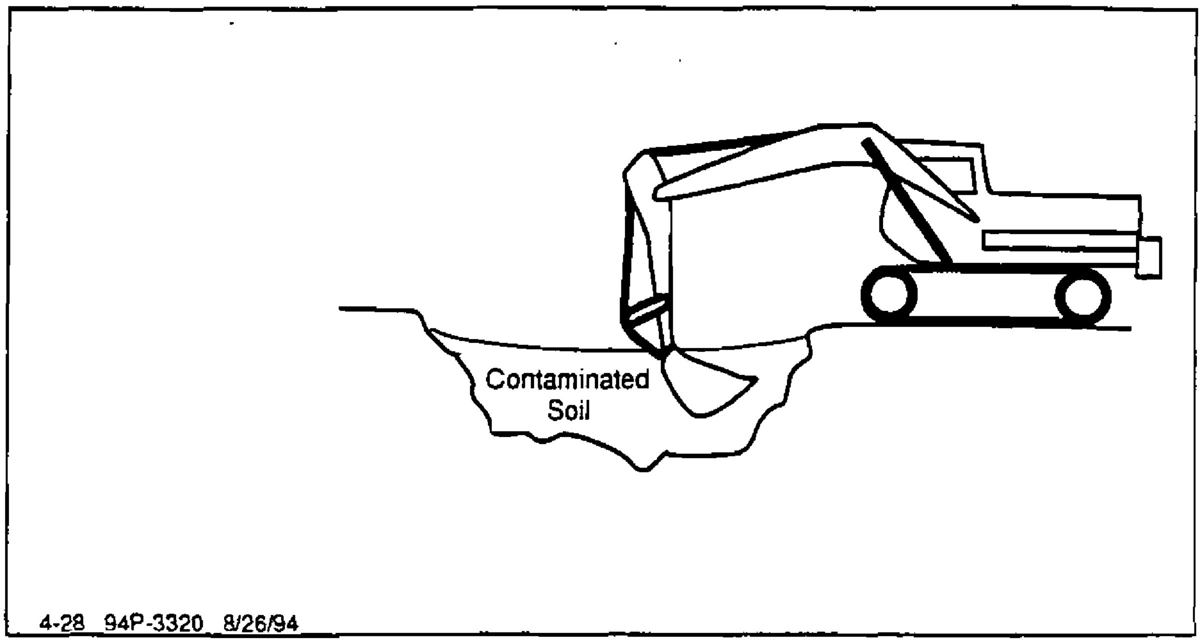
REMEDIAL TECHNOLOGY PROFILES

Excavation, Retrieval, and Offsite Disposal

Free Product Recovery

4.28 EXCAVATION, RETRIEVAL, AND OFF-SITE DISPOSAL

Description: Contaminated material is removed and transported to permitted off-site treatment and/or disposal facilities. Some pretreatment of the contaminated media usually is required in order to meet land disposal restrictions.



4-28 TYPICAL CONTAMINATED SOIL EXCAVATION DIAGRAM

Applicability: Excavation and off-site disposal is applicable to the complete range of contaminant groups with no particular target group. Although excavation and off-site disposal alleviates the contaminant problem at the site, it does not treat the contaminants.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Generation of fugitive emissions may be a problem during operations.
- The distance from the contaminated site to the nearest disposal facility will affect cost.
- Depth and composition of the media requiring excavation must be considered.
- Transportation of the soil through populated areas may affect community acceptability.
- Disposal options for certain waste (e.g., mixed waste or transuranic waste) may be limited. There is currently only one licensed disposal facility for radioactive and mixed waste in the United States.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge).

The type of contaminant and its concentration will impact off-site disposal requirements. Soil characterization as dictated by land disposal restrictions (LDRs) are required. Most hazardous wastes must be treated to meet either RCRA or non-RCRA treatment standards prior to land disposal. Radioactive wastes would have to meet disposal facility waste form requirements based on waste classification.

Performance Data: Excavation and off-site disposal is a well proven and readily implementable technology. Prior to 1984, excavation and off-site disposal was the most common method for cleaning up hazardous waste sites. Excavation is the initial component in all ex situ treatments. As a consequence, the remediation consulting community is very familiar with this option.

The excavation of 18,200 metric tons (20,000 tons) of contaminated soil would require about 2 months. Disposal of the contaminated media is dependent upon the availability of adequate containers to transport the hazardous waste to a RCRA-permitted facility.

CERCLA includes a statutory preference for treatment of contaminants, and excavation and off-site disposal is now less acceptable than in the past. The disposal of hazardous wastes is governed by RCRA (40 CFR Parts 261-265), and the U.S. Department of Transportation (DOT) regulates the transport of hazardous materials (49 CFR Parts 172-179, 49 CFR Part 1387, and DOT-E 8876).

DOE has demonstrated a cryogenic retrieval of buried waste system, which uses liquid nitrogen (LN_2) to freeze soil and buried waste to reduce the spread of contamination while the buried material is retrieved with a series of remotely operated tools. Other excavation/retrieval systems that DOE is currently developing include a remote excavation system, a hydraulic impact end effector, and a high pressure waterjet dislodging and conveyance end effector using confined sluicing.

Cost: Cost estimates for excavation and disposal range from $300 to $510 per metric ton ($270 to $460 per ton) depending on the nature of hazardous materials and methods of excavation. These estimates include excavation/removal, transportation, and disposal at a RCRA permitted facility. Excavation and off-site disposal is a relatively simple process, with proven procedures. It is a labor-intensive practice with little potential for further automation. Additional costs may include soil characterization and treatment to meet land ban requirements.

References:

Church. H.K., 1981. *Excavation Handbook*, McGraw Hill Book Co.. New York, NY.

EPA, 1991. *Survey of Materials-Handling Technologies Used at Hazardous Waste Sites*. EPA, ORD. Washington, DC. EPA/540/2-91/010.

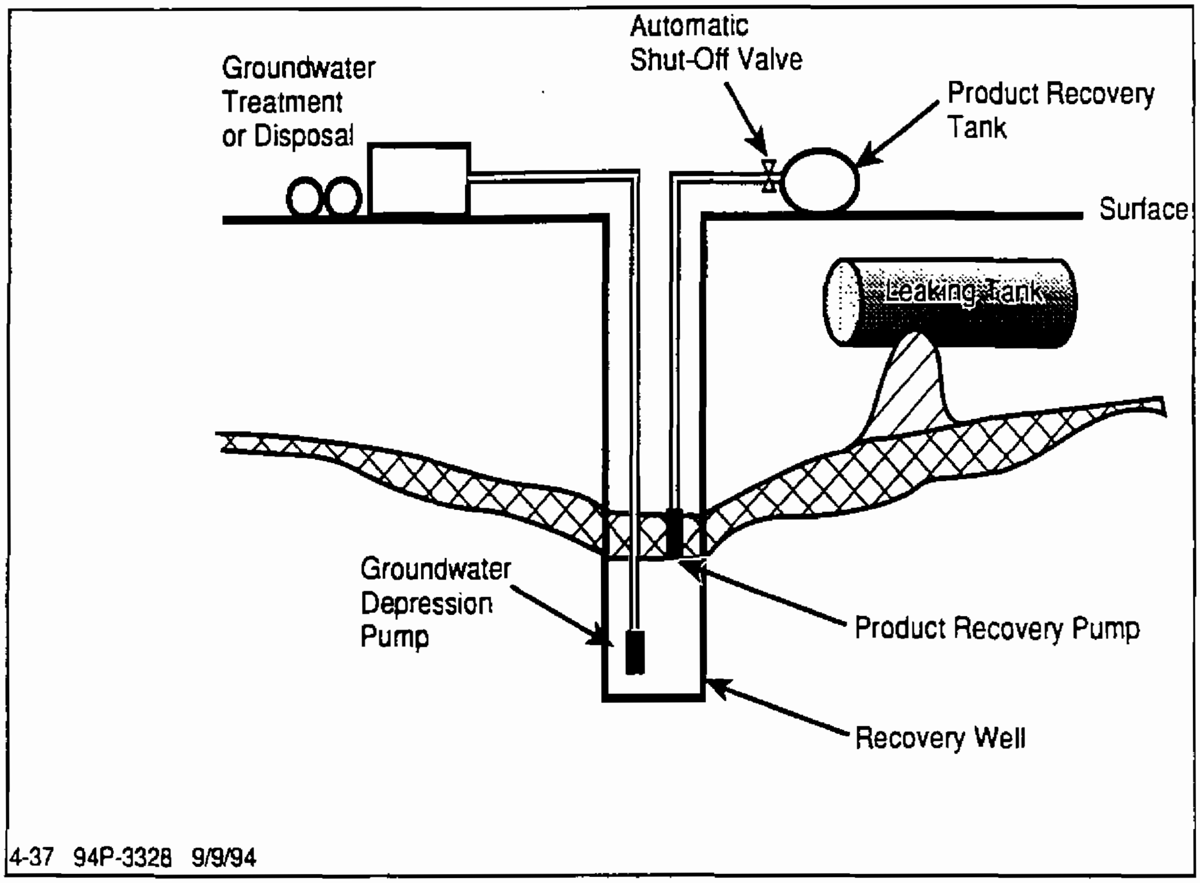
EPA, 1992. *McColl Superfund Site — Demonstration of a Trial Excavation*. EPA RREL, series include Technology Evaluation EPA/S40/R-92/015, PB92-226448; Applications Analysis, EPA/540/AR-92/015; and Technology Demonstration. Summary, EPA/540/SR/-92/015.

Points of Contact:

Contact	Government Agency	Phone	Location
Jaffer Mohiuddin	DOE Program Manager	(301) 903-7965	EM-552, Trevion II Washington, DC 20585
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

4.37 FREE PRODUCT RECOVERY

Description: Undissolved liquid-phase organics are removed from subsurface formations, either by active methods (e.g., pumping) or a passive collection system. This process is used primarily in cases where a fuel hydrocarbon lens more than 20 centimeters (8 inches) thick is floating on the water table. The free product is generally drawn up to the surface by a pumping system. Following recovery, it can be disposed of, re-used directly in an operation not requiring high-purity materials, or purified prior to re-use. Systems may be designed to recover only product, mixed product and water, or separate streams of product and water (i.e., dual pump or dual well systems). Free product recovery is a full-scale technology.



4-37 TYPICAL FREE PRODUCT RECOVERY DUAL PUMP SYSTEM

Applicability: The target contaminant groups for free product recovery are SVOCs and fuels.

Limitations: The following factors may limit the applicability and effectiveness of the process:

- Site geology and hydrogeology.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Groundwater, Surface Water, and Leachate).

The potential for accumulation of liquid phase product that is free to move by gravity above the water table is dependent on several factors, including physical and chemical properties of the product released (e.g., viscosity, density, composition, and solubility in water); soil properties (e.g., capillary forces, effective porosity, moisture content, organic content, hydraulic conductivity, and texture); nature of the release (e.g., initial date of occurrence, duration, volume, and rate); geology (e.g., stratigraphy that promotes trapped pockets of free product); hydrogeologic regime (e.g., depth to water table, groundwater flow direction, and gradient); and anticipated product recharge rate.

Performance Data: Once free product is detected, the immediate response should include both removal of the source and recovery of product by the most expedient means. Free product recovery methods will often extract contaminated water with the product. If economically desirable, water and product can be separated by gravity prior to disposal or recycling of the product. As a result of the removal of substantial quantities of water during dual pumping operations, on-site water treatment will normally be required. When treatment of recovered water is required, permits will usually be necessary.

Cost: Because of the number of variances involved, establishing general costs for free product response is difficult. Some representative costs are $500 per month for a single phase extraction (hand bailing) system; $1,200 to $2,000 per month for a single phase extraction (skimming) system; and $2,500 to $4,000 per month for a dual pumping system. These costs illustrate the relative magnitudes of the various recovery options available, which are typically less than other types of remediation.

Key cost factors for the recovery of free product include waste disposal, potential for sale of recovered product for recycling, on-site equipment rental (e.g., pumps, tanks, treatment systems), installation of permanent equipment, and engineering and testing costs.

References:

American Petroleum Institute, 1989. *A Guide to the Assessment and Remediation of Underground Petroleum Releases*, Publication 1628, API, Washington, DC, 81 pp.

EPA, 1988. *Cleanup of Releases from Petroleum USTs: Selected Technologies*, Washington, DC, EPA/530/UST-88/001.

Kram, M.L., 1990. *Measurement of Floating Petroleum Product Thickness and Determination of Hydrostatic Head in Monitoring Wells*, NEESA Energy and Environmental News Information Bulletin No. 1B-107.

Kram, M.L., 1993. *Free Product Recovery: Mobility Limitations and Improved Approaches*. NFESC Information Bulletin No. IB-123.

NEESA, 1992. *Immediate Response to Free Product Discovery*. NEESA Document No. 20.2-051.4.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Navy Gasoline Station Coastal Area	Mark Kram NFESC Code 413	>0.25 ft floating product; dual pumping extraction and thermal vacuum spray aeration and spray aeration vacuum extraction	About 12,000 gallons of gasoline	4,000 gallons recovered by diesel pump	$75,000 plus vapor extraction costs
Navy Fuel Farm	Mike Radecki SOUTHWESTDIV	0.5-2.5 ft free product. Captured in pit and pumped out with skimmers and french drains	NA	NA	$300,000 to date
Privately Owned Gasoline Station Near Urban Drinking Water Source	Connecticut DEP (203) 566-4630	Immediate response recovery wells and air stripping	NA	NA	NA
Various USAF and Navy Sites	USAF Armstrong Lab/ EQW Tyndall AFB, FL (904) 283-6208 Ron Hoeppel (805) 982-1655	"Bioslurping" technology demonstrations	NA	NA	NA

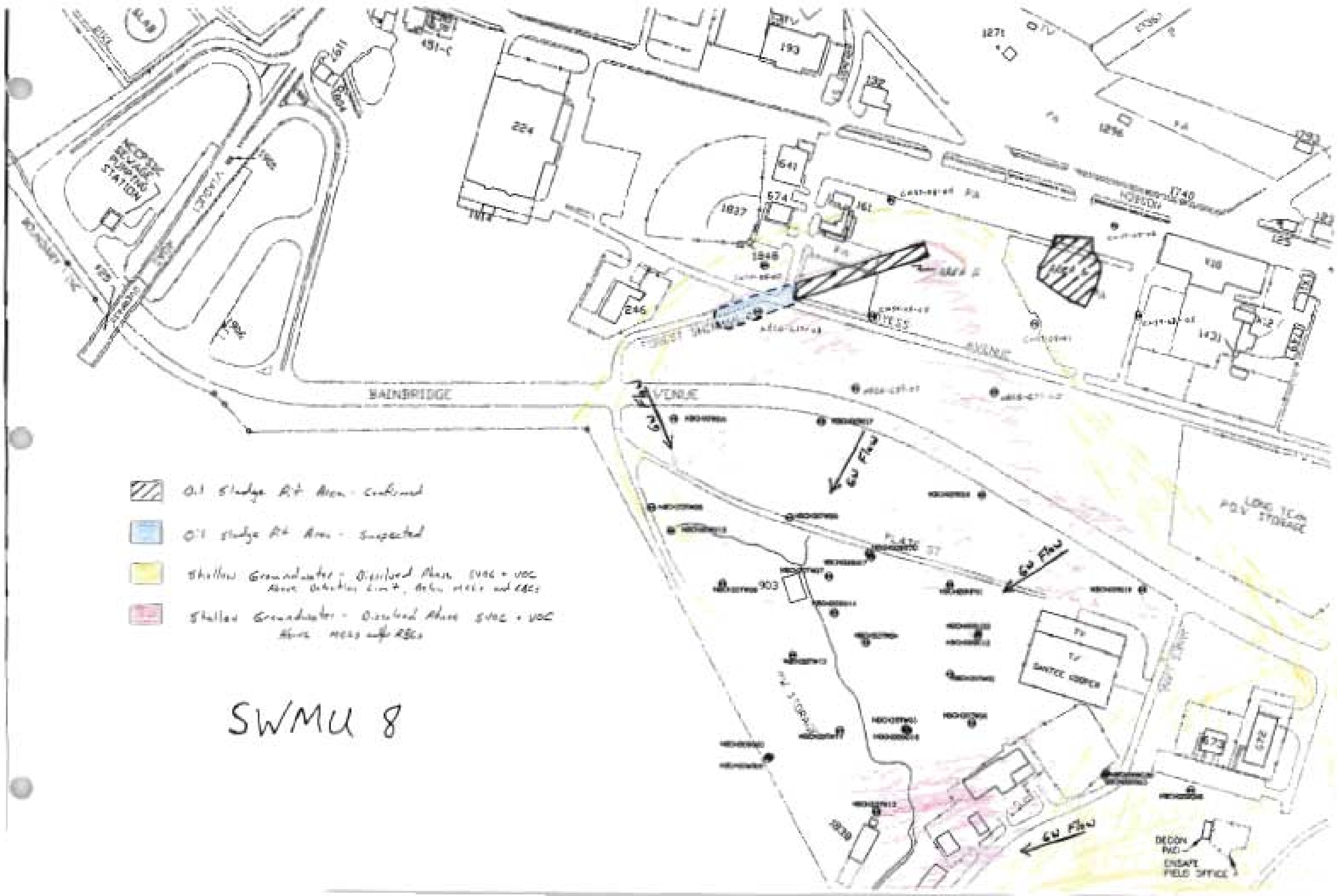
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Mark Kram	NFESC	(805) 982-2669	Code 413 Port Hueneme, CA 93043
Mike Radecki	SOUTHWESTDIV	(619) 532-3874	San Diego, CA
Tom Schruben	EPA Office of USTs	(703) 308-8875	Washington, DC
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

SWMU 8

SITE FIGURES



SWMU 8
Oil Sludge Pit Area - Confirmed
Oil Sludge Pit Area - Suspected
Shallow Groundwater - Dissolved Phase SVOC + VOC Above Detection Limit, Below MCLs and RBCs
Shallow Groundwater - Dissolved Phase SVOC + VOC Above MCLs and RBCs
BAINBRIDGE
AVENUE
HOBSON
SEWAGE PUMPING STATION
VIADUCT
224
246
1837
574
641
161
193
903
GW Flow
LONG TERM P.O.V. STORAGE
DECON PAD
ENSAFE FIELD OFFICE

AOC 607 - Summary of Applicable RFI Data

The former dry-cleaning facility in Building 1189 operated from 1942 to 1986 and also supported the local seamen's housing area. It was used as a general purpose laundry with two industrial washers and dryers during the end of its operational period. The building also contains office space most recently used for miscellaneous storage.

PCE, TCE, DCE, and vinyl chloride have been detected at concentrations above MCLs in the shallow and intermediate portions of the surficial aquifer. Concentrations of PCE were detected as high as 45,000 μg/L in well NBCF-607-006. Low concentrations of contaminant were also found in a single deep well immediately after well construction. However, solvent contamination was not found in any deep well during subsequent sampling events and therefore it is believed that groundwater contamination is limited to the shallow and intermediate levels only.

VOC contaminated groundwater is infiltrating the sanitary sewer line. The infiltration is creating a depression in the piezometric surface which appears to have slowed the lateral migration of contamination. The lateral migration that has occurred appears to be along the sewer line which may be creating a preferential pathway.

AOC 607 - EISM Conceptual Plan

Objective

Mass removal of contaminant (chlorinated solvent) in groundwater. Replacement of the hydraulic control currently caused by the infiltration of groundwater into the adjacent sanitary sewer line.

Task 1

Sample existing site wells and analyze groundwater for monitored natural attenuation parameters. Complete this task in accordance with monitored natural attenuation guidelines currently established by the USGS for SDIV. Also incorporate any other previous and site- or area-specific groundwater sampling event information containing monitored natural attenuation parameters.

Purpose

To establish a base line, as well as an initial line of evidence to demonstrate monitored natural attenuation of chlorinated solvents.

Task 2

Conduct a soil gas survey through foot print of Building 1189.

Purpose

To better define the extent of groundwater contamination below building foot print and to better identify the potential source. This information is required to optimize placement of the remedial treatment system as described in Task 4.

Task 3

Complete some aquifer characterization tests such as slug tests and/or pump tests.

Purpose

To obtain aquifer characteristics that will be required in the subsequent remedial alternative feasibility evaluations.

Task 4

Based on known site conditions and the result of Task 2, design and install an air-sparging/SVE pilot system in the area of greatest groundwater contamination.

Purpose

A pilot study is required to determine remedial system performance capabilities and limitations.

Task 5

Remove potential UST at northwest corner of building and raze building if either activity aids the installation and completion of the pilot study remediation system.

Purpose

To ease implementation of pilot study remediation system.

Task 6

Develop and implement a remedial system optimization plan. Test run the remedial system to identify optimal operating conditions. As an example, cycle system on and off at various intervals to determine maximum contaminant reduction potential. System optimization is a direct function of site conditions and system design.

Purpose

This is the essence of a pilot test, to determine optimal operating parameters and, if needed, scale-up design considerations. In addition, it is important that the system be properly calibrated to maximize contaminant reduction.

End Point

Operate remedial system and demonstrate effectiveness of monitored natural attenuation until the CMS process is completed and a final remedy is selected.

AOC 607

REMEDIAL TECHNOLOGY PROFILES

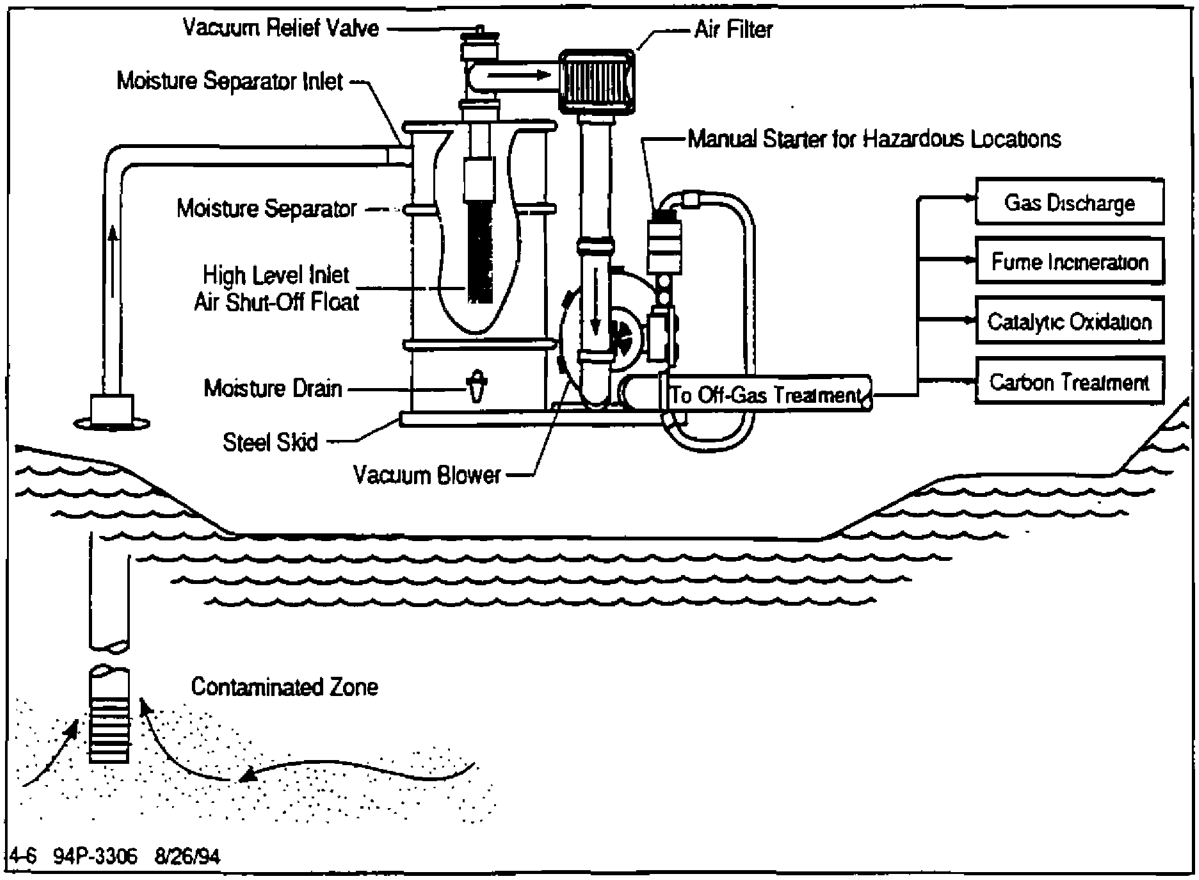
Soil Vapor Extraction

Air Sparging

Natural Attenuation

4.6 SOIL VAPOR EXTRACTION (IN SITU)

Description: Soil vapor extraction (SVE) is an in situ unsaturated (vadose) zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile and some semivolatile contaminants from the soil. The gas leaving the soil may be treated to recover or destroy the contaminants, depending on local and state air discharge regulations. Vertical extraction vents are typically used at depths of 1.5 meters (5 feet) or greater and have been successfully applied as deep as 91 meters (300 feet). Horizontal extraction vents (installed in trenches or horizontal borings) can be used as warranted by contaminant zone geometry, drill rig access, or other site-specific factors.



4-6 TYPICAL IN SITU SOIL VAPOR EXTRACTION SYSTEM

Groundwater depression pumps may be used to reduce groundwater upwelling induced by the vacuum or to increase the depth of the vadose zone. Air injection is effective for facilitating extraction of deep contamination, contamination in low permeability soils, and contamination in the saturated zone (see Treatment Technology Profile 4.34, Air Sparging).

Applicability: The target contaminant groups for SVE are VOCs and some fuels. The technology is typically applicable only to volatile compounds with a Henry's law constant greater than 0.01 or a vapor pressure greater than 0.5 mmHg (0.02 inches Hg). Other factors, such as the moisture content, organic content, and air permeability of the soil, will also affect SVE's effectiveness. SVE will not remove heavy oils, metals, PCBs, or dioxins. Because the process involves the continuous flow of air through the soil, however, it often promotes the in situ biodegradation of low-volatility organic compounds that may be present.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Soil that is tight or has high moisture content (>50%) has a reduced permeability to air, requiring higher vacuums (increasing costs) and/or hindering the operation of SVE.
- Large screened intervals are required in extraction wells for soil with highly variable permeabilities or horizonation, which otherwise may result in uneven delivery of gas flow from the contaminated regions.
- Soil that has high organic content or is extremely dry has a high sorption capacity of VOCs, which results in reduced removal rates.
- Air emissions may require treatment to eliminate possible harm to the public and the environment.
- As a result of off-gas treatment, residual liquids and spent activated carbon may require treatment/disposal.
- SVE is not effective in the saturated zone; however, lowering the water table can expose more media to SVE (this may address concerns regarding LNAPLs).

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Data requirements include the depth and areal extent of contamination, the concentration of the contaminants, depth to water table, and soil type and properties (e.g., structure, texture, permeability, and moisture content).

Pilot studies should be performed to provide design information, including extraction well, radius of influence, gas flow rates, optimal applied vacuum, and contaminant mass removal rates.

Performance Data: A field pilot study is necessary to establish the feasibility of the method as well as to obtain information necessary to design and configure the system. During full-scale operation, SVE can be run intermittently (pulsed operation) once the extracted mass removal rate has reached an asymptotic level. This pulsed operation can increase the cost-effectiveness of the system by facilitating extraction of higher concentrations of contaminants. After the contaminants are removed by SVE, other remedial measures, such as biodegradation, can be investigated if remedial action objectives have not been met. SVE projects are typically completed in 18 months.

Cost: The cost of SVE is site-specific, depending on the size of the site, the nature and amount of contamination, and the hydrogeological setting (EPA, July 1989). These factors affect the number of wells, the blower capacity and vacuum level required, and the length of time required to remediate the site. A requirement for off-gas treatment adds significantly to the cost. Water is also frequently extracted during the process and usually requires treatment prior to disposal, further adding to the cost. Cost estimates for SVE range between $10 and $50 per cubic meter ($10 and $40 per cubic yard) of soil. Pilot testing typically costs $10,000 to $100,000.

References:

EPA, 1989. *Terra Vac, In Situ Vacuum Extraction System*, EPA RREL, Applications Analysis Report, Cincinnati, OH, EPA Report EPA/540/A5-89/003.

EPA, 1989. *Terra Vac — Vacuum Extraction*, EPA RREL, series includes Technology Evaluation, Vol. I, EPA/540/5-89/003a, PB89-192025; Technology Evaluation, Vol. II, EPA/540/A5-89/003b; Applications Analysis, EPA/540/A5-89/003; Technology Demonstration Summary, EPA/540/S5-89/003; and Demonstration Bulletin, EPA/540/M5-89/003.

EPA, 1990. *State of Technology Review: Soil Vapor Extraction System Technology*, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, EPA/600/2-89/024.

EPA, 1991. *AWD Technologies, Inc. — Integrated Vapor Extraction and Stream Vacuum Stripping*, EPA RREL, series includes Applications Analysis, EPA/540/A5-91/002, PB89-192033, and Demonstration Bulletin, EPA/540/M5-89/003.

EPA 1991. *Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction*, OERP, Washington, DC, EPA Report EPA/540/2-91/019A.

EPA, 1991. *In-Situ Soil Vapor Extraction Treatment*, Engineering Bulletin, RREL, Cincinnati, OH, EPA/540/2-91/006.

EPA, 1991. *Soil Vapor Extraction Technology Reference Handbook*, EPA, RREL, Cincinnati, OH, T.A. Pederson and J.T. Curtis, Editors, EPA/540/2-91/003.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
DOE, Savannah River, Aiken, SC	Brian B. Looney Westinghouse Savannah River Co. P.O. Box 616 Aiken, SC 29802 (803) 725-3692	Horizontal wells are concurrently used to remediate soils and groundwater.	1,800 ppb TCE	30 ppb TCE	Demo — $44/kg Prep — $300,000-$450,000
Groveland Wells Superfund Site Groveland, MA	Mary Stinson EPA Technical Support Branch, RREL 2890 Woodbridge Ave. Building 10 Edison, NJ 08837-3679 (908) 321-6683 Terra Vac (714) 252-8900	Pilot system	3-350 ppm TCE	Non-detect to 39 ppm TCE	$30 to $75 per metric ton ($30 to $70 per ton) of soil
Hill AFB, UT	Major Mark Smith USAF	Full-scale system at JP-4 jet fuel spill site	NA	NA	NA
Letterkenny AD Chambersburg, PA	USAEC ETD Bldg. 4435 APG, MD 21010 (410) 671-2054	Large-scale (>50 vents) pilot system. 1,530 m^3 (2,000 yd^3) treated.	> 1,000 ppm total VOCs	NA	$2M design, install, and operation.

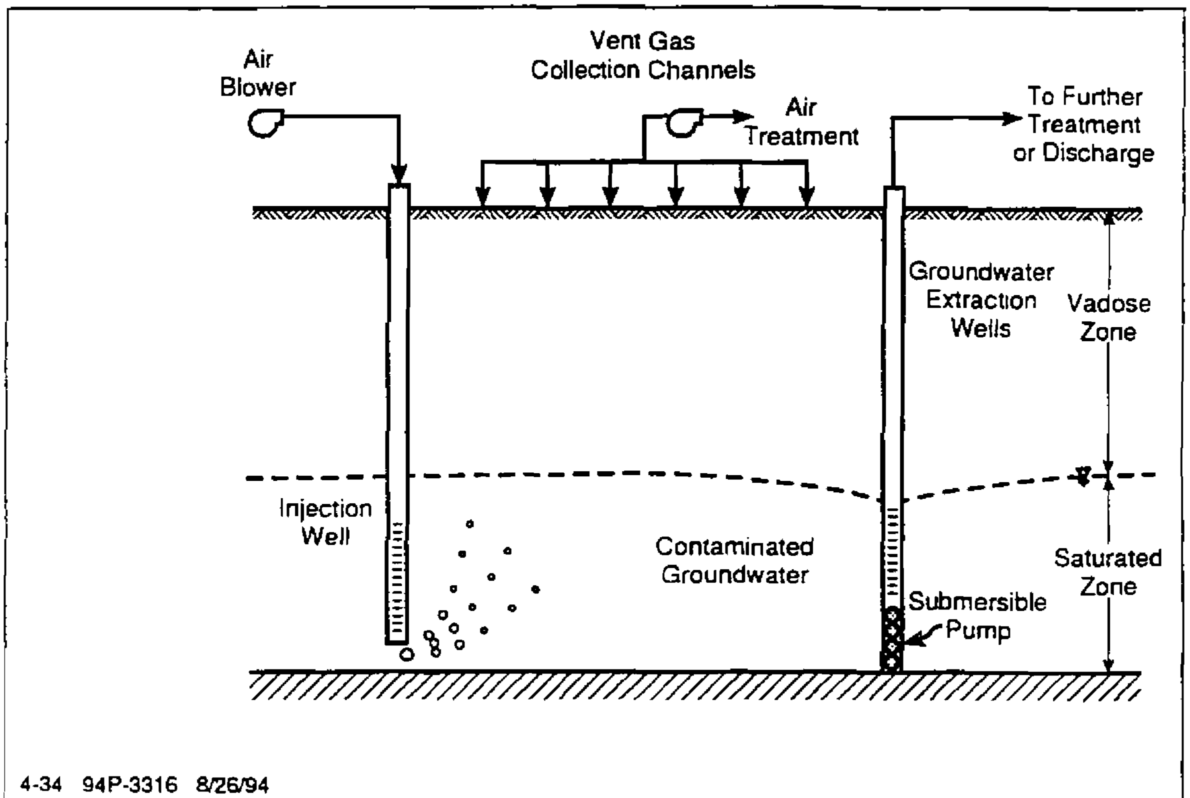
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Mike O'Rear	DOE Savannah River	(803) 725-5541	Aiken, SC
Ramon Mendoza	EPA Region IX	(415) 744-2410	75 Hawthorne Street San Francisco, CA 94105
Arthur L. Baehr	USGS	(609) 771-3978	810 Bear Tavern Rd., Suite 206 West Trenton, NJ 08628
Michael Gruenfeld	EPA Releases Control Branch, RREL	(908) 321-6625	2890 Woodbridge Ave. MS-104 Edison, NJ 08837-3679
Stacy Erikson	EPA	(303) 294-1084	One Denver Place 999 18th Street Denver, CO 80202-2466
Major Mark Smith	USAF	(904) 283-6126	AL/EQW Tyndall AFB, FL 32403
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401
Mary K. Stinson	EPA Technical Support Branch, RREL	(908) 321-6683	2890 Woodbridge Ave MS-104 Edison, NJ 08837-3679

4.34 AIR SPARGING

Description: Air sparging is an in situ technology in which air is bubbled through a contaminated aquifer. Air bubbles traverse horizontally and vertically through the soil column, creating an underground stripper that removes contaminants by volatilization. These air bubbles carry the contaminants to a vapor extraction system. Vapor extraction is implemented in conjunction with air sparging to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between groundwater and soil and strip more groundwater by sparging.



4-34 TYPICAL AIR SPARGING SYSTEM

Applicability: The target contaminant groups for air sparging are VOCs and fuels. Only limited information is available on the process.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Depth of contaminants and specific site geology must be considered.
- Air injection wells must be designed for site-specific conditions.
- Air flow through the saturated zone may not be uniform.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Groundwater, Surface Water, and Leachate). Characteristics that should be determined include vadose zone gas permeability, groundwater flow rate, aquifer permeability, presence of low permeability layers, presence of DNAPLs, depth of contamination, and contaminant volatility and solubility.

Performance Data: This technology will be demonstrated over the next 2 to 3 years at DOE's Hanford Reservation as part of the agency's Integrated Technology Demonstration Program for Arid Sites. Air sparging has demonstrated sensitivity to minute permeability changes, which can result in localized stripping between the sparge and monitoring wells.

Cost: One estimate, $371,000 to $865,000 per hectare ($150,000 to $350,000 per acre) of groundwater plume to be treated, was available.

References: Hildebrandt, W. and F. Jasiulewicz, 1992. "Cleaning Up Military Bases," *The Military Engineer*, No. 55, p. 7, September-October 1992.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Savannah River, IL	NA	NA	PCE 3-124 TCE 10-1,031	<184 ppb <1.8 ppb	NA
Conservancy Site Belen, NM	NA	NA	BTX	49-60% reduction	NA

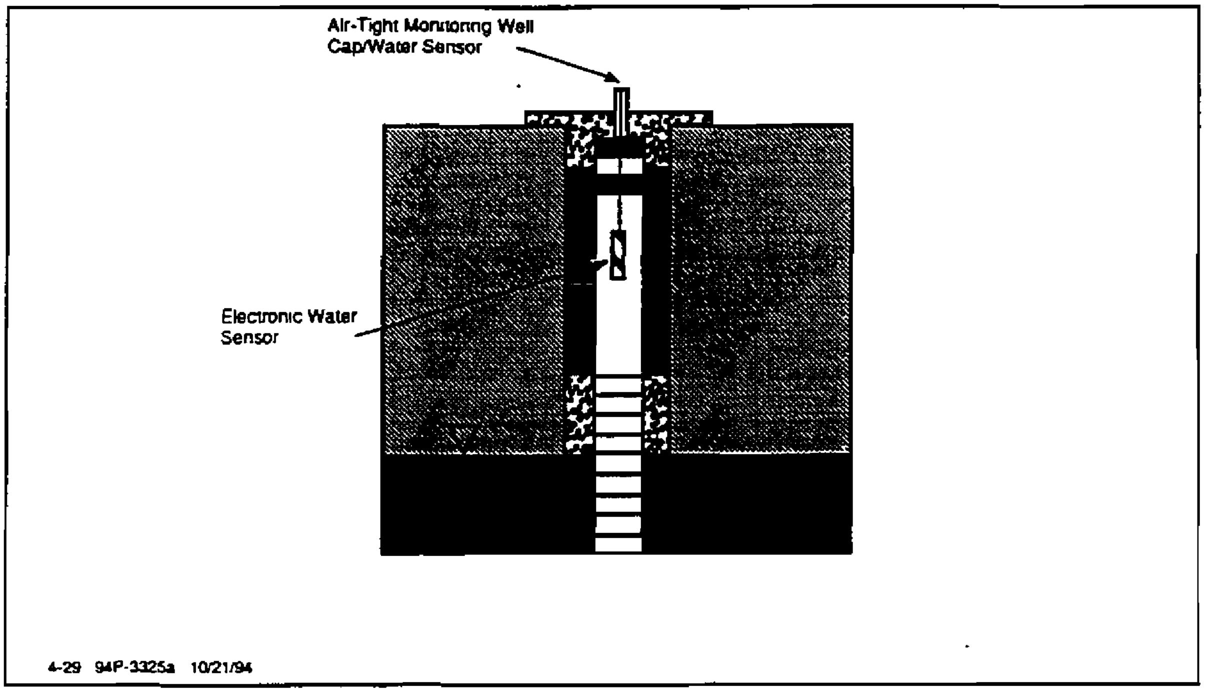
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Steve Stein	Environmental Management Organization, Pacific Northwest Division	(206) 528-3340	4000 N.E. 41st Street Seattle, WA 98105
Steven M. Gorelick	Stanford University Dept. of Applied Earth Sciences	(415) 725-2950	Stanford, CA 94305-2225
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

4.29 NATURAL ATTENUATION

Description: For natural attenuation, natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels. Natural attenuation is not a "technology" per se, and there is significant debate among technical experts about its use at hazardous waste sites. Consideration of this option requires modeling and evaluation of contaminant degradation rates and pathways. The primary objective of site modeling is to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards before potential exposure pathways are completed. In addition, sampling and sample analysis must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.



4-29 TYPICAL MONITORING WELL CONSTRUCTION DIAGRAM

Natural attenuation is not the same as "no action," although it often is perceived as such. CERCLA requires evaluation of a "no action" alternative but does not require evaluation of natural attenuation. Natural attenuation is considered in the Superfund program on a case-by-case basis, and guidance on its use is still evolving. It has been selected at Superfund sites where, for example, PCBs are strongly sorbed to deep subsurface soils and are not migrating; where removal of DNAPLs has been determined to be technically impracticable [Superfund is developing technical impracticability (TI) guidance]; and where it has been determined that active remedial measures would be unable to significantly speed remediation time frames. Where contaminants are expected to remain in place over long periods of time, as in the first two examples, TI waivers must be obtained. In all cases, extensive site characterization is required.

The attitude toward natural attenuation varies among agencies. USAF carefully evaluates the potential for use of natural attenuation at its sites; however, EPA accepts its use only in certain special cases.

Applicability: Target contaminants for natural attenuation are nonhalogenated VOCs, SVOCs, and fuel hydrocarbons. Halogenated VOCs and SVOCs and pesticides may be less responsive to natural attenuation.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Data must be collected to determine model input parameters.
- Although commercial services for evaluating natural attenuation are widely available, the quality of these services varies widely among the many potential suppliers. Highly skilled modelers are required.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation should be used only where there are no impacts on potential receptors.
- Contaminants may migrate before they are degraded.
- The site may have to be fenced and may not be available for re-use until contaminant levels are reduced.
- If source material exists, it may have to be removed.
- Some inorganics can be immobilized, such as mercury, but they will not be degraded.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge).

Many potential suppliers can perform the modeling, sampling, and sample analysis required for justifying and monitoring natural attenuation. The extent of contaminant degradation depends on a variety of parameters, such as contaminant types and concentrations, temperature, moisture, and availability of nutrients/electron acceptors (e.g., oxygen and nitrate).

When available, information to be obtained during data review includes:

- Soil and groundwater quality data:
    - Three-dimensional distribution of residual-, free-, and dissolved-phase contaminants. The distribution of residual- and free-phase contaminants will be used to define the dissolved-phase plume source area.

- Groundwater and soil geochemical data.
- Chemical and physical characteristics of the contaminants.
- Potential for biodegradation of the contaminants.

- Geologic and hydrogeologic data:
  - Lithology and stratigraphic relationships.
  - Grain-size distribution (sand vs. silt vs. clay).
  - Flow gradient.
  - Preferential flow paths.
  - Interaction between groundwater and surface water.
  - Location of potential receptors: groundwater, wells, and surface water discharge points.

Performance Data: Natural attenuation has been selected by AFCEE for remediation at 45 USAF sites.

Cost: There are costs for modeling contamination degradation rates to determine whether natural attenuation is a feasible remedial alternative. Additional costs are for subsurface sampling and sample analysis (potentially extensive) to determine the extent of contamination and confirm contaminant degradation rates and cleanup status. Skilled labor hours are required to conduct the modeling, sampling, and analysis. O&M costs would be required for monitoring to confirm that contaminant migration has not occurred.

References:

Scovazzo, P.E., D. Good, and D.S. Jackson, 1992. "Soil Attenuation: In Situ Remediation of Inorganics," in *Proceedings of the HMC/Superfund 1992*, HMCRI, Greenbelt, MD.

Bailey, G.W., and J.L. White, 1970. "Factors Influencing the Adsorption, Desorption, and Movement of Pesticides in Soil," in *Residue Reviews*, F.A. Gunther and J.D. Gunther, Editors, Springer Verlag, pp. 29-92.

Hassett, J.J., J.C. Means, W.L. Banwart, and S.G. Woods, 1980. *Sorption Properties of Sediments and Energy-Related Pollutants*, EPA, Washington, DC, EPA/600/3-80-041.

Hassett, J.J., W.L. Banwart, and R.A. Griffin, 1983. "Correlations of Compound Properties with Sorption Characteristics of Nonpolar Compounds by Soils and Sediments; Concepts and Limitations," *Environment and Solid*

Wastes, pp. 161-178, C.W. Francis and S.I. Auerbach, Editors, Butterworths, Boston, MA.

Jeng, C.Y., D.H. Chen, and C.L. Yaws. 1992. "Data Compilation for Soil Sorption Coefficient," *Pollution Engineering*, 15 June 1992.

Miller, R.N. 1990. "A Field-Scale Investigation of Enhanced Petroleum Hydrocarbon Biodegradation in the Vadose Zone at Tyndall Air Force Base, Florida," in *Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Groundwater*, pp. 339-351, Prevention, Detection, and Restoration Conference: NWAA/API.

Wiedemeier, T.H., D.C. Downey, J.T. Wilson, D.H. Kampbell, R.N. Miller, and J.E. Hansen. 1994. *Technical Protocol for Implementing the Intrinsic Remediation (Natural Attenuation) with Long-Term Monitoring Option for Dissolved-Phase Fuel Contamination in Ground Water*. Brooks Air Force Base, San Antonio, TX.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Hill AFB, UT	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA
Eglin AFB, FL	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA
Elmendorf AFB, AL	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA

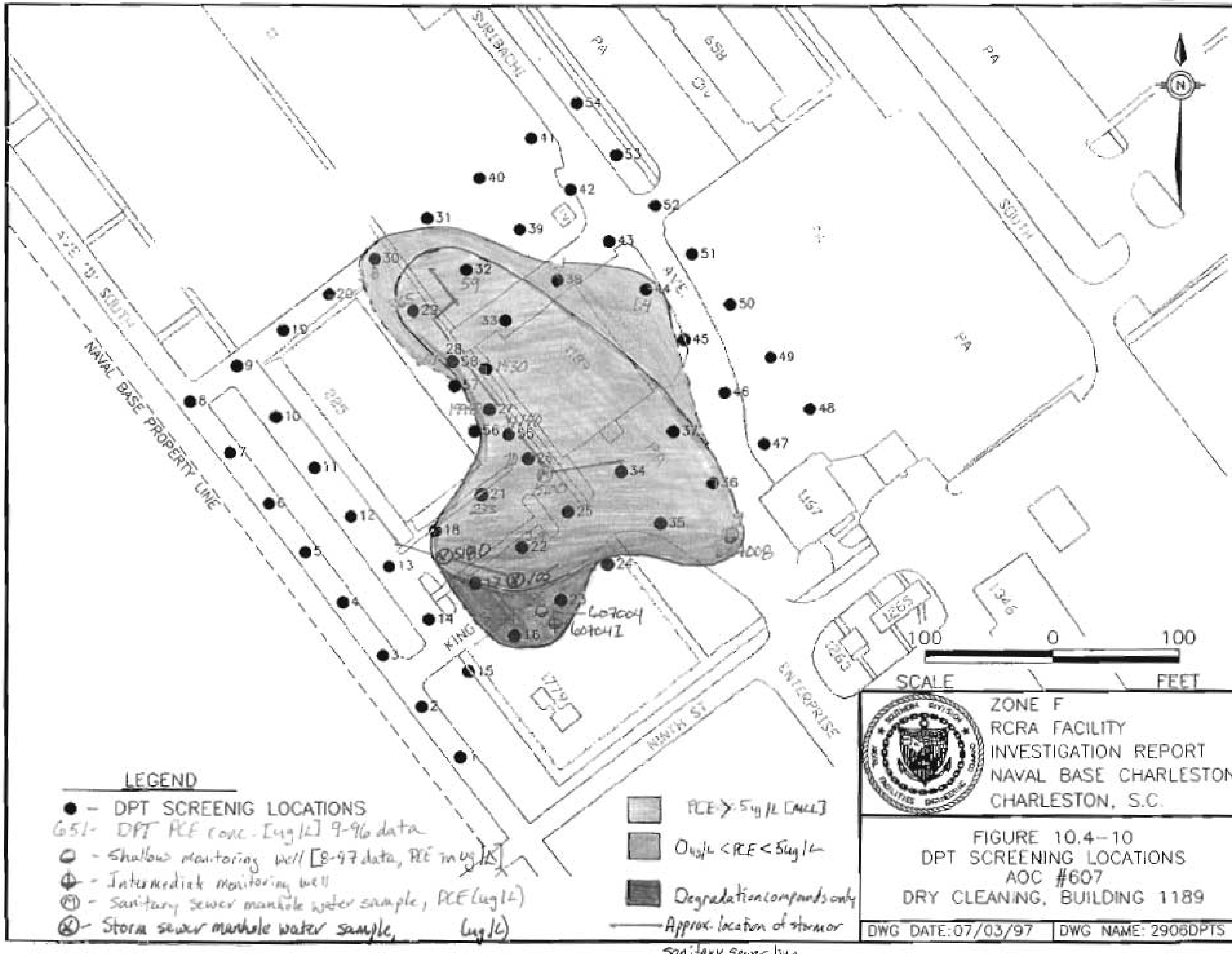
Note: NA = Not available.

Points of Contact:

Contact	Government Agency	Phone	Location
Capt. Tom Venoge	USAF	(904) 283-6205	AL-EQW Tyndall AFB, FL 32403
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

AOC 607

SITE FIGURES



ZONE F
RCRA FACILITY
INVESTIGATION REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

FIGURE 10.4–10
DPT SCREENING LOCATIONS
AOC #607
DRY CLEANING, BUILDING 1189

DWG DATE: 07/03/97 | DWG NAME: 2906DPTS

SWMU 166 - Summary of Applicable RFI Data

SWMU 166 consists of the sanitary sewer system serving the Naval Annex, excluding the housing area. It is comprised of approximately 5,300 linear feet of gravity sewer lines. Most lines are constructed of vitrified clay, although some are constructed of ductile iron, cast iron, PVC, or polypropylene. A former septic tank and drainfield were also identified during research of the sewer system.

In the course of the sanitary sewer investigation, TCE was discovered in groundwater. Subsequent sampling identified an area of surface soil, independent of the sanitary sewer line, as the probable source for the VOC. In addition, a groundwater plume was identified in the same area as the soil source zone.

Chlorinated solvents have been detected in soil at concentrations up to 59 ppm. Subsurface concentrations were detected as high as 3.9 ppm with the concentrations of with individual constituents exceeding their respective SSLs.

Chlorinated solvent contamination in groundwater has been detected at the property boundary at a concentration of 3,940 μg/L.

An investigation of offsite groundwater contamination of a similar type is currently in progress.

Recent information obtained in mid September 1997 has identified impacted groundwater from a drain system that runs under and parallel to the interstate. It is believed that the subsurface drainage system is intercepting groundwater. These drainage pipes eventually flow somewhere and it is apparent that additional investigation will occur at the outfall or receiving area of these pipes.

SWMU 166 - EISM Conceptual Plan

Objective

Decrease solvent mass at estimated source center of plume and mitigate plume at site boundary.

Task 1

Sample existing site wells and analyze groundwater for monitored natural attenuation parameters. Complete this task in accordance with monitored natural attenuation guidelines currently established by the USGS for SDIV. Also incorporate any other previous and site- or area-specific groundwater sampling event information containing monitored natural attenuation parameters.

Purpose

To establish a base line, as well as an initial line of evidence to demonstrate monitored natural attenuation of chlorinated solvents.

Task 2

The source zone (e.g., chlorinated solvent-impacted soil) for this site has been relatively well defined through existing RFI activities. Therefore, excavate soil from area suspected to be the source zone. Risk-derived RGOs indicate a source zone of less than ten square feet. However, as a conservative estimate, an area of approximately 20 feet by 20 feet will be excavated down to the shallow water table. Transport excavated soil offsite for treatment/disposal or reuse. Obtain appropriate confirmation samples and backfill excavation with clean soil, tamp, and level to existing grade.

Purpose

This task's intent is to ensure that all known soil source material of significant risk and/or soil to groundwater migration potential is quickly and permanently removed from the site. Excavation with offsite treatment/disposal or reuse is a simple and fast remedial alternative for relatively small areas considered to be contaminant source zones.

Task 3

Complete some aquifer characterization tests such as slug tests and/or pump tests.

Purpose

To obtain aquifer characteristics that will be required in the subsequent remedial alternative feasibility evaluations.

Task 4

Boundary EISM: Conduct a comparative cost and feasibility analysis between two remedial alternatives at the property boundary near I-26. The first alternative consist of a funnel and gate slurry wall plus in-well air-strippers, and the second alternative consists of the same funnel and gate system plus air-sparging/SVE units. The treatment systems are to be placed immediately upgradient from the gateway.

Purpose

Self explained.

Task 5

Plume EISM: Conduct a comparative cost and feasibility analysis between two remedial alternatives for the plume center. The first alternative consist of in-well air-strippers and the second alternative consists of air-sparging/SVE units.

Purpose

Self explained.

Task 6

Based on site conditions and the results of groundwater modeling, design and install a funnel and gate system in impacted area at the property boundary near I-26.

Purpose

A funnel and gate system will offer site boundary hydraulic control and will permit remedial activity to occur in the area of highest groundwater contamination immediately upgradient of the gate(s).

Task 7

Boundary EISM: Based on the results of Task 4, design and install a pilot prototype of the selected remedial alternative immediately upgradient of the gate(s).

Purpose

A pilot study is required to determine remedial system performance capabilities and limitations.

Task 8

Plume EISM: Based on the results of Task 5, design and install a pilot prototype of the selected remedial alternative near the center of the plume or in the area of the plume most optimal for the selected remedial alternative.

Purpose

A pilot study is required to determine remedial system performance capabilities and limitations.

Task 9

Develop and implement two remedial systems optimization plans. Test run each remedial system to identify optimal operating conditions. As an example, cycle system on and off at various intervals to determine maximum contaminant reduction potential. System optimization is a direct function of site conditions and system design.

Purpose

This is the essence of a pilot test, to determine optimal operating parameters and, if needed, scale-up design considerations. In addition, it is important that the system be properly calibrated to maximize contaminant reduction.

End Point

Operate remedial systems and demonstrate effectiveness of monitored natural attenuation until the CMS process is completed and a final remedy is selected.

SWMU 166

REMEDIAL TECHNOLOGY PROFILES

Slurry Wall

In Well Air Stripping

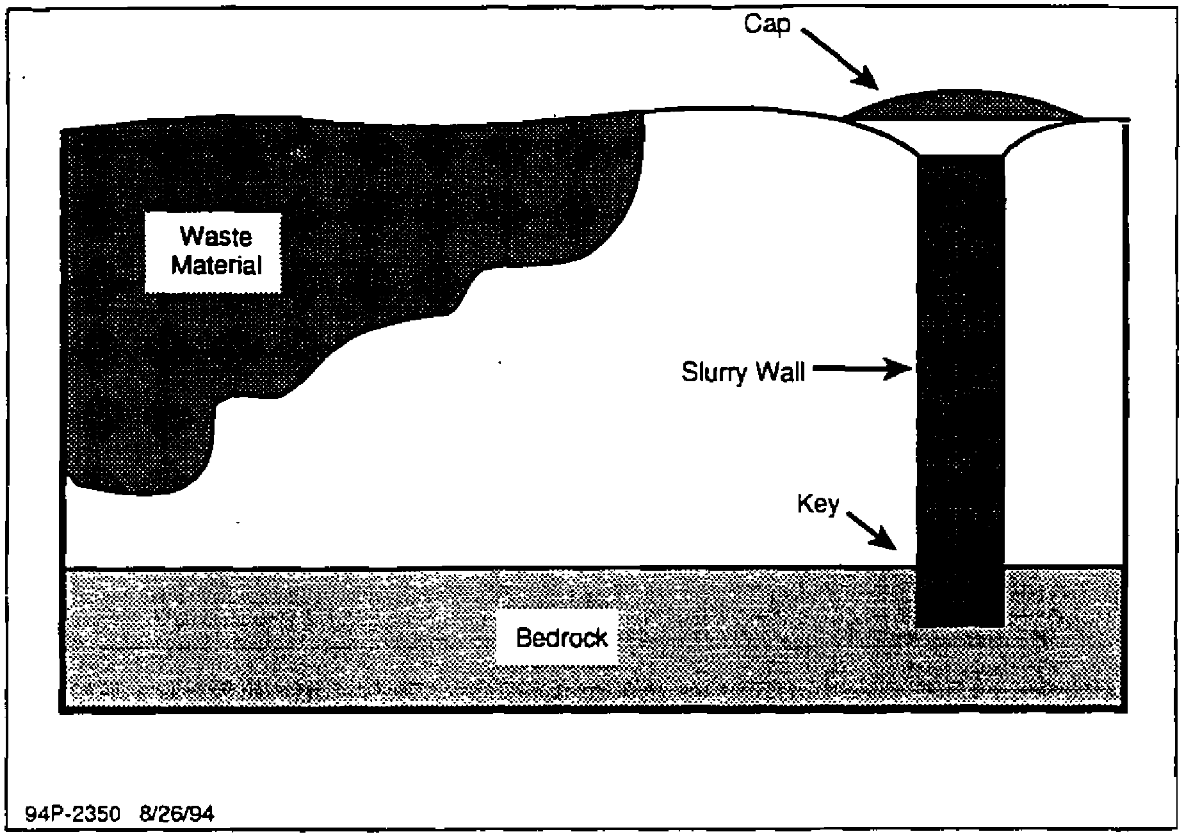
Air Sparging

Soil Vapor Extraction

Excavation, Retrieval and Offsite Disposal

4.41 SLURRY WALLS

Description: Slurry walls are used to contain contaminated groundwater, divert contaminated groundwater from the drinking water intake, divert uncontaminated groundwater flow, and/or provide a barrier for the groundwater treatment system.



4-41 TYPICAL KEYED-IN SLURRY WALL (CROSS SECTION)

These subsurface barriers consist of a vertically excavated trench that is filled with a slurry. The slurry hydraulically shores the trench to prevent collapse and forms a filter cake to reduce groundwater flow. Slurry walls often are used where the waste mass is too large for treatment and where soluble and mobile constituents pose an imminent threat to a source of drinking water.

Slurry walls are a full-scale technology that have been used for decades as long-term solutions for controlling seepage. They are often used in conjunction with capping. The technology has demonstrated its effectiveness in containing greater than 95% of the uncontaminated groundwater; however, in contaminated groundwater applications, specific contaminant types may degrade the slurry wall components and reduce the long-term effectiveness.

Most slurry walls are constructed of a soil, bentonite, and water mixture; walls of this composition provide a barrier with low permeability and chemical resistance at low cost. Other wall compositions, such as sheet piling, cement, bentonite, and water, may be used if greater structural strength is required or if chemical incompatibilities between bentonite and site contaminants exist.

Slurry walls are typically placed at depths less than 15 meters (50 feet) and are generally 0.6 to 1.2 meters (2 to 4 feet) in thickness. The most effective application of the slurry wall for site remediation or pollution control is to base (or key) the slurry wall 0.6 to 0.9 meters (2 to 3 feet) into a low permeability layer such as clay or bedrock, as shown in the preceding figure. This "keying-in" provides for an effective foundation with minimum leakage potential. An alternate configuration for slurry wall installation is a "hanging" wall in which the wall projects into the groundwater table to block the movement of lower density or floating contaminants such as oils, fuels, or gases. Hanging walls are used less frequently than keyed-in walls.

Applicability: Slurry walls contain the groundwater itself, thus treating no particular target group of contaminants. They are used to contain contaminated groundwater, divert contaminated groundwater from drinking water intake, divert uncontaminated groundwater flow, and/or provide a barrier for the groundwater treatment system.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- The technology only contains contaminants within a specific area.
- Soil-bentonite backfills are not able to withstand attack by strong acids, bases, salt solutions, and some organic chemicals. Other slurry mixtures can be developed to resist specific chemicals.
- There is the potential for the slurry walls to degrade or deteriorate over time.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Groundwater, Surface Water, and Leachate).

The following factors, at a minimum, must be assessed prior to designing effective soil-bentonite slurry walls: maximum allowable permeability, anticipated hydraulic gradients, required wall strength, availability and grade of bentonite to be used, boundaries of contamination, compatibility of wastes and contaminants in contact with slurry wall materials, characteristics (i.e., depth, permeability, and continuity) of substrate into which the wall is to be keyed, characteristics of backfill material (e.g., fines content), and site terrain and physical layout.

Performance Data: Slurry walls have been used for decades, so the equipment and methodology are readily available and well known; however, the process of designing the proper mix of wall materials to contain specific contaminants is less well developed. Excavation and backfilling of the trench is critical and requires experienced contractors.

Cost:

Costs likely to be incurred in the design and installation of a standard soil-bentonite wall in soft to medium soil range from $540 to $750 per square meter ($5 to $7 per square foot) (1991 dollars). These costs do not include variable costs required for chemical analyses, feasibility, or compatibility testing. Testing costs depend heavily on site-specific factors.

Factors that have the most significant impact on the final cost of soil-bentonite slurry wall installation include:

- Type, activity, and distribution of contaminants.
- Depth, length, and width of wall.
- Geological and hydrological characteristics.
- Distance from source of materials and equipment.
- Requirements for wall protection and maintenance.
- Type of slurry and backfill used.
- Other site-specific requirements as identified in the initial site assessment (e.g., presence of contaminants or debris).

References:

Goldberg-Zoino and Associates, Inc., 1987. *Construction Quality Control and Post-Construction Performance for the Gilson Road Hazardous Waste Site Cutoff Wall*, EPA Report EPA/600/2-87/065.

McCandless, R.M. and A. Bodocsi, 1987. *Investigation of Slurry Cutoff Wall Design and Construction Methods for Containing Hazardous Wastes*, EPA Report EPA/600/2-87/063.

Miller, S.P., 1979. *Geotechnical Containment Alternatives for Industrial Waste Basin F, Rocky Mountain Arsenal, Denver, Colorado: A Quantitative Evaluation*, USAE-WES Technical Report GL-79-23.

Spooner, P.A., et al., 1984. *Slurry Trench Construction for Pollution Migration Control*, EPA Report EPA/540/2-84/001.

USACE, 1986. *Civil Works Construction Guide Specification for Soil-Bentonite Slurry Trench Cutoffs*, National Institute of Building Sciences, Construction Criteria Base, CW-02214.

Zappi, M.E., D.D. Adrian, and R.R. Shafer, 1989. "Compatibility of Soil-Bentonite Slurry Wall Backfill Mixtures with Contaminated Groundwater," in *Proceedings of the 1989 Superfund Conference*, Washington, DC.

Zappi, M.E., R.A. Shafer, and D.D. Adrian, 1990. *Compatibility of Ninth Avenue Superfund Site Ground Water with Two Soil-Bentonite Slurry Wall Backfill Mixtures*, WES Report No. EL-90-9.

Site Information:

Site Name	Contact	Summary	Costs
Hazardous Waste Landfill	GEO-CON, Inc.	Bentonite alternative used because of saltwater environment and presence of incompatible organic compound.	NA
Sanitary Landfill	GEO-CON, Inc.	Limited working area.	NA
Coal Tar Disposal Pond	NA	Circumferential containment of leachate from pond with metals and phenols. Keyed to impervious till.	NA

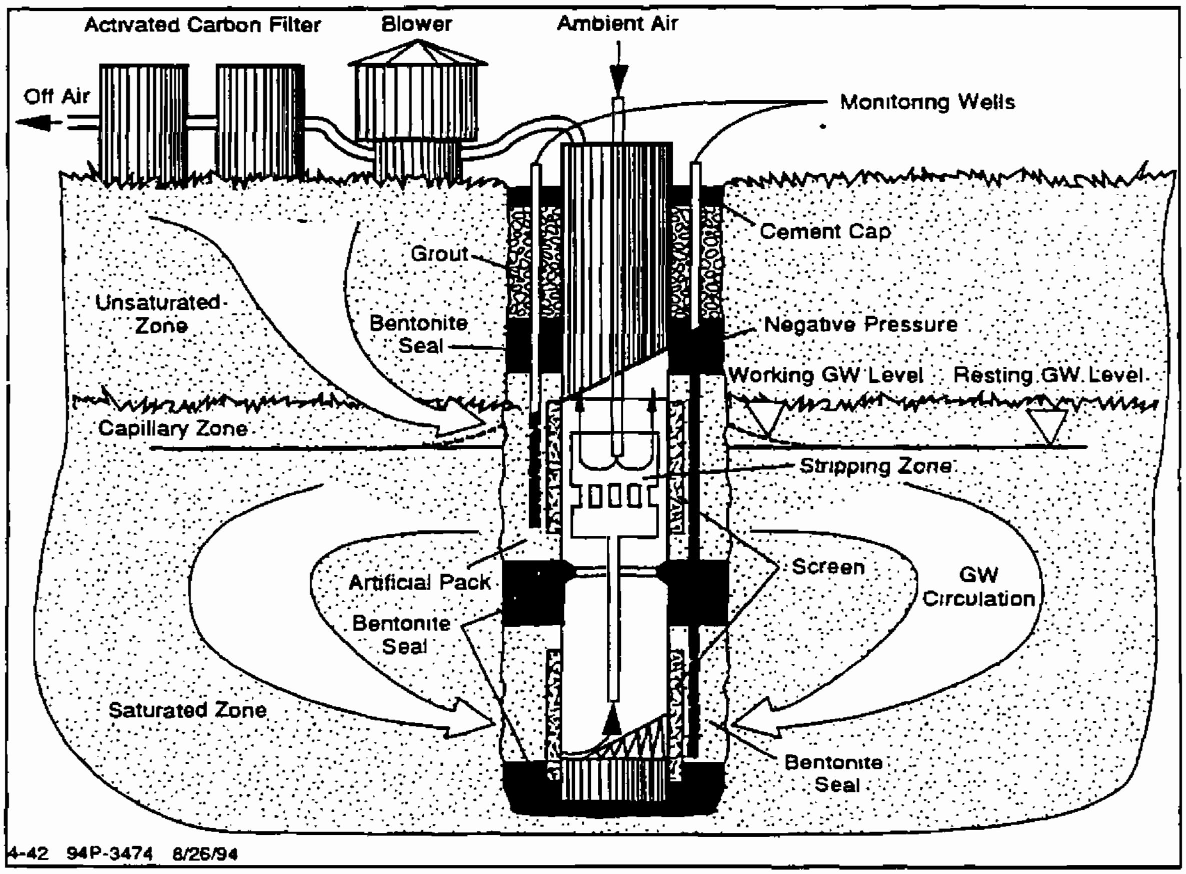
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Jesse Oldham or Mark E. Zappi	USAE-WES	(601) 634-3111 (601) 634-2856	Attn: CEWES-EE-S 3903 Halls Ferry Road Vicksburg, MS 39180-6199
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

4.42 VACUUM VAPOR EXTRACTION

Description: In vacuum vapor extraction (also known as in well air stripping), air is injected into a well, lifting contaminated groundwater in the well and allowing additional groundwater flow into the well. Once inside the well, some of the VOCs in the contaminated groundwater are transferred from the water to air bubbles, which rise and are collected at the top of the well by vapor extraction. The partially treated groundwater is never brought to the surface; it is forced into the unsaturated zone, and the process is repeated. As groundwater circulates through the treatment system in situ, contaminant concentrations are gradually reduced. Vacuum vapor extraction is a pilot-scale technology.



4-42 TYPICAL UVB VACUUM VAPOR EXTRACTION DIAGRAM

Applicability: The target contaminant groups for vacuum vapor extraction are halogenated VOCs, SVOCs, and fuels. Variations of the technology may allow for its effectiveness against some nonhalogenated VOCs, SVOCs, pesticides, and inorganics.

Limitations: The following factors may limit the applicability and effectiveness of the process:

- Fouling of the system may occur by oxidized constituents in the groundwater.

- Shallow aquifers may limit process effectiveness.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Groundwater, Surface Water, and Leachate).

Performance Data: A variation of this process, called UVB (Unterdruck-Verdampfer Brunner), has been used at numerous sites in Germany and has been introduced recently into the United States.

Stanford University has developed another variation of this process, an in-well sparging system, which is currently being evaluated as part of DOE's Integrated Technology Demonstration Program. The Stanford system combines air-lift pumping with a vapor stripping technique.

Awareness of this process is limited in the United States but can be expected to increase as development and demonstration of technologies based on the process continue.

Cost: Not available.

References: Not available.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
March AFB, CA	Jeff Bannon WESTON 100 N. First St. Suite 210 Burbank, CA 91502 (818) 556-5226 Fax: (818) 556-6894	Site demo of UVB system	NA	NA	NA
March AFB, CA	Michelle Simon EPA RREL (513) 569-7469	Site demo: air lift pumping, in situ vapor stripping, and air sparging	30 ppb TCE at well inlet	<1 ppb	NA

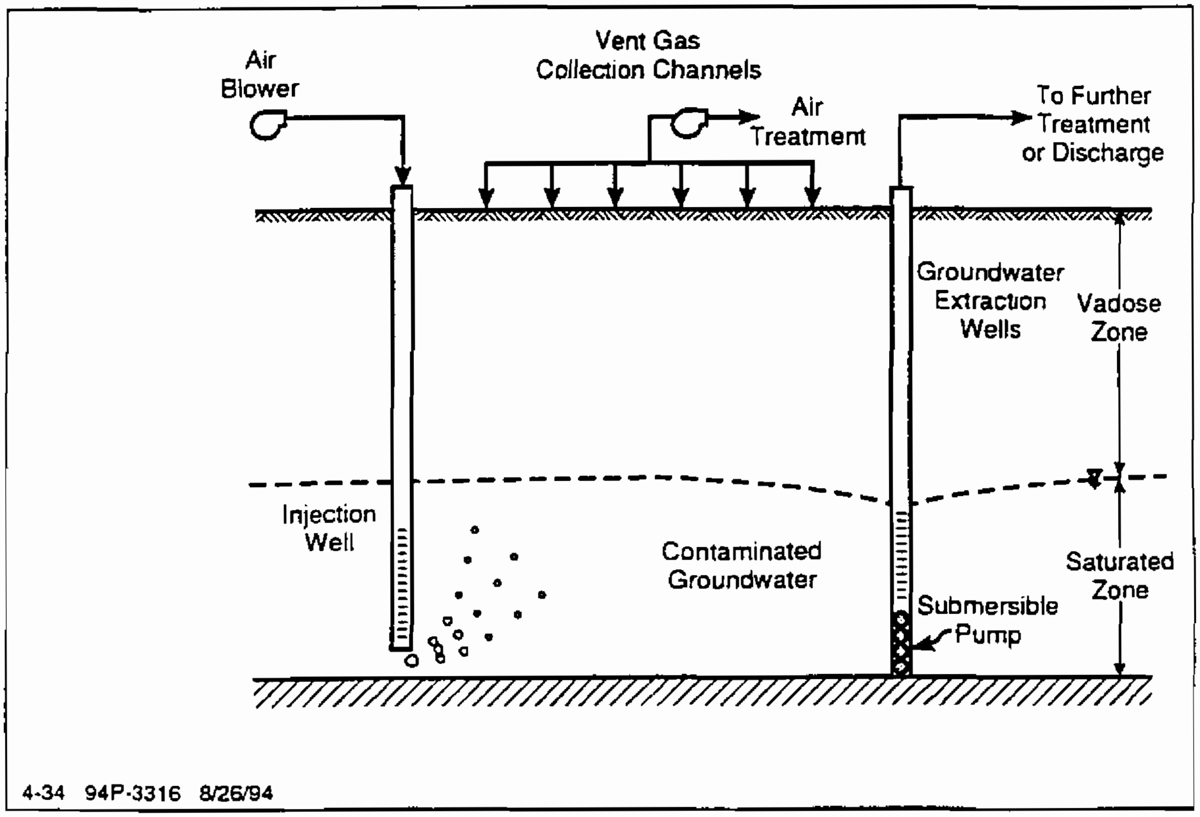
Note. NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Michelle Simon	EPA RREL	(513) 569-7469 Fax: (513) 569-7676	26 West M.L. King Dr. Cincinnati, OH 45268
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

4.34 AIR SPARGING

Description: Air sparging is an in situ technology in which air is bubbled through a contaminated aquifer. Air bubbles traverse horizontally and vertically through the soil column, creating an underground stripper that removes contaminants by volatilization. These air bubbles carry the contaminants to a vapor extraction system. Vapor extraction is implemented in conjunction with air sparging to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between groundwater and soil and strip more groundwater by sparging.



4-34 TYPICAL AIR SPARGING SYSTEM

Applicability: The target contaminant groups for air sparging are VOCs and fuels. Only limited information is available on the process.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Depth of contaminants and specific site geology must be considered.
- Air injection wells must be designed for site-specific conditions.
- Air flow through the saturated zone may not be uniform.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Groundwater, Surface Water, and Leachate). Characteristics that should be determined include vadose zone gas permeability, groundwater flow rate, aquifer permeability, presence of low permeability layers, presence of DNAPLs, depth of contamination, and contaminant volatility and solubility.

Performance Data: This technology will be demonstrated over the next 2 to 3 years at DOE's Hanford Reservation as part of the agency's Integrated Technology Demonstration Program for Arid Sites. Air sparging has demonstrated sensitivity to minute permeability changes, which can result in localized stripping between the sparge and monitoring wells.

Cost: One estimate, $371,000 to $865,000 per hectare ($150,000 to $350,000 per acre) of groundwater plume to be treated, was available.

References: Hildebrandt, W. and F. Jasiulewicz. 1992. "Cleaning Up Military Bases." *The Military Engineer*, No. 55, p. 7, September-October 1992.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Savannah River, IL	NA	NA	PCE 3-124 TCE 10-1,031	<184 ppb <1.8 ppb	NA
Conservancy Site Belen, NM	NA	NA	BTX	49-60% reduction	NA

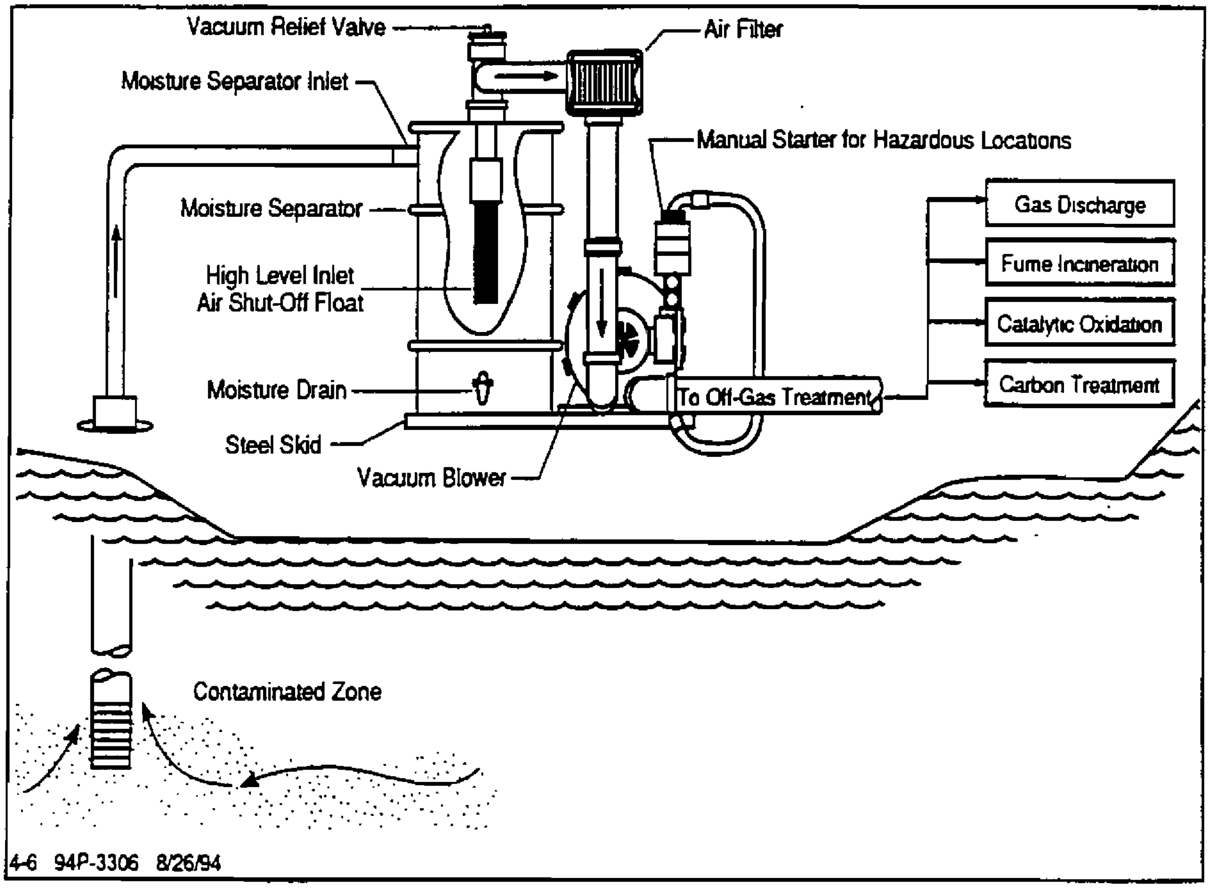
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Steve Stern	Environmental Management Organization, Pacific Northwest Division	(206) 528-3340	4000 N.E. 41st Street Seattle, WA 98105
Steven M. Gorelick	Stanford University Dept. of Applied Earth Sciences	(415) 725-2950	Stanford, CA 94305-2225
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

4.6 SOIL VAPOR EXTRACTION (IN SITU)

Description: Soil vapor extraction (SVE) is an in situ unsaturated (vadose) zone soil remediation technology in which a vacuum is applied to the soil to induce the controlled flow of air and remove volatile and some semivolatile contaminants from the soil. The gas leaving the soil may be treated to recover or destroy the contaminants, depending on local and state air discharge regulations. Vertical extraction vents are typically used at depths of 1.5 meters (5 feet) or greater and have been successfully applied as deep as 91 meters (300 feet). Horizontal extraction vents (installed in trenches or horizontal borings) can be used as warranted by contaminant zone geometry, drill rig access, or other site-specific factors.



4-6 TYPICAL IN SITU SOIL VAPOR EXTRACTION SYSTEM

Groundwater depression pumps may be used to reduce groundwater upwelling induced by the vacuum or to increase the depth of the vadose zone. Air injection is effective for facilitating extraction of deep contamination, contamination in low permeability soils, and contamination in the saturated zone (see Treatment Technology Profile 4.34, Air Sparging).

Applicability: The target contaminant groups for SVE are VOCs and some fuels. The technology is typically applicable only to volatile compounds with a Henry's law constant greater than 0.01 or a vapor pressure greater than 0.5 mmHg (0.02 inches Hg). Other factors, such as the moisture content, organic content, and air permeability of the soil, will also affect SVE's effectiveness. SVE will not remove heavy oils, metals, PCBs, or dioxins. Because the process involves the continuous flow of air through the soil, however, it often promotes the in situ biodegradation of low-volatility organic compounds that may be present.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Soil that is tight or has high moisture content (>50%) has a reduced permeability to air, requiring higher vacuums (increasing costs) and/or hindering the operation of SVE.
- Large screened intervals are required in extraction wells for soil with highly variable permeabilities or horizonation, which otherwise may result in uneven delivery of gas flow from the contaminated regions.
- Soil that has high organic content or is extremely dry has a high sorption capacity of VOCs, which results in reduced removal rates.
- Air emissions may require treatment to eliminate possible harm to the public and the environment.
- As a result of off-gas treatment, residual liquids and spent activated carbon may require treatment/disposal.
- SVE is not effective in the saturated zone; however, lowering the water table can expose more media to SVE (this may address concerns regarding LNAPLs).

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge). Data requirements include the depth and areal extent of contamination, the concentration of the contaminants, depth to water table, and soil type and properties (e.g., structure, texture, permeability, and moisture content).

Pilot studies should be performed to provide design information, including extraction well, radius of influence, gas flow rates, optimal applied vacuum, and contaminant mass removal rates.

Performance Data: A field pilot study is necessary to establish the feasibility of the method as well as to obtain information necessary to design and configure the system. During full-scale operation, SVE can be run intermittently (pulsed operation) once the extracted mass removal rate has reached an asymptotic level. This pulsed operation can increase the cost-effectiveness of the system by facilitating extraction of higher concentrations of contaminants. After the contaminants are removed by SVE, other remedial measures, such as biodegradation, can be investigated if remedial action objectives have not been met. SVE projects are typically completed in 18 months.

Cost: The cost of SVE is site-specific, depending on the size of the site, the nature and amount of contamination, and the hydrogeological setting (EPA, July 1989). These factors affect the number of wells, the blower capacity and vacuum level required, and the length of time required to remediate the site. A requirement for off-gas treatment adds significantly to the cost. Water is also frequently extracted during the process and usually requires treatment prior to disposal, further adding to the cost. Cost estimates for SVE range between $10 and $50 per cubic meter ($10 and $40 per cubic yard) of soil. Pilot testing typically costs $10,000 to $100,000.

References:

EPA, 1989. *Terra Vac, In Situ Vacuum Extraction System*, EPA RREL, Applications Analysis Report, Cincinnati, OH, EPA Report EPA/540/A5-89/003.

EPA, 1989. *Terra Vac — Vacuum Extraction*, EPA RREL, series includes Technology Evaluation, Vol. I, EPA/540/5-89/003a, PB89-192025; Technology Evaluation, Vol. II, EPA/540/A5-89/003b; Applications Analysis, EPA/540/A5-89/003; Technology Demonstration Summary, EPA/540/S5-89/003; and Demonstration Bulletin, EPA/540/M5-89/003.

EPA, 1990. *State of Technology Review: Soil Vapor Extraction System Technology*, Hazardous Waste Engineering Research Laboratory, Cincinnati, OH, EPA/600/2-89/024.

EPA, 1991. *AWD Technologies, Inc. — Integrated Vapor Extraction and Stream Vacuum Stripping*, EPA RREL, series includes Applications Analysis, EPA/540/A5-91/002, PB89-192033, and Demonstration Bulletin, EPA/540/M5-89/003.

EPA 1991. *Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction*, OERP, Washington, DC, EPA Report EPA/540/2-91/019A.

EPA, 1991. *In-Situ Soil Vapor Extraction Treatment*, Engineering Bulletin, RREL, Cincinnati, OH, EPA/540/2-91/006.

EPA, 1991. *Soil Vapor Extraction Technology Reference Handbook*, EPA, RREL, Cincinnati, OH, T.A. Pederson and J.T. Curtis, Editors, EPA/540/2-91/003.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
DOE, Savannah River, Aiken, SC	Brian B. Looney Westinghouse Savannah River Co. P.O. Box 616 Aiken, SC 29802 (803) 725-3692	Horizontal wells are concurrently used to remediate soils and groundwater.	1,800 ppb TCE	30 ppb TCE	Demo — $44/kg Prep — $300,000-$450,000
Groveland Wells Superfund Site Groveland, MA	Mary Stinson EPA Technical Support Branch, RREL 2890 Woodbridge Ave. Building 10 Edison, NJ 08837-3679 (908) 321-6683 Terra Vac (714) 252-8900	Pilot system	3-350 ppm TCE	Non-detect to 39 ppm TCE	$30 to $75 per metric ton ($30 to $70 per ton) of soil
Hill AFB, UT	Major Mark Smith USAF	Full-scale system at JP-4 jet fuel spill site	NA	NA	NA
Letterkenny AD Chambersburg, PA	USAEC ETD Bldg. 4435 APG, MD 21010 (410) 671-2054	Large-scale (>50 vents) pilot system. 1,530 m^3 (2,000 yd^3) treated.	> 1,000 ppm total VOCs	NA	$2M design, install, and operation.

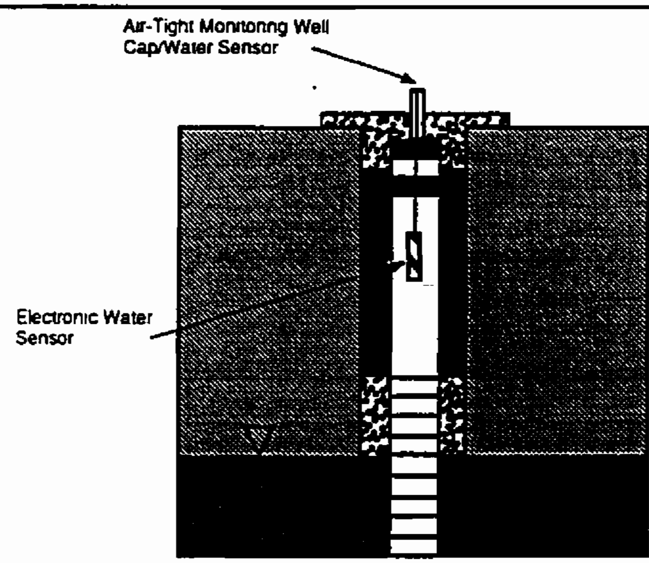
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Mike O'Rear	DOE Savannah River	(803) 725-5541	Aiken, SC
Ramon Mendoza	EPA Region IX	(415) 744-2410	75 Hawthorne Street San Francisco, CA 94105
Arthur L. Baehr	USGS	(609) 771-3978	810 Bear Tavern Rd., Suite 206 West Trenton, NJ 08628
Michael Gruenfeld	EPA Releases Control Branch, RREL	(908) 321-6625	2890 Woodbridge Ave. MS-104 Edison, NJ 08837-3679
Stacy Erikson	EPA	(303) 294-1084	One Denver Place 999 18th Street Denver, CO 80202-2466
Major Mark Smith	USAF	(904) 283-6126	AL/EQW Tyndall AFB, FL 32403
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401
Mary K. Stinson	EPA Technical Support Branch, RREL	(908) 321-6683	2890 Woodbridge Ave MS-104 Edison, NJ 08837-3679

4.29 NATURAL ATTENUATION

Description: For natural attenuation, natural subsurface processes—such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials—are allowed to reduce contaminant concentrations to acceptable levels. Natural attenuation is not a "technology" per se, and there is significant debate among technical experts about its use at hazardous waste sites. Consideration of this option requires modeling and evaluation of contaminant degradation rates and pathways. The primary objective of site modeling is to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards before potential exposure pathways are completed. In addition, sampling and sample analysis must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.



4-29 94P-3325a 10/21/94

4-29 TYPICAL MONITORING WELL CONSTRUCTION DIAGRAM

Natural attenuation is not the same as "no action," although it often is perceived as such. CERCLA requires evaluation of a "no action" alternative but does not require evaluation of natural attenuation. Natural attenuation is considered in the Superfund program on a case-by-case basis, and guidance on its use is still evolving. It has been selected at Superfund sites where, for example, PCBs are strongly sorbed to deep subsurface soils and are not migrating; where removal of DNAPLs has been determined to be technically impracticable [Superfund is developing technical impracticability (TI) guidance]; and where it has been determined that active remedial measures would be unable to significantly speed remediation time frames. Where contaminants are expected to remain in place over long periods of time, as in the first two examples, TI waivers must be obtained. In all cases, extensive site characterization is required.

The attitude toward natural attenuation varies among agencies. USAF carefully evaluates the potential for use of natural attenuation at its sites: however, EPA accepts its use only in certain special cases.

Applicability: Target contaminants for natural attenuation are nonhalogenated VOCs, SVOCs, and fuel hydrocarbons. Halogenated VOCs and SVOCs and pesticides may be less responsive to natural attenuation.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Data must be collected to determine model input parameters.
- Although commercial services for evaluating natural attenuation are widely available, the quality of these services varies widely among the many potential suppliers. Highly skilled modelers are required.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation should be used only where there are no impacts on potential receptors.
- Contaminants may migrate before they are degraded.
- The site may have to be fenced and may not be available for re-use until contaminant levels are reduced.
- If source material exists, it may have to be removed.
- Some inorganics can be immobilized, such as mercury, but they will not be degraded.

Data Needs: A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge).

Many potential suppliers can perform the modeling, sampling, and sample analysis required for justifying and monitoring natural attenuation. The extent of contaminant degradation depends on a variety of parameters, such as contaminant types and concentrations, temperature, moisture, and availability of nutrients/electron acceptors (e.g., oxygen and nitrate).

When available, information to be obtained during data review includes:

- Soil and groundwater quality data:
  - Three-dimensional distribution of residual-, free-, and dissolved-phase contaminants. The distribution of residual- and free-phase contaminants will be used to define the dissolved-phase plume source area.

  - Groundwater and soil geochemical data.
  - Chemical and physical characteristics of the contaminants.
  - Potential for biodegradation of the contaminants.

- Geologic and hydrogeologic data:
  - Lithology and stratigraphic relationships.
  - Grain-size distribution (sand vs. silt vs. clay).
  - Flow gradient.
  - Preferential flow paths.
  - Interaction between groundwater and surface water.
  - Location of potential receptors: groundwater. wells, and surface water discharge points.

Performance Data: Natural attenuation has been selected by AFCEE for remediation at 45 USAF sites.

Cost: There are costs for modeling contamination degradation rates to determine whether natural attenuation is a feasible remedial alternative. Additional costs are for subsurface sampling and sample analysis (potentially extensive) to determine the extent of contamination and confirm contaminant degradation rates and cleanup status. Skilled labor hours are required to conduct the modeling, sampling, and analysis. O&M costs would be required for monitoring to confirm that contaminant migration has not occurred.

References:

Scovazzo, P.E., D. Good, and D.S. Jackson, 1992. "Soil Attenuation: In Situ Remediation of Inorganics," in *Proceedings of the HMC/Superfund 1992*, HMCRI, Greenbelt, MD.

Bailey, G.W., and J.L. White, 1970. "Factors Influencing the Adsorption, Desorption, and Movement of Pesticides in Soil," in *Residue Reviews*, F.A. Gunther and J.D. Gunther, Editors, Springer Verlag, pp. 29-92.

Hassett, J.J., J.C. Means, W.L. Banwart, and S.G. Woods, 1980. *Sorption Properties of Sediments and Energy-Related Pollutants*, EPA, Washington, DC, EPA/600/3-80-041.

Hassett, J.J., W.L. Banwart, and R.A. Griffin, 1983. "Correlations of Compound Properties with Sorption Characteristics of Nonpolar Compounds by Soils and Sediments; Concepts and Limitations," *Environment and Solid*

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Jeng, C.Y., D.H. Chen, and C.L. Yaws. 1992. "Data Compilation for Soil Sorption Coefficient," *Pollution Engineering*, 15 June 1992.

Miller, R.N. 1990. "A Field-Scale Investigation of Enhanced Petroleum Hydrocarbon Biodegradation in the Vadose Zone at Tyndall Air Force Base, Florida," in *Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Groundwater*, pp. 339-351, Prevention, Detection, and Restoration Conference: NWAA/API.

Wiedemeier, T.H., D.C. Downey, J.T. Wilson, D.H. Kampbell, R.N. Miller, and J.E. Hansen. 1994. *Technical Protocol for Implementing the Intrinsic Remediation (Natural Attenuation) with Long-Term Monitoring Option for Dissolved-Phase Fuel Contamination in Ground Water*. Brooks Air Force Base, San Antonio, TX.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Hill AFB, UT	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA
Eglin AFB, FL	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA
Elmendorf AFB, AL	AFCEE/ERT Jerry Hansen (210) 536-4353 Fax: (210) 536-4339	NA	NA	NA	NA

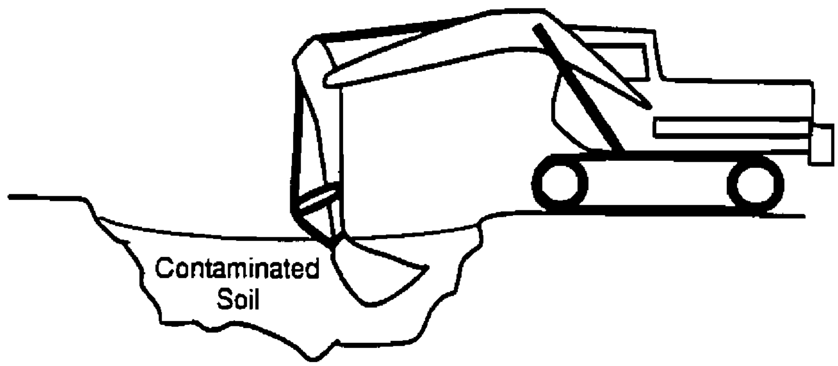
Note: NA = Not available.

Points of Contact:

Contact	Government Agency	Phone	Location
Capt. Tom Venoge	USAF	(904) 283-6205	AL-EQW Tyndall AFB, FL 32403
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

4.28 EXCAVATION, RETRIEVAL, AND OFF-SITE DISPOSAL

Description: Contaminated material is removed and transported to permitted off-site treatment and/or disposal facilities. Some pretreatment of the contaminated media usually is required in order to meet land disposal restrictions.



4-28 94P-3320 8/26/94

4-28 TYPICAL CONTAMINATED SOIL EXCAVATION DIAGRAM

Applicability: Excavation and off-site disposal is applicable to the complete range of contaminant groups with no particular target group. Although excavation and off-site disposal alleviates the contaminant problem at the site, it does not treat the contaminants.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Generation of fugitive emissions may be a problem during operations.
- The distance from the contaminated site to the nearest disposal facility will affect cost.
- Depth and composition of the media requiring excavation must be considered.
- Transportation of the soil through populated areas may affect community acceptability.
- Disposal options for certain waste (e.g., mixed waste or transuranic waste) may be limited. There is currently only one licensed disposal facility for radioactive and mixed waste in the United States.

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.1 (Data Requirements for Soil, Sediment, and Sludge).

The type of contaminant and its concentration will impact off-site disposal requirements. Soil characterization as dictated by land disposal restrictions (LDRs) are required. Most hazardous wastes must be treated to meet either RCRA or non-RCRA treatment standards prior to land disposal. Radioactive wastes would have to meet disposal facility waste form requirements based on waste classification.

Performance Data:

Excavation and off-site disposal is a well proven and readily implementable technology. Prior to 1984, excavation and off-site disposal was the most common method for cleaning up hazardous waste sites. Excavation is the initial component in all ex situ treatments. As a consequence, the remediation consulting community is very familiar with this option.

The excavation of 18,200 metric tons (20,000 tons) of contaminated soil would require about 2 months. Disposal of the contaminated media is dependent upon the availability of adequate containers to transport the hazardous waste to a RCRA-permitted facility.

CERCLA includes a statutory preference for treatment of contaminants, and excavation and off-site disposal is now less acceptable than in the past. The disposal of hazardous wastes is governed by RCRA (40 CFR Parts 261-265), and the U.S. Department of Transportation (DOT) regulates the transport of hazardous materials (49 CFR Parts 172-179, 49 CFR Part 1387, and DOT-E 8876).

DOE has demonstrated a cryogenic retrieval of buried waste system, which uses liquid nitrogen (LN_2) to freeze soil and buried waste to reduce the spread of contamination while the buried material is retrieved with a series of remotely operated tools. Other excavation/retrieval systems that DOE is currently developing include a remote excavation system, a hydraulic impact end effector, and a high pressure waterjet dislodging and conveyance end effector using confined sluicing.

Cost:

Cost estimates for excavation and disposal range from $300 to $510 per metric ton ($270 to $460 per ton) depending on the nature of hazardous materials and methods of excavation. These estimates include excavation/ removal, transportation, and disposal at a RCRA permitted facility. Excavation and off-site disposal is a relatively simple process, with proven procedures. It is a labor-intensive practice with little potential for further automation. Additional costs may include soil characterization and treatment to meet land ban requirements.

References:

Church, H.K., 1981. *Excavation Handbook*, McGraw Hill Book Co., New York, NY.

EPA, 1991. *Survey of Materials-Handling Technologies Used at Hazardous Waste Sites*. EPA, ORD, Washington, DC, EPA/540/2-91/010.

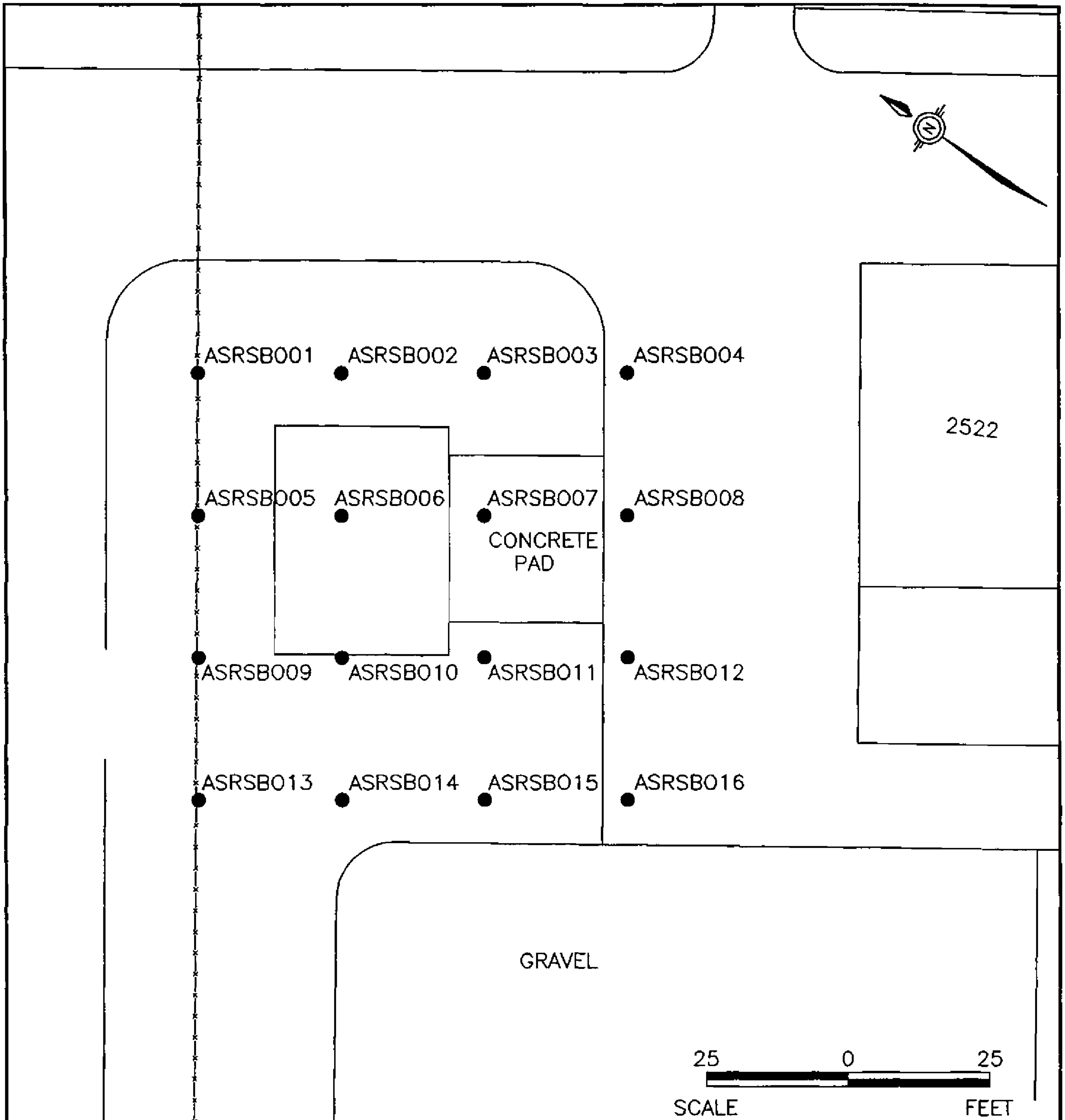
EPA, 1992. *McColl Superfund Site — Demonstration of a Trial Excavation*, EPA RREL, series include Technology Evaluation EPA/S40/R-92/015, PB92-226448; Applications Analysis, EPA/540/AR-92/015; and Technology Demonstration. Summary, EPA/540/SR/-92/015.

Points of Contact:

Contact	Government Agency	Phone	Location
Jaffer Mohiuddin	DOE Program Manager	(301) 903-7965	EM-552, Trevion II Washington, DC 20585
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

SWMU 166

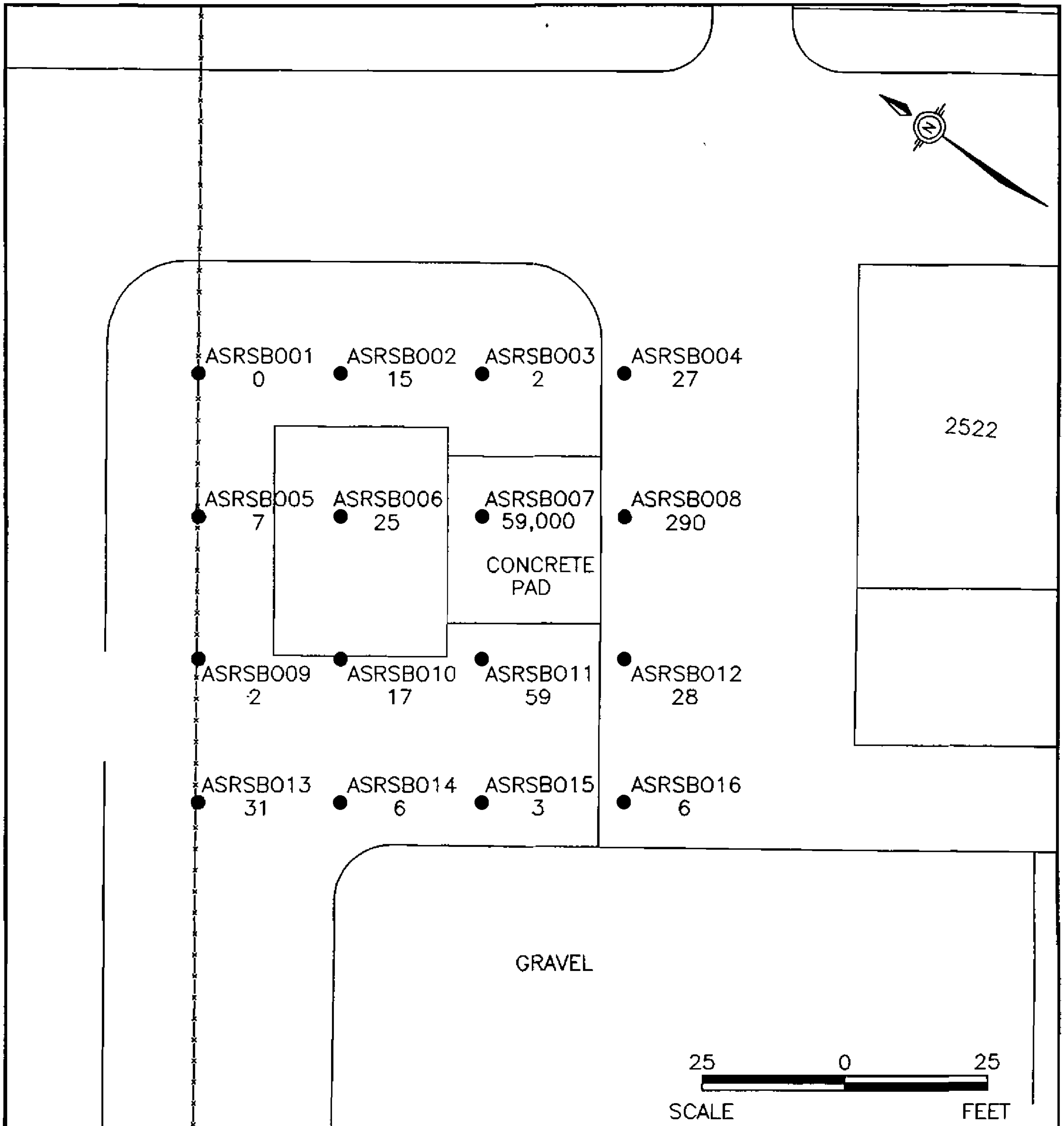
SITE FIGURES



ZONE K
DRAFT RFI REPORT
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

TCE SOURCE AREA
SOIL SAMPLE LOCATIONS

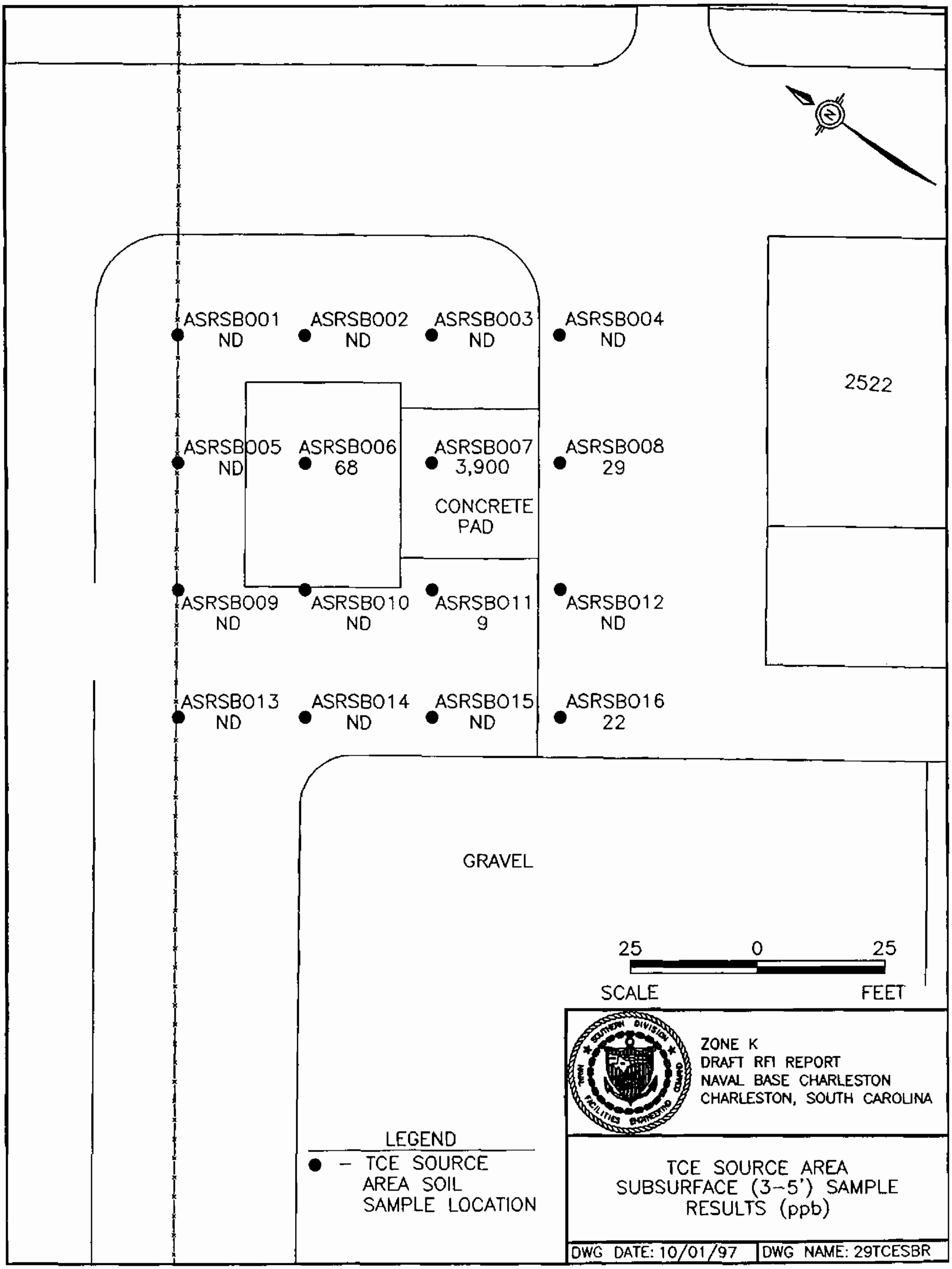
DWG DATE: 10/01/97 | DWG NAME: 29TCESSL



ZONE K
DRAFT RFI REPORT
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

TCE SOURCE AREA
SURFACE (0–1') SAMPLE
RESULTS (ppb)

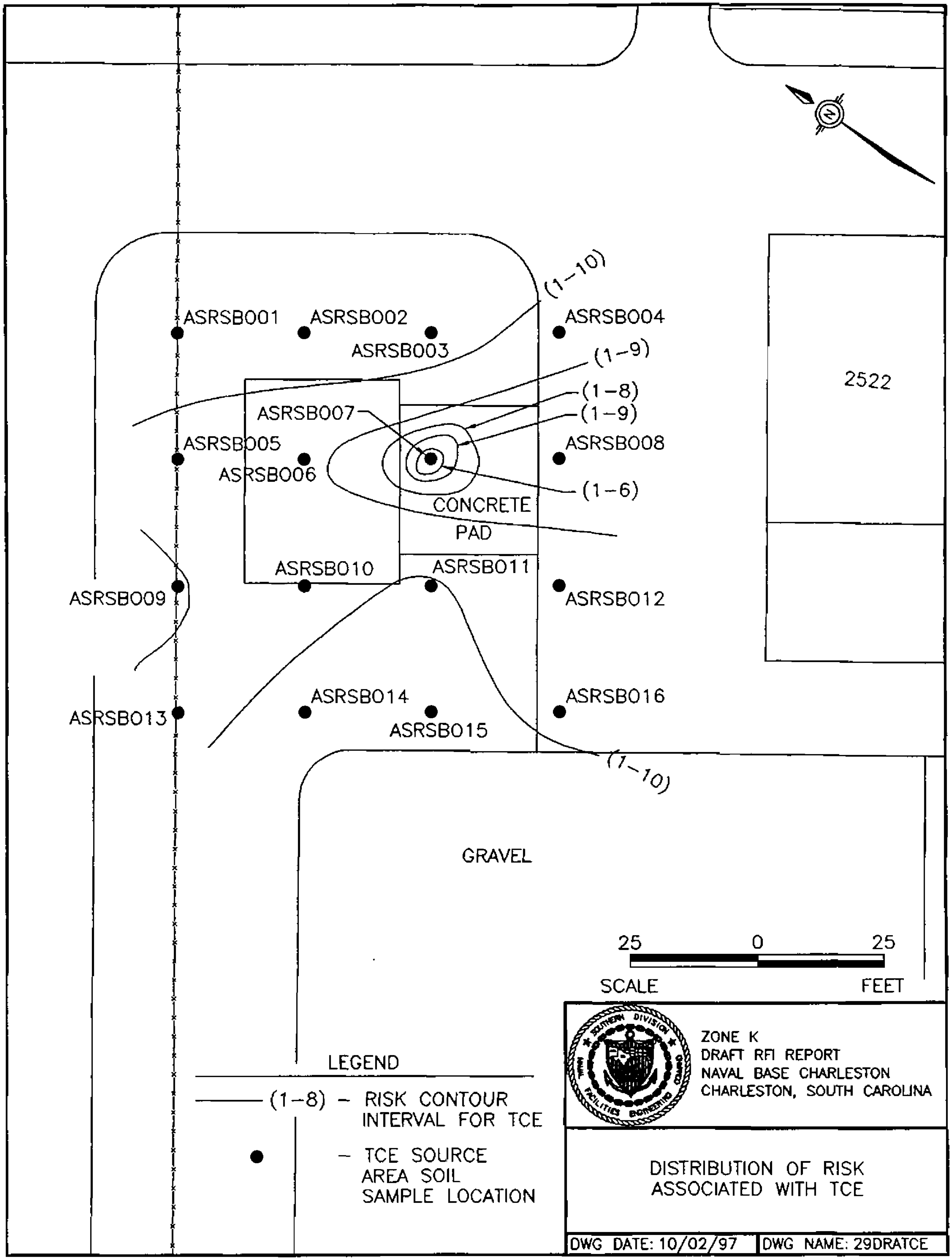
DWG DATE: 10/01/97 | DWG NAME: 29TCESSR



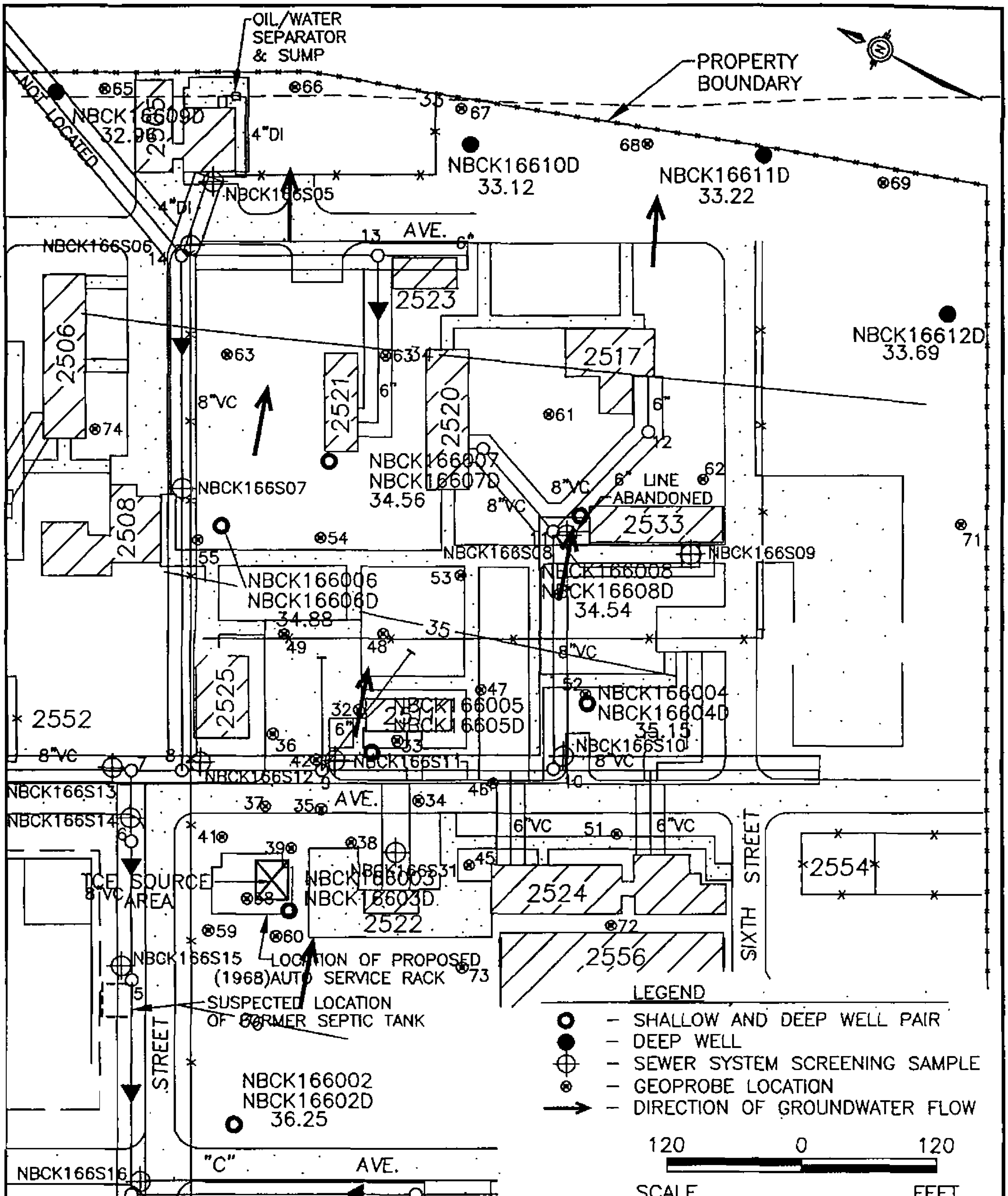
ZONE K
DRAFT RFI REPORT
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA

TCE SOURCE AREA
SUBSURFACE (3–5') SAMPLE
RESULTS (ppb)

DWG DATE: 10/01/97 | DWG NAME: 29TCESBR



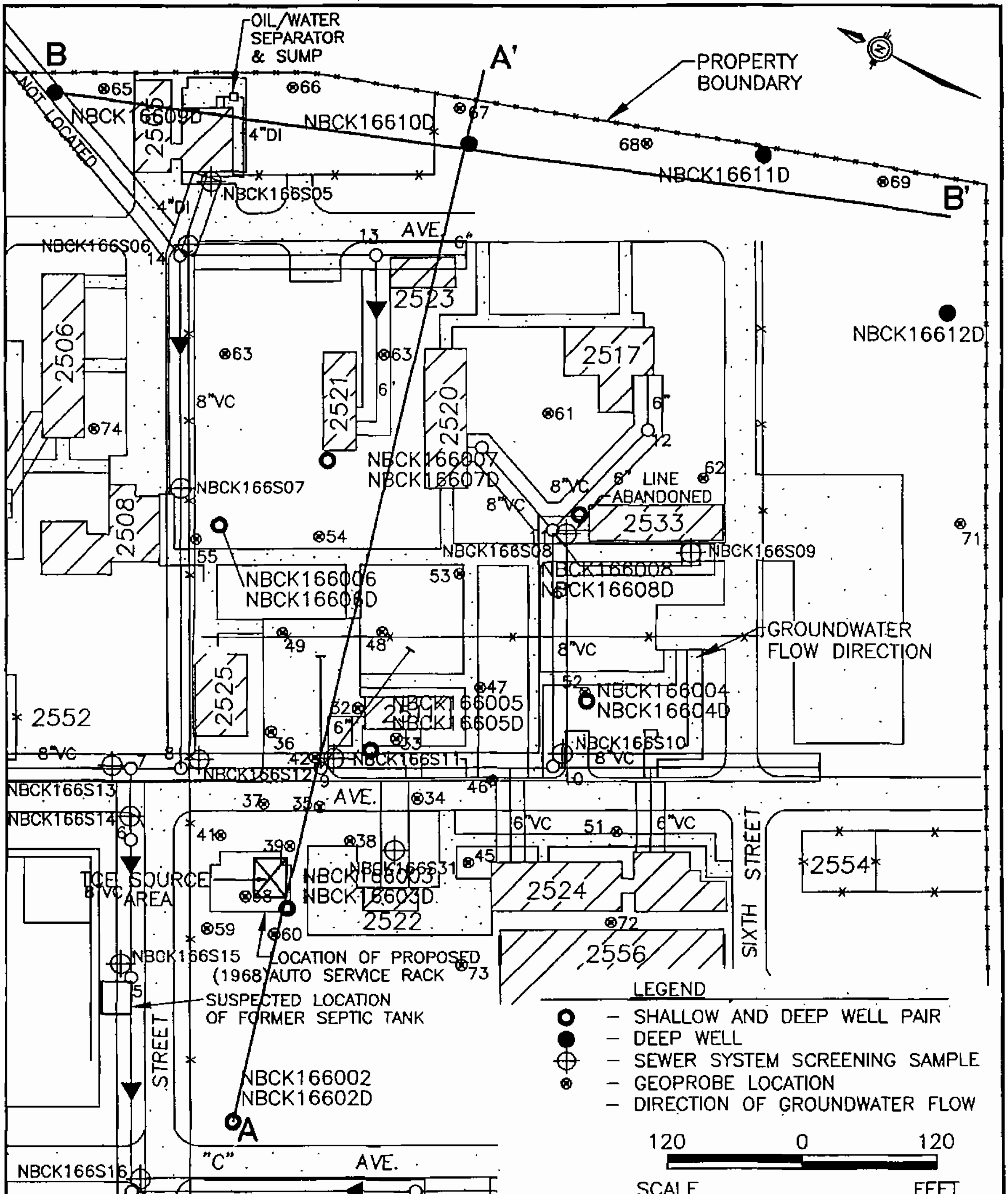
ASRSB001
ASRSB002
ASRSB003
ASRSB004
ASRSB005
ASRSB006
ASRSB007
ASRSB008
ASRSB009
ASRSB010
ASRSB011
ASRSB012
ASRSB013
ASRSB014
ASRSB015
ASRSB016
(1-10)
(1-9)
(1-8)
(1-9)
(1-6)
(1-10)
CONCRETE
PAD
2522
GRAVEL
25 0 25
SCALE FEET
LEGEND
(1-8) - RISK CONTOUR INTERVAL FOR TCE
- TCE SOURCE AREA SOIL SAMPLE LOCATION
SOUTHERN DIVISION NAVAL FACILITIES ENGINEERING COMMAND
ZONE K
DRAFT RFI REPORT
NAVAL BASE CHARLESTON
CHARLESTON, SOUTH CAROLINA
DISTRIBUTION OF RISK
ASSOCIATED WITH TCE
DWG DATE: 10/02/97
DWG NAME: 29DRATCE



ZONE K
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

POTENTIOMETRIC SURFACE MAP FOR LOWER PORTION OF THE WATER TABLE AQUIFER

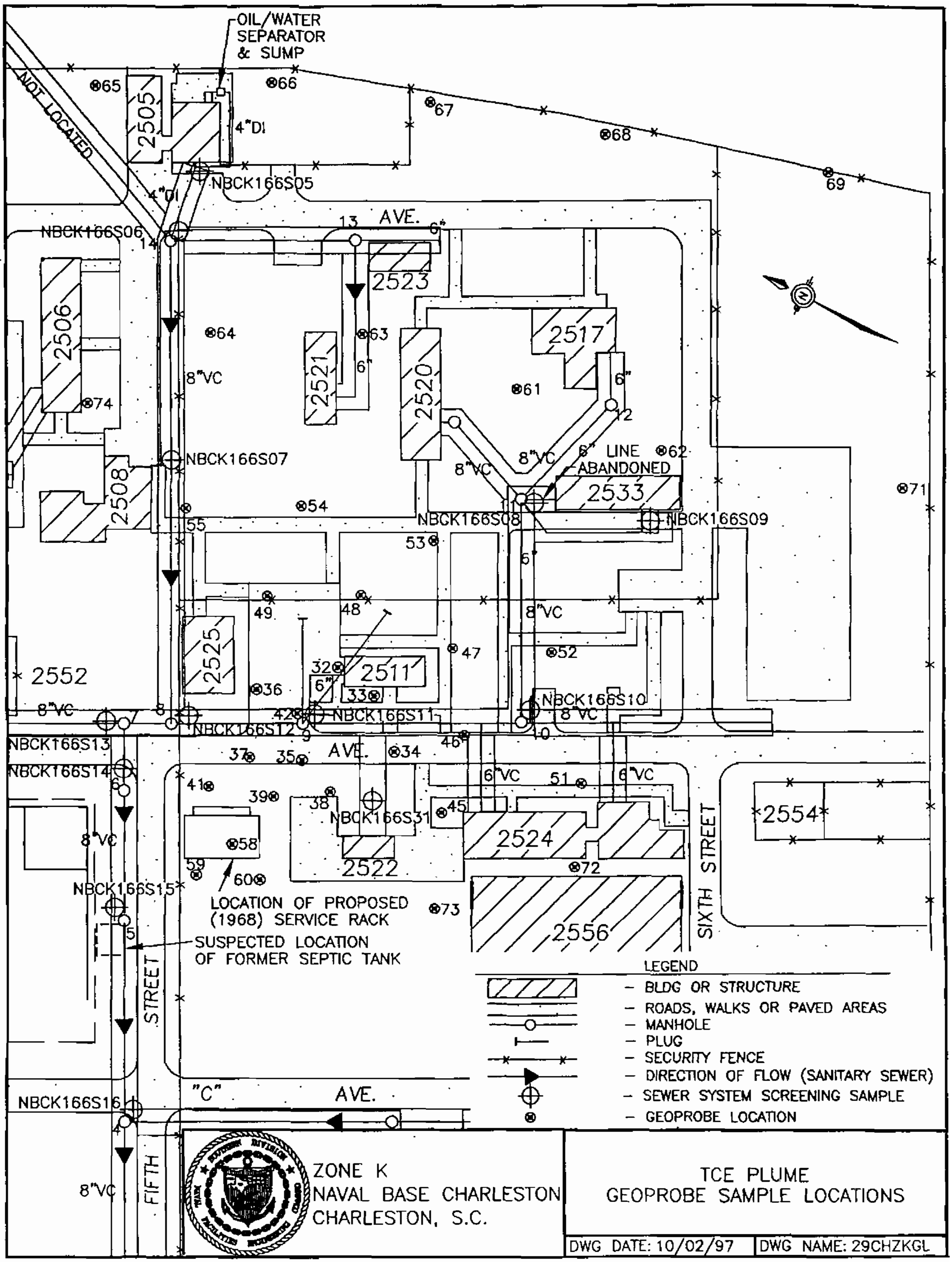
DWG DATE: 10/02/97 | DWG NAME: 2911PSML

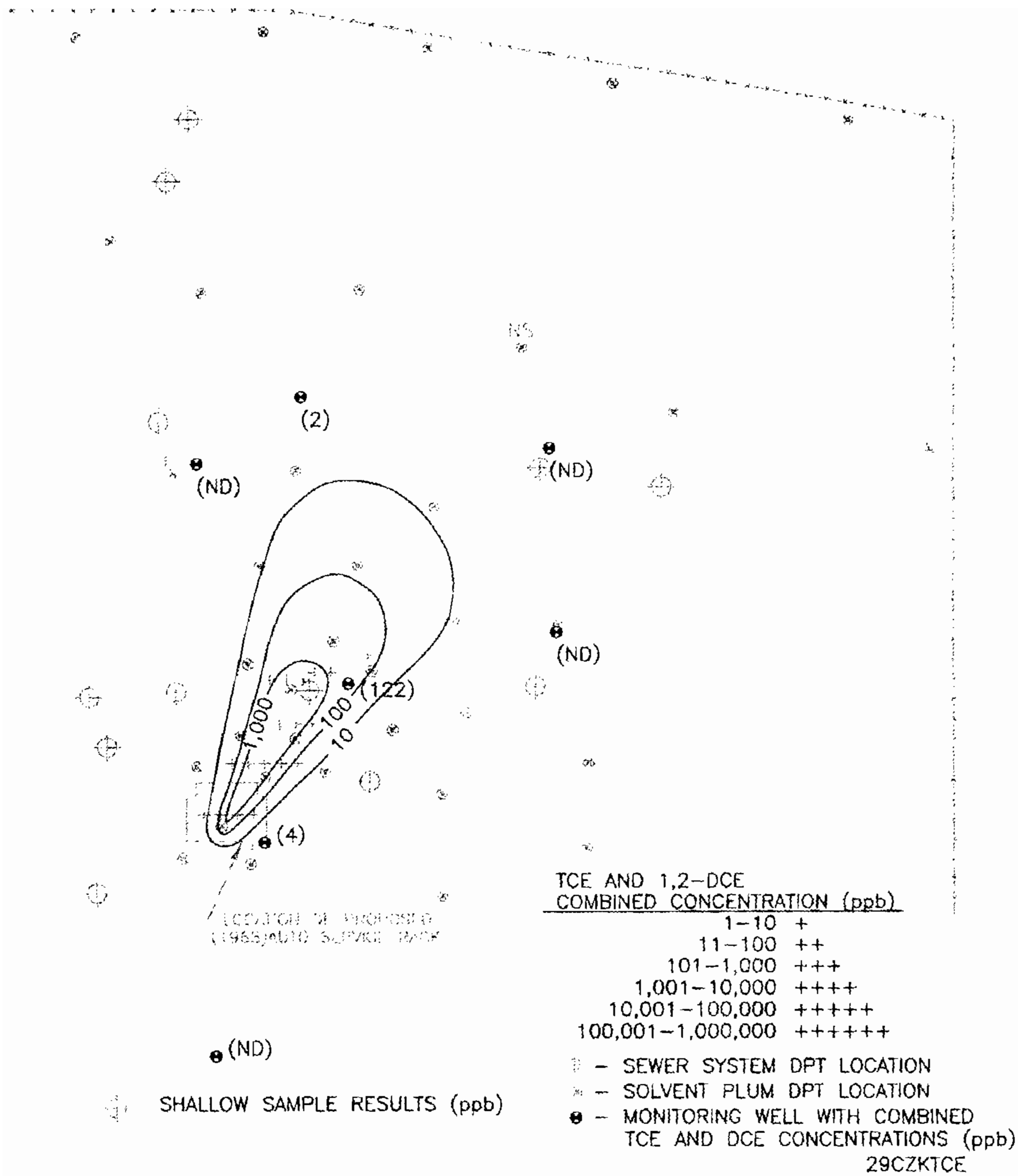


ZONE K
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

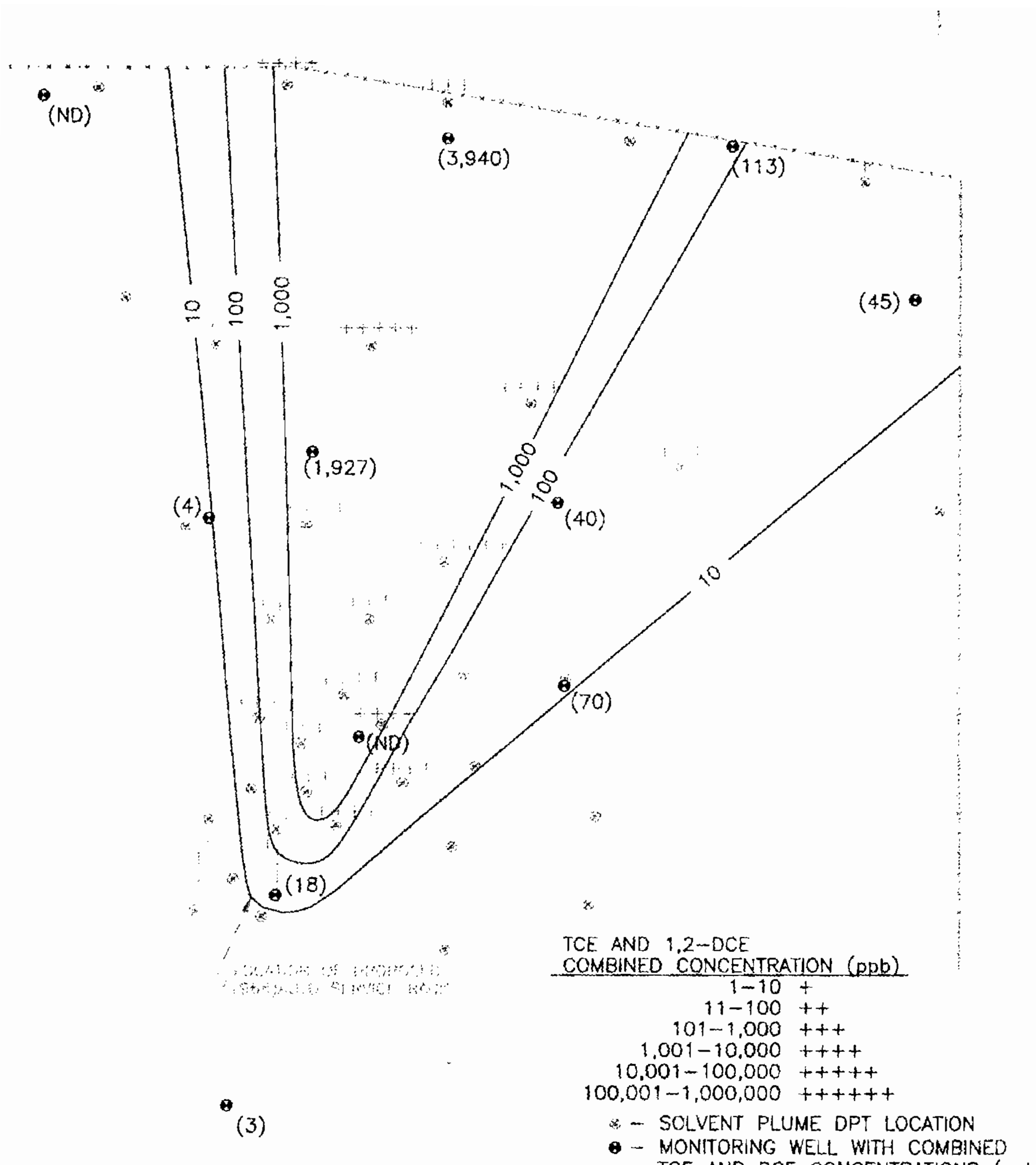
TCE PLUME
GEOPROBE AND MONITORING WELL
SAMPLE LOCATIONS

DWG DATE: 10/02/97 | DWG NAME: 2911TCEP


OIL/WATER SEPARATOR & SUMP
NOT LOCATED
2505
4"DI
NBCK166S05
NBCK166S06
13 AVE.
2523
2506
2521
2520
2517
8"VC
6"
6" LINE ABANDONED
2533
NBCK166S07
NBCK166S08
NBCK166S09
2508
2552
2525
2511
NBCK166S10
NBCK166S11
NBCK166S12
NBCK166S13
NBCK166S14
NBCK166S15
NBCK166S16
NBCK166S31
AVE.
6"VC
2554
2524
2522
2556
SIXTH STREET
FIFTH STREET
"C" AVE.
LOCATION OF PROPOSED (1968) SERVICE RACK
SUSPECTED LOCATION OF FORMER SEPTIC TANK
LEGEND
– BLDG OR STRUCTURE
– ROADS, WALKS OR PAVED AREAS
– MANHOLE
– PLUG
– SECURITY FENCE
– DIRECTION OF FLOW (SANITARY SEWER)
– SEWER SYSTEM SCREENING SAMPLE
– GEOPROBE LOCATION
ZONE K
NAVAL BASE CHARLESTON
CHARLESTON, S.C.
TCE PLUME
GEOPROBE SAMPLE LOCATIONS
DWG DATE: 10/02/97
DWG NAME: 29CHZKGL



(2)
(ND)
(ND)
(ND)
(122)
1,000
100
10
(4)
(ND)
SHALLOW SAMPLE RESULTS (ppb)
TCE AND 1,2-DCE
COMBINED CONCENTRATION (ppb)
1-10 +
11-100 ++
101-1,000 +++
1,001-10,000 ++++
10,001-100,000 +++++
100,001-1,000,000 ++++++
– SEWER SYSTEM DPT LOCATION
– SOLVENT PLUM DPT LOCATION
– MONITORING WELL WITH COMBINED
TCE AND DCE CONCENTRATIONS (ppb)
29CZKTCE



DEEP SAMPLE RESULTS (ppb)

29CZKDCE

SWMU 17 – Summary of Applicable RFI Data

SWMU 17 is the site of a release in 1987 of approximately 14,000 gallons of #5 Fuel Oil beneath Building FMB 61 due to a ruptured underground fuel pipe

The only analytical data from this site that has not been previously presented was the analysis of the DNAPL found in NBCH-017-002 during the 3rd quarter of sampling. Results were as follows: Arochlor 1260 - 290,000 ppm; 1,3 dichlorobenzene - 13,000 ppm; 1,4 dichlorobenzene - 23,000; 1,2,4 trichlorobenzene -160,000 ppm; gasoline range organics -5,100 μg/L; cyanide -1,100,000 μg/L.

SWMU 17 – EISM Conceptual Plan

Objective

DNAPL and LNAPL recovery. It is not the intent of this EISM to correct soil contamination or dissolved phase-impacted groundwater. Though in an indirect way, groundwater contamination would be beneficially influenced.

Task 1

Continue to monitor existing 55-gallon container sumps along edge of warehouse annex and impacted wells. It is understood that product has been identified in the drum sumps and that a recovery program has not been active for the last few years. If NAPL found in sumps, or area wells, measure, remove and containerize all product for shipment offsite and treatment/disposal.

Purpose

NAPL mass reduction.

Task 2

Visually monitor recovery devices (sumps and wells) and perform a manual product recovery test. Recovery test consists of gauging and manually bailing sumps and wells to determine approximate rates and quantities of recoverable product. Then implement appropriate product recovery method (continued hand bailing, oil skimmer, high viscosity and low flow pump system, etc.). Collect and containerize product for transportation to an offsite treatment/recovery facility

Purpose

Optimize rate of NAPL mass reduction.

End Point

Continue product recovery through appropriate means and at appropriate frequency until the CMS process is completed and a final remedy is selected.

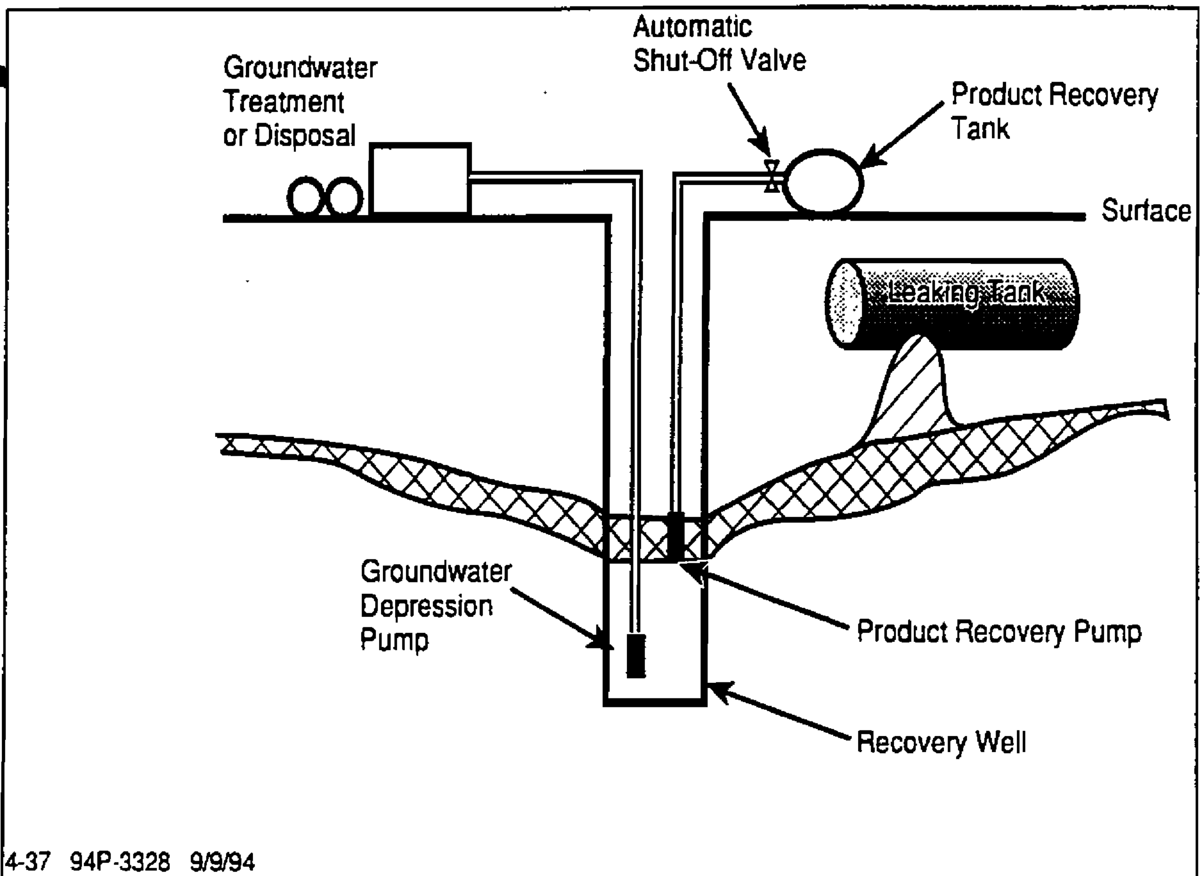
SWMU 17

REMEDIAL TECHNOLOGY PROFILES

Free Product Recovery

4.37 FREE PRODUCT RECOVERY

Description: Undissolved liquid-phase organics are removed from subsurface formations, either by active methods (e.g., pumping) or a passive collection system. This process is used primarily in cases where a fuel hydrocarbon lens more than 20 centimeters (8 inches) thick is floating on the water table. The free product is generally drawn up to the surface by a pumping system. Following recovery, it can be disposed of, re-used directly in an operation not requiring high-purity materials, or purified prior to re-use. Systems may be designed to recover only product, mixed product and water, or separate streams of product and water (i.e., dual pump or dual well systems). Free product recovery is a full-scale technology.



4-37 TYPICAL FREE PRODUCT RECOVERY DUAL PUMP SYSTEM

Applicability: The target contaminant groups for free product recovery are SVOCs and fuels.

Limitations: The following factors may limit the applicability and effectiveness of the process:

- Site geology and hydrogeology.

* MARGINALLY APPLICABLE TO SWMU 17 *

Data Needs:

A detailed discussion of these data elements is provided in Subsection 2.2.2 (Data Requirements for Groundwater, Surface Water, and Leachate).

The potential for accumulation of liquid phase product that is free to move by gravity above the water table is dependent on several factors, including physical and chemical properties of the product released (e.g., viscosity, density, composition, and solubility in water); soil properties (e.g., capillary forces, effective porosity, moisture content, organic content, hydraulic conductivity, and texture); nature of the release (e.g., initial date of occurrence, duration, volume, and rate); geology (e.g., stratigraphy that promotes trapped pockets of free product); hydrogeologic regime (e.g., depth to water table, groundwater flow direction, and gradient); and anticipated product recharge rate.

Performance Data:

Once free product is detected, the immediate response should include both removal of the source and recovery of product by the most expedient means. Free product recovery methods will often extract contaminated water with the product. If economically desirable, water and product can be separated by gravity prior to disposal or recycling of the product. As a result of the removal of substantial quantities of water during dual pumping operations, on-site water treatment will normally be required. When treatment of recovered water is required, permits will usually be necessary.

Cost:

Because of the number of variances involved, establishing general costs for free product response is difficult. Some representative costs are $500 per month for a single phase extraction (hand bailing) system; $1,200 to $2,000 per month for a single phase extraction (skimming) system; and $2,500 to $4,000 per month for a dual pumping system. These costs illustrate the relative magnitudes of the various recovery options available, which are typically less than other types of remediation.

Key cost factors for the recovery of free product include waste disposal, potential for sale of recovered product for recycling, on-site equipment rental (e.g., pumps, tanks, treatment systems), installation of permanent equipment, and engineering and testing costs.

References:

American Petroleum Institute, 1989. *A Guide to the Assessment and Remediation of Underground Petroleum Releases*, Publication 1628, API, Washington, DC, 81 pp.

EPA, 1988. *Cleanup of Releases from Petroleum USTs: Selected Technologies*. Washington, DC, EPA/530/UST-88/001.

Kram, M.L., 1990. *Measurement of Floating Petroleum Product Thickness and Determination of Hydrostatic Head in Monitoring Wells*, NEESA Energy and Environmental News Information Bulletin No. IB-107.

Kram, M.L., 1993. *Free Product Recovery: Mobility Limitations and Improved Approaches*. NFESC Information Bulletin No. IB-123.

NEESA, 1992. *Immediate Response to Free Product Discovery*. NEESA Document No. 20.2-051.4.

Site Information:

Site Name	Contact	Summary	Beginning Levels	Levels Attained	Costs
Navy Gasoline Station Coastal Area	Mark Kram NFESC Code 413	>0.25 ft floating product; dual pumping extraction and thermal vacuum spray aeration and spray aeration vacuum extraction	About 12,000 gallons of gasoline	4,000 gallons recovered by diesel pump	$75,000 plus vapor extraction costs
Navy Fuel Farm	Mike Radecki SOUTHWESTDIV	0.5-2.5 ft free product. Captured in pit and pumped out with skimmers and french drains	NA	NA	$300,000 to date
Privately Owned Gasoline Station Near Urban Drinking Water Source	Connecticut DEP (203) 566-4630	Immediate response recovery wells and air stripping	NA	NA	NA
Various USAF and Navy Sites	USAF Armstrong Lab/ EQW Tyndall AFB, FL (904) 283-6208 Ron Hoeppel (805) 982-1655	"Bioslurping" technology demonstrations	NA	NA	NA

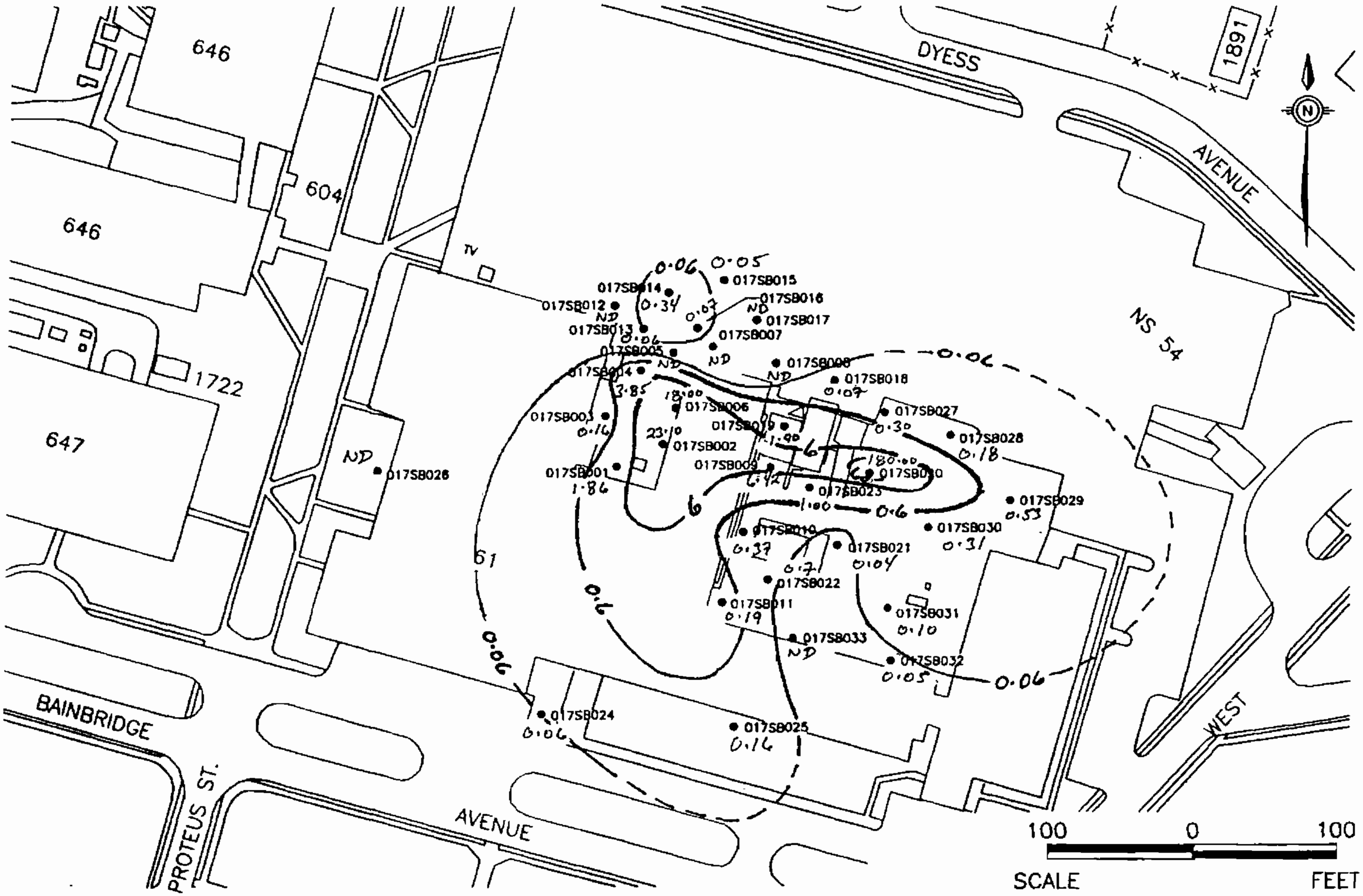
Note: NA = Not Available.

Points of Contact:

Contact	Government Agency	Phone	Location
Mark Kram	NFESC	(805) 982-2669	Code 413 Port Hueneme, CA 93043
Mike Radecki	SOUTHWESTDIV	(619) 532-3874	San Diego, CA
Tom Schruben	EPA Office of USTs	(703) 308-8875	Washington, DC
Technology Demonstration and Transfer Branch	USAEC	(410) 671-2054 Fax: (410) 612-6836	SFIM-AEC-ETD APG, MD 21010-5401

SWMU 17

SITE FIGURES



LEGEND

• – SOIL SAMPLE LOCATION

ZONE H
RFI REPORT
NAVAL BASE CHARLESTON
CHARLESTON, S.C.

SWMU 17 AROCLOR 1260
ISOCONCENTRATION
CONTOURS (0.06, 0.6, 6 & 60mg/kg)

DWG DATE: 10/02/97 | DWG NAME: 2900SW17