TRC

Customer-Focused Solutions

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TRC Reference No. E9202-2401-02250

July 7, 2000

Ms Jennifer-Eck
Project Manager
Bureau of Waste Site Cleanup
Massachusetts Department of Environmental Protection
205A Lowell Street
Wilmington, MA 01887

Subject: Phase IV Remedy Implementation Plan
Eastern Parking Lot Area

Reference: Former GE Facility (RTN# 3-0518)
50 Fordham Road, Wilmington, MA

Dear Ms Eck:

Enclosed please find the Phase IV Remedy Implementation Plan for the Eastern Parking Lot Area at the above referenced site. Also enclosed is the Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup Comprehensive Response Action Transmittal Form and Phase I Completion Statement BWSC-108.

Should you have any questions or comments, please feel free to contact me at (978) 656-3582.

Sincerely;

Paola E. Macchiaroli, Ph.D.
Project Manager

Enclosures

CC: Bruce Hoskins, LSP, URS
Gene Matsushita, Lockheed Martin Corporation
Frank Bomba, Wilmington Realty Trust (w/o enclosures)
Michael Caira, Town Manager, Town of Wilmington (w/o enclosures)
Frank Dardeno, Jr., Wilmington Realty Trust
Gregory Erickson, Board of Health, Town of Wilmington (w/o enclosures)
Martin Fair, Board of Health, Town of North Reading (w/o enclosures)
Jane Fiore, Board of Health, Town of Reading (w/o enclosures)
Peter Hechenbleikner, Town Manager, Town of Reading (w/o enclosures)
Bradley Jones, Jr. State Representative (w/o enclosures)
John Keeley, Conservation Commission, Town of Wilmington (w/o enclosures)
Ted McIntire, Dept. of Public Works, Town of Reading (w/o enclosures)
James Micelli, State Representative (w/o enclosures)
Gina Snyder, Key PIP Petitioner (w/o enclosures)
Bruce Tarr, State Senator (w/o enclosures)
Richard Tisei, State Senator (w/o enclosures)
Mary Trudeau, Conservation Commission, Town of North Reading (w/o enclosures)
Thomas Younger, Town Administrator, Town of North Reading (w/o enclosures)
Document Repository, Reading Public Library

TRC Companies, Inc.
Boott Mills South, Foot of John Street • Lowell, Massachusetts 01852
Telephone 978-970-5600 • Fax 978-453-1995

Massachusetts Department of Environmental Protection **BWSC-108**
Bureau of Waste Site Cleanup

COMPREHENSIVE RESPONSE ACTION TRANSMITTAL FORM & PHASE I COMPLETION STATEMENT

Pursuant to 310 CMR 40.0484 (Subpart D) and 40.0800 (Subpart H)

Release Tracking Number: 3 - 00518

A. SITE LOCATION:

Site Name: (optional) Former General Electric Facility (Eastern Parking Lot/Drum Storage Area)

Street: 50 Fordham Road Location Aid:

City/Town: Wilmington ZIP Code: 01887

Related Release Tracking Numbers that this Form Addresses:

Tier Classification: (check one of the following) [X] Tier IA [ ] Tier IB [ ] Tier IC [ ] Tier II [ ] Not Tier Classified

If a Tier I Permit has been issued, state the Permit Number: 83052

B. THIS FORM IS BEING USED TO: (check all that apply)

[ ] Submit a **Phase I Completion Statement**, pursuant to 310 CMR 40.0484 (complete Sections A, B, C, G, H, I and J).

[ ] Submit a **Phase II Scope of Work**, pursuant to 310 CMR 40.0834 (complete Sections A, B, C, G, H, I and J).

[ ] Submit a final **Phase II Comprehensive Site Report and Completion Statement**, pursuant to 310 CMR 40.0836 (complete Sections A, B, C, D, G, H, I and J).

[ ] Submit a **Phase III Remedial Action Plan and Completion Statement**, pursuant to 310 CMR 40.0862 (complete Section A, B, C, G, H, I and J).

[X] Submit a **Phase IV Remedy Implementation Plan**, pursuant to 310 CMR 40.0874 (complete Sections A, B, C, G, H, I and J).

[ ] Submit a **As-Built Construction Report**, pursuant to 310 CMR 40.0875 (complete Sections A, B, C, G, H, I and J).

[ ] Submit a **Phase IV Final Inspection Report and Completion Statement**, pursuant to 310 CMR 40.0878 and 40.0879 (complete Sections A, B, C, E, G, H, I and J).

[ ] Submit a periodic **Phase V Inspection & Monitoring Report**, pursuant to 310 CMR 40.0892 (complete Sections A, B, C, G, H, I and J).

[ ] Submit a final **Phase V Final Inspection & Monitoring Report and Completion Statement**, pursuant to 310 CMR 40.0893 (complete Sections A, B, C, F, G, H, I and J).

You must attach all supporting documentation required for each use of form indicated, including copies of any Legal Notices and Notices to Public Officials required by 310 CMR 40.1400.

C. RESPONSE ACTIONS:

[ ] Check here if any response action(s) that serves as the basis for the Phase submittal(s) involves the use of Innovative Technologies. (DEP is interested in using this information to create an Innovative Technologies Clearinghouse.)

Describe Technologies:

D. PHASE II COMPLETION STATEMENT:

Specify the outcome of the Phase II Comprehensive Sites Assessment:

[ ] Additional Comprehensive Response Actions are necessary at this Site, based on the results of the Phase II Comprehensive Site Assessment.

[ ] The requirements of a Class A Response Action Outcome have been met and a completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

[ ] The requirements of a Class B Response Action Outcome have been met and a completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

[ ] Rescoring of this Site using the Numerical Ranking System is necessary, based on the results of the final Phase II Report.

E. PHASE IV COMPLETION STATEMENT:

Specify the outcome of the Phase IV activities:

[ ] Phase V operation, maintenance or monitoring of the Comprehensive Response Action is necessary to achieve a Response Action Outcome. (This site will be subject to a Phase V Operation, Maintenance and Monitoring Annual Compliance Fee.)

[ ] The requirements of a Class A Response Action Outcome have been met. No additional operation, maintenance or monitoring is necessary to ensure the integrity of the Response Action Outcome. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

[ ] The requirements of a Class B Response Action Outcome have been met. No additional operation, maintenance or monitoring is necessary to ensure the integrity of the Response Action Outcome. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

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DEP/NORTHEAST REGION
WOBURN, MASS.

Section E is continued on the next page

E. PHASE IV COMPLETION STATEMENT: (continued)

☐ The requirements of a Class C Response Action Outcome have been met. Further operation, maintenance or monitoring of the remedial action is necessary to ensure that conditions are maintained and that further progress is made toward a Permanent Solution. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

Indicate whether the operation and maintenance will be Active or Passive. (Active Operation and Maintenance is defined at 310 CMR 40.0006.):

○ Active Operation and Maintenance ○ Passive Operation and Maintenance

(Active Operation and Maintenance makes the Site subject to a Post-RAO Class C Active Operation and Maintenance Annual Compliance Fee.)

F. PHASE V COMPLETION STATEMENT

Specify the outcome of Phase V activities:

☐ The requirements of a Class A Response Action outcome have been met and a completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

☐ The requirements of a Class B Response Action Outcome have been met. No additional operation, maintenance or monitoring is necessary to ensure the integrity of the Response Action Outcome. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

☐ The requirements of a Class C Response Action Outcome have been met. Further operation, maintenance or monitoring of the remedial action is necessary to ensure that conditions are maintained and that further progress is made toward a Permanent Solution. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

Indicate whether the operation and maintenance will be Active or Passive. (Active Operation and Maintenance is defined at 310 CMR 40.0006.):

○ Active Operation and Maintenance ○ Passive Operation and Maintenance

(Active Operation and Maintenance makes the Site subject to a Post-RAO Class C Active Operation and Maintenance Annual Compliance Fee.)

G. LSP OPINION:

I attest under the pains and penalties of perjury that I have personally examined and am familiar with the information contained in this transmittal form, including any and all documents accompanying this submittal. In my professional opinion and judgement based upon application of (i) the standard of care in 309 CMR 4.02(1), (ii) the applicable provisions of 309 CMR 4.02(2) and (3), and (iii) the provisions of 309 CMR 4.03(5), to the best of my knowledge, information and belief,

> if Section B indicates that a **Phase I, Phase II, Phase III, Phase IV or Phase V Completion Statement** is being submitted, the response actions(s) that is (are) the subject of this submittal (i) has (have) been developed and implemented in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes off such response action(s) as set forth in the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, and (iii) complies(y) with the identified provisions of all orders, permits, and approvals identified in this submittal;

> if Section B indicates that a **Phase II Scope of Work** or a **Phase IV Remedy Implementation Plan** is being submitted, the response action(s) that is (are) the subject of this submittal (i) has (have) been developed in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes of such response action(s) as set forth in the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, and (iii) complies(y) with the identified provisions of all orders, permits, and approvals identified in this submittal;

> if Section B indicates that as **As-Built Construction Report** or a **Phase V Inspection and Monitoring Report** is being submitted, the response action(s) that is (are) the subject of this submittal (i) is (are) being implemented in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes of such response action(s) as set forth in the applicable provisions of M.G. L. c. 21E and 310 CMR 40.0000, and (iii) complies(y) with the identified provisions of all orders, permits, and approvals identified in this submittal.

I am aware that significant penalties may result, including, but not limited to, possible fines and imprisonment, if I submit information which I know to be false, inaccurate or materially incomplete.

☐ Check here if the Response Action(s) on which this opinion is based, if any, are (were) subject to any order(s), permit(s) and/or approval(s) issued by DEP or EPA. If the box is checked, you MUST attach a statement identifying the applicable provisions thereof.

LSP Name: Bruce A. Hoskins LSP #: 7109 Stamp: COMMONWEALTH OF MASSACHUSETTS BRUCE A. HOSKINS No. 7109 REGISTERED LICENSED SITE PROFESSIONAL

Telephone: (603) 893-0616 Ext.:

FAX: (optional)

Signature: B A Hoskins

Date: July 7, 2000

Massachusetts Department of Environmental Protection **BWSC-108**

Bureau of Waste Site Cleanup

COMPREHENSIVE RESPONSE ACTION TRANSMITTAL FORM & PHASE I COMPLETION STATEMENT

Pursuant to 310 CMR 40.0484 (Subpart D) and 40.0800 (Subpart H)

Release Tracking Number 3 - 00518

H. PERSON UNDERTAKING RESPONSE ACTION(S):

Name of Organization: TRC Environmental Corporation

Name of Contact: Joseph Yeasted Title: Vice President

Street: Boott Mills South, Foot of John Street

City/Town: Lowell State: MA ZIP Code: 01852

Telephone: (978) 970-5600 Ext.: FAX: (optional)

☐ Check here if there has been a change in the person undertaking the Response Action.

I. RELATIONSHIP TO SITE OF PERSON UNDERTAKING RESPONSE ACTION(S): (check one)

[X] RP or PRP Specify: ○ Owner ○ Operator ○ Generator ○ Transporter Other RP or PRP: Other legally responsible party

☐ Fiduciary, Secured Lender or Municipality with Exempt Status (as defined by M.G.L. c. 21E, s.2)

☐ Agency or Public Utility on a Right of Way (as defined by M.G.L. c. 21E, s.5(j))

☐ Any Other Person Undertaking Response Action Specify Relationship:

J. CERTIFICATION OF PERSON UNDERTAKING RESPONSE ACTION(S):

I Joseph Yeasted , attest under the pains and penalties of perjury (i) that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this transmittal form, (ii) that based on my inquiry of those individuals immediately responsible for obtaining the information, the material information contained in this submittal is, to the best of my knowledge and belief, true, accurate and complete, and (iii) that I am fully authorized to make this attestation on behalf of the entity legally responsible for this submittal. I/the person or entity on whose behalf this submittal is made am/is aware that there are significant penalties, including, but not limited to, possible fines and imprisonment, for willfully submitting false, inaccurate, or incomplete information.

By: Joseph H Yeasted (signature) Title: Vice President

For Joseph Yeasted (print name of person or entity recorded in Section H) Date: July 7, 2000

Enter address of the person providing certification, if different from address recorded in Section H:

Street:

City/Town: State: ZIP Code:

Telephone: Ext.: Fax: (optional)

YOU MUST COMPLETE ALL RELEVANT SECTIONS OF THIS FORM OR DEP MAY RETURN THE DOCUMENT AS INCOMPLETE. IF YOU SUBMIT AN INCOMPLETE FORM, YOU MAY BE PENALIZED FOR MISSING A REQUIRED DEADLINE.

SL=ECK

TRC

Customer-Focused Solutions

PHASE IV REMEDY IMPLEMENTATION PLAN EASTERN PARKING LOT AREA

Former GE Facility 50 FORDHAM RD
RTN 3-0518
Wilmington, Massachusetts

Submitted to:

Massachusetts Department of
Environmental Protection – NERO
205 A Lowell Street
Wilmington, Massachusetts 01887

Prepared by

TRC Environmental Corporation
Boott Mills South, Foot of John Street
Lowell, Massachusetts 01852
(978) 970-5600

TRC Project No. E9202-2402
July 7, 2000

PHASE IV REMEDY IMPLEMENTATION PLAN
EASTERN PARKING LOT AREA

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TRC Project No. E9202-2402
July 7, 2000

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GLOSSARY OF TERMS

Aquifer – Underground water supply located in soils and rock.

AUL – Activity and Use Limitation indicating an environmental restriction on a property.

Background – the level of oil and/or hazardous material that would exist in the absence of the site of concern.

Bailer – Field equipment used to sample groundwater from a monitoring well.

Degradation – The natural breakdown of contaminants.

Dense Non-aqueous Phase Liquid (DNAPL) – A distinct accumulation of liquid chemicals, such as solvents, in the subsurface that are more dense than water, and tend to sink.

Dig-Safe – Utility underground plant damage prevention system.

Downgradient – "Downstream" from an area of concern.

Extractable Petroleum Hydrocarbons (EPH) – Petroleum hydrocarbons found in "heavier" petroleum products, such as fuel oil.

Fingerprint Analysis – Laboratory analysis of sample to characterize the type of petroleum.

Flame Ionization Detection – field equipment used to screen headspace to identify the mass transfer of volatile oil and/or hazardous material to the sample headspace.

Fractured Bedrock – Rock located deep in the subsurface that is broken or split.

Groundwater – Water stored in aquifers (i.e. below the earth's surface).

Headspace Screening – analytical screening procedure identifying the mass transfer of volatile oil and/or hazardous material from a solid or liquid test sample to an overlying confined space.

Light Non-aqueous Phase Liquid (LNAPL) – A distinct accumulation of liquid oil or other chemicals, such as gasoline, in the subsurface that is less dense than water, and tends to float on water.

MCP – The Massachusetts Contingency Plan that defines environmental investigation and remediation requirements.

Outfall – The exit point of stormwater lines or other drains.

Overburden – Soil, sediments and gravel deposits on top of bedrock.

Part Per Billion (ppb) – A unit of measure used to express how much of a substance or compound is present in the environment. For example, one drop of trichloroethylene (TCE) in 26,000 gallons of water is approximately equal to 1 ppb of TCE in water.

Part Per Million (ppm) – A unit of measure used to express how much of a substance or compound is present in the environment. For example, one drop of trichloroethylene (TCE) in 26 gallons of water is approximately equal to 1 ppm of TCE in water.

PCE – Tetrachloroethylene, a commonly used chlorinated solvent used for machinery degreasing, and is denser than water.

PetroFlag Field Test Kit – A field analytical tool used to analyze concentrations of petroleum hydrocarbons.

Photo-Ionization – Field equipment used to screen headspace using an ultraviolet light source to identify the mass transfer of volatile oil and/or hazardous material to the sample headspace.

Piezometer – A groundwater well installed to measure vertical head differences.

Plume – The area impacted by contaminants commonly used to describe contaminants moving in groundwater.

Remedial Action – Containment or clean up of contaminated media.

Remedial Action Plan (RAP) – A document that presents the reasons for selecting a remedial action.

Remedy Implementation Plan (RIP) – A document that explains how a remedial action will be carried out.

Remedial Technology – A technological approach to contain or clean up site contamination.

Responsible Party (RP) – A person (or party) who is liable under M.G.L. c. 21E for any costs or damages.

Risk Characterization – the procedures for characterizing risks of harm to health, safety, public welfare and the environment.

Sediments – Material that accumulates on the bottom of lakes, ponds, streams, rivers or other surface water bodies.

Soil – Loose material overlying bedrock.

Upgradient – "Upstream" from an area of concern.

Soil Borings – A borehole constructed to determine subsurface conditions.

Stoddard fuel/solvent – A type of petroleum used to fuel aerospace engines.

TCE – Trichloroethylene, a commonly used chlorinated solvent used for machinery degreasing and dry cleaning, and is denser than water.

Volatile Petroleum Hydrocarbons (VPH) – Petroleum hydrocarbons found in "lighter" petroleum products, such as gasoline.

Volatile Organic Compound (VOC) – A substance containing carbon that has a tendency to evaporate.

Water Table – The top of the groundwater zone.

1.0 INTRODUCTION

This report presents a Remedy Implementation Plan (RIP) as part of Phase IV activities for the Eastern Parking Lot (EPL) Area at the former General Electric (GE) Facility site located at 50 Fordham Road in Wilmington, Massachusetts. This RIP conforms to the regulatory requirements under 310 CMR 40.0874 of the Massachusetts Contingency Plan (MCP). The site is listed as a Tier IA site with Release Tracking Number 3-0518. Regulatory oversight is provided by the Massachusetts Department of Environmental Protection (MA DEP).

Prior remedial actions in the EPL included the removal of Stoddard fuel (sometimes referred to as Stoddard solvent) from the groundwater surface as light non-aqueous phase liquids (LNAPL). LNAPL removal was successful and was completed in 1992. However, residual Stoddard fuel-related contaminants remain in the subsurface soil at and near the top of the groundwater table. This is a result of the contaminants adsorbing onto the soil from the groundwater. This RIP is designed to remove these contaminated soils from the EPL + in well P2-2S

The Phase III Remedial Action Plan Addendum for the EPL and Drum Storage (DS) Areas prepared by TRC Environmental Corporation (TRC) and submitted to MA DEP on March 16, 2000 selected soil excavation and off-site disposal as the remedy to implement at the EPL Area. Furthermore, this report concluded that remediation of the DS Area was unwarranted given that elevated contaminant levels, including that at boring B-1 (located in the same area that previously revealed elevated levels), were no longer observed. Therefore, per MA DEP's Conditional Approval Letter dated June 9, 2000, this RIP presents the approach for implementation of this remedy at the EPL Area.

Note that this RIP applies only to the EPL Area at the site. RIPs will be prepared individually for the other areas of concern at the site.

1.1 Site Description

The site property is an approximately 13-acre parcel of land located east of Fordham Road and north of Concord Street within an industrial park in the towns of Wilmington and North Reading, Massachusetts. Fordham Road is located along the western property boundary with industrial parcels located further to the west of Fordham Road. Commercial and industrial properties are located to the south. Wooded wetlands are located to the east and north. Residential properties are located beyond the wetlands further east and north. The site location is indicated on Figure 1-1. The EPL Area is located on the east side of Buildings 1 and 1A (Figure 1-2). Other areas, such as the former Tank Farm Area (where four underground storage tanks were located until 1987) are also shown on the site map.

The property buildings were used for manufacturing and to support research and development by the GE Aerospace Instruments Control Systems Department from the time they were built in 1970 through August 1989. A portion of Building 2 was subleased to Converse, Inc. (Converse), a sports shoe manufacturer, from 1973 to 1986, and a portion of Building 1A was subleased to Hamilton Standard, a manufacturer of hydrogen generators, from 1983 to 1985. In August 1989, GE's operations at the facility were sold to AMETEK Aerospace Products, Inc. (AMETEK).

AMETEK and General Scanning are the current tenants at the site. The Wilmington Realty Trust currently owns the site.

1.1.1 Contaminants to be Encountered During Implementation of Remedy

The contaminants known or expected to be encountered during the implementation of this RIP include:

- Stoddard fuel adsorbed to soil and possibly floating on the water table as LNAPL.
- Stoddard fuel-related petroleum hydrocarbons dissolved in groundwater.
- Chlorinated volatile organic compounds (VOCs) dissolved in groundwater.

Stoddard fuel is a liquid petroleum mixture that is colorless and flammable. It smells like kerosene and it will turn into a vapor at temperatures of 150° - 200° C. It is less dense than water and will tend to float on the water table.

As a petroleum product, it contains both aliphatic and aromatic hydrocarbons (Note: the terms aliphatic and aromatic reflect the structure of the hydrocarbon molecule). Per the MCP, a two-part specialized analytical method is used to determine the concentrations of these petroleum hydrocarbons so that health risks can be more appropriately evaluated. The Volatile Petroleum Hydrocarbon (VPH) method was developed to characterize potential health effects associated with the "lighter" portion of petroleum products (like gasoline). The Extractable Petroleum Hydrocarbon (EPH) method was developed to evaluate the potential health effects associated with the "heavier" petroleum products (like fuel oil). Both aromatic and aliphatic hydrocarbons are present in both the lighter and heavier products.

The chlorinated VOCs in groundwater are primarily trichloroethene (TCE) and tetrachloroethene (PCE) and the associated degradation products, cis 1,2-dichloroethene and vinyl chloride. TCE and PCE are solvents once used for degreasing metal parts. These VOCs entered the groundwater in the Tank Farm Area, and then migrated to the east in the direction of groundwater flow, into the aquifer under the EPL.

1.2 Nature and Extent of Contamination

1.2.1 Overview of Investigation History

The *Phase II Comprehensive Site Assessment Report*, prepared by GZA in April 1990, and the *Phase II Supplemental Investigation Report*, prepared by Wehran Engineering Corporation (Wehran) in November 1991 documented the discovery of a release of Stoddard fuel in the Tank Farm Area and the EPL area. As presented in the Supplemental Investigation Report (1991), Wehran discovered approximately one foot of LNAPL floating on the water table in piezometer PZ-2S, located east of Building 3. Wehran collected LNAPL and soil samples from the Tank Farm and EPL areas for total petroleum hydrocarbon (TPH) fingerprint analyses. Laboratory results indicated that the LNAPL was Stoddard fuel. The report suggested that a release of

Stoddard fuel may have occurred in the Tank Farm Area (former Tank G) and migrated to the east in the direction of groundwater flow (i.e., downgradient of the Tank Farm). However, it was also possible (although not documented) that a release occurred in the area of PZ-2S. Note that the "S" indicates this is a shallow (overburden) well. To date, a surface spill/release in the area of PZ-2S has not been confirmed.

In December 1991, MA DEP approved an Interim Measure for the EPL area that included the installation of two LNAPL recovery wells (RW-1 and RW-2). Recovery operations began in March 1992. Recovery well RW-1 was equipped with a groundwater and product recovery pump, while recovery well RW-2 was equipped with a belt skimmer. A total of 415 gallons of Stoddard fuel was recovered from these wells and disposed of properly.

There has been no recoverable LNAPL from RW-1 since October 1992, or from RW-2 since March 1992. The most recent monitoring of these wells, conducted in June 1999, revealed that there continues to be no recoverable LNAPL in the recovery wells.

In addition, Stoddard fuel was recovered in the bedrock recovery well TF-1, located in the Tank Farm Area during system start-up in 1991 through 1992. A total of 196 gallons of Stoddard fuel was recovered from well TF-1. No LNAPL is currently being recovered from this well despite continuous pumping of groundwater.

Based on the continued site groundwater monitoring, LNAPL on the groundwater table is essentially gone except for the appearance of LNAPL in well PZ-2S as detailed later in this section. It is believed that the actual amount of remaining LNAPL is very small and located only in the vicinity of well PZ-2S. Therefore, remaining Stoddard fuel contamination relates mainly to the fuel residuals that have adsorbed onto soils at and near the water table surface. Low volume recovery continues at PZ-2S by manual bailing.

In 1995, MA DEP established the site cleanup goals as the Method 1 S-3/GW-1 standards as established in the MCP. The numerical cleanup standards for Method 1 S-3/GW-1 for soil are shown in Table 1-1 below. The Method 1 S-3/GW-1 standards were selected by MA DEP as being appropriate for the site. GW-1 represents potential drinking water aquifers, which is appropriate for the site area. S-3 soils represent soils which have the lowest likelihood of contact with people. S-3 soils are soils that are isolated in the subsurface (greater than 15-foot depth) or are paved or otherwise covered with a barrier preventing direct contact by people. S-3 soils can also be unpaved surface soils, but only adults may be present and only for low frequency and low intensity uses. Again, this standard is appropriate for the site as it is used for industrial purposes and will continue to remain such for the foreseeable future. Also, the vast majority of the site is either paved or covered by buildings.

Use of the S-3 standards for site soil cleanup goals will limit future site use and require use restrictions under an Activity and Use Limitation (AUL); see Section 3.1 for a further discussion of this issue.

In May and August of 1996, EMCON (formerly known as Wehran) conducted soil sampling and analysis activities to define the limits of impacted soil and to design a soil remediation plan for the EPL Area and the Tank Farm Area. Results of this investigation were presented in the *Wilmington Soil Sampling Report*, prepared by EMCON in 1996.

Table 1-1
EPL Area Soil Remedial Action Cleanup Goals

CONTAMINANT OF CONCERN	S-3/GW-1 SOIL CLEANUP GOAL (MG/KG)
Volatile Petroleum Hydrocarbons (VPH)	
$C_5 - C_8$ Aliphatic Hydrocarbons	500
$C_9 - C_{12}$ Aliphatic Hydrocarbons	5,000
$C_9 - C_{10}$ Aromatic Hydrocarbons	100
Extractable Petroleum Hydrocarbons (EPH)	
$C_9 - C_{18}$ Aliphatic Hydrocarbons	5,000
$C_{19} - C_{36}$ Aliphatic Hydrocarbons	5,000
$C_{11} - C_{22}$ Aromatic Hydrocarbons	200
Total Petroleum Hydrocarbons (TPH)	200*

*Note that the cleanup goal for TPH is used only in the absence of VPH and EPH data.

EMCON advanced 34 initial soil borings in May 1996 and 13 additional soil borings in August 1996. A minimum of one soil sample was taken from each boring for laboratory analysis of TPH per Method 8100M (the established method at that time) and volatile organic compounds (VOCs) per Method 8010/8020. Four soil samples were also collected for analysis of the latest MA DEP analysis method (extractable petroleum hydrocarbons (EPH) and volatile petroleum hydrocarbons (VPH)) for comparison to the TPH results and in anticipation of MA DEP establishing EPH/VPH as the new standard for petroleum hydrocarbon analysis. Due to exceedances of the sample holding time and surrogate recovery results, the EPH and VPH sample results were qualified as "estimated concentrations." The results of two duplicate soil samples analyzed for TPH and EPH/VPH revealed no consistent correlation between TPH concentrations and EPH/VPH concentrations (relative percent difference of 59 and 101 percent). Several elevated TPH sample results in six boring locations were detected at depths of 4 to 7 feet in the EPL area, exceeding the proposed Method 1 S-3/GW-1 clean-up criteria. These locations were distributed in different areas of the EPL.

with methanol preservation

also exceeded holding times?

→ 1 of which exceeded S-3 std (that we know of since no methanol preservation).

In addition, in 1996, detectable concentrations of tetrachloroethene (PCE) were present in three samples in the DS area. Shallow bedrock in the DS vicinity limited sampling to a depth of 3 feet. An approximate area of impacted soil exceeding the Method 1 S-3/GW-1 clean-up criteria was outlined.

A *Phase IV Remedy Implementation Plan*, prepared by EMCON in April 10, 1998, proposed two areas of excavation based on Method 1 S-3/GW-1 exceedances. The excavation areas were identified in the area of the loading dock of Building 1 (Drum Storage Area) and the area east of Building 3 (Eastern Parking Lot). However, in 1999, TRC and MA DEP agreed that the locations of potentially contaminated soil that exceeds the current MCP soil cleanup criteria based on EPH and VPH analyses were insufficiently defined to proceed with the earlier remediation plans.

Therefore, to determine the degree and extent of VOC contamination in soil within the DS area, and EPH/VPH and VOC contamination in soil within the EPL area before initiating clean-up activities, TRC conducted a supplemental investigation using current MA DEP methodologies. The Scope of Work included:

- Collection of continuous soil samples at 31 locations along a proposed grid to a depth of 10 feet below ground surface (bgs) using Geoprobe drilling methods;
- Preliminary evaluation screening of soil samples for TPH and VOCs; and
- Collection of 25 confirmatory soil samples for laboratory analysis for EPH/VPH, and VOCs where appropriate.

Field soil screening evaluations included soil headspace analysis for VOCs using flame ionization detection and photo-ionization detection (FID/PID) and relative TPH concentrations using Petroflag field test kits. A full explanation of these field screening techniques is provided along with the results of this investigation in the *Phase III Remedial Action Plan Addendum Report, Eastern Parking Lot Supplemental Soil Sampling*, dated March 16, 2000. The results enabled TRC to establish approximate boundaries for soil to be excavated and removed, as well as to collect additional subsurface data that enabled the construction of a refined conceptual model of subsurface conditions and contaminant migration pathways. Figure 1-3 shows the approximate boundaries of the planned excavation areas.

These boundaries include all areas that clearly warrant soil removal. Not every soil sample that exceeded the field screening criteria is necessarily included because these are located close to the planned limits, and confirmation laboratory sampling of the sidewalls may indicate that the sidewall and therefore the area beyond the sidewall does not exceed the cleanup goal. In the event that a given location that originally exceeded the field screening criteria is not removed during excavation procedures and is not evaluated by confirmatory sidewall analysis, TRC will consider obtaining a separate soil sample from that location for laboratory analysis to complete the risk assessment for the EPL. The confirmation sampling will ultimately determine the final extent of the excavation. Therefore, the excavation area may ultimately increase in size to include these areas.

DEP to require....

It should be noted that TRC has expanded the targeted remediation area presented in the Phase III Addendum Report to include soil in the vicinity of monitoring well DP-6. This well has historically contained LNAPL. Approximately 0.2 feet of LNAPL was detected in April 1994, decreasing to approximately 0.03 feet in 1997, and 0.01 feet in 1998. Recent monitoring reveals a slight sheen on the water table. Therefore, TRC anticipates that the soil in this area contains petroleum hydrocarbons that will warrant remediation.

Cross sections of the EPL extending through the approximate excavation areas are shown in Figures 1-4a through 1-4d.

Cross Section A-A'

Figure 1-4a shows cross section A to A', a north-south transect across the targeted remediation area surrounding borings B17 and B18. The subsurface geology as depicted in this cross section consists of fine to coarse sand and gravel deposits that extend over 10 feet in thickness. In some areas the gravel thins out with depth.

Based on Petroflag and headspace screening and confirmatory sampling results, the targeted remediation area is from 4 to 10 feet below grade at boring B17 and from 4 to 8 feet below grade at boring B18.

Cross Section B-B'

Figure 1-4b shows cross section B to B', a north-south transect along the fence-line of the Site including the targeted remediation area surrounding borings B12, B13, and B14. The subsurface geology as depicted in this cross section consists of the sand and gravel deposits described in section A-A'.

Based on PetroFLAG and headspace screening and confirmatory sampling results, the targeted area is from 6 to 10 feet below grade. The figure also highlights zones at each boring where globules of LNAPL (Stoddard fuel) were observed during soil sampling. These zones extend 8.5 to 9.5 feet bgs, below both the seasonal low and high water table elevations observed to date. Further discussion of the presence of LNAPL appears in Section 1.2.3.

Cross Section C-C'

Figure 1-4c shows cross section C to C', an east-west transect including the two targeted areas for remediation. Bedrock in the area of boring B7A is approximately 8 feet bgs. Based on drilling logs for other borings in the Eastern Parking Lot, the bedrock surface drops, extending more than 30 feet bgs in the area of well EMW-11R. The unconsolidated deposits are the same sand and gravel deposits presented in sections A-A' and B-B', extending from approximately 8 feet at boring B7A to more than 27 feet at boring B23 (per drilling log interpretations in the area).

Laboratory results at boring B17 (4-10 feet bgs) and soil screening results (both headspace and PetroFlag) at boring B14 reveal exceedances, and therefore are included within the targeted remediation areas. Also included in the targeted area is well DP-6, as discussed above.

Cross Section D-D'

Figure 1-4d shows cross section D to D', an east-west transect through the two targeted remediation areas through monitoring well PZ-2S and boring B12 (further south of section C-C'). According to boring log information, monitoring well PZ-2S is located in the overburden, and completed on top of the bedrock surface, approximately 7.5 feet bgs. However, log information for neighboring borings and wells indicate that bedrock is located approximately 5 to 6 feet bgs in the area. Given that the shallow zone of bedrock is highly fractured and weathered, it is TRC's opinion that the bottom of the well screen for PZ-2S may be located in the shallow weathered/fractured bedrock portion of the aquifer. The possibility that monitoring well PZ-2S extends into rock is reflected on section D-D'. As depicted in section C-C', the bedrock surface drops further east under the EPL, extending more than 30 feet bgs in the area of well EMW-11R. The unconsolidated deposits are the same sand and gravel deposits presented in sections A-A', B-B', and C-C'.

The targeted remediation area includes boring B12, and extends from 6 to 10 feet bgs.

The TRC *Phase III Remedial Action Plan Addendum Report, Eastern Parking Lot Supplemental Soil Sampling* report also provided a summary of remaining LNAPL in the subsurface. Based on the monitoring data collected to date, LNAPL appears to be limited to the area of well PZ-2S. Historical data has shown that LNAPL in this well fluctuates with season (LNAPL thickness is generally greatest in the winter months and reduces in summer months). well dries out....

During December 1999 and January 2000, TRC manually removed LNAPL from well PZ-2S using a bailer on a weekly basis. Following six bailing events, the LNAPL thickness reduced to less than 0.6 feet. Based on these observations, it appears that the well is a preferential collection point for LNAPL, and the measured thickness is not representative of local aquifer conditions.

Historical data on thickness of LNAPL in well PZ-2S has been presented previously in the Eastern Parking Lot Area Interim Measure Annual Reports. A summary of LNAPL thickness data since 1994 is presented in Table 1-2.

Table 1-2
LNAPL Thickness in Monitoring Well PZ-2S

Date	LNAPL Thickness (feet)
April 15, 1994	0.85
June 20, 1994	0.22
December 14, 1994	0.39
June 14, 1995	0
December 19, 1995	0.25
June 10, 1996	0.21
December 9, 1996	0.83
June 30, 1997	0.17
December 29, 1997	0
September 11, 1998	0.15
December 23, 1998	0.99
June 23, 1999	0.11
December 6, 1999	1.3
December 20, 1999	1.5
December 29, 1999	0.60
January 4, 2000	0.53
January 10, 2000	0.63
January 25, 2000	0.60

recent bailing program

1.2.2 Current Subsurface Conditions

The original Phase IV Remedy Implementation Plan, as prepared by EMCON in 1998, identified two areas of soil excavation: one in the EPL and one in the DS area. EMCON based their area delineations on 1996 data. Based on the supplemental 1999 data, which included more extensive EPH/VPH analyses, TRC has been able to refine the delineation of contaminant distributions remaining in the subsurface. TRC's approximate soil excavation boundaries are based on MA DEP and MCP protocols commonly used to achieve the established cleanup standards. A comparison of the original soil excavation areas and the revised excavation areas is shown in Figure 1-5. As is shown in the figure, the revised excavation areas are substantially different and of less area than that originally proposed.

In accordance with MCP risk assessment protocols as they apply to MA DEP-established cleanup standards (S-3/GW-1 standards), and as previously described in the Phase III Remedial Action Plan Addendum Report (TRC, March 16, 2000), not every soil sample collection point above the cleanup standards was included in the approximate area of soil excavation. The reason for this is that the average overall concentration for each contaminant of any specific exposure point area (in this case the entire Eastern Parking Lot) must achieve the cleanup standard, although individual sample points may exceed the standard. In particular, current MCP regulations state that as long as the average concentration is below the cleanup standard, at least 75% of the data points are at or below the standard, and no single point exceeds the standard by more than a factor of 10, then the cleanup goal has been achieved. Certain locations with soil cleanup goal exceedances satisfy these three conditions and are not included in the planned excavation areas. Such sampling locations include B11, B15, and B28 (which have confirmatory laboratory results). Their individual exceedances do not preclude the overall achievement of the cleanup goal, and removal of the areas designated by TRC will achieve the cleanup goal for the EPL.

"75/10" rule
40.0926(3)(

Chlorinated VOCs

A review of the 1996 VOC data showed only a single data point within the Drum Storage Area exceeding the S-3/GW-1 standards for a single compound (PCE was detected at a concentration of 2.8 mg/kg in EMCON boring SB-23 at a 0.5 ft depth, as compared to a S-3/GW-1 cleanup goal of 0.5 mg/kg). However, using the MCP risk assessment protocols discussed earlier in this section that allow the use of data averaging, the 1996 VOC data successfully demonstrate a level of no significant risk for VOCs using Method 1 S-3/GW-1 standards.

Nevertheless, TRC proceeded to collect samples for VOC analysis in the area of concern (TRC borings B-1 and B-4). No VOCs were detected in any of the samples, including the sample from boring B-1, located immediately next to the EMCON boring that revealed elevated PCE concentrations. This indicates that the former elevated PCE levels in that discrete area within the Drum Storage Area are no longer present, most likely due to either volatilization or natural degradation. Given the lack of any other 1996 or 1999 soil data showing elevated concentrations of chlorinated VOCs in the EPL/DS areas, chlorinated VOCs can be eliminated as contaminants of concern and therefore, soil remediation in the Drum Storage Area is unwarranted.

→ Agreed

Stoddard Fuel-Related Petroleum Hydrocarbons

A review of the 1996 EMCON data for TPH analysis showed a total of nine boring locations (out of 47 locations) where TPH exceeded the S-3/GW-1 soil cleanup goal. These points are not located near any one area, but are located sporadically in the EPL/DS areas. There were also substantial areas of the EPL where no samples were collected. The original excavation area proposed by EMCON was very conservative and included all sample points with soil cleanup goal exceedances in two large areas – one in the EPL and one in the DS area. As a result, the proposed excavation areas included zones where either no sampling was performed or samples below cleanup goals were present. In addition, these earlier boundaries were defined exclusively using TPH results. The use of EPH/VPH data for delineating the need for remediation is now preferred under the MCP.

The new targeted remediation area delineated by TRC ~~are~~ is based on the most recent EPH/VPH data and are intended to remove only soil from those areas that prevent the achievement of the site cleanup goal. Both the 1996 and 1999 soil data for petroleum hydrocarbons confirms that petroleum contamination from Stoddard fuel remains in the EPL soils at levels that require remediation. The 1999 soil data has given a clearer indication of the remaining levels in the EPL by providing a more complete characterization and by showing that some biodegradation had occurred since the 1996 data was collected.

75/10 rule

Remaining petroleum contamination is present in the EPL soils at or near the top of the groundwater table. These impacted soils are located at depths between the seasonable high and low water table elevations (sometimes also known as the "smear zone"). The remaining contamination is located in this zone because LNAPL was dragged up and down along the top of the water table with the seasonal changes in water table elevation. Therefore, soil contamination with Stoddard fuel contaminants came to be located in soil in the smear zone, with contamination depth reflecting the annual changes in groundwater elevation. As such, the soil contamination is limited to a zone approximately at depths from 4-10 feet from the surface (refer to Figures 1-4a through 1-4d). At certain sampling locations (B-12 and B-13), TRC also identified small globules of Stoddard fuel in soil below the water table from approximately 8.5 to 9.5 feet bgs.

LNAPL

As previously documented in the Eastern Parking Lot Interim Measure Annual Reports, historical data on LNAPL thickness has shown the presence of LNAPL in well PZ-2S. However, historical data on LNAPL thickness in the wells closest to and surrounding PZ-2S (GZA-103, GZA-15, WE-5, GZA-7, GZA-102, and RW-2) have not detected the presence of measurable LNAPL since 1992. The surrounding wells are located at distances between 30 and 100 feet from PZ-2S. Given that LNAPL has been encountered only in PZ-2S and not in these nearby wells, TRC believes that the amount of LNAPL remaining in the subsurface is limited and is localized around well PZ-2S. The remaining volume of LNAPL is considered to be very low, and is not expected to migrate and significantly impact the soils and groundwater in the EPL. TRC's continuing program to periodically remove LNAPL from well PZ-2S will further retard any migration and impacts.

=Key concern (re-contamination).

TRC Evaluation of Relevance of Previous Investigation Data

In the MA DEP letter of Conditional Approval of the EPL/DS Phase III Remedial Action Plan Addendum dated June 9, 2000, MA DEP requested that TRC discuss the relevance of previous investigation data and consider this data, to the extent relevant, to delineate soil excavation areas. The data that MA DEP was specifically referring to is data in the *Wilmington Soil Sampling Report* (EMCON, 1996).

As discussed previously in this section, TRC did use this 1996 data as a comparison to the 1999 data for both chlorinated VOCs in the DS area and Stoddard fuel-related petroleum hydrocarbons in the EPL. TRC did not use the 1996 data for the delineation of soil excavation areas, however, because TRC determined that the old data was not relevant for such determinations. TRC based this conclusion on the following facts:

- Biodegradation has taken place since 1996. This was evidenced by the fact that TRC collected samples in some locations where previous data had shown elevated contaminant levels and found that the elevated levels are no longer present.

- There have been substantial changes in analytical procedures since 1996. In 1996, TPH analysis was commonly performed using EPA Method 8100 Modified. Since 1997, EPH/VPH analysis has become the standard methodology for petroleum hydrocarbon analysis, and MA DEP considers the EPH/VPH analysis to be superior to TPH analysis. Data from the two methods are not directly comparable to one another, and thus the value of the 1996 TPH data is compromised. + methanol preservation for VOC sampling.

- The 1996 data did not fully characterize the EPL. The 1999 data set methodology ensured that more complete characterization would be achieved. The TRC excavation area delineations are based on samples collected in areas where no previous data was obtained.

1.2.3 Conceptual Model of Subsurface

TRC was able to develop a conceptual model to explain the distribution and occurrence of contamination in the subsurface within the EPL study area with the data collected during the Supplemental Sampling Program (as reported in the Phase III Addendum Report dated March 16, 2000).

As described in the cross section analysis, the bedrock surface in the Tank Farm Area is shallow, extending 3 to 5 feet bgs. However, the rock surface drops down to more than 25 feet bgs in the area of the fenceline (east of the Tank Farm Area), and further increases in depth across the EPL toward the wetlands. Recent water table measurements indicate that the water table fluctuates from 5.6 to 6.1 feet bgs. Historically, significantly wet or dry years increase the water table fluctuation.

Any LNAPL that accumulates on top of the water table will move up and down through the aquifer as the water table changes in elevation. In the unconsolidated portion of the aquifer (sand and gravel deposits) the fuel adsorbs to the sand and gravel as the water table fluctuates, creating what is referred to as a "smear zone" of residual Stoddard fuel (i.e., petroleum hydrocarbons).

As described in the Remedial Investigation – Progress Report prepared by Goldberg-Zoino & Associates in December 1988, Stoddard fuel was stored in the Tank Farm Area, including Stoddard fuel. These associated underground storage tanks (USTs) were located within a "grave" constructed in bedrock to accommodate the tanks. Therefore, any release of fuel from the USTs would have either migrated through a thin layer of overburden (approximately 3-5 feet in thickness) around the tanks, or through shallow fractures in the rock in the direction of groundwater flow (eastward), depending on the location and depth where the release occurred (i.e., supply line leak, surface spill, tank leak, etc.)

Today, only residual contamination appears in the EPL area, and an isolated area of LNAPL appears at well PZ-2S. In monitoring well PZ-2S, a narrow smear zone most likely has developed. However, field monitoring has shown that as the water table drops into the fractured rock portion of the aquifer, the thickness of LNAPL decreases and sometimes disappears. Given these observations, it appears that the LNAPL is adsorbed to the soils, and releases when the water table rises. LNAPL is still detected on the water table in well PZ-2S. However, given that LNAPL has not been detected in any of the neighboring monitoring wells, TRC believes that the mass amount of free product remaining is very small and localized around PZ-2S.

At certain sampling locations (B-12 and B-13), TRC identified small globules of Stoddard fuel in soil below the water table. The presence of these globules was unexpected since this material would tend to float on the water table and no floating product was observed in these locations. Locations B-12 and B-13 are located near the bedrock drop-off. TRC believes these globules are the result of very small amounts of Stoddard fuel being released from the shallow bedrock fractures into the overburden below the water table at these locations. Today, the amount of fuel is either not sufficient to become a free-phase that would float upward to the water table or is trapped within the soil matrix. This conceptual flow pathway of LNAPL through shallow bedrock fractures is depicted on Figure 1-4d (Section D-D').

or water table dropped very low during drought

It is unclear how the Stoddard fuel was released. However, based on the present day distribution of contamination and the appearance of LNAPL globules below the water table along the bedrock drop-off, it is possible that Stoddard fuel released in the Tank Farm Area migrated through shallow bedrock fractures to the east, in the direction of groundwater flow. The LNAPL would tend to stay in the shallow fractures because it is less dense than water and has a tendency to float. Some of the LNAPL that entered the fractures would have followed the groundwater migration pathways until emerging in the sand and gravel deposits in the EPL under the water table. In some areas, the LNAPL floated to the top of the water table and continued to migrate east.

The LNAPL was removed during product recovery operations in 1991-1992 from recovery wells RW-1 and RW-2. However, given the most recent data regarding the subsurface conditions, residual contamination remains trapped from adsorption onto soil (4 - 10 ft bgs), and is not of sufficient concentration to be released as LNAPL onto the water table across the area.

1.3 Work Rationale

As previously discussed, MA DEP has previously established the site cleanup goals as the Method 1 S-3/GW-1 standards (individual soil contaminant cleanup standards are shown in Table 1-1). In the EPL Area, remediation is limited to soil impacted with EPH/VPH. Remediation is based on the removal of EPH/VPH to achieve the S-3/GW-1 soil standards.

2.0 MANAGEMENT

2.1 Project Organization

2.1.1 Key Contacts

The responsible party for this site and for implementation of this RIP is TRC Environmental Corporation (TRC). The contact person at TRC is:

Paola Macchiaroli, Ph.D., Project Manager
TRC Environmental Corporation
Boott Mills South, Foot of John Street
Lowell, MA 01852
(978) 656-3582

The Licensed Site Professional (LSP) of Record is:

Mr. Bruce Hoskins, LSP #7109
URS Corporation
5 Industrial Way
Salem, NH 03079-2830
(603) 893-0616

2.1.2 TRC Personnel

TRC's remediation team will be led by a field program supervisor or site manager. The TRC project field team will include a Site Manager/Health and Safety Officer, a Project Engineer, and engineering assistants and technicians as needed. The Site Manager/Health and Safety Officer will remain onsite throughout the duration of the field effort. The LSP will also be onsite as needed. The LSP is responsible for ensuring that all work is performed in accordance with the MCP and other applicable regulations. The LSP will ensure that the work performed does not deviate from the goals described in this RIP and that established remediation objectives are met.

2.2 Schedule

It is the intent to begin excavation at a time when the groundwater table is at its lowest point. Therefore, anticipated field start time is in the beginning of September, 2000. If the remedial action is delayed, it will have significant impacts on the ability to perform the response action in a timely and safe manner. Schedule delays could result in the following:

1. Excavation at a time with an elevated groundwater table will significantly increase the time necessary to complete excavation and generate more wastewater requiring disposal.

2. During the autumn and winter months, the ability to remove contaminated materials could be reduced as disposal facility capacity decreases (e.g., facilities that recycle petroleum

impacted soil are limited by cold weather). This could impact the ability to remove the contaminated soil in a safe and timely manner.

3. Additional health and safety issues will occur if excavation is performed during colder weather or when the water table is higher. Hurricane season also begins in late September, and such weather patterns must be considered as health and safety concerns.

Therefore, TRC has set September 15, 2000 as the latest possible excavation start date for the 2000 work season. Every effort will be made to achieve this goal. If excavation cannot begin before this date, then the field actions will need to be postponed until the summer of 2001.

The proposed timeline for the Phase IV activities is as follows:

- August 1, 2000 – Public meeting for this RIP in accordance with the site Public Involvement Plan
- August 10, 2000 – End of public comment period
- August 28, 2000 – MA DEP approval of the RIP
- September 5, 2000 – Begin soil excavation
- September 19, 2000 – Complete soil excavation
- October 3, 2000 – Complete site restoration
- October 30, 2000 – Complete installation of new and replacement groundwater wells
- November 7, 2000 – Complete sampling of new and replacement wells
- December 23, 2000 – Submit Phase IV Final Inspection Report

2.3 Inspections and Monitoring

Inspections and monitoring will be conducted to ensure adequate performance of the remedial action. The types and frequencies of inspections and monitoring are described in Section 4.3.

2.4 Deliverables

Following the completion of field activities (soil excavation and off-site disposal), a Phase IV Final Inspection Report will be prepared. The Final Inspection Report will document the findings of the inspection as conducted by the LSP. The final inspection will ensure that the remedial action has been performed in accordance with the RIP and has met the objectives. The Final Inspection Report will be accompanied, if applicable, with a Phase IV Completion Statement; this will include an opinion by the LSP as to whether the RIP implementation has been completed in accordance with the MCP.

3.0 ENGINEERING DESIGN

3.1 Remedial Action Goals and Performance Requirements

Response actions in the EPL Area are limited to soil. The remedial action goals for soil cleanup are the MCP Method 1 S-3/GW-1 standards. These standards for the contaminants of concern are listed in Table 1-1, and are discussed in Section 1.2.1.

The Method 1 S-3/GW-1 standards were selected by MA DEP as being appropriate for the site. GW-1 represents potential drinking water aquifers, which is appropriate for the site area. S-3 soils represent soils which have the lowest likelihood of contact by people. This standard is appropriate for the site as it is used for industrial purposes and will continue to remain such for the foreseeable future. Also, the vast majority of the site is either paved or covered by buildings.

Under MCP regulations, the use of the S-3/GW-1 standards assumes that residual soil contamination will remain, but remaining levels will not be a significant risk to human health or the environment. However, the use of these standards will limit future site use. Use of the S-3/GW-1 standards assumes the following conditions:

- Groundwater is to be used for drinking water purposes either currently or potentially in the future.

- Soils are to be either at substantial depths (greater than 15 feet) or otherwise paved or covered by a building structure.

- AULs are required at the site to prevent unauthorized use.

Ultimately, when field remedial response actions have been completed and the S-3/GW-1 has been achieved for soil, an AUL will need to be placed on the property to disallow certain site uses and activities. Site use limitations that will be required by the use of the S-3/GW-1 standards include the following:

- Current and future site use is limited to adult commercial or industrial use.

- Residential and public site use is prohibited.

- Institutional, educational, or commercial uses where children are present (i.e., day care, school, hotel) are prohibited.

- Soils that exceed the GW-1/S-1 criteria (i.e., residential criteria) must remain covered by pavement or permanent building structures to prevent direct contact.

Specifically, all uses other than commercial/industrial will be prohibited and the soil in the EPL area will have to remain paved or otherwise covered to prevent direct contact with the soil. These limitations may inhibit the future use of the site. The AUL is required under the MCP unless response actions have removed sufficient contamination to allow unrestricted uses of the site. In the 1993 *Phase III Remedial Action Plan*, prepared by Wehran Engineering, it was determined that is was not feasible or cost effective to remediate the site to unrestricted use conditions. MA DEP accepted this conclusion.

Alternative to Improve Site Reuse Options

In an attempt to reduce some of the eventual property use restrictions, TRC prepared a preliminary Method 3 site-specific risk characterization in accordance with MCP protocols using data in the EPL Area. This risk characterization is not intended to be used to reduce the scope of field actions and contaminated soil removal, but to see if the level of cleanup expected to result from this RIP would result in a sufficiently low level of residual risk to reduce the future use restrictions.

In the Method 3 approach, total risk levels were calculated for several human exposure scenarios (e.g., future site resident, commercial worker, and construction/utility worker). Under current conditions, there is a significant risk to both the future site resident and site commercial worker; this was an expected conclusion and validates the need for soil remediation in the EPL Area. However, using the projected soil excavation areas determined using the Method 1 S-3/GW-1 approach, the Method 3 risk assessment shows that a level of no significant risk could be achieved for the future commercial worker without the need for soil pavement or covering. The level of post-remediation risk would still be unsuitable for future residential use.

These results are preliminary and would need to be finalized using soil data collected during and after the completion of soil removal activities. They indicate, however, that if a Method 3 risk assessment is allowed by MA DEP once Method 1 S-3/GW-1 cleanup goals are achieved, a lower level of residual risk could be demonstrated without changing the field soil remediation plan. The advantage of using the Method 3 would be in placing an AUL on the site with much less restrictions than would be required under the Method 1 S-3/GW-1 approach. This would allow more flexibility in future commercial site use while still ensuring a level of no significant risk.

The preliminary Method 3 risk characterization is presented in Appendix A.

As an alternative to the Method 3 approach, Method 1 S-2/GW-1 standards could also be used to limit site restrictions in the same way as the Method 3 approach. Use of the S-2 standards for site cleanup goals will limit future site use to industrial or commercial activities and permit limited human access to the soil. The Method 1 S-2/GW-1 standards are more conservative than the S-3/GW-1 standards and require a higher level of cleanup. If the S-2/GW-1 standards are achieved, then less site use restrictions would be necessary. A comparison of the S-3/GW-1 and S-2 GW-1 standards for EPL contaminants of concern are shown in Table 3-1.

Table 3-1
EPL Area Soil Remedial Action Cleanup Standard Comparison

CONTAMINANT OF CONCERN	S-2/GW-1 STANDARD (MG/KG)	S-3/GW-1 STANDARD (MG/KG)
Volatile Petroleum Hydrocarbons (VPH)		
$C_5 - C_8$ Aliphatic Hydrocarbons	500	500
$C_9 - C_{12}$ Aliphatic Hydrocarbons	2,500	5,000
$C_9 - C_{10}$ Aromatic Hydrocarbons	100	100
Extractable Petroleum Hydrocarbons (EPH)		
$C_9 - C_{18}$ Aliphatic Hydrocarbons	2,500	5,000
$C_{19} - C_{36}$ Aliphatic Hydrocarbons	5,000	5,000
$C_{11} - C_{22}$ Aromatic Hydrocarbons	200	200

Therefore, the following approach will be used by TRC to determine the degree to which the remedial action goals have been achieved:

- The final database of soil data quality in the EPL will be compared to the Method 1 S-3/GW-1 standards as the established site cleanup goals. Applicable MCP risk assessment regulations and protocols will be utilized in performing this Method 1 characterization.
- If the S-3/GW-1 standards are not achieved, additional remediation will be necessary.
- If the S-3/GW-1 standards are achieved, then the remedial goals are achieved and no further remediation will be necessary to satisfy the requirements of this RIP.
- Once the goals are achieved, the soil database will be compared to the Method 1 S-2/GW-1 standards to determine if these more restrictive goals have been concomitantly achieved.
- If the Method 1 S-2/GW-1 standards have been achieved, then less restrictive AULs will be sought and no Method 3 risk characterization will be performed.
- If the Method 1 S-2/GW-1 standards have not been achieved, then a site-specific Method 3 risk characterization would be performed to determine whether a less restrictive AUL can be supported.

3.2 Significant Changes/New Information

There have been no significant changes in or new information related to conditions within this area of concern, which were not included in previous submittals. The Phase III Addendum Report for the Eastern Parking Lot was submitted to the MA DEP on March 16, 2000. There have been no on-site activities conducted in the Eastern Parking Lot since the soil sampling that was documented in the Phase III Addendum Report.

3.3 Remedial Action Area Description

The EPL area is currently paved and utilized by AMETEK for parking. Utilities including electrical, drainage and sanitary sewers are located within the proposed area of excavation.

Soil exceeding the cleanup criteria is located within the western portion of the EPL. The Phase III Addendum Report defines the horizontal and vertical extent of the contaminated soil based on laboratory and screening data.

The proposed limits of soil excavation include two specific areas as shown in Figure 1-3. The first area is centered around sample locations B-12, B-13, and B-14, with the most heavily contaminated soil to be removed located at the 6 to 10 bgs depth region. The second area is located around sample points B-17 and B-18, with contaminated soil to be removed at the 4 to 8 feet bgs depth range. The conditions in the EPL area can be summarized as follows:

- The bedrock surface drops abruptly to the east, to depths greater than 10 feet in the EPL.
- The distribution of LNAPL in the overburden, and related EPH and VPH compounds appear to be related to a single release (presumably from the former Tank Farm).
- There is one anomaly to this model. Soils located in the area of B-18 also exhibit elevated concentrations of EPH and VPH compounds. It is possible that a separate surface spill may be the cause of this seemingly separate area of impact. ✗
- Scattered LNAPL globules are present in soils under the water table, immediately beyond the bedrock "drop-off" (borings B-12 and B-13). The presence of globules of LNAPL under the water table is unexpected, given that the Stoddard fuel (as LNAPL) would tend to float on top of the water table. In addition, a depression in historical water table elevations cannot account for the presence of LNAPL at 8 to 10 feet bgs. These globules most likely are attributed to the past migration of LNAPL through bedrock fractures in the area of PZ-2S. The LNAPL likely seeped from a bedrock fracture system located under the water table into the overburden, and is either trapped in the soil matrix or remains of insufficient mass to behave as a floating product.

The approximate total volume of soil to be excavated is 5,450 cubic yards, with approximately 2,560 cubic yards representing contaminated soil to be disposed offsite. The remainder of the soil represents uncontaminated soil located in the shallow depths above the contaminated soil; this soil will be used for on-site backfill following appropriate field screening.

3.4 Remedial Action Conceptual Plan

The general remedial action plan for the EPL Area is for soil excavation and off-site disposal for the most heavily contaminated soils located in the Eastern Parking Lot. Remedial action plan specifics are detailed in Section 3.5.

Soil will be excavated in the areas designated in Figure 1-3. All necessary safety, security and erosion/sedimentation control measures will be implemented prior to remedial activities. As necessary, dewatering activities will take place in the excavation. Removed groundwater will be stored temporarily in an on-site storage tank and will ultimately be taken offsite for disposal at a licensed facility. The upper uncontaminated soil will be stockpiled onsite and used as backfill. The contaminated soil will be removed and placed directly in trucks for offsite disposal at a licensed facility. If necessary, some contaminated soil may be placed in secured and covered roll-off containers for temporary storage. All efforts will be made to transport these filled roll-off containers off-site for disposal the following day. Field screening will be used to delineate the extent of the excavations, and post-excavation soil samples will be collected and analyzed to confirm that cleanup goals have been achieved. Excavations will be backfilled with previously excavated uncontaminated soil (per field screening) and clean soil from off-site sources. Any groundwater wells (except recovery well RW-1), as well as any utility lines disrupted during excavation will be replaced and the parking lot will be restored to its original surface. After the restoration, additional shallow overburden groundwater wells would be installed in the EPL. These wells would be sampled periodically for EPH/VPH to determine groundwater quality in the EPL.

In addition to the excavation, active LNAPL recovery will be performed on well PZ-2S. Vacuum extraction on this well will occur on a monthly basis (during months where LNAPL is present in the well) until the LNAPL thickness is reduced to less than 1/8 inch. Monitoring of this well will continue to be part of the EPL monitoring program. and maintained at

3.5 Design and Operating Parameters

This section describes the tasks to be conducted and the requirements to be followed during remedial activities in the EPL Area. Significant modifications to the procedures outlined in this section due to field conditions or other unforeseen conditions will be recorded in the field book. The LSP will be notified of any major modifications necessary; the LSP will approve such modifications before they take place.

State and local permits (if applicable as described in Section 6.0), will be acquired prior to mobilizing and conducting remedial activities.

The site-wide Health and Safety Plan (HASP), described in Section 5.0, will be used as the base HASP during EPL Remedial Activities. This HASP covers all investigative and remedial activities that will be conducted at the former GE Facility. Project-specific health and safety activities and concerns not addressed in the site-wide HASP will be added via amendment.

TRC has included Division II construction specifications in Appendix B, detailing all anticipated site work activities. The Division I specifications (general requirement) that include confidential information will be provided to MA DEP after bidder solicitation and selection of a remedial contractor, prior to implementation of this RIP.

3.5.1 Remedial Design Criteria, Assumptions, Calculations

The aerial extent of the proposed soil excavations are shown in Figure 1-3. Geologic cross-sections showing the depths of the excavations are included as Figures 1-4a through 1-4d. There are two specific areas selected for soil removal based upon the confirmed presence (based on laboratory data) or suspected presence (based on screening data) of the highest contaminant concentrations that result in the majority of area risk. The first area is centered around sample locations B-12, B-13 and B-14 with the most heavily contaminated soil to be removed from the 6 to 10 ft depth region. This results in the planned removal of approximately 1,360 cubic yards of soil for treatment, recycling or disposal. The second area is centered around sample points B-17 and B-18 with contaminated soil to be removed from 4 to 8 ft and 4 to 10 ft depths. This would result in the removal of approximately 1,200 cubic yards of contaminated soil.

Field screening and confirmatory soil samples (as detailed in Section 4.0) will be collected at the limits of the excavation. If such samples indicate the presence of elevated concentrations of contaminants (as defined in Section 4.3), excavation will continue until the levels are confirmed to be within the cleanup goals for the area. Once excavation is complete, a reevaluation of risk will be performed to evaluate and establish a condition of no significant risk for current and future commercial site use.

3.5.1.1 Site Preparation

Proposed excavation areas, as shown on Figure 3-1, will be marked prior to remedial activities. TRC will coordinate with AMETEK (current occupant) to determine the location of underground utilities in the areas where excavation and remedial activities will take place. In addition, all other available utility markout procedures, including the use of Dig-Safe, will be employed to ensure that no additional privately-owned utilities are located within the vicinity of remedial activities. Locations of utilities will be clearly marked.

The Outfall 001 drainage line (shown in Figure 3-1) has already been identified to exist in the proposed excavation area. This drainage line is currently active and discharges storm water and non-contact cooling water under a NPDES permit to the wetlands. Should the drainage line be breached in the area of the proposed excavation, the line will be repaired to prevent leaking.

Other activities that will be conducted prior to remedial activities include:

- Establishing existing site grades to ensure that these grades are reestablished after excavation activities;
- Installation of erosion and sedimentation controls (described in Section 3.9);
- Identifying haul road and staging areas for equipment, supplies, clean soil stockpile and dewatering storage tanks (described in Section 7.0); and

- Establishing an Exclusion Zone for the remedial action in which only those involved with the remedial action will be allowed entry. A temporary barrier will be erected at the boundary of the Exclusion Zone to restrict unauthorized personnel.

3.5.1.2 *Excavation and Dewatering Activities*

During all excavation and dewatering activities, site health and safety monitoring will be conducted in accordance with the HASP. Groundwater dewatering will be necessary as the proposed limit of the excavation is below the groundwater table. Appropriate measures, as detailed in Section 3.9, will be maintained to minimize impacts to the environment.

As previously discussed, excavation activities will commence in the area of the drainage line for Outfall 001 to determine if it is damaged or leaking such that significant quantities of water could be released into the excavation. If this is so, the line will be repaired prior to additional excavation. good idea!

Excavation and backfilling activities will progress along the portions of the excavation areas in stages as opposed to performing excavation in all areas prior to any backfilling. This will minimize related safety concerns and the impact of rainfall events on site operations.

backfill as they progress to next stage.

Asphalt

The asphalt in the area of excavation will be cut and removed prior to soil excavation. The contractor will dispose of the asphalt at an approved facility.

Uncontaminated Surface Soil

Soil sampling efforts performed prior to this RIP indicate that soil at shallower depths is uncontaminated and therefore can be retained on site to be used as backfill. It is anticipated that approximately 2,890 cubic yards of clean soil will be retained and used as backfill. In the proposed excavation area around B12, B13 and B14, soil excavated to a depth of 6 feet will be retained on-site and used as backfill. In the proposed excavation area around B17 and B18, soil excavated to a depth of 4 feet will be retained on-site and used as backfill.

To ensure that the surface soil is not contaminated, composite samples will be collected from each 100 cubic yards of soil removed and field screened using the PID headspace screening method (as described in Section 4.0). If contaminated soil is encountered, it will be segregated from the uncontaminated soil and will be managed as contaminated soil, following the specifications in Appendix B. The uncontaminated soil will be stockpiled onsite and will be segregated from contaminated soil areas to prevent cross-contamination. Stockpiling of the uncontaminated soil, including erosion control, will be conducted following the specifications detailed in Section 3.9.

Stoddard Fuel Contaminated Soil

In the area of sample points B12, B13 and B14, approximately 1,360 cubic yards of contaminated soil will be excavated from the 6 to 10 ft depth region. In the area of sample points B17 and B18, approximately 1,200 cubic yards of contaminated soil will be excavated from the 4 to 8 ft and 4 to 10 ft depths. Soil Excavation calculations are included as Appendix C. Excavation activities will be conducted in a manner that will reduce fugitive dust and odors (as described in Section 3.9).

The contaminated soil is planned to be directly loaded into trucks and immediately transported off site to the licensed treatment, recycling or disposal facility. Analytical data collected during the previous investigations in the EPL area are to be used to obtain pre-approval of soil acceptance from the disposal facility prior to excavation activities. The trucks hauling contaminated material off site will be fitted with a snuggly fitting tarp to prevent material and debris from flying out of the truck. The soil will be suitably dewatered prior to leaving the site to prevent free water from developing during transport to the disposal facility. In addition, the trucks will be decontaminated, if necessary, following the procedures outlined in Section 3.9.

In the event that a sufficient number of trucks are not available to maintain progress with soil excavation, the contaminated soil will be loaded into roll-off containers for transport off site the following day. The contaminated soil will be managed following the specifications in Section 3.7. The roll-offs will be covered and secured in the work zone, and appropriate sedimentation/erosion and odor controls will be implemented.

Groundwater Dewatering

Because the limits of the soil excavation extend beneath the groundwater table, localized groundwater dewatering will be required. Temporary dewatering sumps will be installed in each excavation to lower and maintain groundwater levels below depths required for soil excavation. Dewatering operations will be conducted in a manner that does not cause disturbance to pipe bedding or soil supporting overlying or adjacent structures. Dewatered conditions will be maintained during active work periods until regrading activities are completed.

The pumped groundwater will be stored in a temporary on-site 20,000-gallon above ground storage tank (AST), which will be periodically pumped out during excavation activities for disposal at a licensed off-site facility. This water will be managed following the specifications in Section 3.7 in accordance with applicable local, state, and federal requirements and permits. It is anticipated that approximately 11,000 gallons of groundwater will be pumped during excavation activities. However, the 20,000 gallon AST will be used to provide for contingency volume.

Confirmatory Soil Sampling

Soil samples will be collected for field screening at the limits of the proposed excavations. Field screening will be conducted following the procedures outlined in Section 4.0. If the screening samples indicate that cleanup goals for the area are met, confirmation soil samples will be collected for laboratory analysis. The procedures for confirmation soil sampling are detailed in

Section 4.0. If the screening samples indicate the presence of contaminants above the cleanup goals for soil, excavation will continue until field screening indicates the cleanup goals for soil are met. Excavation activities will continue until contaminant concentrations are confirmed by laboratory methods to be within the cleanup goals for the area.

3.5.1.3 Backfilling/Compaction and Paving

Once excavation activities are completed, backfilling will occur. The stockpiled uncontaminated soil and certified clean sand and gravel from off site sources will be used as the backfill materials. The fill will be placed into the excavation and built up in successive layers until the required elevations are reached. The fill will be brought up on essentially level lifts not exceeding twelve inches in uncompacted thickness and will be placed in levels by standard methods. Each layer of material will be compacted so as to secure a dense, stable and thoroughly compacted mass. Filling operations will continue until the fill has been brought up to the finished grade, making proper allowances for thickness of surface treatment.

The excavated areas will be uniformly graded so the finished surfaces are returned to the original grades. The finished surfaces to receive pavement and stone bases will be graded to be reasonably smooth and free of irregular surface drainage. The final grading will be performed in such manner as to provide proper drainage from the site.

A 8-inch modified crushed stone sub-base will be installed under the areas to be paved, and 2-inches of bituminous concrete pavement will be applied. All materials and work will conform to those specified in the latest edition of the Standards Specifications for Highways and Bridges, Commonwealth of Massachusetts, Highway Department. A tack coat will be installed at the connection of existing and new bituminous concrete. Finished paving will conform to the finish grade and elevations of the surrounding topography and the paving surface will be a uniformly closed, dense and smooth surface to allow complete surface draining.

3.5.1.4 Groundwater Monitoring

During soil excavation, all attempts will be made to maintain the existing groundwater wells located in the soil excavation area (GZA-105, WE-105R2). If any of the monitor wells are destroyed during soil excavation, they will be replaced in kind after the parking lot restoration is completed. Recovery well RW-1 will be removed and not replaced as recovery actions were completed in 1992. In addition, three new shallow overburden groundwater wells will be installed in the parking lot after restoration is complete. The approximate locations of the new wells are shown in Figure 3-1. The new wells will extend approximately 12 - 15 feet bgs. These wells will be installed as permanent 1-inch diameter microwells.

okay

The existing and new wells in the parking lot will be sampled for EPH and VPH. Samples to establish a baseline condition will be collected within two weeks after well installation. Additional samples will be collected six months after installation and annually thereafter to document any changes in EPH/VPH concentrations. The purpose of this monitoring is to document that recontamination of groundwater underlying the EPL does not occur after soil

sounds good

removal, as for example, from the unlikely migration of remaining LNAPL (Stoddard fuel) from the well PZ-2S area.

In the June 9, 2000 letter issued by MA DEP on the conditional approval of the EPL/DS Area Phase III Addendum, MA DEP requested that groundwater sampling be performed prior to soil excavation. In subsequent discussions with MA DEP, it was decided that a more appropriate baseline for groundwater conditions would be provided if sampling is performed after soil excavation is complete. There are currently not enough wells at differing locations in the EPL to provide a good baseline (new wells will be installed after soil excavation), and the purpose of groundwater monitoring is to detect if groundwater is recontaminated in the future (groundwater sampling before excavation will only document pre-remedial contaminant levels and groundwater quality should improve substantially after remediation). okay

3.5.1.5 LNAPL Recovery from Well PZ-2S

As previously discussed in Section 1.0, Stoddard fuel as LNAPL has been periodically present in well PZ-2S. The presence of LNAPL is a seasonal event when the groundwater table is at high levels. Since LNAPL has not been documented in surrounding wells, there is no indication that there is a substantial quantity of Stoddard fuel remaining as LNAPL in the subsurface. To enhance LNAPL recovery from well PZ-2S, the well will be widened (a new well with a larger diameter will be installed in the PZ-2S location). This larger well will undergo vacuum extraction on a monthly basis. This extraction will continue until the measurable LNAPL thickness in the well has been permanently reduced + maintained to below 1/8 inch thickness.

3.5.2 Expected Efficiency

The proposed design is considered to be a highly effective approach to achieve a Permanent Solution for the contamination associated with the Stoddard fuel release(s). All remedial action goals for the EPL area would be fulfilled, including reducing Stoddard fuel concentrations in soil to levels that would not represent an unacceptable risk to human health and the environment for the continued and planned future commercial use of the site.

Excavation and off-site disposal is a common technology with proven performance in site remediation. Excavated soil and dewatered groundwater will be effectively managed off site at appropriate treatment and/or disposal facilities.

3.5.3 Construction Plans and Specifications

Detailed remedial action plans and specifications are included as Appendix B.

3.6 Emergency Control Features

The following spill prevention measures will be used to prevent and/or control any accidental release of fuels, decontamination fluids, or other potential waste materials including groundwater generated during dewatering:

- Care will be taken when transferring soil or groundwater; work will be performed in a methodological manner.
- Coverings will be established and maintained around catch basins.
- A containment dike will be constructed around filled soil roll-off containers (if applicable).
- Storage tanks and containment structures will be inspected on a daily basis for leaks.
- Where spills, leaks, or ruptures may occur, adequate quantities of spill containment equipment will be stationed in the immediate area. The spill containment equipment must be sufficient to contain and isolate the entire volume of hazardous substances being transferred or stored.
- A fire extinguisher meeting 29 CFR Part 1926, Subpart F, will be on hand and ready for use to control fires.

All reasonable measures necessary will be taken to ensure that spills or releases of oil and hazardous materials do not occur or spread. Immediate measures will be taken to control and contain the spill within the immediate location (where feasible) or site boundaries. All reporting and cleanup activities will be conducted in accordance with all applicable regulations.

The following minimum equipment will be kept on-site at all times during site work activities for any unexpected spills or discharges:

- Sand, clean fill and absorbant pillows
- Drums (55 gallon, U.S. DOT 17-E or 17-H)
- Shovels
- Steam cleaner for decontamination of tools and equipment

Should a spill or release occur, the liquid will be contained by the berm/dike materials. The spill will be removed using absorbents, pumps, and/or vacuum equipment, as appropriate, and disposed of in accordance with state, federal, and local guidelines. Before continuing work in the vicinity of the release, the cause of the spill or release will be determined and corrective action measures will be instituted.

TRC will immediately notify the AMETEK Environmental Manager (or designed alternate) in the event of a material release.

The Licensed Site Professional (LSP) for the site, Mr. Bruce Hoskins, will also be contacted immediately following a spill. If the spill is outdoors, the LSP will determine if a reportable condition exists under 310 CMR 40.0300. If a 2-hour or 72-hour reportable condition exists, the LSP will then notify MA DEP of the reportable condition. If a 120-day reportable condition exists, MA DEP will be notified in writing.

3.7 Waste Management Plan

This Waste Management Plan (WMP) has been developed to establish required procedures and protocols for identifying, containing, labeling, storing, handling, and disposing of Stoddard fuel contaminated materials that will be generated during remedial activities at the EPL area. These materials include Stoddard fuel contaminated soil, groundwater and personal protective equipment (PPE).

3.7.1 Work Plans and Procedures

To prevent both exposure to remediation workers and migration of contamination, work areas and PPE requirements will be clearly identified. All signs required by federal and state regulations will be posted to give notice of the work area to site personnel and visitors prior to remedial activities.

An exterior sign will be posted detailing whom to notify in case of emergency, including points of contact, job title, and phone number(s) where the contact may be reached 24-hours a day. The proposed limits of the work area, as shown in Figure 3-1, will be delineated during site preparation activities. An exclusion zone will be established around the work area and temporary caution tape, safety fences, and traffic cones/drums, as appropriate, will be installed outside the active work area prior to startup of remedial activities. Pedestrian traffic will be rerouted as necessary by TRC and AMETEK staff. All visitors will be required to sign in and will not be allowed within the work exclusion zone without providing documentation of appropriate training and medical monitoring.

Air monitoring for VOCs and dust will be performed as described in the HASP. The HASP will be used as a guideline for monitoring procedures. Detailed procedures for truck decontamination, if applicable, prior to transport of contaminated soil off site are contained in Section 3.9.

3.7.2 Waste Materials

<u>*Soil*</u>

As previously discussed, TRC estimates that approximately 2,560 cubic yards of contaminated soil will be generated during remedial activities at the EPL area. Approximately 1,360 cubic yards of contaminated soil will be generated from the excavation in the vicinity of borings B12, B13 and B14, and approximately 1,200 cubic yards of soil will be generated from the excavation in the vicinity of borings B17 and B18.

Groundwater

Because the limits of the soil excavation extend beneath the groundwater table, localized groundwater dewatering will be required. TRC estimates that approximately 11,000 gallons of groundwater will be pumped during excavation activities. This water may contain low concentrations of Stoddard fuel constituents and chlorinated VOCs.

Personal Protective Equipment (PPE)

Any spent PPE will be containerized in pails and/or drums, characterized for off site disposal, and disposed.

3.7.3 Waste Storage

Soil

The contaminated soil is planned to be directly loaded into trucks and immediately transported off site to the licensed disposal facility. Analytical data collected during the previous investigations in the EPL area will be used to obtain approval from the disposal facility prior to excavation activities. The trucks hauling contaminated material off site will be fitted with a snuggly fitting tarp and the soil will be suitably dewatered prior to leaving the site to prevent free water from developing during transport to the disposal facility. In addition, the trucks will be decontaminated, if necessary, following the procedures outlined in Section 3.9. In the event that trucks are not available to maintain the plan for direct filling and immediate transport, the contaminated soil will be loaded into secured and covered roll-off containers for transport off site the following day. Necessary precautions as specified in Section 3.9 will be maintained to prevent impacts to the environment.

Groundwater

The pumped groundwater will be stored in a temporary, secured on-site 20,000-gallon AST, which will be periodically pumped out during excavation activities for disposal at a licensed off-site facility. Safety procedures, as outlined in Section 3.6, will be followed to ensure containment and control of any potential spills and/or releases.

3.7.4 Waste Characterization/Transportation/Disposal

Because the contaminated soil is to be immediately transported off site for disposal at a licensed facility, approval will be obtained from the disposal facility prior to commencement of excavation activities. Soil analytical results from previous EPL investigations will be used to characterize the soil. Additional soil characterization for soil disposal will be conducted during excavation to provide data as required by the soil disposal facility.

In addition, analytical data will be required to characterize the groundwater that will be generated as a result of dewatering activities. Water samples will be collected from the temporary AST to determine contaminant content and disposal requirements. It is presumed that all groundwater will be characterized as nonhazardous and will be disposed as MCP remediation waste (wastes that are generated by MCP remedial actions and are properly managed under the MCP regulations).

Laboratory analysis of all waste materials will be consistent with state and federal requirements for off site disposal and within the proposed disposal facility's operating permit.

Waste profile sheets will be completed for submittal to a licensed and appropriate disposal facility for acceptance. TRC will review the current status of the selected disposal facilities to confirm that the current operating permits are in compliance with applicable state and federal regulations. The contaminated soil and groundwater will be transported under a Massachusetts Bill of Lading Form.

An authorized representative from TRC will be on site at the time of shipment to sign the Bill of Lading as the generator. Trucks transporting contaminated soil or water will be weighed using a certified scale, upon arrival at the disposal facility. A weight ticket will be generated for each arriving truck and will be used to keep a running total of contaminated soil or water sent for disposal. Copies of the weight tickets will be maintained by TRC. Contaminated soils and/or water arriving at the disposal (processing or recycling) facility will be handled in accordance with the requirements of the facility permit. The original Bill of Lading Forms will be submitted to the MA DEP after they are returned to TRC by the disposal facility.

3.8 Site-Specific Features Potentially Impacted by Remedial Action

3.8.1 Existing Site Operations

Site access and remedy implementation will be coordinated with Wilmington Trust, the current site owners, and AMETEK, the current tenant that occupies Buildings 1, 1A and 3 and utilizes the parking area. The proposed excavation will affect utilities, parking lot lighting, a designated smoking area, and parking.

The security fence may also be affected and will be relocated to the west if necessary. The security fence will be maintained at all times in coordination with the AMETEK security guards.

Existing site groundwater monitoring wells located in and near the planned excavation area may be destroyed during excavation. While measures will be taken to avoid well destruction, any monitoring well destroyed during excavation will be replaced after the completion of site excavation and backfilling. The exception to this is recovery well RW-1; this well is not active and will not be replaced.

3.8.2 Drainage Features

Implementation of the selected remedies should not significantly alter drainage features at the Site. To the extent possible, all disturbed areas will be restored to original grades. Appropriate preventative measures will be implemented such as restoring original grades, shoring of the drainage pipe and maintaining catch basins.

3.8.3 Natural Resource Areas

Wetlands are situated along the eastern margin of the facility's property. The boundary of the excavation and related work zone area will be located more than 100 feet from the wetlands. Potential impacts to these areas will be prevented as discussed in Section 3.9.

3.8.4 Local Planning and Development

Implementation of the selected remedies should not adversely impact local planning or development. There are currently no known planning or development proposals for the Eastern Parking Lot. The site property is zoned industrial and can continue to be used for industrial or commercial activities.

3.9 Environmental Receptor Protection Plan

The objective of the Environmental Receptor Protection Plan (EPP) is to define the environmental protection requirements associated with land, water, air and noise pollution during remediation activities at the EPL. This section summarizes the protective measures that will be employed to minimize and control any potential pollution releases and to preserve environmental conditions at the site.

Remedial activities at the EPL will be conducted in the area shown in Figure 3-1. All applicable work zones will be delineated (as described in Section 7.0) and maintained throughout the duration of the project to closely monitor site activities, quality control and safety to ensure that the project objectives are achieved. In addition, access to the work zone will be regulated (as described in Section 7.0) to prevent unauthorized entry.

3.9.1 Protection of Land Resources

The activities covered under this EPP specifically include all areas associated with soil excavation activities in the EPL area. Protection of areas will be performed during mobilization, excavating and staging of materials and demobilization. Areas to be protected include the wetland areas to the east, existing paved area and other landscaped features. Disturbed areas will be restored as necessary to their existing condition following completion of remedial activities.

All trucks and heavy equipment will be decontaminated prior to leaving the site to ensure that any loose soil debris does not impact outside properties. All heavy equipment will be decontaminated at an area that will be established in the contaminant reduction zone (see Figure 3-1). This area shall be used to support dry decontamination procedures (i.e., brushing-off of soil, etc.). All vehicles/equipment leaving the exclusion and/or contaminant reduction zones must stop and be inspected by TRC to ensure any excess soil or debris is removed from the vehicle and its tires.

The following procedures will be used to decontaminate heavy equipment and/or vehicle tires:

- Trucks or equipment leaving the exclusion zone, but not leaving the contaminant reduction zone, may be staged in the contaminant reduction zone without being decontaminated.

- Trucks or equipment leaving the contamination reduction zone for entry into the support zone will be thoroughly inspected to verify the absence or presence of potential contamination. Trucks or equipment showing signs of potential contamination on the vehicle body or tires shall be brushed to remove loose debris.

- A follow-up inspection following decontamination procedures will be conducted to verify vehicle decontamination prior to leaving.

- Decontaminated equipment may be staged in the support zone or loaded on transport equipment for return to the subcontractor's location.

3.9.2 Temporary Protection of Disturbed Areas

Preventative erosion and sedimentation control measures will be implemented in order to limit and retard run-off within the established work zone limits in the EPL. All disturbed areas in the EPL will be protected as described in the Erosion Control and Sedimentation specifications in Section 3.9.8.

3.9.3 Noise Protection

Protection against the effects of noise exposure will be provided when the sound levels exceed those limits as established by 29 CFR 1929.52 (Occupational Noise Exposure Standards). TRC will provide hearing protection to employees involved in the EPL remedial activities to minimize potential exposures to noise levels greater than the permissible exposure limits.

3.9.4 Waste Disposal

Procedures for the characterization, handling, labeling, storage, transportation, and disposal of waste generated as a result of remedial activities in the EPL area are detailed in the Waste Management Plan (Section 3.7). Wastes addressed under this plan include Stoddard fuel contaminated soil, groundwater, and personal protective equipment.

As previously described, contaminated soil will be directly loaded into trucks and immediately disposed off site at a licensed facility. In the event excavated contaminated soil needs to be stored on site, it will be stored in a secured and covered roll-off container and transported off site the following day. In addition, roll-off containers will be covered during storm events.

Contaminated groundwater that is generated during dewatering activities will be stored in a temporary, secured 20,000-gallon AST. This AST will be pumped out periodically during remedial activities and the contaminated groundwater will be transported off site for disposal at a licensed facility. Daily inspections will be conducted to ensure that spills/releases do not occur from the AST, and absorbant material will be stored on site in the event of any spills and/or releases.

3.9.5 Historical Resources Protection

There are no known historical areas of the former GE site.

3.9.6 Wetland and Water Resource Protection

All remedial activities in the EPL will be monitored, managed and controlled to avoid impacts to the wetland areas to the east of the EPL. Site environmental receptors including the wetlands will be protected during construction and operation of the remedial action alternatives. A Determination of Applicability or Notice of Intent is not required by the North Reading Conservation Commission since the boundary of the work area is more than 100 feet from the wetlands (see Figure 3-1). In accordance with 310 CMR 10.02, the work area is not located in the wetland buffer zone (within 100 feet of the wetlands), and hence is not subject to these regulations. However, as a courtesy, TRC will issue a letter to the North Reading Conservation Commission to notify them of the start of remedial actions.

Protection measures will be implemented to ensure that the remedial actions will not adversely affect the wetlands due to excavation, soil stockpiling, and groundwater dewatering. Such measures will include:

- Silt bags in catch basins and hay bales surrounding catch basins;

- Hay bales and silt fencing along the perimeter of the wetlands potentially affected by remedial activities; and

- Covering the clean stockpiled soil with polyethylene sheeting and surrounding the stockpiled clean soil with hay bales and/or silt fencing.

Daily inspections of sedimentation and erosion control measures will be conducted and maintenance will be performed, as necessary, to ensure proper protection of the wetland areas. In addition, emergency control features, as detailed in Section 3.6, will be used to prevent and/or control accidental spills and releases.

3.9.7 Air Resources Protection

Work activities will be conducted to comply with all dust regulations imposed by local air pollution agencies. Continuous dust monitoring will be conducted in the work zone area using a Miniram Dust Control Monitoring Meter Model MIE/PDR/1000 or equivalent. As a minimum, at no time will dust generation be allowed to exceed 1 mg/m^3 without implementing appropriate controls. During the progress of work, the contractor will conduct operations and maintain the areas of activities, including sweeping and sprinkling water where necessary to minimize the creation and dispersion of dust. Water will not be used if it results in hazardous or objectionable conditions such as ice or flooding. The stockpiled clean soil will be secured with a 6-ml poly covering to eliminate particulate emissions. In addition, all roll-off containers used for contaminated soil handling will be covered with tarps during materials storage, transportation, and disposal for dust and odor control.

An odor suppression foam will be used, as necessary, during excavation and loading activities of contaminated soil to mitigate nuisance odors. Potential nuisance odors will be monitored in the work zone using an organic vapor analyzer (OVA) or equivalent in accordance with the HASP. Odor suppression foam will be used if nuisance odors are detected above concentrations set forth in the HASP and will also be used at the discretion of the designated Health and Safety Officer.

3.9.8 Erosion and Sedimentation Control Procedures

Erosion and sedimentation control procedures will be installed as shown in Figure 3-1. The sedimentation and erosion controls will be constructed prior to commencement of remedial activities at the EPL. Areas in need of repair during the course of remedial activities will be repaired and will be maintained for the duration of the project. Sedimentation areas will be inspected daily to maintain compliance and to avoid siltation of surface water and groundwater. At the completion of remedial activities, all sedimentation and erosion control measures will be removed and the area will be restored to its existing condition.

The erosion and sedimentation control measures that will be implemented are presented in the Wetland and Water Resource Protection section of this Environmental Receptor Protection Plan. The following describes installation of these erosion and sedimentation control measures.

Silt Bags

The silt bags will be constructed of a non-rotting, ultraviolet light resistant woven polyester geotextile with sufficient strength for their intended purpose. The silt bags will be placed just beneath the catch basin grate and the catch basin grate will be used to secure the silt bags in place.

Straw Bale Barrier and/or Silt Fencing

Straw bales will be placed in a single row with the ends of adjacent bales tightly abutting one another. The bales will be securely anchored (except in the parking lot) by driving at least two stakes through each bale. For straw bale barriers placed in the parking lot, the bales will be fastened together with wooden stakes, rebar, wire or other acceptable means.

The straw bales will consist of straw from acceptable grasses and legumes, free from weeds, reeds, twigs, chaff, debris and other objectionable material or excessive amounts of seeds and grains. The straw will be securely bailed with wire of adequate size to allow for rusting while in use and still permit rehandling when the bale is in a saturated condition.

The silt fence will be constructed of a non-rotting, ultraviolet light resistant woven polyester geotextile with sufficient strength for its intended purpose. The silt fencing will be installed in accordance with manufacturer's recommendations.

Soil Stockpile

Prior to excavation work, a temporary soil storage area will be established and clearly designated on site for the uncontaminated excavated soil. The storage area will be lined with 6 mil (or higher) gauge polyethylene sheeting. In addition, the stockpiled soil will be covered with 6-mil (or higher) gauge polyethylene sheeting and will be surrounded by straw bales and/or silt fencing to prevent runoff. The polyethylene will be adequately secured to prevent damage or loss by wind or other elements. In the event of extreme weather conditions, additional actions will be taken to ensure appropriate containment of stockpiled soils. Surface water runoff will be directed away from the stockpile to prevent erosion and deterioration of materials. The stockpiles will not exceed 35 feet in height with maximum side slopes of 2:1 (horizontal:vertical).

4.0 MONITORING

4.1 Contacts

The contact person at TRC is:

> Ms. Paola Macchiaroli, Project Manager
> TRC Environmental Corporation
> Boott Mills South, Foot of John Street
> Lowell, MA 01852
> (978) 656-3582

The Licensed Site Professional (LSP) of Record is:

> Mr. Bruce Hoskins, LSP # 7109
> URS Corporation
> 5 Industrial Way
> Salem, NH 03079-2830
> (603) 893-0616

4.2 Emergency/Contingency Procedures

Although earlier investigations of the EPL area have defined the expected, approximate limits of the proposed excavations, field screening and confirmatory soil sampling may indicate that additional soil removal is necessary. Of concern is the area between the western limit of the proposed excavation and borings B7 through B10. If it is determined that additional soil removal is necessary, AMETEK's security fence will need to be relocated. The sanitary sewer line located in this area will also need to be properly supported and/or temporarily relocated. TRC will first initiate excavation procedures in this area to determine whether this relocation needs to occur. The security fence and sanitary sewer will be returned to the original locations and conditions after completion of excavation activities in this area. Bedrock is shallow in this area; therefore, excavating will stop if bedrock is encountered.

Excavation, loading and transportation activities will be conducted in accordance with specifications previously detailed. Although not anticipated, contaminated soils will not be excavated below existing site buildings. In addition, in the unlikely event that soil contamination is found adjacent to site buildings, any necessary excavation up to the limits of the building foundation will proceed in a cautious manner to ensure the structural integrity of the building(s).

4.3 Remedial Action Monitoring Program

Health and Safety Monitoring

Adherence to strict health and safety procedures will apply to all field activities performed for this program. All TRC staff and subcontractors will follow those procedures detailed in the site-wide HASP.

Soil Monitoring

sampling frequency?

The soil monitoring program planned for the EPL area includes field headspace and petroleum hydrocarbon screening (PetroFLAG), with confirmatory soil sampling for laboratory analyses. Specifically, soil samples will be collected for field screening at the limits of the proposed excavations. If the field screening samples are within the field screening guidance criteria (i.e., <200 ppm headspace and <3,000 ppm PetroFlag), confirmation soil samples will be collected for expedited laboratory analysis to confirm that cleanup goals are met. Excavation activities will continue until contaminant concentrations are confirmed to be within the cleanup goals for the area by laboratory methods. Throughout the remediation process, soil data will be evaluated using the Method 1 protocols to determine when excavation is completed in any particular area.

Results of the Phase III Supplemental Soil Sampling in the EPL indicated that there is generally a positive correlation between the PetroFLAG results and EPH laboratory results, and field headspace screening and VPH laboratory results. There are a few exceptions; however, these exceptions were shown to overestimate the EPH and VPH concentrations in the soil. Therefore, the screening levels will delineate a conservative impact area (i.e., more soil may be removed than is necessary for meeting the cleanup goals). Based on the results of the Phase III sampling, a headspace reading of < 200 ppm and a PetroFLAG screening result of <3,000 ppm will be used to define the limits of the excavation during remedial activities. Once these limits are attained, confirmatory soil samples will be collected for laboratory analyses.

Further statistical analysis to correlate the field screening results to the confirmatory sampling has not been conducted given that the field screening techniques are expected to overestimate the area impacted by Stoddard fuel, and that composite soil samples of the excavation walls and floor will be analyzed by a Massachusetts certified laboratory.

okay

Groundwater

Groundwater monitoring will not be performed until completion of soil excavation, backfilling, and restoration activities. Groundwater monitoring related to the EPL remedial action will be limited to Stoddard fuel contaminants of concern (EPH/VPH).

4.3.1 Soil Headspace Analysis

Two representative composite soil samples will be collected for every 100 cubic yards of excavated soil and contained within labeled, sealable bags for analysis by a PID or equivalent using standard MA DEP headspace techniques. These headspace techniques are detailed in the HASP. The soil within the bag will be shaken several times over 15 minutes, the organic vapor analyzer (OVA) tip will be inserted into the bag, and the result recorded. The second sample bag will be temporarily placed on ice until petroleum hydrocarbon screening is conducted.

soil to go off site?

4.3.2 Petroleum Hydrocarbon Soil Screening

In addition to headspace screening, each bagged sample will be screened for petroleum hydrocarbons using the PetroFLAG methodology calibrated for a response factor consistent with lighter hydrocarbons associated with Stoddard fuel (detection limit ~ 200 ppm). TRC will ensure that a stable, consistent environment for soil screening is established prior to conducting all analytical work. Experienced TRC personnel will operate the PetroFLAG analyzer in accordance with the manufacturer's recommendations.

The PetroFLAG meter will be recalibrated every 10 samples, as recommended by the manufacturer. A background soil sample will also be collected daily to establish a site-specific reference background concentration for the PetroFLAG hydrocarbon analyzer.

All procedures will be consistent with those employed during the Phase III investigation.

4.3.3 Confirmatory Soil Sampling

Headspace and PetroFLAG screening results will be used as a guidance to determine the extent and depth of the excavation before collecting confirmation samples. Composite soil samples will then be collected from the sidewalls of the excavation every 50 feet of linear wall length at various depths along the impacted area. Composite samples of the excavation floor will also be collected at a frequency of one per 2,500 square feet of floor area. The soil samples will be analyzed for EPH and VPH using a Massachusetts certified laboratory.

Soil samples collected for EPH analysis will be packed into the appropriate laboratory supplied sample containers. Soil samples collected for VPH analysis will be captured in a truncated syringe and placed in a laboratory supplied sampling jar containing a known volume (and total mass) of methanol. All soil samples collected for analysis will be labeled with the appropriate sample number, site name, date and time of collection, preservation used and analysis requested. The samples will be placed on ice in a cooler following appropriate Chain-of-Custody procedures and shipped to a Massachusetts certified laboratory for analysis.

To ensure proper quality assurance and quality control (QA/QC), the sampling protocol will include one trip blank per cooler and field duplicates at the rate of one duplicate per 20 laboratory samples. Dedicated soil sampling equipment will be used; therefore, equipment blanks will not be collected.

4.3.4 Groundwater Monitoring

+ VOCs

The existing and new wells in the parking lot will be sampled for EPH and VPH. Samples to establish a baseline condition will be collected within two weeks after well installation. Additional samples will be collected six months after installation and annually thereafter to document any changes in EPH/VPH concentrations.

All groundwater samples collected for analysis will be labeled with the appropriate sample number, site name, date and time of collection, preservation used and analysis requested. The samples will be placed on ice in a cooler following appropriate Chain-of-Custody procedures and shipped to a Massachusetts certified laboratory for analysis.

To ensure proper QA/QC, the sampling protocol for each round of sampling will include one trip blank per cooler and one field duplicate. Dedicated groundwater sampling equipment will be used; therefore, equipment blanks will not be collected.

5.0 Health and Safety Plan

The site-wide Health and Safety Plan for all remedial response actions at the former GE site is included as Appendix D. This plan may include more information than that required for the actions in the EPL Area.

6.0 Required Permits, Approvals, or Licenses

The actions presented in this RIP will not require any permits, special approvals, or licenses. Approval of this RIP will be required from MA DEP in accordance with the MCP. Public notification requirements will be performed in accordance with the Public Involvement Plan for this site. In addition, a notice of commencement of soil remediation will be sent to the North Reading Conservation Commission.

7.0 Property Access Issues

To prevent both exposure to unprotected personnel and migration of contamination as a result of tracking by personnel or equipment, work areas and PPE requirements will be clearly identified. All signs required by federal and state regulations will be posted to give notice of the work area to site personnel and visitors prior to remedial activities.

An exterior sign will be posted detailing whom to notify in case of emergency, including points of contact, job title, and phone number(s) where the contact may be reached 24-hours a day. The proposed limits of the work area, as shown in Figure 3-1, will be delineated during site preparation activities. An exclusion zone will be established around the work area and temporary caution tape, safety fences, and traffic cones/drums, as appropriate, will be installed outside the active work area prior to startup of remedial activities. Pedestrian traffic will be rerouted as necessary by TRC and AMETEK staff. All visitors will be required to sign in and will not be allowed within the work exclusion zone without providing documentation of appropriate training and medical monitoring.

AMETEK facility security fence in the area of the proposed excavations may need to be relocated to allow further excavation of contaminated soil (see Section 4.2 Emergency/Contingency Procedures). The fence relocation will be done in a manner that the existing security fence is not breached and eastern access to AMETEK facility remains at the same location. Fence relocation will be done in coordination with AMETEK.

Approximately 61,000 square feet of parking space, as shown in Figure 3-1, will need to be relocated because of remedial activities. Relocation of parking will be coordinated with

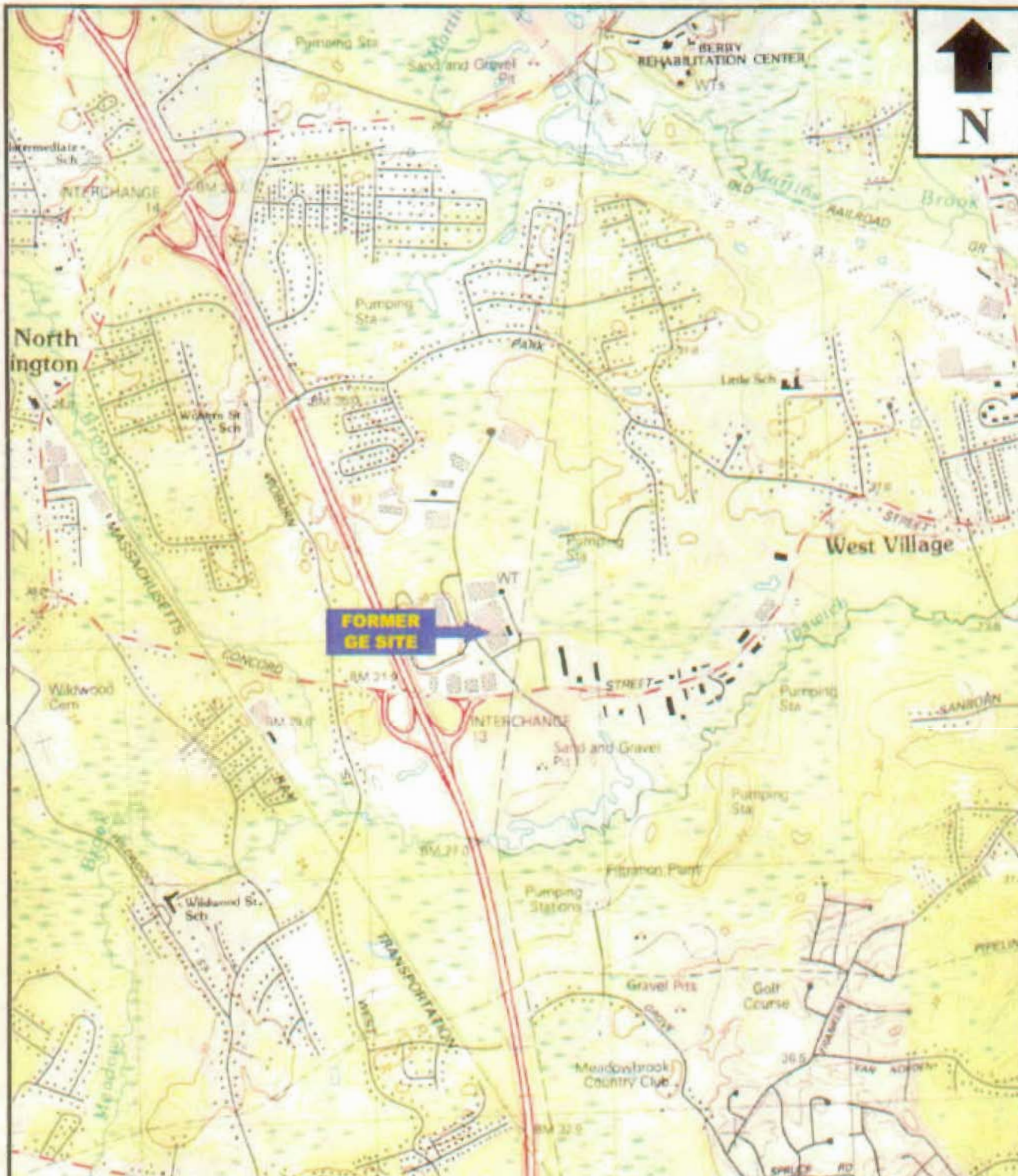
AMETEK and will be conducted to minimize impacts to AMETEK operations. A traffic lane will be maintained to allow access to the parking lot and to allow continued operation of shipping/receiving.

Traffic control during mobilization, construction, and demobilization within the EPL Area will be monitored and maintained to an efficient level by the Site Manager. The appropriate signs, signals, and barricades will be used to ensure that traffic along construction routes to the site will be kept at a minimum and will not hinder flow or direction of regular AMETEK facility staff.

Mobilization of heavy equipment will be scheduled during business hours and AMETEK will be notified at least 48 hours prior to mobilization.

Traffic during demobilization operations will also be monitored. No equipment will leave the site without being approved following decontamination. The equipment will be logged out by TRC and will be dispersed accordingly to prevent buildup at the site gate.

Emergency vehicle access will be maintained at all times in the event of an emergency. During excavation activities a clear means of road access of at least 25 feet in width around the perimeter of the work area will be maintained for fire department and emergency response vehicles' access to buildings at the site. Traffic entering the site and parking areas by non-site personnel will be monitored by on-site personnel. A designated area will be made available for parking for construction personnel.



BASE MAP IS A PORTION OF THE FOLLOWING 7.5' x 15' USGS TOPOGRAPHIC QUADRANGLE: READING, MA 1987

0 1000 2000

Scale in Feet

QUADRANGLE LOCATION

TRC

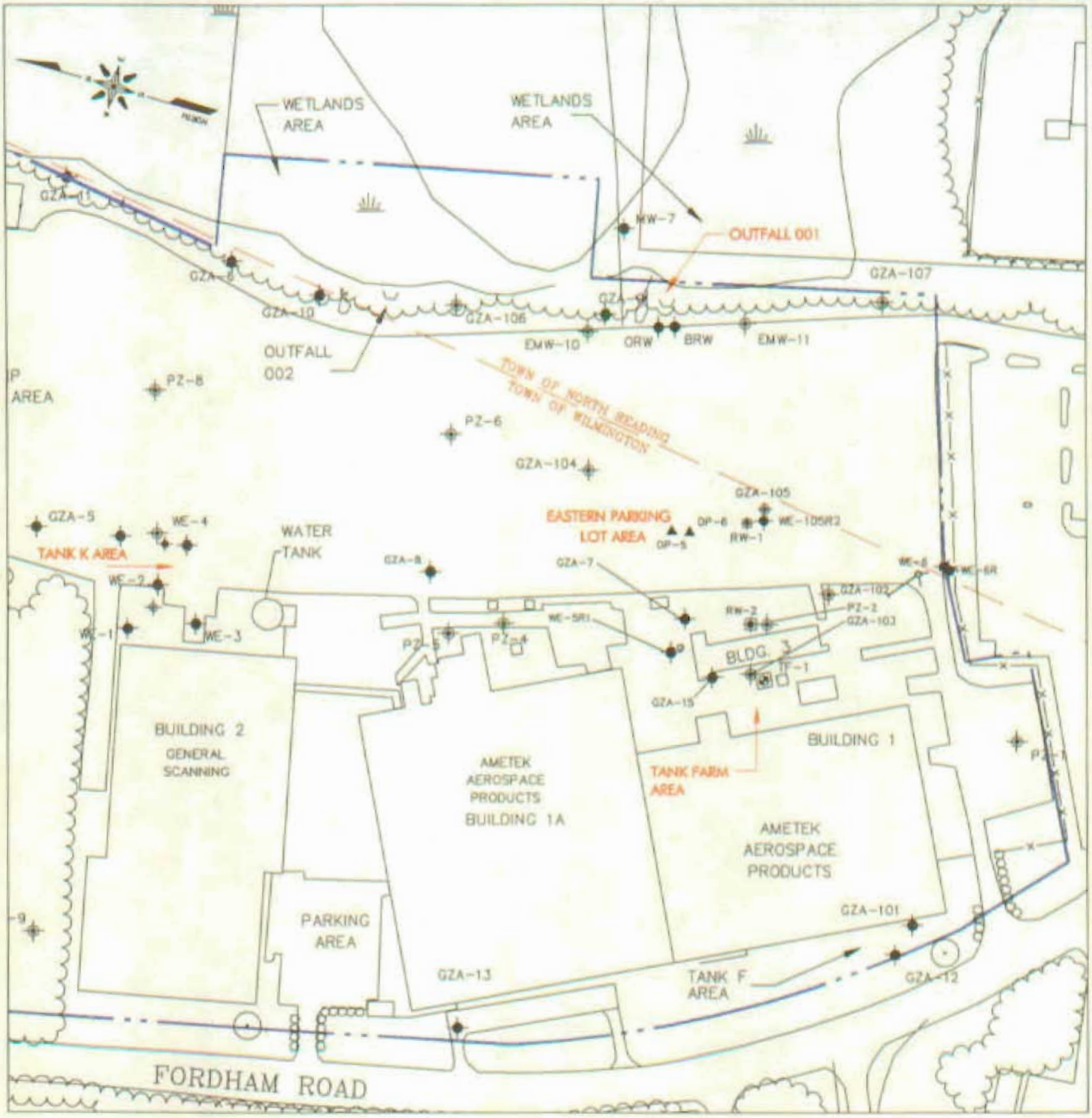
Boott Mills South
Foot of John Street
Lowell, MA 01852
(978) 970-5600

FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 1-1
SITE LOCATION MAP

Date: 6/00	Project No. E9202

E9202/EPL/RJP/TOPO



NOTES

1. TOPOGRAPHIC AND PLANIMETRIC FEATURES SHOWN WERE COMPILED PHOTOGRAMMETRICALLY FROM AERIAL PHOTOGRAPHY DATED APRIL 16, 1992 BY EAST COAST MAPPING INC., CONCORD, NEW HAMPSHIRE. MAPPING GROUND CONTROL ESTABLISHED BY FIELD SURVEYS CONDUCTED IN APRIL 1992.
2. THE GRID SYSTEM DEPICTED ON THIS PLAN IS BASED ON THE MASSACHUSETTS STATE PLAN COORDINATE SYSTEM NORTH AMERICAN DATUM OF 1926.
3. ELEVATIONS ARE BASED ON THE NATIONAL GEODETIC VERTICAL DATUM OF 1929.
4. MONITORING WELL LOCATIONS ARE APPROXIMATE.
5. PROPERTY AND TOWN LINE BOUNDARIES WERE ADAPTED FROM "REGIONAL EXPLORATION PLAN", GENERAL ELECTRIC COMPANY, 50 FORDHAM ROAD PROPERTY, WILMINGTON/NORTH READING, MASS., BY GOLDBERG - ZOINO & ASSOCIATES, INC., DATED APRIL 1995.

0 50 100 150 200 250

GRAPHIC SCALE

LEGEND

BUILDING
APPROXIMATE PROPERTY LINE
APPROXIMATE TOWN LINE
FENCE
MULTI-LEVEL MONITORING WELL/PIEZOMETER LOCATION
SINGLE-LEVEL MONITORING WELL/PIEZOMETER LOCATION
RW RECOVERY WELL
TF GROUNDWATER RECOVERY WELL
DP MONITORING WELL

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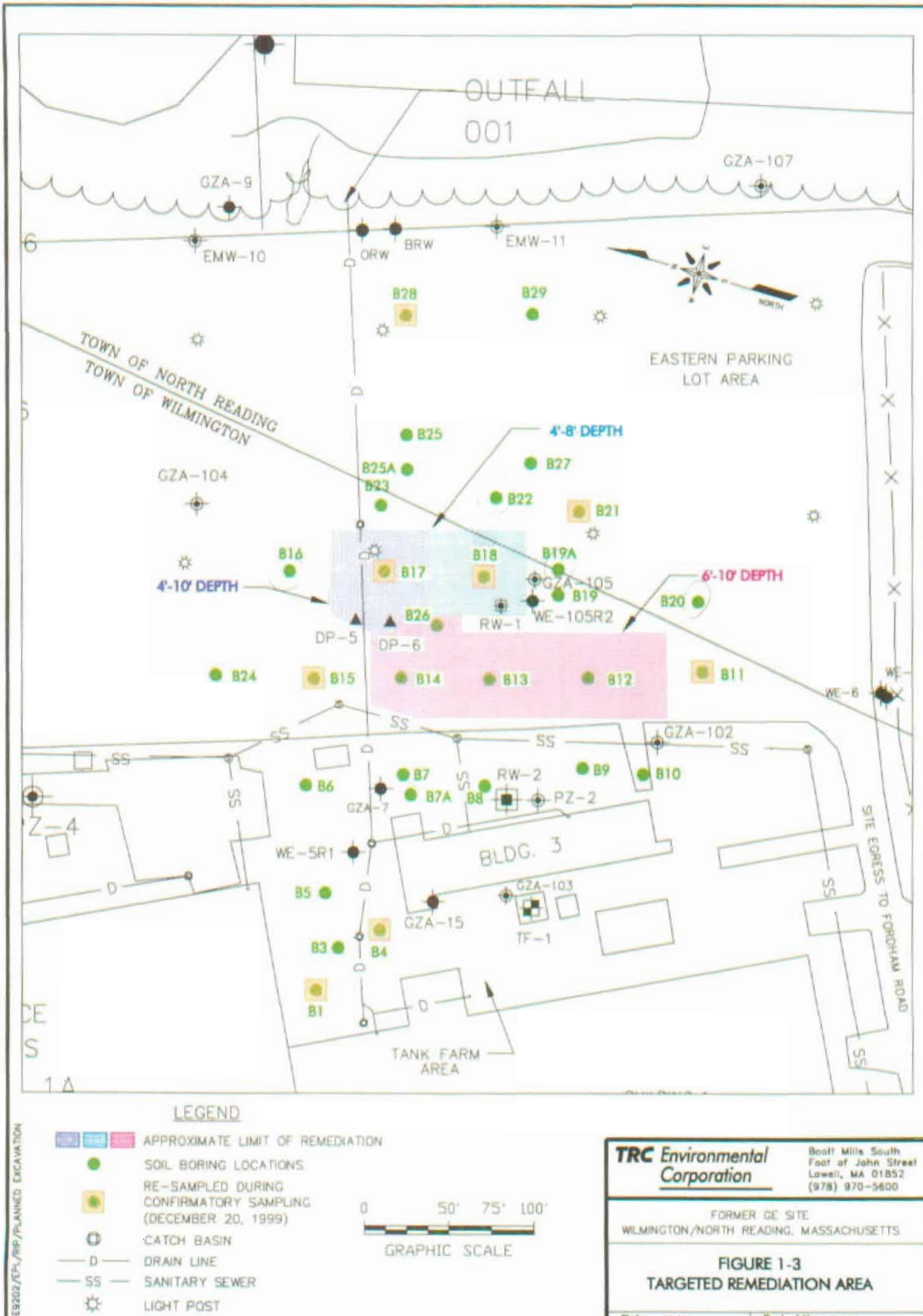
FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 1-2
SITE PLAN

Date 06/00 | Project No. E9202

E9202\DPL\RIP\SITE PLAN



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WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 1-3
TARGETED REMEDIATION AREA

Date 06/00 | Project No. E9202

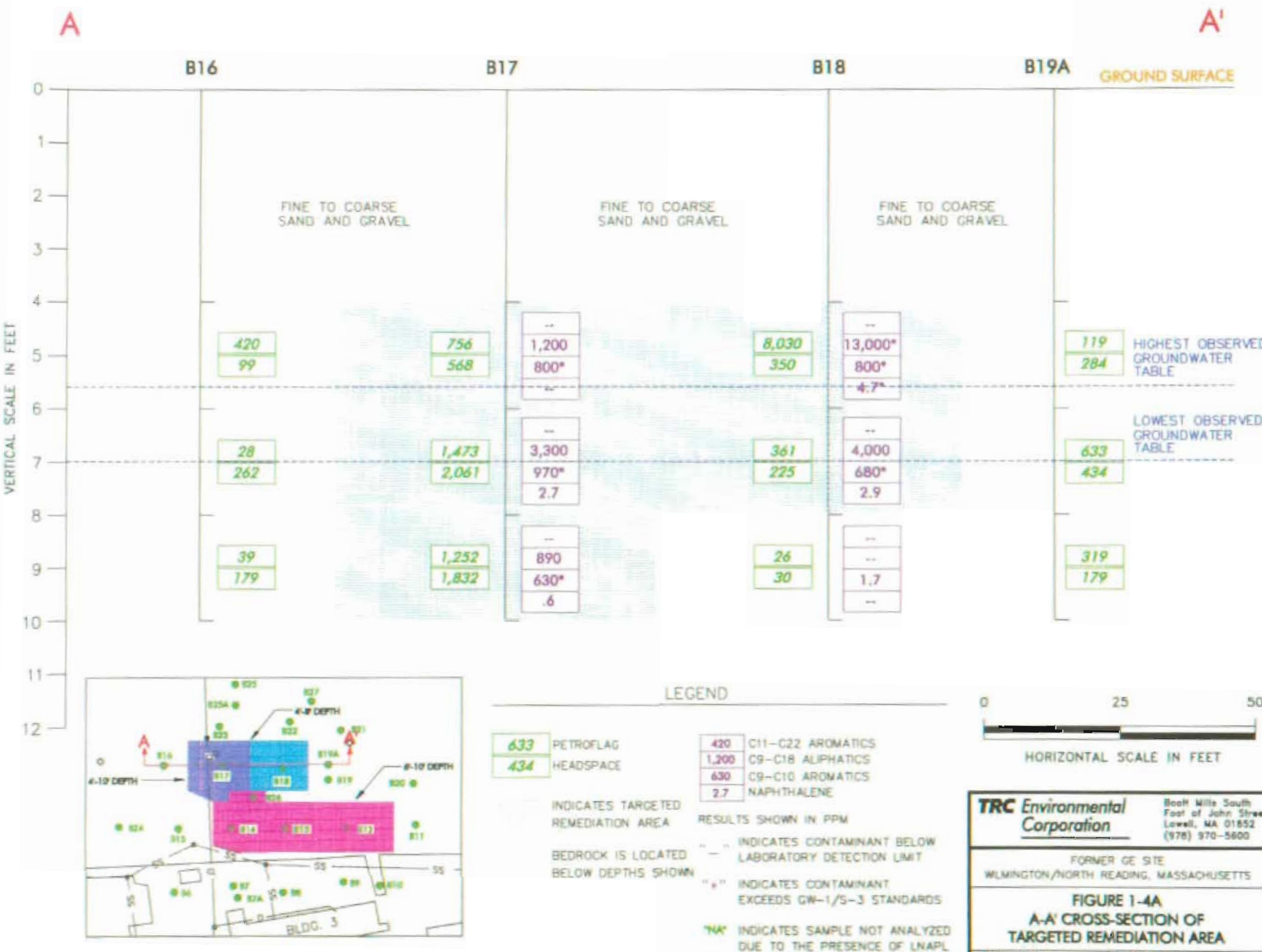

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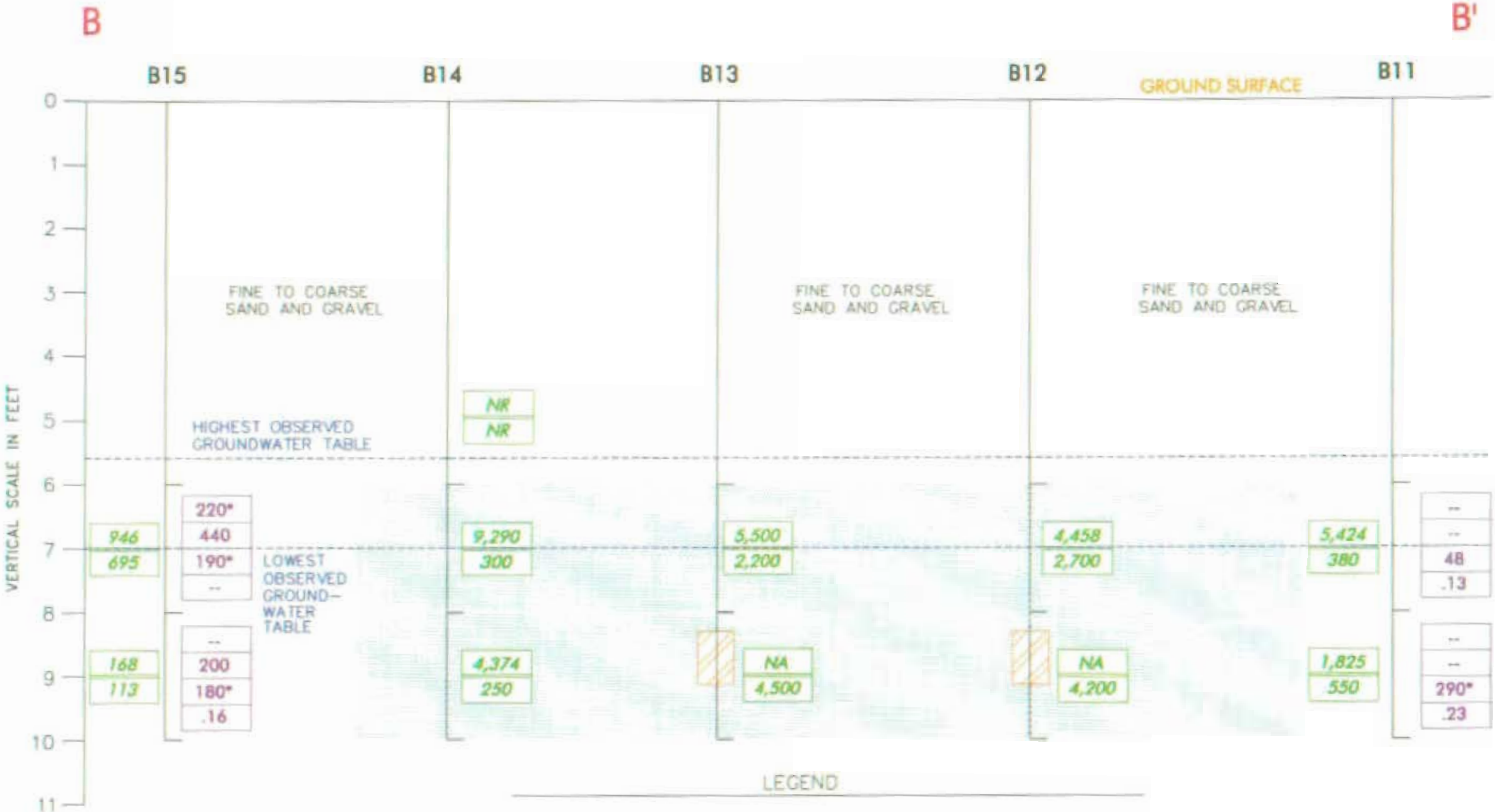
FIGURE 1-4A
A-A' CROSS-SECTION OF TARGETED REMEDIATION AREA

Date 05/00 | Project No. E3202

E3202/EPL/RIP/A-A



LEGEND

4,374	PETROFLAG
250	HEADSPACE

INDICATES TARGETED REMEDIATION AREA

INDICATES APPROXIMATE AREA WITH OBSERVED LNAPL

BEDROCK IS LOCATED BELOW DEPTHS SHOWN

220	C11–C22 AROMATICS
440	C9–C18 ALIPHATICS
190	C9–C10 AROMATICS
.16	NAPHTHALENE

RESULTS SHOWN IN PPM

"--" INDICATES CONTAMINANT BELOW LABORATORY DETECTION LIMIT

"*" INDICATES CONTAMINANT EXCEEDS GW-1/S-3 STANDARDS

"NA" INDICATES SAMPLE NOT ANALYZED DUE TO THE PRESENCE OF LNAPL

"NR" INDICATES SAMPLE NOT ANALYZED DUE TO INSUFFICIENT RECOVERY

0 15 30

HORIZONTAL SCALE IN FEET

TRC Environmental Corporation

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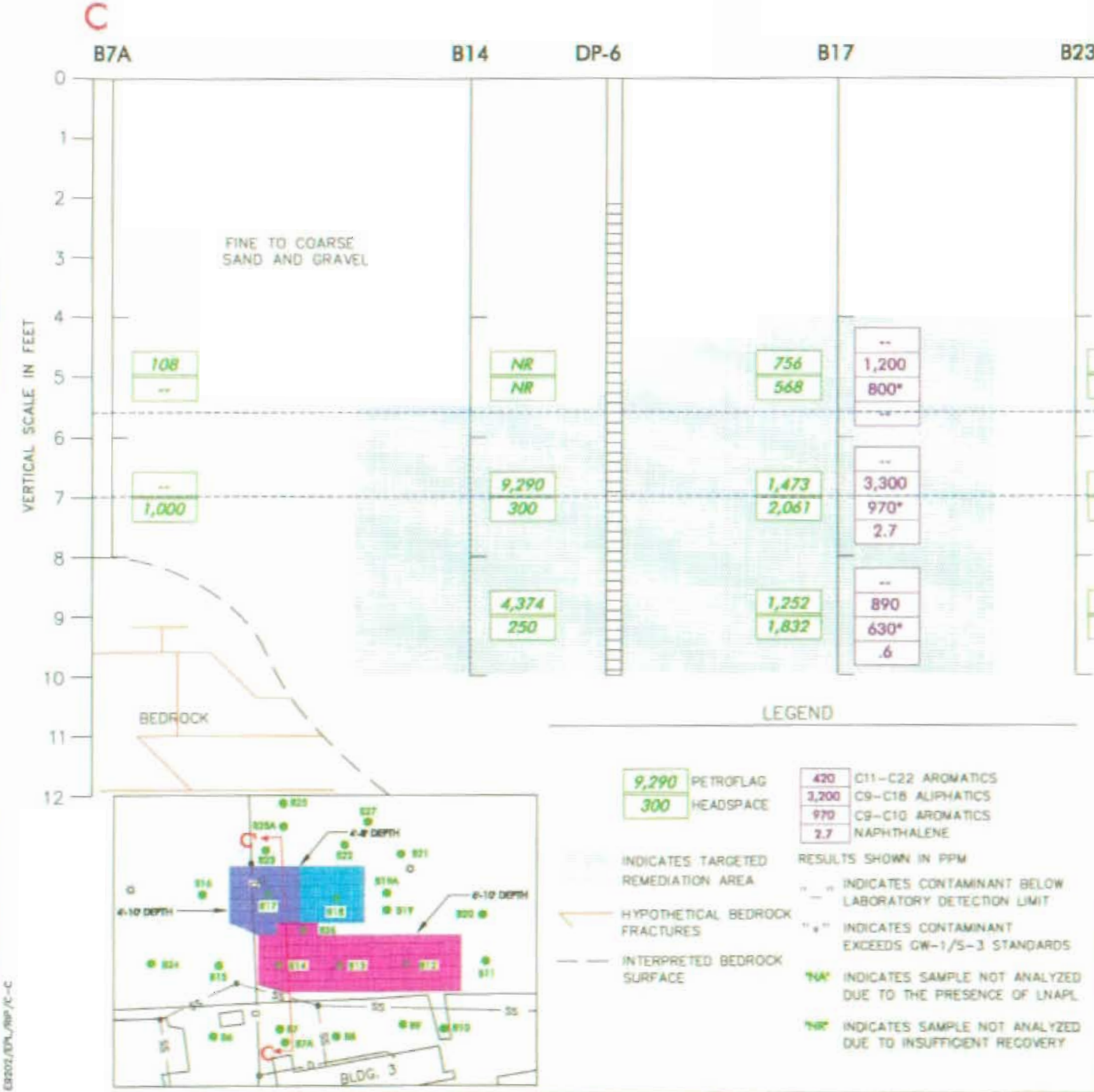
Foot of John Street
Lowell, MA 01852
(978) 970-5600

FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 1-4B
B-B' CROSS-SECTION OF TARGETED REMEDIATION AREA

Date 05/00 | Project No. E3202

E3202/EPL/MP/B-B



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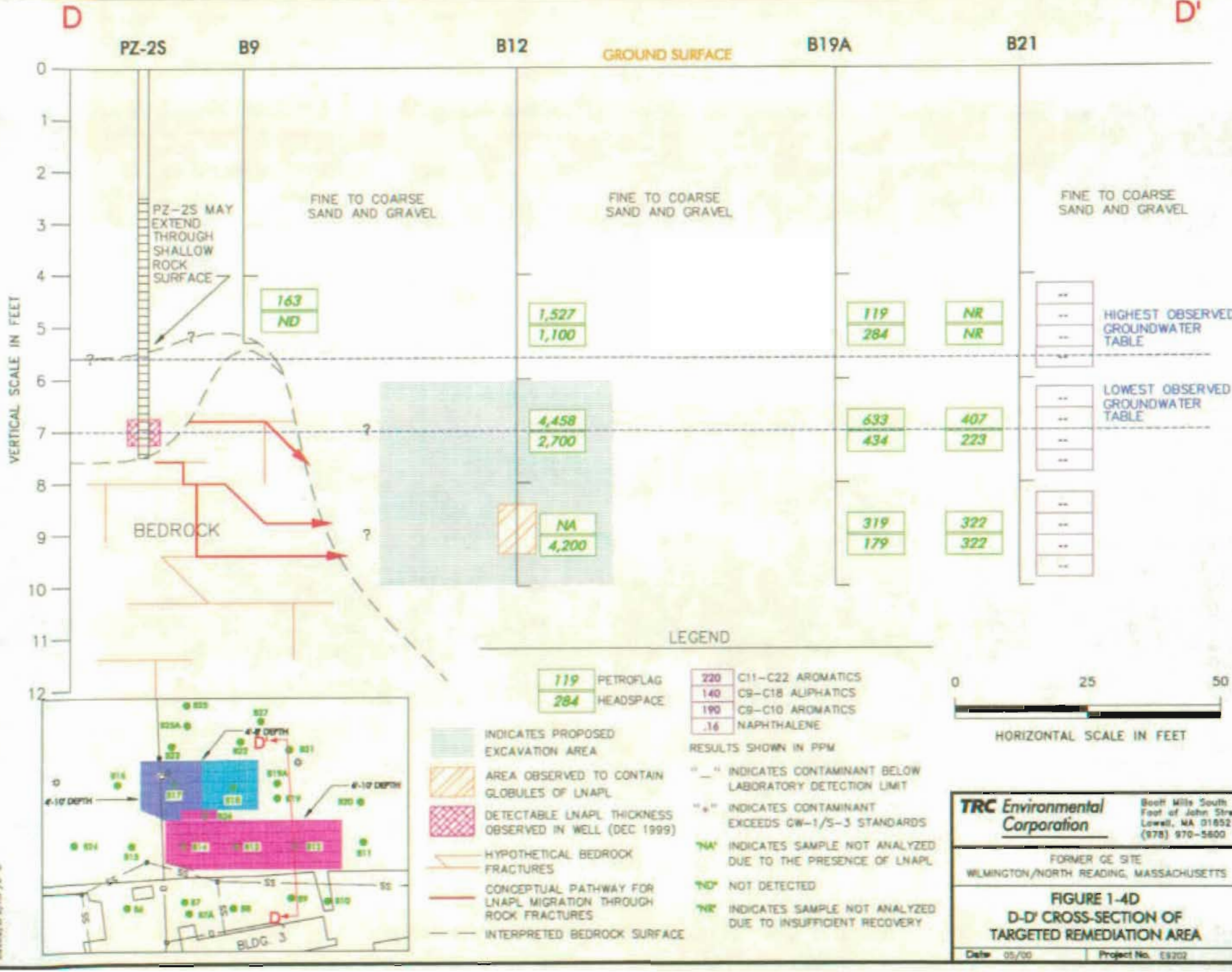
Lowell, MA 01852
(978) 970-5600

FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 1-4C
C-C' CROSS-SECTION OF TARGET REMEDIATION AREA

Date 05/00 Project No. E9202



LEGEND

119	PETROFLAG
284	HEADSPACE

220	C11–C22 AROMATICS
140	C9–C18 ALIPHATICS
190	C9–C10 AROMATICS
.16	NAPHTHALENE

RESULTS SHOWN IN PPM

- INDICATES PROPOSED EXCAVATION AREA
- AREA OBSERVED TO CONTAIN GLOBULES OF LNAPL
- DETECTABLE LNAPL THICKNESS OBSERVED IN WELL (DEC 1999)
- HYPOTHETICAL BEDROCK FRACTURES
- CONCEPTUAL PATHWAY FOR LNAPL MIGRATION THROUGH ROCK FRACTURES
- INTERPRETED BEDROCK SURFACE

- "--" INDICATES CONTAMINANT BELOW LABORATORY DETECTION LIMIT
- "*" INDICATES CONTAMINANT EXCEEDS GW-1/S-3 STANDARDS
- "NA" INDICATES SAMPLE NOT ANALYZED DUE TO THE PRESENCE OF LNAPL
- "ND" NOT DETECTED
- "NR" INDICATES SAMPLE NOT ANALYZED DUE TO INSUFFICIENT RECOVERY

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FORMER GE SITE
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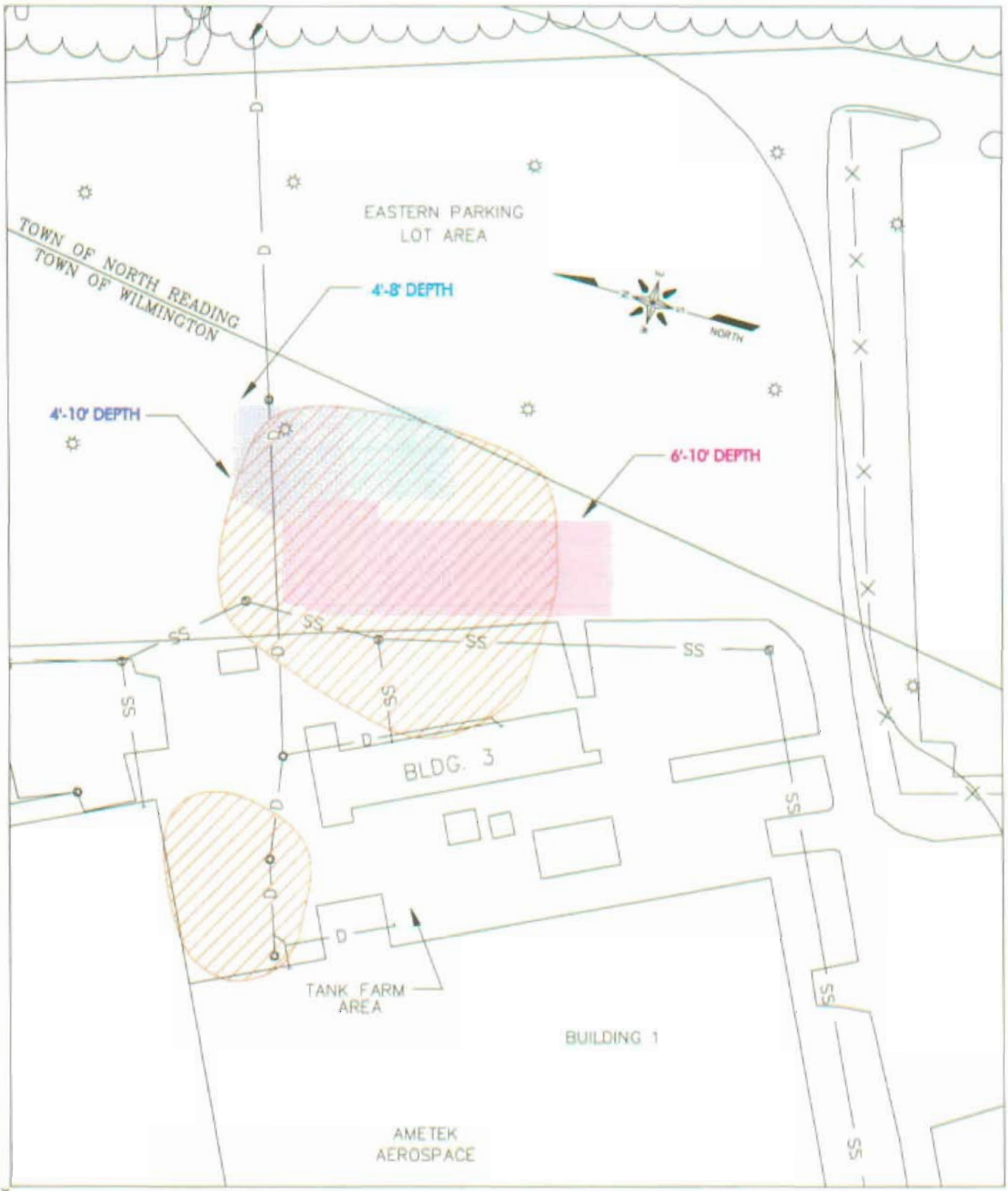
FIGURE 1-4D
D-D' CROSS-SECTION OF TARGETED REMEDIATION AREA

Date 05/00 | Project No. E9202

E9202/EPL/RIP/D-D



0 50' 75' 100'

GRAPHIC SCALE

LEGEND

PROPOSED EXCAVATION AREAS
(FROM PHASE IV REMEDY IMPLEMENTATION PLAN PREPARED BY EMCON, APRIL 19, 1998)

REVISED TARGETED REMEDIATION AREAS
(FROM PHASE III REMEDIAL ACTION PLAN ADDENDUM PREPARED BY TRC, MARCH 20, 2000)

TRC *Environmental Corporation*
Boott Mills South
Foot of John Street
Lowell, MA 01852
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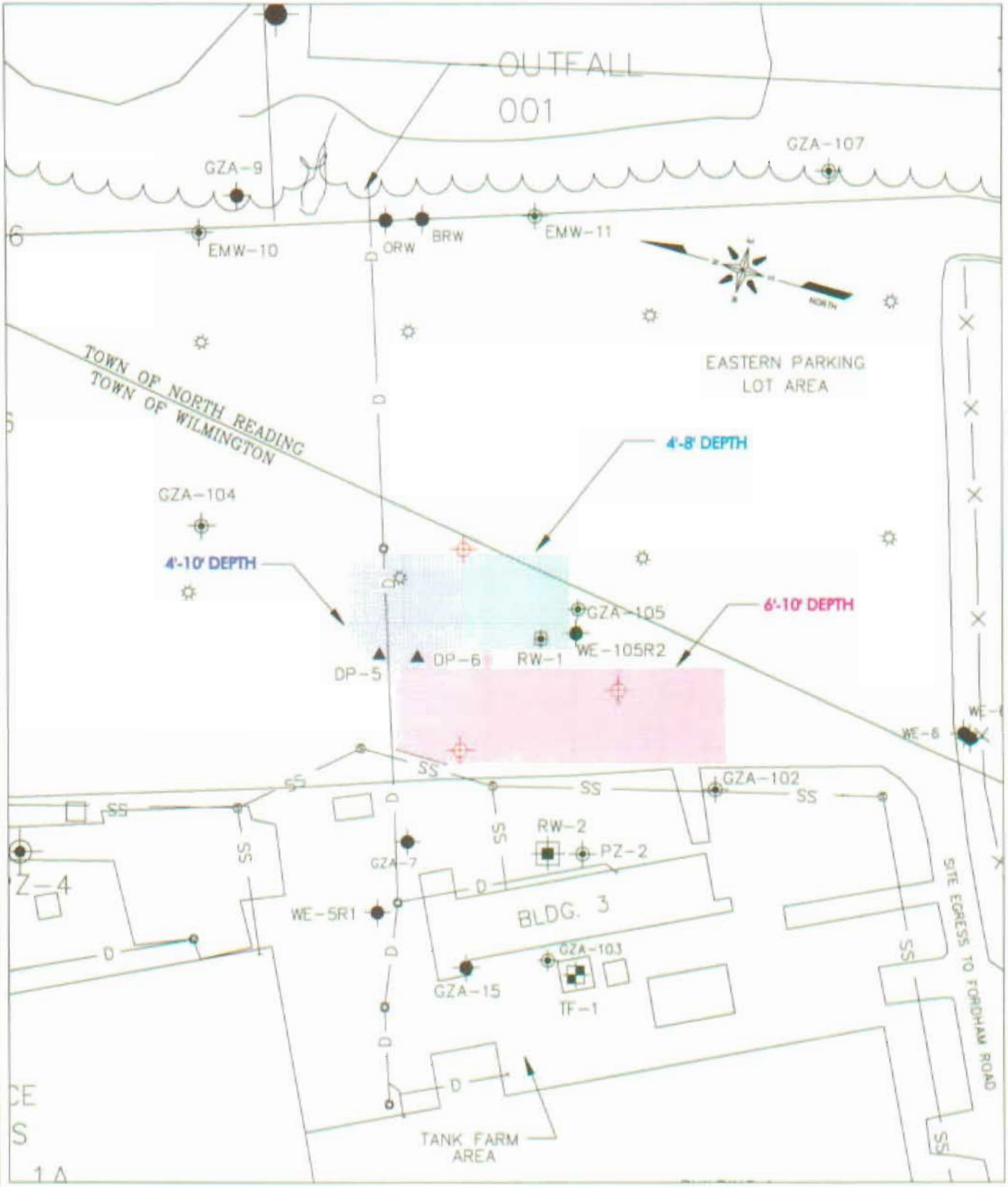
FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 1-5
ORIGINAL AND REVISED TARGETED REMEDIATION AREAS

Date: 03/00 | Project No. E9202

E9202/EPL/CONFIRM/OR AND REV PROP EX



LEGEND

TARGETED REMEDIATION AREAS

NEW GROUNDWATER MONITORING WELL TO BE INSTALLED

CATCH BASIN

— D — DRAIN LINE

— SS — SANITARY SEWER

LIGHT POST

0 50' 75' 100'

GRAPHIC SCALE

E9202/EPL/RIP/GW WELLS

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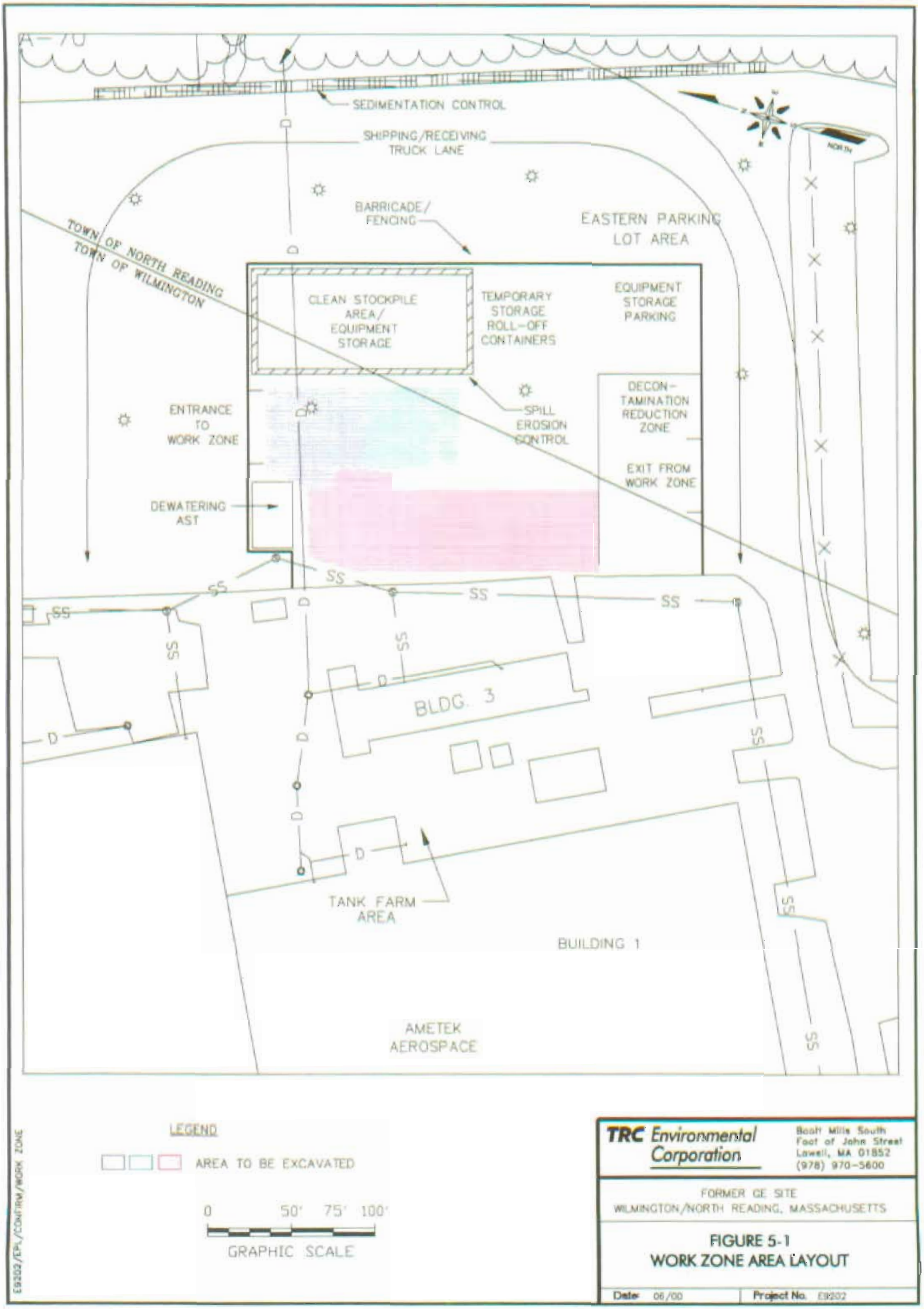
(978) 970-5600

FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 3-1
TARGETED REMEDIATION AREA AND LOCATION OF REPLACEMENT WELLS

Date 06/00 | Project No. E9202



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WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 5-1
WORK ZONE AREA LAYOUT

Date: 06/00 | Project No. E9202

APPENDIX A

PRELIMINARY METHOD 3 RISK CHARACTERIZATION

A.1 Introduction

A preliminary screening level Method 3 Risk Assessment was performed for the Eastern Parking Lot of the Former GE Site in Wilmington/North Reading, Massachusetts. This evaluation resulted in quantitative estimates of the potential human health risks associated with three exposure scenarios; namely, future utility/excavation, future commercial/industrial, and future residential at the Site.

A.2 Hazard Identification

Detailed information pertaining to the nature and extent of contamination in each media sampled is provided in the *Phase III Remedial Action Plan Addendum Report, Eastern Parking Lot Supplemental Soil Sampling,* dated March 16, 2000, prepared by TRC. Table 1 provides summary statistics for contaminants detected in site soil. All of the constituents detected in one or more soil samples within the Site are identified as constituents of concern (COCs) at the Site. Only data from the Phase III Addendum report has been used to perform the risk calculations presented here. Additional data collected at the conclusion of excavation activities would be used to prepare a finalized Method 3 risk assessment if desired.

A.3 Dose-Response Assessment

As part of the dose-response assessment, toxicity values are identified for the selected COCs. This risk assessment evaluation considers carcinogenic (non-threshold-based) and non-carcinogenic (threshold-based) toxicity values, as applicable. In order of preference, these values are obtained from the EPA's (2000) Integrated Risk Information System (IRIS), EPA's (1997) Health Effects Assessment Summary Tables (HEAST), MA DEP's (1994a) Background Documentation for the Development of MCP Numerical Standards, and MA DEP's (1997b) Characterizing Risks Posed by Petroleum Contaminated Sites: Implementation of MA DEP VPH/EPH Approach (Public Comment Draft). The COCs for the Site includes two EPH and three VPH fractions. Table 2 provides the toxicity values and absorption values used in this evaluation.

A.4 Exposure Assessment

The exposure assessment component of the Method 3 risk assessment (i) identifies the current and potential human receptors, (ii) identifies the exposure pathways, (iii) estimates exposure point concentrations (EPCs), and (iv) estimates the average daily doses (ADDs) (or average daily exposures [ADEs]) for the selected receptors. The latter estimates combine the EPCs with assumptions about the magnitude, frequency, and duration of exposure for each exposure pathway under each receptor (or land use) scenario. For the purposes of this risk assessment, ADEs and/or ADDs are estimated for three exposure scenarios; namely, future utility/excavation, future commercial/industrial, and future residential.

Identification of Exposure Pathways

The current and anticipated activities and uses, points at which exposure occurs (i.e., exposure points), and the pathways through which a receptor comes in contact with the exposure point(s) (i.e., exposure pathways) are discussed below for each of the receptors quantitatively evaluated in the risk assessment:

- Future Utility and Excavation: The exposure point for future excavation workers is the volume of contaminated subsurface soil. On-site workers may be exposed to these soils as a result of subsurface excavation and maintenance/repair work. Future Utility and Excavation workers could also come into contact with contaminated surface soil. However, the concentrations of COCs detected in the subsurface soil is significantly higher and will result in the most conservative evaluation for this scenario. The key exposure pathways for excavation workers are expected to include incidental ingestion of, and dermal contact with soils and inhalation of outdoor-suspended particulates and outdoor volatiles.

- Future Commercial: The exposure points for future on-site commercial/industrial workers are the ground surface due to exposure to relocated contaminated subsurface soil and potentially contaminated air. Although future exposures to deeper soils are unlikely, for purposes of this risk characterization, future workers could be exposed to currently unexposed subsurface soils. Contact with the deeper soils containing the greatest concentrations of EPH/VPH would require some mechanism to bring these soils closer to (or to) the soil surface, such as construction of subgrade structures and relocation of excavated soils, (e.g., establishment of final grades). In addition, because the subsurface soil had significantly higher concentrations of EPH/VPH compared to surface soil, the subsurface soil data was used to provide the most conservative evaluation of exposure to soil. The key exposure pathways for commercial workers are expected to include incidental ingestion of, and dermal contact with, subsurface soil, inhalation of airborne particulates from surface soil, and inhalation of indoor volatiles via subsurface soil.

- Future Residential: The exposure points for future on-site residents are the ground surface due to exposure to relocated contaminated subsurface soil and potentially contaminated air. Although future exposures to deeper soils is unlikely, for purposes of this risk characterization, future residents could be exposed to currently unexposed subsurface soils (e.g., while playing, doing yard work, etc.). Contact with the deeper soils containing the greatest concentrations of EPH/VPH would require some mechanism to bring these soils closer to (or to) the soil surface, such as construction of subgrade structures (e.g., residential basements) and relocation of excavated soils, (e.g., establishment of final grades). In addition, because the subsurface soil had significantly higher concentrations of EPH/VPH compared to surface soil, the subsurface soil data was used to provide the most conservative evaluation of exposure to soil. The key exposure pathways for future residents are expected to include incidental ingestion of, and dermal contact with, soils, inhalation of airborne particulates (assuming the relocation of subsurface soil to the surface), and inhalation of volatiles in air via subsurface soil. Future residential exposures were conservatively evaluated on the basis of residential children.

Identification of Exposure Points

An exposure point concentration (EPC) is the measured or estimated amount of a constituent in the environmental medium of concern at the point of human contact. Based on MA DEP (1995) guidance, the EPCs for the environmental media should correspond to the arithmetic mean of the reported results for each data set (i.e., each volume of contaminated soil for soil and each well for groundwater) for areas of contiguous contamination that do not show evidence for the presence of hotspots. The arithmetic means were used as the EPCs for the exposure scenarios used in this Risk Assessment to account for equal probability of exposure at any sample location. This was assumed to be likely because the parking lot is relatively small and uniform. For the purposes of this risk assessment, the following approaches are used:

- Soil: EPCs in subsurface (potentially accessible) soil were calculated as the arithmetic mean concentration for each COC. The analytical results for subsurface soil samples are presented in the *Phase III Remedial Action Plan Addendum Report, Eastern Parking Lot Supplemental Soil Sampling*, dated March 16, 2000, and summary statistics are presented in Table 1. The EPCs for soils are presented in Table 3.

- Air: EPCs in air were calculated for volatiles in air via soil. Procedures for calculating EPCs in indoor air due to volatilization of constituents detected in soil are presented in the exposure and risk estimate spreadsheet tables (Tables B-4 and C-5).

Exposure Point Hotspot Assessment

Based on the data available for the Site, there is one potential area that contains residual concentrations of a COC that fall within the 10-times to 100- times criteria for identification of potential hotspots in environmental media. However, only one constituent (C9-C18 aliphatics) of the 27 detected constituents was elevated 10x (Sample B-18-SS3-4/6; 13,000 mg/kg) as compared to the detection in the corresponding depth in an adjacent sample (Sample B-17-SS1-4/6; 1200 mg/kg). All other detections were comparable between the two samples. Therefore, there are no hotspots considered for this site.

A.5 Estimation of Average Daily Doses

The following standard MA DEP equations (MA DEP, 1995) were used to estimate the average daily dose (ADD) associated with the exposure of receptors through the following exposure pathways:

Incidental ingestion of soils (i.e., ADD_i):

$$ADD_i = \frac{EPC \times UC \times RAFo \times IR \times EF \times ED}{BW \times AP}$$

Where:

ADD_i	=	Average daily dose via ingestion (mg/kg-d)
EPC	=	Exposure point concentration in soils (mg/kg)
UC	=	Units conversion (1E-06 kg/mg)
RAFo	=	Oral relative absorption factor (--)
IR	=	Soil ingestion rate (mg/d)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AP	=	Averaging period (days)

Dermal contact (i.e., ADD_d) with COCs in soils:

$$ADD_d = \frac{EPC \times UC \times RAFd \times SA \times EF \times ED \times AF}{BW \times AP}$$

Where:

ADD_d	=	Average daily dose via dermal contact (mg/kg-d)
EPC	=	Exposure point concentration in soils (mg/kg)
UC	=	Units conversion (1E-06 kg/mg)
RAFd	=	Dermal relative absorption factor (--)
SA	=	Body surface area (cm^2)
FE	=	Fraction exposed (--)
AF	=	Adherence factor (mg/cm^2)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AP	=	Averaging period (days)

Inhalation of airborne particulates (fugitive dust) for soils (i.e., ADDp):

$$ADDp = \frac{EPC \times IR \times ET \times EF \times ED \times PM_{10} \times UC}{BW \times AP}$$

Where:

ADDp	=	Average daily dose via inhalation of airborne particulates (fugitive dust) (mg/kg-d)
EPC	=	Exposure point concentration in soils (mg/kg)
IR	=	Inhalation rate (m^3/hour)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (day/yr)
ED	=	Exposure duration (year)
PM_{10}	=	Concentration of respirable particles in air (ug/m^3)
UC	=	Units conversion (1E-06 kg/mg)
BW	=	Body weight (kg)
AP	=	Averaging period (days)

Average daily exposures (ADEs) to volatiles in outdoor air:

$$ADE = \frac{MOVC \times ET \times EF \times ED \times UC}{AP}$$

Where:

ADE	=	Average daily exposure via inhalation (ug/m^3)
MOVC	=	Modeled outdoor vapor concentration in air (ug/m^3)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
UC	=	Units conversion (0.04 days/hr)
AP	=	Averaging period (days)

Average daily exposures (ADEs) to volatiles in indoor air:

$$ADE = \frac{EPC \times ET \times EF \times ED \times UC}{AP}$$

Where:

ADE	=	Average daily exposure via inhalation (ug/m^3)
EPC	=	Modeled exposure point concentration in air (ug/m^3)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
UC	=	Units conversion (0.04 days/hr)
AP	=	Averaging period (days)

The specific equations and input parameter values used for the exposure scenarios correspond to those available and recommended by MA DEP (1994a, 1995).

Risk Characterization

The risk characterization combines the previously described components of the Method 3 Risk Assessment (i.e., hazard identification, dose-response assessment, and exposure assessment) to provide quantitative estimates of human health risk. In general, these risk estimates are expressed in terms of excess lifetime cancer risk (ELCR) for cancer endpoints and in terms of non-cancer hazard quotients/hazard indices (HQs/HIs) for non-cancer endpoints.

The ELCR is estimated as the product of the estimated lifetime average daily dose (LADD) (mg/kg-d) times the identified cancer slope factor ($[mg/kg\text{-}d]^{-1}$) for oral and dermal exposures or, for inhalation exposures, the product of the lifetime average daily exposure (LADE) ($\mu g/m^3$) times the unit risk ($[\mu g/m^3]^{-1}$). However, this site is not contaminated by the release of carcinogenic substances. Therefore, the ELCR is not discussed further. (The ELCR and similar carcinogenic related calculations are contained in the supporting spreadsheets since they are associated with the calculation template).
The COC-specific non-cancer HQ is estimated as the ratio of the estimated ADD (mg/kg-d) and the identified RfD (mg/kg-d) for oral and dermal exposures, and for inhalation exposures, as the ratio of the ADE ($\mu g/m^3$) and the RfC ($\mu g/m^3$). These individual cancer risks and HQs are then summed to yield an estimate of the pathway cancer risk and HI, respectively.

Finally, a cumulative cancer risk and non-cancer HI for the scenario is estimated for each hot spot and non-hotspot areas at the site by summing the pathway cancer risks and HIs, respectively. If the cumulative HI exceeds unity (1.0), then the individual HQs are segregated by target organ or critical effect. The estimated cancer risks and/or HQs/HIs are evaluated in the context of MA DEP (1995) guidance (i.e., a cancer risk limit of 1E-05 and a non-cancer HQ/HI limit of 1E+00).

Table 4 presents the estimated cancer risks and cumulative HIs for the evaluated scenarios. Detailed risk calculation spreadsheets for each scenario are presented in Tables A-1 through A-4, Tables B-1 through B-4, and tables C-1 through C-5.

- The utility/excavation scenario evaluated exposures through the incidental ingestion of soil, dermal contact with soil, inhalation of airborne particulates and inhalation of outdoor volatiles. The utility/excavation scenario is shown to have a total cancer risk of 6E-07 and a total HI of 7.5E-01, which is below the cancer and non-cancer HQ/HI limit of 1E-05 and 1E+00, respectively.

- The Future commercial/industrial scenario evaluated exposures through the incidental ingestion of soil, dermal contact with soil, inhalation of airborne particulates and inhalation of indoor volatiles. A total cancer risk of 2E-06 was calculated for this scenario, which is below the cancer limit of 1E-05. A total non-cancer HI of 8.4+02 was calculated for this scenario. The non-cancer HQ/HI limit of 1E+00 has therefore been exceeded for this scenario. This risk was driven by the inhalation of volatiles pathway. The constituent primarily driving this risk is the C5-C8 aliphatics.

- The residential scenario evaluated exposures through the incidental ingestion of soil, dermal contact with soil, and inhalation of airborne particulates, and inhalation of indoor volatiles. A total cancer risk of 8E-06 was calculated for this scenario, which is below the cancer limit of 1E-05. A total non-cancer HI of 3.7+03 was calculated for this scenario. The non-cancer HQ/HI limit of 1E+00 has therefore been exceeded for this scenario. This risk was driven by the inhalation of volatiles pathway. The constituents primarily driving this risk are the C9-C18 aliphatics, the C5-C8 aliphatics, the C9-C12 aliphatics and the C9-C10 aromatics.

In accordance with 310 CMR 40.0993(7), under the current conditions, a condition of no significant risk of harm to human health has not been achieved for in the Eastern Parking Lot due to potential risks associated with future commercial and residential use of the property. This conclusion is consistent with the need for remedial action in the Eastern Parking Lot soils as determined by the use of the Method 1 S-3/GW-1 standards. However, when the planned excavation is complete, the recalculated risk under Method 3 is likely to be acceptable to the future commercial/industrial scenario. This would mean that no site Activity and Use Limitation restrictions would be required for continued industrial/commercial property use other than to prohibit future residential use. There would be no need to have additional restrictions, such as mandatory paving or prohibition of commercial building. Such restrictions would be required using the Method 1 S-3 standards.

Note: While scenarios other than those evaluated by this risk assessment are possible at the Site, the selected scenarios are intended to provide conservative estimates of the potential health impacts associated with the range of current and reasonably foreseeable future uses of the Site.

TABLE 1
SUMMARY STATISTICS
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

Constituent	Number of Samples (a)	Number of Detects	Frequency of Detection	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration. (mg/kg)	Mean Ln(x) (a)	Mean Concentration (mg/kg)	St. Dev. Ln(x) (a)	H Stat.(a)	95% UCL Concentration (mg/kg)
Extractable Petroleum Hydrocarbons (EPH) (mg/kg)										
C9-C18 Aliphatic Hydrocarbons	27	8	30%	1.10E+02	1.30E+04	5.31E+00	9.27E+02	1.38E+00	3.31E+00	1.29E+03
C19-C36 Aliphatics	27	0	0%	- -	- -	4.61E+00	- -	0.00E+00	--	--
C11-C22 Aromatics	27	1	4%	2.20E+02	2.20E+02	4.63E+00	1.04E+02	1.52E-01	1.77E+00	1.10E+02
Unadjusted C11-C22 Aromatics	27	1	4%	2.20E+02	2.20E+02	4.63E+00	1.04E+02	1.52E-01	1.77E+00	1.10E+02
Napthalene	27	1	4%	8.20E-01	8.20E-01	-6.75E-01	5.12E-01	9.52E-02	1.72E+00	5.28E-01
Methylnaphthalene, 2-	27	2	7%	9.30E-01	1.30E+00	-6.35E-01	5.46E-01	2.15E-01	1.83E+00	5.86E-01
Acenaphthylene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Acenaphthene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Fluorene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Phenanthrene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Anthracene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Fluoranthene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Pyrene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Benzo(a)Anthracene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Chrysene	27	1	4%	1.60E+00	1.60E+00	-6.50E-01	5.41E-01	2.24E-01	1.83E+00	5.80E-01
Benzo(b)Fluoranthene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Benzo(k)Fluoranthene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Benzo(a)Pyrene	27	1	4%	2.90E+00	2.90E+00	-6.28E-01	5.89E-01	3.38E-01	1.91E+00	6.41E-01
Indeno(1,2,3-cd)Pyrene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Dibenzo(a,h)Anthracene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
Benzo(g,h,i)Perylene	27	0	0%	- -	- -	-6.93E-01	- -	0.00E+00	--	--
							- -			
Volatile Petroleum Hydrocarbons (VPH) (mg/kg)							- -			
C5-C8 Aliphatics	27	16	59%	1.70E+00	1.40E+02	1.62E+00	4.18E+02	1.80E+00	4.14E+00	1.09E+02
C9-C12 Aliphatics	27	24	89%	1.00E+00	2.30E+03	3.68E+00	1.86E+02	2.66E+00	6.82E+00	4.86E+04 *
C9-C10 Aromatics	27	22	81%	1.70E+00	9.70E+02	3.16E+00	2.63E+01	2.46E+00	5.01E+00	5.43E+03 *
Unadjusted C5-C8 Aliphatics	27	16	59%	1.70E+00	1.60E+02	1.65E+00	6.18E+02	1.83E+00	4.14E+00	1.23E+02
Unadjusted C9-C12 Aliphatics	27	24	89%	1.40E+00	3.40E+03	4.09E+00	3.74E-01	2.73E+00	6.82E+00	9.40E+04 *
Benzene	27	0	0%	- -	- -	-1.74E+00	- -	1.08E+00	--	--
Toluene	27	2	7%	1.00E-01	2.00E-01	-1.71E+00	1.05E+00	1.08E+00	2.92E+00	5.99E-01 *
Ethylbenzene	27	8	30%	1.20E-01	7.20E+00	-1.35E+00	5.02E+00	1.52E+00	3.72E+00	2.48E+00
Xylene	27	18	67%	1.40E-01	2.80E+01	-1.23E-01	3.74E-01	2.06E+00	5.01E+00	5.51E+01 *
MTBE	27	0	0%	- -	- -	-1.74E+00	- -	1.08E+00	--	--
Napthalene	27	10	37%	1.10E-01	4.70E+00	-1.45E+00	1.38E+03	1.28E+00	3.31E+00	1.22E+00

TABLE 2
SUMMARY OF TOXICITY AND OTHER CHEM-SPECIFIC VALUES
USED IN EXPOSURE AND RISK ESTIMATES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

	Oral			Inhalation			Oral		Dermal	
Chemical	Cancer Slope Factor (mg/kg-d)-1	Noncancer Chronic Reference Dose (mg/kg-d)	Noncancer Subchronic Reference Dose (mg/kg-d)	Cancer Unit Risk Factor (ug/m3)-1	Noncancer Chronic Reference Conc. (ug/m3)	Noncancer Subchronic Reference Conc. (ug/m3)	Relative Absorption Factor (cancer)	Relative Absorption Factor (non-cancer)	Relative Absorption Factor (cancer)	Relative Absorption Factor (non-cancer)
	D	E	F	H	I	J	(--)	(--)	(--)	(--)
EPH										
C9-C18 Aliphatics	NA	6.00E-01	6.00E+00	NA	2.0E+03	2.0E+03	NA	0.91	NA	0.20
C11-C22 Aromatics	NA	3.00E-02	3.00E-01	NA	7.1E+01	7.1E+01	NA	0.91	NA	0.18
Benzo(a)pyrene	7.3E+00	2.00E-02	2.00E-02	1.7E-03	NA	NA	1.00	0.91	0.20	0.18
Chrysene	7.3E-03	2.00E-02	2.00E-02	NA	NA	NA	1.00	0.91	0.20	0.18
Methylnaphthalene, 2-	NA	2.00E-02	2.00E-02	NA	NA	NA	NA	1.00	NA	0.20
VPH										
C5-C8 Aliphatics	NA	6.00E-02	6.00E-01	NA	2.00E+02	2.00E+02	NA	0.91	NA	0.5
C9-C12 Aliphatics	NA	6.00E-01	6.00E+00	NA	2.00E+03	2.00E+03	NA	0.91	NA	0.2
C9-C10 Aromatics	NA	3.00E-02	3.00E-01	NA	6.00E+01	6.00E+01	NA	0.91	NA	0.18
Ethylbenzene	NA	1.00E-01	1.00E+00	NA	1.00E+03	1.00E+03	NA	1	NA	0.2
Napthalene	NA	2.00E-02	2.00E-02	NA	NA	NA	NA	0.91	NA	0.18
Toluene	NA	2.00E-01	2.00E+00	NA	4.00E+02	4.00E+02	NA	1	NA	0.12
Xylene	NA	2.00E+00	4.00E+00	NA	3.00E+02	3.00E+02	NA	1	NA	0.12

TABLE 3
EXPOSURE POINT CONCENTRATIONS
EASTERN PARKING LOT
LOCKHEED MARTIN
WILMINGTON/NORTH READING, MA

Constituent	Average Exposure Point Concentration mg/kg
Extractable Petroleum Hydrocarbons (EPH) (mg/kg)	
C9-C18 Aliphatic Hydrocarbons	927.41
C11-C22 Aromatics	104.44
Benzo(a)Pyrene	0.59
Chrysene	0.54
Methylnaphthalene, 2-	0.55
Volatile Petroleum Hydrocarbons (VPH) (mg/kg)	
C5-C8 Aliphatics	417.85
C9-C12 Aliphatics	185.80
C9-C10 Aromatics	26.34
Ethylbenzene	5.02
Napthalene	1379.60
Toluene	1.05
Xylene	0.37

TABLE 4
SUMMARY OF TOTAL CANCER RISK AND NON-CANCER HIs
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

	Risk Estimates	
	Total Cancer Risk (--)	Total Hazard Index (--)
Current/Future Utility/Excavation	6E-07	7E-01
Future Commercial/Industrial	2E-06	8E+02
Future Residential	8E-06	4E+03

[shaded box] = Cancer risk > 1E-05 or HQ/HI > 1E+00

TABLE A-1
CURRENT/FUTURE UTILITY/EXCAVATION
EXPOSURE AND RISK ESTIMATES
INCIDENTAL INGESTION OF SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

		Exposure Estimates				Toxicity Values		Risk Estimates	
Constituent	Exposure Point Conc. (a) (mg/kg)	Relative Absorption Factor (b) (Cancer) (--)	LADD (Cancer) (mg/kg-d)	Relative Absorption Factor (b) (Noncancer) (--)	ADD (Noncancer) (mg/kg-d)	Cancer Slope Factor (Oral) (mg/kg-d)-1	Subchronic Noncancer Reference Dose (Oral) (mg/kg-d)	Cancer Risk (--)	Hazard Quotient (--)
EPH									
C9-C18 Aliphatics	9.3E+02	NA	NA	0.91	4.5E-03	NA	6.0E+00	NA	8E-04
C10-C22 Aromatics	1.0E+02	NA	NA	0.91	5.1E-04	NA	3.0E-01	NA	2E-03
Benzo(a)pyrene	5.9E-01	1.00	4.2E-08	0.91	2.9E-06	7.3E+00	2.0E-02	3E-07	1E-04
Chrysene	5.4E-01	1.00	3.9E-08	0.91	2.6E-06	7.3E-03	2.0E-02	3E-10	1E-04
Methylnaphthalene, 2-	5.5E-01	NA	NA	1.00	2.9E-06	NA	2.0E-02	NA	1E-04
VPH									
C5-C8 Aliphatics	4.2E+02	NA	NA	0.91	2.0E-03	NA	6.0E-01	NA	3E-03
C9-C12 Aliphatics	1.9E+02	NA	NA	0.91	9.0E-04	NA	6.0E+00	NA	2E-04
C9-C10 Aromatics	2.6E+01	NA	NA	0.91	1.3E-04	NA	3.0E-01	NA	4E-04
Ethylbenzene	5.0E+00	NA	NA	1.00	2.7E-05	NA	1.0E+00	NA	3E-05
Napthalene	1.4E+03	NA	NA	0.91	6.7E-03	NA	2.0E-02	NA	3E-01
Toluene	1.1E+00	NA	NA	1.00	5.6E-06	NA	2.0E+00	NA	3E-06
Xylene	3.7E-01	NA	NA	1.00	2.0E-06	NA	4.0E+00	NA	5E-07

NA = Not available/applicable

(a) Average for post-excavation soil samples
(b) MADEP (1994a, 1997b)

	Cancer Risk	Hazard Index
TOTAL:	3E-07	3E-01

= Cancer risk > 1E-05 or HQ/HI> 1E+00

Where:

LADDcancer = [EPC x UC x RAFo x IRc(daily) x EDc x EPc] / [BWc x APc]
ADDnon-cancer = [EPC x UC x RAFo x IRnc(daily) x EDnc x EPnc] / [BWnc x APnc]
IRc(daily) = IRc x EFc = 342 mg*event/d2
IRnc(daily) = IRnc x EFnc = 342 mg*event/d2
Cancer Risk = LADDcancer x Slope Factor
Hazard Quotient = ADDnon-cancer / Reference Dose

TABLE A-1 (cont.)
CURRENT/FUTURE UTILITY/EXCAVATION
EXPOSURE AND RISK ESTIMATES
INCIDENTAL INGESTION OF SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Unit Conversion (UC) =	1E-06 kg/mg
Ingestion Rate - Cancer (IRc) =	500 mg/d [1]
Ingestion Rate - Non-Cancer (IRnc) =	500 mg/d [1]
Exposure Frequency - Cancer (EFc) =	0.68 events/d (i.e., 250 events per 365 days) [1,2]
Exposure Frequency - Non-Cancer (EFnc) =	0.68 events/d (i.e., 250 events per 365 days) [1,2]
Exposure Duration - Cancer (EDc) =	1 d/event [1]
Exposure Duration - Non-Cancer (EDnc) =	1 d/event [1]
Exposure Period - Cancer (EPc) =	1 yr [1]
Exposure Period - Non-Cancer (EPnc) =	1 yr [1]
Body Weight - Cancer (BWc) =	64 kg (avg male/female 18-25) [1]
Body Weight - Non-Cancer (BWnc) =	64 kg (avg male/female 18-25) [1]
Averaging Period (Cancer) (APcancer) =	75 yr [1]
Averaging Period (Non-Cancer) (APnon-cancer) =	1.0 yr [1]

Note:	(IRc(daily) x EDc x EPc / BWc) =	5 mg-yr/kg-d	
	(IRnc(daily) x EDnc x EPnc / BWnc) =	5.4 mg-yr/kg-d =	1953 mg-d/kg-d

Effective NLADSIR = LADDcancer / [EPC x UC x RAFo] =	0.07 mg/kg-d
Effective NADSIR = ADDnon-cancer / [EPC x UC x RAFo] =	5.4 mg/kg-d

[1] MADEP (1995)
[2] Assumes five days per week for one year

TABLE A-2
CURRENT/FUTURE UTILITY/EXCAVATION
EXPOSURE AND RISK ESTIMATES
DERMAL CONTACT WITH SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

	Exposure Estimates					Toxicity Values		Risk Estimates	
Constituent	Exposure Point Conc. (a) (mg/kg)	Relative Absorption Factor (b) (Cancer) (--)	LADD (Cancer) (mg/kg-d)	Relative Absorption Factor (b) (Noncancer) (--)	ADD (Noncancer) (mg/kg-d)	Cancer Slope Factor (Oral) (mg/kg-d)-1	Subchronic Noncancer Reference Dose (Oral) (mg/kg-d)	Cancer Risk (--)	Hazard Quotient (--)
EPH									
C9-C18 Aliphatics	9.3E+02	NA	NA	0.20	5.5E-03	NA	6.0E+00	NA	9E-04
C10-C22 Aromatics	1.0E+02	NA	NA	0.18	5.6E-04	NA	3.0E-01	NA	2E-03
Benzo(a)pyrene	5.9E-01	0.20	4.7E-08	0.18	3.2E-06	7.3E+00	2.0E-02	3E-07	2E-04
Chrysene	5.4E-01	0.20	4.3E-08	0.18	2.9E-06	7.3E-03	2.0E-02	3E-10	1E-04
Methylnaphthalene, 2	5.5E-01	NA	NA	0.20	3.2E-06	NA	2.0E-02	NA	2E-04
VPH									
C5-C8 Aliphatics	4.2E+02	NA	NA	0.50	6.2E-03	NA	6.0E-01	NA	1E-02
C9-C12 Aliphatics	1.9E+02	NA	NA	0.20	1.1E-03	NA	6.0E+00	NA	2E-04
C9-C10 Aromatics	2.6E+01	NA	NA	0.18	1.4E-04	NA	3.0E-01	NA	5E-04
Ethylbenzene	5.0E+00	NA	NA	0.20	3.0E-05	NA	1.0E+00	NA	3E-05
Napthalene	1.4E+03	NA	NA	0.18	7.4E-03	NA	2.0E-02	NA	4E-01
Toluene	1.1E+00	NA	NA	0.12	3.8E-06	NA	2.0E+00	NA	2E-06
Xylene	3.7E-01	NA	NA	0.12	1.3E-06	NA	4.0E+00	NA	3E-07

NA = Not available/applicable

(a) Average for post-excavation soil samples
(b) MADEP (1994a, 1997b)

	Cancer Risk	Hazard Index
TOTAL:	3E-07	4E-01

= Cancer risk > 1E-05 or HQ/HI> 1E+00

Where:

LADDcancer = [EPC x UC x RAFd x CRc(daily) x EDc x EPc] / [BWc x APc]
ADDnon-cancer = [EPC x UC x RAFd x CRnc(daily) x EDnc x EPnc] / [BWnc x APnc]
CRc(daily) = SAc x FEc x AFc x EFc = 1902 mg*event/d2
CRnc(daily) = SAnc x FEnc x AFnc x EFnc = 1902 mg*event/d2
Cancer Risk = LADDcancer x Slope Factor
Hazard Quotient = ADDnon-cancer / Reference Dose

TABLE A-2 (cont.)
CURRENT/FUTURE UTILITY/EXCAVATION
EXPOSURE AND RISK ESTIMATES
DERMAL CONTACT WITH SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Unit Conversion (UC) =	1E-06 kg/mg
Surface Area - Cancer (SAc) =	18150 cm2/d (avg male/female 18-25) [1]
Surface Area - Non-Cancer (SAnc) =	18150 cm2/d (avg male/female 18-25) [1]
Fraction Exposed - Cancer (FEc) =	0.30 unitless (hands, forearms, lower legs, feet) [2]
Fraction Exposed - Non-Cancer (FEnc) =	0.30 unitless (hands, forearms, lower legs, feet) [2]
Adherence factor - Cancer (AFc) =	0.51 mg/cm2 [1]
Adherence factor - Non-Cancer (AFnc) =	0.51 mg/cm2 [1]
Exposure Frequency - Cancer (EFc) =	0.68 events/d (i.e., 250 events per 365 days) [2,3]
Exposure Frequency - Non-Cancer (EFnc) =	0.68 events/d (i.e., 250 events per 365 days) [1,3]
Exposure Duration - Cancer (EDc) =	1 d/event [1]
Exposure Duration - Non-Cancer (EDnc) =	1 d/event [1]
Exposure Period - Cancer (EPc) =	1 yr [1]
Exposure Period - Non-Cancer (EPnc) =	1 yr [1]
Body Weight - Cancer (BWc) =	64 kg (avg male/female 18-25) [1]
Body Weight - Non-Cancer (BWnc) =	64 kg (avg male/female 18-25) [1]
Averaging Period (Cancer) (APcancer) =	75 yr [1]
Averaging Period (Non-Cancer) (APnon-cancer) =	1.0 yr [1]

Note:	(CRc(daily) x ED x EPc / BWc)	30 mg-yr/kg-d	
	(CRnc(daily) x ED x EPnc / BWnc)	29.7 mg-yr/kg-d =	10847 mg-d/kg-d

Effective NLADSCR = LADDcancer / [EPC x UC x RAFd] = 0.40 mg/kg-d

TABLE A-3
CURRENT/FUTURE UTILITY/EXCAVATION
EXPOSURE AND RISK ESTIMATES
INHALATION OF OUTDOOR SUSPENDED PARTICULATES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

				Toxicity Values		Risk Estimates	
Constituent	Modeled Outdoor Particulate Conc. (ug/m3)	LADE (Cancer) (ug/m3)	ADE (Noncancer) (ug/m3)	Cancer Unit Risk (Inhl.) (ug/m3)-1	Subchronic Noncancer Reference Dose (Inhl.) (ug/m3)	Cancer Risk (--)	Hazard Quotient (--)
EPH							
C9-C18 Aliphatics	5.6E-02	1.7E-04	1.3E-02	NA	2.0E+03	NA	6E-06
C10-C22 Aromatics	6.3E-03	1.9E-05	1.4E-03	NA	7.1E+01	NA	2E-05
Benzo(a)pyrene	3.5E-05	1.1E-07	8.1E-06	1.7E-03	NA	2E-10	NA
Chrysene	3.2E-05	9.9E-08	7.4E-06	NA	NA	NA	NA
Methylnaphthalene, 2	3.3E-05	1.0E-07	7.5E-06	NA	NA	NA	NA
VPH							
C5-C8 Aliphatics	2.5E-02	7.6E-05	5.7E-03	NA	2.0E+02	NA	3E-05
C9-C12 Aliphatics	1.1E-02	3.4E-05	2.5E-03	NA	2.0E+03	NA	1E-06
C9-C10 Aromatics	1.6E-03	4.8E-06	3.6E-04	NA	6.0E+01	NA	6E-06
Ethylbenzene	3.0E-04	9.2E-07	6.9E-05	NA	1.0E+03	NA	7E-08
Napthalene	8.3E-02	2.5E-04	1.9E-02	NA	NA	NA	NA
Toluene	6.3E-05	1.9E-07	1.4E-05	NA	4.0E+02	NA	4E-08
Xylene	2.2E-05	6.8E-08	5.1E-06	NA	3.0E+02	NA	2E-08

NA = Not available/applicable

(a) Based on average for post-excavation soil samples
and TSP conc = 32 ug/m3

Where:

LADEcancer = EPC x EDc x EFc x EPc x UC1 / APc
ADEnon-cancer = EPC x EDnc x EFnc x EPnc x UC1 / APnc
Cancer Risk = LADEcancer x Unit Risk
Hazard Quotient = ADEnon-cancer / Reference Concentration

	Cancer Risk	Hazard Index
TOTAL:	2E-10	6E-05

= Cancer risk > 1E-05 or HQ/HI> 1E+00

TABLE A-3 (cont.)
CURRENT/FUTURE UTILITY/EXCAVATION
EXPOSURE AND RISK ESTIMATES
INHALATION OF OUTDOOR SUSPENDED PARTICULATES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Exposure Duration - Cancer (EDc) =	8	hr/event [1]
Exposure Duration - Non-Cancer (EDnc) =	8	hr/event [1]
Exposure Frequency - Cancer (EFc) =	0.68	events/d (i.e., 250 events per 365 days) [2,3]
Exposure Frequency - Non-Cancer (EFnc) =	0.68	events/d (i.e., 250 events per 365 days) [2,3]
Exposure Period - Cancer (EPc) =	1	yr [2]
Exposure Period - Non-Cancer (EPnc) =	1	yr [2]
Unit Conversion (UC1) =	0.04	d/hr
Averaging Period - Cancer (APc) =	75	yr [2]
Averaging Period - Non-Cancer (APnc) =	1	yr [2]

[1] BPJ
[2] MADEP (1995)
[3] Assumes five days per week for one year

TABLE A-4
CURRENT/FUTURE UTILITY/EXCAVATION
EXPOSURE AND RISK ESTIMATES
INHALATION OF OUTDOOR VOLATILES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

Constituent				Exposure Estimates		Toxicity Values		Risk Estimates	
Constituent	Exposure Point Conc. (a) (mg/kg)	Volatilization Factor (b) (m3/kg)	Modeled Outdoor Vapor Conc. (b) (mg/m3)	ADE (Cancer) (ug/m3)	ADE (Noncancer) (ug/m3)	Cancer Unit Risk (Inhl.) (ug/m3)-1	Subchronic Noncancer Reference Dose (Inhl.) (ug/m3)	Cancer Risk (- -)	Hazard Quotient (- -)
EPH									
C9-C18 Aliphatics	9.3E+02	5.1E+04	1.8E-02	5.3E-02	4.0E+00	NA	2.0E+03	NA	2E-03
C10-C22 Aromatics	1.0E+02	5.1E+04	2.0E-03	5.9E-03	4.4E-01	NA	7.1E+01	NA	6E-03
Benzo(a)pyrene	5.9E-01	NA	NA	NA	NA	1.7E-03	NA	NA	NA
Chrysene	5.4E-01	NA	NA	NA	NA	NA	NA	NA	NA
Methylnaphthalene,	5.5E-01	5.1E+04	1.1E-05	3.1E-05	2.3E-03	NA	NA	NA	NA
VPH									
C5-C8 Aliphatics	4.2E+02	4.2E+04	1.0E-02	2.9E-02	2.2E+00	NA	2.0E+02	NA	1E-02
C9-C12 Aliphatics	1.9E+02	5.1E+04	3.6E-03	1.1E-02	7.9E-01	NA	2.0E+03	NA	4E-04
C9-C10 Aromatics	2.6E+01	5.1E+04	5.1E-04	1.5E-03	1.1E-01	NA	6.0E+01	NA	2E-03
Ethylbenzene	5.0E+00	5.1E+04	9.9E-05	2.9E-04	2.2E-02	NA	1.0E+03	NA	2E-05
Napthalene	1.4E+03	5.1E+04	2.7E-02	7.8E-02	5.9E+00	NA	NA	NA	NA
Toluene	1.1E+00	5.1E+04	2.1E-05	6.0E-05	4.5E-03	NA	4.0E+02	NA	1E-05
Xylene	3.7E-01	5.1E+04	7.3E-06	2.1E-05	1.6E-03	NA	3.0E+02	NA	5E-06

(a) Average for post-excavation soil samples
(b) calculated for constituents with a MW of 200 g/mol or less

	Cancer Risk	Hazard Index
TOTAL:	NA	2E-02

= Cancer Risk >1E-05 or HQ/HI > 1E+00

Where:
Modeled Outdoor Vapor Conc. (MOVC) = Soil Concentration x 1/VF
VF= ((LS x V x DH)/A) x (3.14 x alpha x T)^1/2/ 2 x Dei x E x Kas x UC1
alpha = (Dei x E)/E + (ps)(1-E)/Kas
Adjusted Air Concentration (cancer) = MOVC x UC2 x EF x ED x EP x UC3/ AP(c)
Adjusted Air Concentration (non-cancer) = MOVC x EF x ED x EP x UC3/ AP(nc)
Cancer Risk = Adjusted Air Concentration (cancer) x Unit Risk
Hazard Quotient = Adjusted Air Concentration / Reference Concentration

TABLE A-4 (cont.)
CURRENT/FUTURE UTILITY/EXCAVATION
EXPOSURE AND RISK ESTIMATES
INHALATION OF OUTDOOR VOLATILES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

Volatilization Factor =	CS	m3/kg (1)
Length of side of contaminated area (LS) =	1.37E+02	m, site specific
Wind speed in mixing zone (V) =	2.25E+00	m/s
Diffusion height (D)	2.00E+00	m
Area of contamination (A) =	1.72E+08	cm2, site specific
Effective diffusivity (Dei) =	CS	cm2/s
True soil porosity (E) =	3.50E-01	--
Soil/air partition coefficient (Kas) =	CS	g soil/cm3 air
True soil density (ps) =	2.65E+00	g/cm3
Exposure Interval (T) =	3.2E+07	s (one year)
Molecular Diffusivity (Di) =	CS	
Units conversion (UC1) =	1.00E-03	kg/g
Henry's Law Constant (H) =	CS	
Soil-water partition coefficient (Kd) =	CS	
Unit Conversion (UC2) =	1.00E+03	ug/mg
Exposure Frequency (EF) =	0.68	events/d
Exposure Period (EP) =	1	yr (2)
Exposure Duration (ED) =	8	hr/event
Units Conversion (UC3) =	0.04	d/hr
Averaging Period (AP) =	75	yr (cancer) (3)
	1	yr (noncancer)

(1) EPA, 1991
(2) Best Professional Judgement

TABLE B-1
FUTURE COMMERCIAL
EXPOSURE AND RISK ESTIMATES
INCIDENTAL INGESTION OF SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

Constituent	Exposure Point Conc. (a) (mg/kg)	Exposure Estimates: Relative Absorption Factor (b) (Cancer) (--)	Exposure Estimates: LADD (Cancer) (mg/kg-d)	Exposure Estimates: Relative Absorption Factor (b) Noncancer (--)	Exposure Estimates: ADD Noncancer) (mg/kg-d)	Toxicity Values: Cancer Slope Factor (Oral) (mg/kg-d)-1	Toxicity Values: Chronic Noncancer Reference Dose (Oral) (mg/kg-d)	Risk Estimates: Cancer Risk (--)	Risk Estimates: Hazard Quotient (--)
EPH									
C9-C18 Aliphatics	9.3E+02	NA	NA	0.91	2.2E-04	NA	6.0E-01	NA	4E-04
C10-C22 Aromatics	1.0E+02	NA	NA	0.91	2.5E-05	NA	3.0E-02	NA	8E-04
Benzo(a)pyrene	5.9E-01	1.00	5.5E-08	0.91	1.4E-07	7.3E+00	2.0E-02	4E-07	7E-06
Chrysene	5.4E-01	1.00	5.0E-08	0.91	1.3E-07	7.3E-03	2.0E-02	4E-10	6E-06
Methylnaphthalene,	5.5E-01	NA	NA	1.00	1.4E-07	NA	2.0E-02	NA	7E-06
VPH									
C5-C8 Aliphatics	4.2E+02	NA	NA	0.91	9.9E-05	NA	6.0E-02	NA	2E-03
C9-C12 Aliphatics	1.9E+02	NA	NA	0.91	4.4E-05	NA	6.0E-01	NA	7E-05
C9-C10 Aromatics	2.6E+01	NA	NA	0.91	6.3E-06	NA	3.0E-02	NA	2E-04
Ethylbenzene	5.0E+00	NA	NA	1.00	1.3E-06	NA	1.0E-01	NA	1E-05
Napthalene	1.4E+03	NA	NA	0.91	3.3E-04	NA	2.0E-02	NA	2E-02
Toluene	1.1E+00	NA	NA	1.00	2.7E-07	NA	2.0E-01	NA	1E-06
Xylene	3.7E-01	NA	NA	1.00	9.8E-08	NA	2.0E+00	NA	5E-08

	Cancer Risk	Hazard Index
TOTAL:	4E-07	2E-02

[shaded box] = Cancer risk > 1E-05 or HQ/HI> 1E+00

NA = Not available/applicable
(a) Average for post-excavation soil samples
(b) MADEP (1994a, 1997b)

Where:

LADDcancer = EPC x UC x RAFo x IRtot / APcancer
ADDnon-cancer = EPC x UC x RAFo x IRtot / APnon-cancer
IRtot = (IR1daily x ED x EP1/ BW1) + (IR2daily x ED x EP2 / BW2)+
(IR3daily x ED x EP3 / B\ 6.5 mg*event/d2

IR1daily = IR1 x EF1 = 17.7 mg*event/d2
IR2daily = IR2 x EF2 = 17.7 mg*event/d2
IR3daily = IR3 x EF3 = 17.7 mg*event/d2
Cancer Risk = LADDcancer x Slope Factor
Hazard Quotient = ADDnon-cancer / Reference Dose

TABLE B-1 (cont.)
FUTURE COMMERCIAL
EXPOSURE AND RISK ESTIMATES
INCIDENTAL INGESTION OF SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Unit Conversion (UC) =	1E-06 kg/mg
Ingestion Rate - 18<25yrs (IR1) =	50 mg/d [1]
Ingestion Rate - 25<35yrs (IR2) =	50 mg/d [1]
Ingestion Rate - 35<43yrs (IR3) =	50 mg/d [1]
Exposure Frequency - 18<25yrs (EF1) =	0.35 events/d (i.e., 129 events per 365 days) [2,3]
Exposure Frequency - 25<35yrs (EF2) =	0.35 events/d (i.e., 129 events per 365 days) [2,3]
Exposure Frequency - 35<43yrs (EF3) =	0.35 events/d (i.e., 129 events per 365 days) [2,3]
Exposure Duration (ED) =	1 d/event [1]
Exposure Period - 18<25yrs (EP1) =	7 yr [2]
Exposure Period - 25<35yrs (EP2) =	10 yr [2]
Exposure Period - 35<43yrs (EP3) =	8 yr [4]
Body Weight - 18<25yrs (BW1) =	64.0 kg [1]
Body Weight - 25<35yrs (BW2) =	68.3 kg [1]
Body Weight - 35<43yrs (BW3) =	70.6 kg [1]
Averaging Period (Cancer) (APcancer) =	70 yr [1]
Averaging Period (Non-Cancer) (APnon-cancer) =	25 yr [1]

Note:	(IR1daily x ED x EP1 / BW1) =	1.9 mg-yr/kg-d
	(IR2daily x ED x EP2 / BW2) =	2.6 mg-yr/kg-d
	(IR3daily x ED x EP3 / BW3) =	2.0 mg-yr/kg-d

Effective NLADSIR = LADDcancer / [EPC x UC x RAFo] = 0.09 mg/kg-d

TABLE B-2
FUTURE COMMERCIAL
EXPOSURE AND RISK ESTIMATES
DERMAL CONTACT WITH SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

		Exposure Estimates				Toxicity Values		Risk Estimates	
Constituent	Exposure Point Conc. (a) (mg/kg)	Relative Absorption Factor (b) (Cancer) (--)	LADD (Cancer) (mg/kg-d)	Relative Absorption Factor (b) (Noncancer) (--)	ADD (Noncancer) (mg/kg-d)	Cancer Slope Factor (Oral) (mg/kg-d)-1	Chronic Noncancer Reference Dose (Oral) (mg/kg-d)	Cancer Risk (--)	Hazard Quotient (--)
EPH									
C9-C18 Aliphatics	9.3E+02	NA	NA	0.20	1.1E-03	NA	6.0E-01	NA	2E-03
C10-C22 Aromatics	1.0E+02	NA	NA	0.18	1.1E-04	NA	3.0E-02	NA	4E-03
Benzo(a)pyrene	5.9E-01	0.20	2.3E-07	0.18	6.2E-07	7.3E+00	2.0E-02	2E-06	3E-05
Chrysene	5.4E-01	0.20	2.1E-07	0.18	5.7E-07	7.3E-03	2.0E-02	2E-09	3E-05
Methylnaphthalene,	5.5E-01	NA	NA	0.20	6.4E-07	NA	2.0E-02	NA	3E-05
VPH									
C5-C8 Aliphatics	4.2E+02	NA	NA	0.50	1.2E-03	NA	6.0E-02	NA	2E-02
C9-C12 Aliphatics	1.9E+02	NA	NA	0.20	2.2E-04	NA	6.0E-01	NA	4E-04
C9-C10 Aromatics	2.6E+01	NA	NA	0.18	2.8E-05	NA	3.0E-02	NA	9E-04
Ethylbenzene	5.0E+00	NA	NA	0.20	5.9E-06	NA	1.0E-01	NA	6E-05
Napthalene	1.4E+03	NA	NA	0.18	1.5E-03	NA	2.0E-02	NA	7E-02
Toluene	1.1E+00	NA	NA	0.12	7.4E-07	NA	2.0E-01	NA	4E-06
Xylene	3.7E-01	NA	NA	0.12	2.6E-07	NA	2.0E+00	NA	1E-07

	Cancer Risk	Hazard Index
TOTAL:	2E-06	1E-01

[shaded box] = Cancer risk > 1E-05 or HQ/HI> 1E+00

NA = Not available/applicable
(a) Average for post-excavation soil samples
(b) MADEP (1994a, 1997b)

Where:

LADDcancer = EPC x UC x RAFd x CRtot / APcancer
ADDnon-cancer = EPC x UC x RAFd x CRtot / APnon-cancer
CRtot = (CR1daily x ED x EP1/ BW1) + (CR2daily x ED x EP2 / BW2)+
(CR3daily x ED x EP3 / 146

CR1daily = SA1 x FE1 x AF x EF1 396
CR2daily = SA2 x FE2 x AF x EF2 396
CR3daily = SA3 x FE3 x AF x EF3 396
Cancer Risk = LADDcancer x Slope Factor
Hazard Quotient = ADDnon-cancer / Reference Dose

TABLE B-2 (cont.)
FUTURE COMMERCIAL
EXPOSURE AND RISK ESTIMATES
DERMAL CONTACT WITH SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Unit Conversion (UC) =	1E-06 kg/mg
Surface Area - 18<25yrs (SA1) =	18150 cm2/d [1]
Surface Area - 25<35yrs (SA2) =	18150 cm2/d [1]
Surface Area - 35<43yrs (SA3) =	18150 cm2/d [1]
Fraction Exposed - 18<25yrs (FE1) =	0.12 unitless [2,3]
Fraction Exposed - 25<35yrs (FE2) =	0.12 unitless [2,3]
Fraction Exposed - 35<43yrs (FE3) =	0.12 unitless [2,3]
Adherence factor (AF) =	0.51 mg/cm2 [1]
Exposure Frequency - 18<25yrs (EF1) =	0.35 events/d (i.e., 129 events per 365 days) [4,5]
Exposure Frequency - 25<35yrs (EF2) =	0.35 events/d (i.e., 129 events per 365 days) [4,5]
Exposure Frequency - 35<43yrs (EF3) =	0.35 events/d (i.e., 129 events per 365 days) [4,5]
Exposure Duration (ED) =	1 d/event [1]
Exposure Period - 18<25yrs (EP1) =	7 yr [4]
Exposure Period - 25<35yrs (EP2) =	10 yr [4]
Exposure Period - 35<43yrs (EP3) =	8 yr [6]
Body Weight - 18<25yrs (BW1) =	64.0 kg [1]
Body Weight - 25<35yrs (BW2) =	68.3 kg [1]
Body Weight - 35<43yrs (BW3) =	70.6 kg [1]
Averaging Period (Cancer) (APcancer) =	75 yr [1]
Averaging Period (Non-Cancer) (APnon-cancer) =	25 yr [1]

Note: (CR1daily x ED x EP1 / BW1) 43 mg-yr/kg-d

TABLE B-3
FUTURE COMMERCIAL
EXPOSURE AND RISK ESTIMATES
INHALATION OF OUTDOOR SUSPENDED PARTICULATES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

Constituent	Modeled Outdoor Particulate Conc. (a) (ug/m3)	LADE (Cancer) (ug/m3)	ADE (Noncancer) (ug/m3)	Toxicity Values: Cancer Unit Risk (Inhl.) (ug/m3)-1	Toxicity Values: Chronic Noncancer Reference Dose (Inhl.) (ug/m3)	Risk Estimates: Cancer Risk (--)	Risk Estimates: Hazard Quotient (--)
EPH							
C9-C18 Aliphatics	3.0E-02	1.2E-03	3.5E-03	NA	2.0E+03	NA	2E-06
C10-C22 Aromatics	3.3E-03	1.3E-04	3.9E-04	NA	7.1E+01	NA	6E-06
Benzo(a)pyrene	1.9E-05	7.4E-07	2.2E-06	1.7E-03	NA	1E-09	NA
Chrysene	1.7E-05	6.8E-07	2.0E-06	NA	NA	NA	NA
Methylnaphthalene,	1.7E-05	6.9E-07	2.1E-06	NA	NA	NA	NA
VPH							
C5-C8 Aliphatics	1.3E-02	5.3E-04	1.6E-03	NA	2.0E+02	NA	8E-06
C9-C12 Aliphatics	5.9E-03	2.3E-04	7.0E-04	NA	2.0E+03	NA	4E-07
C9-C10 Aromatics	8.4E-04	3.3E-05	9.9E-05	NA	6.0E+01	NA	2E-06
Ethylbenzene	1.6E-04	6.3E-06	1.9E-05	NA	1.0E+03	NA	2E-08
Napthalene	4.4E-02	1.7E-03	5.2E-03	NA	NA	NA	NA
Toluene	3.4E-05	1.3E-06	4.0E-06	NA	4.0E+02	NA	1E-08
Xylene	1.2E-05	4.7E-07	1.4E-06	NA	3.0E+02	NA	5E-09

	Cancer Risk	Hazard Index
TOTAL:	1E-09	2E-05

[shaded] = Cancer risk > 1E-05 or HQ/HI> 1E+00

NA = Not available/applicable
(a) Based on average for post-excavation soil samples and TSP conc = 32 ug/m3 per MADEP (1995)

Where:

LADEcancer = EPC x WFtot x UC1 / APc
ADEnon-cancer = EPC x WFtot x UC1 / APnc
WFtot = (EF1 x ED1 x EP1 + EF2 x ED2 x EP2 + EF3 x ED3 x EP3) = 70.7

Cancer Risk = LADEcancer x Unit Risk
Hazard Quotient = ADEnon-cancer / Reference Concentration

TABLE B-3 (cont.)
FUTURE COMMERCIAL
EXPOSURE AND RISK ESTIMATES
INHALATION OFOUTDOOR SUSPENDED PARTICULATES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Exposure Frequency - 18<25yrs (EF1) =	0.35 events/d (i.e., 129 events per 365 days) [1,2]
Exposure Frequency - 25<35yrs (EF2) =	0.35 events/d (i.e., 129 events per 365 days) [1,2]
Exposure Frequency - 35<45yrs (EF3) =	0.35 events/d (i.e., 129 events per 365 days) [1,2]
Exposure Duration (ED) =	8 hr/event [3]
Exposure Period - 18<25yrs (EP1) =	7 yr [1]
Exposure Period - 25<35yrs (EP2) =	10 yr [1]
Exposure Period - 35<45yrs (EP3) =	8 yr [4]
Unit Conversion (UC1) =	0.04 d/hr
Averaging Period (Cancer) (APcancer) =	75 yr [5]
Averaging Period (Non-Cancer) (APnon-cancer)	25 yr [5]

[1] MADEP (1994a)
[2] Assumes 5 days per week during April through October less 24 days (e.g., due to weather, vacation)
[3] BPJ
[4] Based on a total exposure period of 25 years per EPA (1993)
[5] MADEP (1995)

TABLE B-4
FUTURE COMMERCIAL
EXPOSURE AND RISK ESTIMATES
INHALATION OF INDOOR VOLATILES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

				Toxicity Values		Risk Estimates	
Constituent	Modeled Indoor Air Conc. (a) (ug/m3)	ADE (Cancer) (ug/m3)	ADE (Noncancer) (ug/m3)	Cancer Unit Risk (Inhl.) (ug/m3)-1	Chronic Noncancer Reference Dose (Inhl.) (ug/m3)	Cancer Risk (--)	Hazard Quotient (--)
EPH							
C9-C18 Aliphatics	6.1E+03	4.6E+02	1.4E+03	NA	2.0E+03	NA	7E-01
C10-C22 Aromatics	3.5E+01	2.6E+00	7.9E+00	NA	7.1E+01	NA	1E-01
Benzo(a)pyrene	NA	NA	NA	1.7E-03	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA
Methylnaphthalene,	1.6E-03	1.2E-04	3.6E-04	NA	NA	NA	NA
VPH							
C5-C8 Aliphatics	7.3E+05	5.6E+04	1.7E+05	NA	2.0E+02	NA	8E+02
C9-C12 Aliphatics	5.2E+03	3.9E+02	1.2E+03	NA	2.0E+03	NA	6E-01
C9-C10 Aromatics	3.1E+02	2.4E+01	7.2E+01	NA	6.0E+01	NA	1E+00
Ethylbenzene	1.1E+02	8.5E+00	2.5E+01	NA	1.0E+03	NA	3E-02
Napthalene	9.4E+02	7.1E+01	2.1E+02	NA	NA	NA	NA
Toluene	7.9E+01	6.0E+00	1.8E+01	NA	4.0E+02	NA	5E-02
Xylene	6.9E+00	5.3E-01	1.6E+00	NA	3.0E+02	NA	5E-03

NA = Not available/applicable
a = average of post-excavation samples
Where:

LADEcancer = EPC x WFtot x UC2 / APc
ADEnon-cancer = EPC x WFtot x UC2 / APnc
WFtot = (EF1 x ED x EP1 + EF2 x ED x EP2 + EF3 x ED x EP3) = 137
Cancer Risk = LADEcancer x Unit Risk
Hazard Quotient = ADEnon-cancer / Reference Concentration

	Cancer Risk	Hazard Index
TOTAL:	NA	8E+02

[shaded] = Cancer risk > 1E-05 or HQ/HI > 1E+00

TABLE B-4 (cont.)
FUTURE COMMERCIAL
EXPOSURE AND RISK ESTIMATES
INHALATION OF INDOOR VOLATILES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Exposure Frequency - 18<25yrs (EF1) =	0.68	events/d (i.e., 250 events per 365 days) [2]
Exposure Frequency - 25<35yrs (EF2) =	0.68	events/d (i.e., 250 events per 365 days) [2]
Exposure Frequency - 35<43yrs (EF3) =	0.68	events/d (i.e., 250 events per 365 days) [2]
Exposure Duration (ED) =	8	hr/event [3]
Exposure Period - 18<25yrs (EP1) =	7	yr [1]
Exposure Period - 25<35yrs (EP2) =	10	yr [1]
Exposure Period - 35<43yrs (EP3) =	8	yr [2,4]
Unit Conversion (UC2) =	0.04	d/hr
Averaging Period (Cancer) (APcancer) =	75	yr [5]
Averaging Period (Non-Cancer) (APnon-cance	25	yr [5]

[1] MADEP (1994a)
[2] EPA (1993)
[3] BPJ
[4] Based on a total exposure period of 25 years
[5] MADEP (1995)

TABLE B-4 (cont.)
FUTURE COMMERCIAL
CALCULATION OF INDOOR AIR CONCENTRATIONS
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

		Chemical Specific Constants			Flux Estimates	
Constituent	Soil Concentration (a) (mg/kg)	Henry's Law Constant (H') (b) (--)	Organic Carbon/Water Partition Coeficient (koc) (b) (--)	Vapor Diffusion Coefficient In Air (Da) (b) (cm2/s)	Flux due to Soil (g/s*cm2)	Indoor Air Concentration (mg/m3)
EPH						
C9-C18 Aliphatics	9.3E+02	6.9E+01	6.8E+05	7.0E-02	1.5E-07	6.1E+00
C10-C22 Aromatics	1.0E+02	3.0E-02	5.0E+03	6.0E-02	8.8E-10	3.5E-02
Benzo(a)pyrene	5.9E-01	NA	NA	NA	NA	NA
Chrysene	5.4E-01	NA	NA	NA	NA	NA
Methylnaphthalene,	5.5E-01	7.0E-06	7.2E+02	3.2E-01	3.9E-14	1.6E-06
VPH						
C5-C8 Aliphatics	4.2E+02	5.4E+01	2.3E+03	8.0E-02	1.9E-05	7.3E+02
C9-C12 Aliphatics	1.9E+02	6.5E+01	1.5E+05	7.0E-02	1.3E-07	5.2E+00
C9-C10 Aromatics	2.6E+01	3.3E-01	1.8E+03	7.0E-02	8.0E-09	3.1E-01
Ethylbenzene	5.0E+00	2.6E-01	8.3E+02	7.7E-02	2.8E-09	1.1E-01
Napthalene	1.4E+03	2.0E-02	1.4E+03	5.3E-02	2.4E-08	9.4E-01
Toluene	1.1E+00	2.8E-01	3.3E+02	9.7E-02	2.0E-09	7.9E-02
Xylene	3.7E-01	2.9E-01	1.1E+03	7.7E-02	1.8E-10	6.9E-03

a = average of post-excavation samples
b = Shown only for constituents with molecular weights of 200 g/mol or less

Where:

Cin = [Jsoil x UC1 x UC2 x A x F] / [Q]
Jsoil = [Dt x SGsoil] / r
Dt = [Da x Pa^(10/3)] / [Pt]^2
SGsoil = [Concentration x UC3 x UC4 x H'] / [Koc x foc]
H' = H / R x T

TABLE B-4 (cont.)
FUTURE COMMERCIAL
CALCULATION OF INDOOR AIR CONCENTRATIONS
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

Indoor Ambient Air Concentration (Cin)	CS	mg/m3
Flux from Soil (Jsoil) =	CS	g/s*cm2
Unit Conversion (UC1) =	1E+03	mg/g
Unit Conversion (UC2) =	1E+06	cm3/m3
Cross-sectional Area of Foundation (A) =	1.4E+06	cm2
Fraction of Soil Gas Permeable Floor (F)	0.001	(--)
Building Ventilation Rate (Q) =	3.5E+04	cm3/s
Porous Media Diffusion Coefficient (Dt) =	CS	cm2/s
Soil Gas from Soil (SG dsoil)	CS	g/cm3
Radius (zone of influence	5	cm
Vapor Diffusion Coefficient in Air (Da)	CS	cm2/s
Air Filled Porosity of Soil (Pa) =	0.28	(--)
Total Soil Porosity (Pt) =	0.43	(--)
Unit Conversion for Soil Density (UC3) =	1.5E-03	kg/cm3
Unit Conversion (UC4) =	1E-03	g/mg
Dimensionless Henry's Law Constant (H'	CS	(--)
Organic Carbon Water Partition Coeffici	CS	(--)
Fraction Organic Carbon (foc) =	0.001	(--)
Henry's Law Constant (H) =	CS	(atm*m3/mol)
Universal Gas Constant (R) =	8.2E-05	atm*m3/mol*Ko
Soil Temperature (T) =	293	Ko

TABLE C-1
FUTURE RESIDENTIAL
EXPOSURE AND RISK ESTIMATES
INCIDENTAL INGESTION OF SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

Constituent	Exposure Point Conc. (a) (mg/kg)	Exposure Estimates: Relative Absorption Factor (b) (Cancer) (--)	LADD (Cancer) (mg/kg-d)	Relative Absorption Factor (b) (Noncancer) (--)	ADD (Noncancer) (mg/kg-d)	Toxicity Values: Cancer Slope Factor (Oral) (mg/kg-d)-1	Chronic Noncancer Reference Dose (Oral) (mg/kg-d)	Risk Estimates: Cancer Risk (--)	Hazard Quotient (--)
EPH									
C9-C18 Aliphatics	9.3E+02	NA	NA	0.91	3.1E-03	NA	6.0E-01	NA	5E-03
C10-C22 Aromatics	1.0E+02	NA	NA	0.91	3.5E-04	NA	3.0E-02	NA	1E-02
Benzo(a)pyrene	5.9E-01	1.00	2.5E-07	0.91	2.0E-06	7.3E+00	2.0E-02	2E-06	1E-04
Chrysene	5.4E-01	1.00	2.3E-07	0.91	1.8E-06	7.3E-03	2.0E-02	2E-09	9E-05
Methylnaphthalene,	5.5E-01	NA	NA	1.00	2.0E-06	NA	2.0E-02	NA	1E-04
VPH									
C5-C8 Aliphatics	4.2E+02	NA	NA	0.91	1.4E-03	NA	6.0E-02	NA	2E-02
C9-C12 Aliphatics	1.9E+02	NA	NA	0.91	6.2E-04	NA	6.0E-01	NA	1E-03
C9-C10 Aromatics	2.6E+01	NA	NA	0.91	8.8E-05	NA	3.0E-02	NA	3E-03
Ethylbenzene	5.0E+00	NA	NA	1.00	1.8E-05	NA	1.0E-01	NA	2E-04
Napthalene	1.4E+03	NA	NA	0.91	4.6E-03	NA	2.0E-02	NA	2E-01
Toluene	1.1E+00	NA	NA	1.00	3.8E-06	NA	2.0E-01	NA	2E-05
Xylene	3.7E-01	NA	NA	1.00	1.4E-06	NA	2.0E+00	NA	7E-07

NA = Not available/applicable
(a) Average for post-excavation soil samples
(b) MADEP (1994a; 1997b)

	Cancer Risk	Hazard Index
TOTAL:	2E-06	3E-01

= Cancer risk > 1E-05 or HQ/HI > 1E+00

Where:

LADDcancer = EPC x UC x RAFo x [(IRc x ED x EPc / BWc) + (IRa x ED x EPa / BWa)] / APcancer
ADDnon-cancer = [EPC x UC x RAFo x IRc x ED x EPc] / [BWc x APnon-cancer]
IRc = IRc(o/i) x EFc(o/i) + IRc(i) x EFc(i) x F! 51
IRa = IRa(o/i) x EFa(o/i) = 21
Cancer Risk = LADDcancer x Slope Factor
Hazard Quotient = ADDnon-cancer / Reference Dose

TABLE C-1 (cont.)
FUTURE RESIDENTIAL
EXPOSURE AND RISK ESTIMATES
INCIDENTAL INGESTION OF SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Unit Conversion (UC) =	1E-06	kg/mg
Ingestion Rate - Child (Outdoor/Indoor) (IRc(o/i)) =	100	mg/d [1]
Ingestion Rate - Child (Indoor Only) (IRc(i)) =	20	mg/d [1]
Exposure Frequency - Child (Outdoor/Indoor) (EFc(o/i)) =	0.42	events/d (i.e., 153 events per 365 days)[2]
Exposure Frequency - Child (Indoor Only) (EFc(i)) =	0.58	events/d (i.e., 212 events per 365 days) [3]
Fraction from Site (FS) =	0.8	unitless [4]
Exposure Period - Child (EPc) =	6	yr
Body Weight - Child (BWc) =	14	kg (see Table D-6)
Ingestion Rate - Adult (Outdoor/Indoor) (IRa(o/i)) =	50	mg/d [1]
Exposure Frequency - Adult (Outdoor/Indoor) (EFa(o/i))	0.42	events/d (i.e., 153 events per 365 days) [2]
Exposure Period - Adult (EPa) =	24	yr
Body Weight - Adult (BWa) =	54	kg (see Table D-6)
Exposure Duration (ED) =	1	d/event
Averaging Period (Cancer) (APcancer) =	75	yr
Averaging Period (Non-Cancer) (APnon-cancer) =	6	yr
Note: (IRc x ED x EPc / BWc) =	22	mg-yr/kg-d
(IRa x ED x EPa / BWa) =	9.3	mg-yr/kg-d
Effective NLADSIR = LADDcancer / [EPC x UC x RAFo] =	0.42	mg/kg-d
Effective NADSIR = ADDnon-cancer / [EPC x UC x RAFo]	3.7	mg/kg-d

TABLE C-2
FUTURE RESIDENTIAL
EXPOSURE AND RISK ESTIMATES
DERMAL CONTACT WITH SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

		Exposure Estimates				Toxicity Values		Risk Estimates	
Constituent	Exposure Point Conc. (a) (mg/kg)	Relative Absorption Factor (b) (Cancer) (--)	LADD (Cancer) (mg/kg-d)	Relative Absorption Factor (b) Noncancer (--)	ADD Noncancer) (mg/kg-d)	Cancer Slope Factor (Oral) (mg/kg-d)-1	Chronic Noncancer Reference Dose (Oral) (mg/kg-d)	Cancer Risk (--)	Hazard Quotient (--)
EPH									
C9-C18 Aliphatics	9.3E+02	NA	NA	0.20	4.6E-03	NA	6.0E-01	NA	8E-03
C10-C22 Aromatics	1.0E+02	NA	NA	0.18	4.6E-04	NA	3.0E-02	NA	2E-02
Benzo(a)pyrene	5.9E-01	0.20	8.0E-07	0.18	2.6E-06	7.3E+00	2.0E-02	6E-06	1E-04
Chrysene	5.4E-01	0.20	7.4E-07	0.18	2.4E-06	7.3E-03	2.0E-02	5E-09	1E-04
Methylnaphthalene,	5.5E-01	NA	NA	0.20	2.7E-06	NA	2.0E-02	NA	1E-04
VPH									
C5-C8 Aliphatics	4.2E+02	NA	NA	0.50	5.2E-03	NA	6.0E-02	NA	9E-02
C9-C12 Aliphatics	1.9E+02	NA	NA	0.20	9.2E-04	NA	6.0E-01	NA	2E-03
C9-C10 Aromatics	2.6E+01	NA	NA	0.18	1.2E-04	NA	3.0E-02	NA	4E-03
Ethylbenzene	5.0E+00	NA	NA	0.20	2.5E-05	NA	1.0E-01	NA	2E-04
Napthalene	1.4E+03	NA	NA	0.18	6.1E-03	NA	2.0E-02	NA	3E-01
Toluene	1.1E+00	NA	NA	0.12	3.1E-06	NA	2.0E-01	NA	2E-05
Xylene	3.7E-01	NA	NA	0.12	1.1E-06	NA	2.0E+00	NA	6E-07

	Cancer Risk	Hazard Index
TOTAL:	6E-06	4E-01

NA = Not available/applicable
(a) Average for post-excavation soil samples
(b) MADEP (1994a/1997b)

Where:

LADDcancer = EPC x UC x FS x RAFd x [(CRc x ED x EPc / BWc) + (CRa x ED x EPa / BWa)] / APcancer
ADDnon-cancer = [EPC x UC x FS x RAFd x CRc x ED x EPc] / [BWc x APnon-cancer]
CRc = [SAc x FEc(1) x AF(o) x EFc(1)] + [SAc x FEc(2) x AF(i) x EFc(2)]
+ [SAc x FEc(3) x AF(i) x EFc(3)] = 432
CRa = [SAa x FEa(o) x AF(o) x EFa(o)] = 1024
Cancer Risk = LADDcancer x Slope Factor
Hazard Quotient = ADDnon-cancer / Reference Dose

= Cancer risk > 1E-05 or HQ/HI > 1E+00

TABLE C-2 (cont.)
FUTURE RESIDENTIAL
EXPOSURE AND RISK ESTIMATES
DERMAL CONTACT WITH SOIL
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Unit Conversion (UC) =	1E-06	kg/mg
Fraction from Site (FS) =	0.8	unitless [1]
Surface Area - Child (SAc) =	6123	cm2/d (see Table D-6)
Fraction Exposed - Child (Outdoor, May - Sept.) (FEc(1))	0.43	unitless (see Table D-6)
Fraction Exposed - Child (Indoor, May - Sept.) (FEc(2)) =	0.50	unitless (see Table D-6)
Fraction Exposed - Child (Indoor, Oct. - April) (FEc(3)) =	0.05	unitless (see Table D-6)
Exposure Frequency - Child (Outdoor, May - Sept.) (EFc(	0.30	events/d (i.e., 109 events per 365 days) [2]
Exposure Frequency - Child (Indoor, May - Sept.) (EFc(2)	0.12	events/d (i.e., 44 events per 365 days) [3]
Exposure Frequency - Child (Indoor, Oct. - April) (EFc(i))	0.58	events/d (i.e., 212 events per 365 days) [4]
Exposure Period - Child (EPc) =	6	yr
Body Weight - Child (BWc) =	14	kg (see Table D-6)
Surface Area - Adult (SAa) =	15634	cm2/d (see Table D-6)
Fraction Exposed - Adult (Outdoor, May - Sept.) (FEa(o))	0.43	unitless (see Table D-6)
Exposure Frequency - Adult (Outdoor, May - Sept.) (EFa(	0.30	events/d (i.e., 153 events per 109 days) [2]
Exposure Period - Adult (EPa) =	24	yr
Body Weight - Adult (BWa) =	54	kg (see Table D-6)
Adherence factor (Outdoor) (AF(o)) =	0.51	mg/cm2 [5]
Adherence factor (Indoor) (AF(i)) =	0.056	mg/cm2 [6]
Exposure Duration (ED) =	1	d/event
Averaging Period (Cancer) (APcancer) =	75	yr
Averaging Period (Non-Cancer) (APnon-cancer) =	6	yr

TABLE C-3
FUTURE RESIDENTIAL
EXPOSURE AND RISK ESTIMATES
INHALATION OF OUTDOOR SUSPENDED PARTICULATES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

				Toxicity Values		Risk Estimates	
Constituent	Modeled Indoor Air Conc. (ug/m3)	ADE (Cancer) (ug/m3)	ADE (Noncancer) (ug/m3)	Cancer Unit Risk (Inhl.) (ug/m3)-1	Chronic Noncancer Reference Dose (Inhl.) (ug/m3)	Cancer Risk (--)	Hazard Quotient (--)
EPH							
C9-C18 Aliphatics	3.0E-02	1.2E-02	3.0E-02	NA	2.0E+03	NA	1E-05
C10-C22 Aromatics	3.3E-03	1.3E-03	3.3E-03	NA	7.1E+01	NA	5E-05
Benzo(a)pyrene	1.9E-05	7.5E-06	1.9E-05	1.7E-03	NA	1E-08	NA
Chrysene	1.7E-05	6.9E-06	1.7E-05	NA	NA	NA	NA
Methylnaphthalene, 2-	1.7E-05	7.0E-06	1.7E-05	NA	NA	NA	NA
VPH							
C5-C8 Aliphatics	1.3E-02	5.3E-03	1.3E-02	NA	2.0E+02	NA	7E-05
C9-C12 Aliphatics	5.9E-03	2.4E-03	5.9E-03	NA	2.0E+03	NA	3E-06
C9-C10 Aromatics	8.4E-04	3.4E-04	8.4E-04	NA	6.0E+01	NA	1E-05
Ethylbenzene	1.6E-04	6.4E-05	1.6E-04	NA	1.0E+03	NA	2E-07
Napthalene	4.4E-02	1.8E-02	4.4E-02	NA	NA	NA	NA
Toluene	3.4E-05	1.3E-05	3.4E-05	NA	4.0E+02	NA	8E-08
Xylene	1.2E-05	4.8E-06	1.2E-05	NA	3.0E+02	NA	4E-08

NA = Not available/applicable
(a) Average for post-excavation soil samples

	Cancer Risk	Hazard Index
TOTAL:	1E-08	1E-04

Where:

LADEcancer = EPC x (EDc x EFc x EPc + EDa x EFa x EPa) x UC1 / APc
ADEnon-cancer = EPC x EDc x EFc x EPc x UC1 / APnc
Cancer Risk = LADEcancer x Unit Risk
Hazard Quotient = ADEnon-cancer / Reference Concentration

[shaded box] = Cancer risk > 1E-05 or HQ/HI > 1E+00

TABLE C-5 (cont.)
FUTURE RESIDENTIAL
EXPOSURE AND RISK ESTIMATES
INHALATION OF OUTDOOR SUSPENDED PARTICULATES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Exposure Duration - Child (EDc) =	24 hr/event
Exposure Duration - Adult (EDa) =	24 hr/event
Exposure Frequency - Child (EF(c)) =	1 events/d (i.e., 365 events per 365 days)
Exposure Frequency - Adult (EF(a)) =	1 events/d (i.e., 365 events per 365 days)
Exposure Period - Child (EPc) =	6 yr
Exposure Period - Adult (EPa) =	24 yr
Unit Conversion (UC1) =	0.04 d/hr
Averaging Period (Cancer) (APcancer) =	75 yr
Averaging Period (Non-Cancer) (APnon-cancer)	6 yr

TABLE C-4
FUTURE RESIDENTIAL
EXPOSURE AND RISK ESTIMATES
INHALATION OF INDOOR VOLATILES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

Constituent	Modeled Indoor Air Conc. (ug/m3)	ADE (Cancer) (ug/m3)	ADE (Noncancer) (ug/m3)	Toxicity Values: Cancer Unit Risk (Inhl.) (ug/m3)-1	Toxicity Values: Chronic Noncancer Reference Dose (Inhl.) (ug/m3)	Risk Estimates: Cancer Risk (--)	Risk Estimates: Hazard Quotient (--)
EPH							
C9-C18 Aliphatics	6.1E+03	2.4E+03	6.1E+03	NA	2.0E+03	NA	3E+00
C10-C22 Aromatics	3.5E+01	1.4E+01	3.5E+01	NA	7.1E+01	NA	5E-01
Benzo(a)pyrene	NA	NA	NA	1.7E-03	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA
Methylnaphthalene, 2-	1.6E-03	6.2E-04	1.6E-03	NA	NA	NA	NA
VPH							
C5-C8 Aliphatics	7.3E+05	2.9E+05	7.3E+05	NA	2.0E+02	NA	4E+03
C9-C12 Aliphatics	5.2E+03	2.1E+03	5.2E+03	NA	2.0E+03	NA	3E+00
C9-C10 Aromatics	3.1E+02	1.3E+02	3.1E+02	NA	6.0E+01	NA	5E+00
Ethylbenzene	1.1E+02	4.5E+01	1.1E+02	NA	1.0E+03	NA	1E-01
Napthalene	9.4E+02	3.7E+02	9.4E+02	NA	NA	NA	NA
Toluene	7.9E+01	3.2E+01	7.9E+01	NA	4.0E+02	NA	2E-01
Xylene	6.9E+00	2.8E+00	6.9E+00	NA	3.0E+02	NA	2E-02

NA = Not available/applicable

Where:

LADEcancer = EPC x (EDc x EFc x EPc + EDa x EFa x EPa) x UC1 / APc
ADEnon-cancer = EPC x EDc x EFc x EPc x UC1 / APnc
Cancer Risk = LADEcancer x Unit Risk
Hazard Quotient = ADEnon-cancer / Reference Concentration

	Cancer Risk	Hazard Index
TOTAL:	NA	4E+03

[shaded] = Cancer risk > 1E-05 or HQ/HI > 1E+00

TABLE C-4 (cont.)
FUTURE RESIDENTIAL
EXPOSURE AND RISK ESTIMATES
INHALATION OF INDOOR VOLATILES
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Exposure Duration - Child (EDc) =	24 hr/event
Exposure Duration - Adult (EDa) =	24 hr/event
Exposure Frequency - Child (EF(c)) =	1 events/d (i.e., 365 events per 365 days)
Exposure Frequency - Adult (EF(a)) =	1 events/d (i.e., 365 events per 365 days)
Exposure Period - Child (EPc) =	6 yr
Exposure Period - Adult (EPa) =	24 yr
Unit Conversion (UC1) =	0.04 d/hr
Averaging Period (Cancer) (APcancer) =	75 yr
Averaging Period (Non-Cancer) (APnon-cancer)	6 yr

TABLE C-5
FUTURE COMMERCIAL
CALCULATION OF INDOOR AIR CONCENTRATIONS
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

		Chemical Specific Constants			Flux Estimates	
Constituent	Soil Concentration (a) (mg/kg)	Henry's Law Constant (H') (b) (--)	Organic Carbon/Water Partition Coeficient (koc) (b) (--)	Vapor Diffusion Coefficient In Air (Da) (b) (cm2/s)	Flux due to Soil (g/s*cm2)	Indoor Air Concentration (mg/m3)
EPH						
C9-C18 Aliphatics	9.3E+02	6.9E+01	6.8E+05	7.0E-02	1.5E-07	6.1E+00
C10-C22 Aromatics	1.0E+02	3.0E-02	5.0E+03	6.0E-02	8.8E-10	3.5E-02
Benzo(a)pyrene	5.9E-01	NA	NA	NA	NA	NA
Chrysene	5.4E-01	NA	NA	NA	NA	NA
Methylnaphthalene,	5.5E-01	7.0E-06	7.2E+02	3.2E-01	3.9E-14	1.6E-06
VPH						
C5-C8 Aliphatics	4.2E+02	5.4E+01	2.3E+03	8.0E-02	1.9E-05	7.3E+02
C9-C12 Aliphatics	1.9E+02	6.5E+01	1.5E+05	7.0E-02	1.3E-07	5.2E+00
C9-C10 Aromatics	2.6E+01	3.3E-01	1.8E+03	7.0E-02	8.0E-09	3.1E-01
Ethylbenzene	5.0E+00	2.6E-01	8.3E+02	7.7E-02	2.8E-09	1.1E-01
Napthalene	1.4E+03	2.0E-02	1.4E+03	5.3E-02	2.4E-08	9.4E-01
Toluene	1.1E+00	2.8E-01	3.3E+02	9.7E-02	2.0E-09	7.9E-02
Xylene	3.7E-01	2.9E-01	1.1E+03	7.7E-02	1.8E-10	6.9E-03

a = average of post-excavation samples
b = Shown only for constituents with molecular weights of 200 g/mol or less

Where:
Cin = [Jsoil x UC1 x UC2 x A x F] / [Q]
Jsoil = [Dt x SGsoil] / r
Dt = [Da x Pa^(10/3)] / [Pt]^2
SGsoil = [Concentration x UC3 x UC4 x H'] / [Koc x foc]
H' = H / R x T

TABLE C-5 (cont.)
FUTURE COMMERCIAL
CALCULATION OF INDOOR AIR CONCENTRATIONS
EASTERN PARKING LOT
LOCKHEED MARTIN, WILMINGTON/NORTH READING, MA

And where:

Indoor Ambient Air Concentration (Cin)	CS	mg/m3
Flux from Soil (Jsoil) =	CS	g/s*cm2
Unit Conversion (UC1) =	1E+03	mg/g
Unit Conversion (UC2) =	1E+06	cm3/m3
Cross-sectional Area of Foundation (A) =	1.4E+06	cm2
Fraction of Soil Gas Permeable Floor (F) =	0.001	(--)
Building Ventilation Rate (Q) =	3.5E+04	cm3/s
Porous Media Diffusion Coefficient (Dt) =	CS	cm2/s
Soil Gas from Soil (SG dsoil)	CS	g/cm3
Radius (zone of influence) (r) =	5	cm
Vapor Diffusion Coefficient in Air (Da) =	CS	cm2/s
Air Filled Porosity of Soil (Pa) =	0.28	(--)
Total Soil Porosity (Pt) =	0.43	(--)
Unit Conversion for Soil Density (UC3) =	1.5E-03	kg/cm3
Unit Conversion (UC4) =	1E-03	g/mg
Dimensionless Henry's Law Constant (H') =	CS	(--)
Organic Carbon Water Partition Coefficient (Koc) =	CS	(--)
Fraction Organic Carbon (foc) =	0.001	(--)
Henry's Law Constant (H) =	CS	(atm*m3/mol)
Universal Gas Constant (R) =	8.2E-05	tm*m3/mol*Ko
Soil Temperature (T) =	293	Ko

2.9E+03

APPENDIX B

CONSTRUCTION SPECIFICATIONS

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SECTION 01400

QUALITY CONTROL

PART 1 GENERAL

1.1 <u>CONTRACT REFERENCES</u>

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 <u>DESCRIPTION</u>

A. This section includes requirements of a general nature related to the Contractor's responsibility for quality control involving inspections, tests, certificates, and reports.

B. Unless otherwise indicated on the Drawings or Specifications, only new materials shall be incorporated in the Work. All materials furnished by the Contractor to be incorporated in the Work shall be subject to the inspection and approval of TRC. No material shall be processed for, or delivered to the Work without prior approval by TRC.

1.3 <u>SECTION INCLUDES</u>

A. Inspections.

B. Quality Assurance - Control of Installation.

C. References.

D. Inspecting and Physical Testing Laboratory Services.

E. Contractor's responsibilities.

F. Reports.

G. Equipment Calibration.

1.4 <u>RELATED SECTIONS</u>

A. Section 01070 - Reference Standards.

B. Section 01300 - Submittals: Submission of manufacturers' instructions and certificates.

1.5 INSPECTIONS

A. TRC shall have the right to inspect all materials and equipment at all stages of collection and processing, and shall be allowed access to the site and to the Contractor's and supplier's facilities to conduct such inspections. On-site work shall be subject to continuous inspection. Inspection by TRC shall not release the Contractor from responsibility or liability with respect to material. TRC will supply the Contractor with a minimum of 24 hours notice prior to unscheduled off-site inspections.

B. When local codes or laws require approval and inspection of the work by other agencies or organizations before backfilling, the Contractor shall obtain such approval and submit one signed original and three copies of the approval to TRC.

1.6 QUALITY ASSURANCE - CONTROL OF INSTALLATION

A. The Contractor shall monitor quality control over suppliers, products, services, site conditions, and workmanship, to produce Work of specified quality.

B. The Contractor shall comply with manufacturers' instructions, including each step in sequence.

C. The Contractor shall examine the areas and conditions where Work is to be performed and notify TRC of conditions detrimental to the proper and timely completion of the Work. The Contractor shall not proceed with the Work until unsatisfactory conditions have been corrected by the Contractor in a manner acceptable to TRC.

D. The Contractor shall request clarification from TRC should manufacturers' instructions conflict with Contract Documents. The clarification shall be received prior to proceeding. Contractor shall request a verbal clarification to be followed by a written clarification.

E. The Contractor shall comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

F. Work shall be performed by persons qualified to produce workmanship of specified quality.

1.7 REFERENCES

A. The Contractor shall comply with the reference standards presented in Section 01070 at a minimum.

B. For products or workmanship specified by association, trade, or other consensus standards, the Contractor shall comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes.

C. The Contractor shall be familiar with applicable standards. Copies of these standards shall be obtained by the Contractor where required by product specification sections.

D. The contractual relationship, duties, and responsibilities of the parties in Contract nor those of TRC shall not be altered from the Contract Documents by mention or inference otherwise in any reference document.

1.8 INSPECTING AND PHYSICAL TESTING LABORATORY SERVICES

A. The Contractor shall contract with an independent geotechnical Subcontractor, upon review and acceptance by TRC, to perform laboratory testing as required by these Specifications and as required by TRC, including the following periodic inspections and associated services:

1. Soils - Inspect and test the placement and compaction of soils used as site grading or structural fill. Perform field (in-place) density and moisture control testing using a nuclear moisture-density gauge or other TRC-accepted method to assess the adequacy of compaction.

B. The independent testing firm(s) shall have performed previous similar work in a satisfactory manner and be an approved subcontractor. The Contractor shall include the costs of this service in his bid.

C. The Contractor shall provide labor and materials and necessary testing facilities at the site as required by Specifications. The Contractor shall cooperate with TRC and shall provide at least 24 hours notice prior to specified testing.

D. The Contractor shall be solely responsible for the adequate stability of cut soil slopes at the site and for providing a safe working condition within excavated areas.

E. Inspecting, testing, and source quality control may occur on or off the project site. Off-site inspecting or testing shall be performed as required by TRC.

1.9 CONTRACTOR RESPONSIBILITIES

A. The Contractor shall provide incidental labor and facilities:

1. to provide access to Work to be tested,

2. to obtain and handle samples at the site,

3. to facilitate tests and inspections,

4. to provide storage of test samples.

B. TRC shall be notified 48 hours prior to expected time for operations requiring services.

C. The Contractor shall make arrangements for and pay for additional samples and tests required for Contractor's use.

D. Testing or inspecting does not relieve Contractor to perform Work to contract requirements.

E. Retesting required because of non-conformance to specified requirements shall be performed by the same independent firm on instructions by TRC at the Contractor's expense.

1.10 REPORTS

A. Transcripts or certified test reports including all test results shall be submitted for review to TRC. Acceptance by TRC shall be received prior to delivery of material. The testing shall have been performed by an approved independent testing facility within the previous six months of submittal of the reports for review. Transcripts of test results shall be accompanied by a certificate in the form of a letter from the manufacturer or supplier certifying that the tested material meets the specified requirements and is of the same type, quality, manufacturer, and make as that specified.

B. The Contractor shall submit for review a notarized Certificate of Compliance in the form of a letter from the manufacturer. The Certificate shall state the following:

1. Manufacturer has performed all required tests.
2. Materials supplied meet all test requirements.

3. Test were performed within six months of submittal of the Certificate.

4. Materials that were tested are the same type, quality, manufacture, and make as those specified.

5. Include identification of the materials.

C. Reports will be submitted by the independent laboratory to the Contractor, in triplicate, indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents. One copy of these results will be provided to TRC on the same day as the testing is performed.

1.11 EQUIPMENT CALIBRATION

A. All field test equipment will be kept under control of the Contractor's geotechnical Subcontractor. The geotechnical Subcontractor will be fully trained in the use of equipment, test procedures, and interpretations of results for each piece of test equipment. A copy of calibration certification will be kept by the geotechnical Subcontractor and supplied to TRC.

B. Calibration of nuclear-density gauges shall conform to the frequencies and methods outlined in ASTM D2922 and D3017. Unstable or erratic gauges shall not be used in density testing and shall be immediately removed from the site.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 02100

SITE PREPARATION

PART 1 GENERAL

1.1 CONTRACT REFERENCES

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly, or system, other than those named or described in this Section, shall be determined in accordance with the provisions of the Contract and General Conditions.

1.2 WORK INCLUDES

A. Identifying haul road and staging areas for equipment, supplies, uncontaminated surface soil stockpile and dewatering storage tank(s). Erection of appropriate barricades to secure the work zone.

B. Establishing existing site grades to ensure that these grades are reestablished after excavation activities.

C. Installation of erosion and sedimentation controls.

D. Demolition, handling, and disposal of designated bituminous pavement and concrete. The proposed disposal facility shall be state approved.

E. Demolition and handling of parking lot lighting and associated electrical wiring and conduits.

F. Relocation of an outdoor shelter, used for smoking to a designated temporary location.

G. Excavation and exposure of an existing stormwater drainage line to determined if it is breached in the vicinity of the proposed excavation area. If it is found to be damaged, the Contractor will take appropriate measures to prevent infiltration of sewer water into the excavation.

1.3 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Bituminous pavement disposal facility: The Contractor shall submit copies of current permits verifying MADEP approval for proposed disposal facilities.

C. Concrete disposal facility: The Contractor shall submit waste disposal documentation including facility name, location and permit number.

1.4 REGULATORY REQUIREMENTS

A. All work shall comply with safety rules and regulations of local and State agencies having jurisdiction. Nothing contained herein shall be construed as permitting work that is contrary to such rules, regulations, and codes.

B. The Contractor shall obtain and pay for required permits from authorities, notify affected utility companies before starting work, and comply with authorities' and utility companies' requirements.

1.5 SCHEDULING AND SEQUENCING

A. Erosion control measures shall be established at the beginning of construction in accordance with the requirements established in Section 02270 and maintained during the entire period of construction. On-site areas that are subject to severe erosion, and off-site areas that are especially vulnerable to damage from erosion and/or sedimentation shall be identified and receive special attention.

B. The work zone will be clearly marked and secured using barricades and/or fencing to prevent unauthorized entry.

C. All land-disturbing activities shall be planned and conducted to minimize the size of the area exposed at any one time and the length of the time of exposure.

D. Surface water runoff originating from upgrade of exposed areas shall be controlled to reduce erosion and sediment loss during the period of exposure.

E. Clearing activities shall be performed only after erosion and sediment controls are in place.

PART 2 PRODUCTS

2.1 WATER

A. Water used for dust control and equipment washes shall be clean and free of salt, oil, and other injurious materials.

PART 3 EXECUTION

3.1 PREPARATION

A. The Contractor shall be deemed to have inspected the site and satisfied himself as to actual grades and levels and true conditions under which the work will be performed.

B. Movement or settlement of adjacent structures shall be prevented. The Contractor shall be responsible for providing and installing appropriate bracing and shoring as specified in Section 02221, if necessary.

C. The Contractor shall be responsible for the markout of underground utilities prior to excavation. The Contractor shall also be responsible to contact DIGSAFE to mark out underground utilities.

D. The Contractor shall exercise reasonable care to verify locations of existing subsurface structures and utilities.

E. The Contractor, in conjunction with TRC, shall check immediate and adjacent areas subject to excavation by visual examination for indications of subsurface structures and utilities.

F. Exploratory excavations may be made at the Contractor's expense where existing subsurface structures and utilities may potentially conflict with proposed construction. Exploratory excavations shall be made in the presence of TRC and sufficiently ahead of construction to avoid possible delays to Contractor's work.

H. Temporary barriers and security devices shall be provided, erected, and maintained by the Contractor. Erosion and sedimentation controls shall be installed prior to any excavation activities and maintained by the Contractor during the course of the entire project.

3.2 PROTECTION

A. The Contractor shall locate, identify, and protect utilities and fencing that remain from damage.

B. Trees, plant growth, and features designated to remain shall be protected as final landscaping.

C. Benchmarks and existing structures shall be protected from damage or displacement.

3.3 UTILITY LINES

A. Prior to excavation, the Contractor shall contact Dig-Safe and coordinate with AMETEK to identify the locations of utility lines. Lines will be clearly marked out prior to any activities.

B. Prior to removal, the Contractor, TRC and AMETEK shall verify all structures and utilities to be removed and depth of removal.

C. Prior to removing, disconnecting and capping utility lines, TRC and the Contractor shall identify lines, coordinate with AMETEK to terminate service to those lines, and lock-out power to electrical lines.

D. Operations shall cease immediately if adjacent structures appear to be in danger. The Contractor shall notify TRC immediately and shall not resume operations until directed by the TRC.

E. Operations shall be conducted with minimum interference to public or private accesses and shall maintain protected egress and access at all times.

F. Work Areas shall be sprinkled with water as necessary to minimize dust. The Contractor shall provide hoses and water.

G. Materials shall not be burned or buried. Site shall be left in a clean condition.

3.8 DISPOSAL

A. All debris shall be removed and disposed off-site. Debris not salvageable shall be disposed at a permitted landfill. Burning will not be permitted.

B. Asphalt, brick and concrete (ABC) rubble coated or impregnated with any substance shall not be used as on-site fill material or disposed at a construction debris landfill or recycling facility.

C. All liquid waste (i.e., dewatering effluent) shall be disposed of at a state approved and permitted facility in accordance with local, state, and federal regulations.

END OF SECTION

SECTION 02140

DEWATERING AND DRAINAGE

PART 1 GENERAL

1.1 CONTRACT REFERENCES

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly, or system, other than those named or described in this Section, shall be determined in accordance with the provisions of the Contract and General Conditions.

1.2 WORK INCLUDES

A. Furnish, install, operate, monitor, maintain and remove temporary dewatering and drainage systems as necessary to lower and maintain groundwater levels below subgrades of excavations where required for soil excavation. Dewatering will be continuous during excavation activities and the pumped groundwater will be stored in an on-site 20,000-gallon storage tank (provided by the Contractor) for proper disposal. It is anticipated that temporary dewatering sumps can be installed to maintain groundwater levels below the subgrades of excavations.

B. Prevent surface water runoff from entering or accumulating in excavations.

C. Obtain and pay for all permits required for temporary dewatering and drainage systems.

D. Collect and properly dispose of all discharge water from dewatering and drainage systems in accordance with applicable local, state, and federal requirements and permits.

E. Repair damage caused by dewatering and drainage system operations.

F. Remove temporary dewatering and drainage systems when no longer needed. Restore all disturbed areas.

1.3 RELATED SECTIONS

A. Section 02221 – Earthwork.

B. Section 02270 - Sedimentation and Erosion Control.

1.4 SUBMITTALS

A. Submit in accordance with Section 01300 the temporary dewatering and drainage system designs. Submittal will be for information only. The Contractor shall remain responsible for adequacy and safety of construction means, methods and techniques. If required, the Contractor shall engage a licensed professional engineer or geotechnical engineer to design the dewatering systems.

B. Liquid waste (i.e., dewatering effluent) disposal Facility: The Contractor shall submit waste disposal documentation including facility name, location and permit number.

1.5 DEFINITIONS

A. Where the phrase "in-the-dry" is used in these specifications, it shall be defined as in-situ soil moisture content of no more than two percentage points above the optimum moisture content for that soil.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 GENERAL

A. Control surface water and groundwater such that excavation to final grade is made in-the-dry, and bearing soils are maintained undisturbed. Prevent softening, or instability of, or disturbance to, the subgrade due to water seepage.

B. The impact of anticipated subsurface soil/water conditions shall be considered when selecting methods of excavation and temporary dewatering and drainage systems. Where groundwater levels are above the proposed bottoms of excavations, a pumped dewatering system is expected for predrainage of the soils prior to excavation to final grade and for maintenance of the lowered groundwater level until construction has been completed. Type of dewatering system, spacing of dewatering units and other details of the work are expected to vary with soil/water conditions at a particular location.

3.2 SURFACE WATER CONTROL

A. Control surface water runoff to prevent flow into excavations. Provide temporary measures such as dikes, ditches and sumps.

3.3 EXCAVATION DEWATERING

A. Provide and maintain adequate equipment and facilities to remove promptly and dispose of properly all water entering excavations. Excavations shall be kept in-the-dry, so as to maintain an undisturbed subgrade condition throughout construction below grade, including backfill and fill placement.

B. Storm and sanitary pipe and electrical conduit, potentially needing replacement shall not be installed in water or allowed to be submerged prior to backfilling. Pipe and conduit which becomes submerged shall be removed and the excavation dewatered and restored to proper conditions prior to reinstalling the pipe and conduit.

C. Dewatering and drainage operations shall at all times be conducted in such a manner as to preserve the natural undisturbed bearing capacity of the subgrade at the bottom of the excavation. If the subgrade becomes disturbed for any reason, the unsuitable subgrade material shall be removed and replaced with compacted granular fill, or other approved material to restore the bearing capacity of the subgrade to its original undisturbed condition.

D. Dewatering and drainage operations shall be conducted in a manner which does not cause loss of ground or disturbance to the pipe bedding or soil which supports overlying or adjacent structures.

3.4 DISPOSAL OF DRAINAGE

A. Water discharged from temporary dewatering and drainage systems may be disposed of by collecting the water in a temporary 20,000-gallon above ground storage tank and removing it from the site.

B. Contaminated groundwater collected during dewatering activities shall be stored, tested and disposed of in accordance with all applicable federal, state and local regulations.

E. A Licensed Site Professional (LSP) is required when contaminated groundwater above notification thresholds is withdrawn. TRC shall provide said LSP.

F. There will be no discharges to sewer, groundwater, or stormwater conveyance without prior approval by TRC. Any discharges to a sewer system, surface water or ground surface or subsurface must be performed in accordance with 310 CMR 40.0040.

END OF SECTION

SECTION 02221

EARTHWORK

PART 1 GENERAL

1.1 CONTRACT REFERENCES

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly, or system, other than those named or described in this Section, shall be determined in accordance with the provisions of the Contract and General Conditions.

1.2 DESCRIPTION

A. The Contractor shall furnish all labor, material, tools and equipment necessary to excavate and backfill for soil remediation; and handle, transport, and regrade as indicated on the Drawings. The Contractor shall furnish and place all bracing, and supports for excavations and utilities, if necessary; and shall do all pumping and draining, if necessary. The Contractor shall raise the site to original, pre-surveyed grades and compact the subgrade and intermediate layers to the required criteria. The Contractor shall supply and stockpile all required soil materials for supplemental backfill to the site.

B. Uncontaminated surface soil as determined by field screening and laboratory analysis conducted by TRC will be stockpiled on-site, using appropriate sedimentation controls, for reuse as clean backfill. Contaminated soil will be transported off-site immediately for disposal according to applicable local, state and federal regulations.

C. In cases where contaminated soil cannot be transported off-site immediately, the contaminated soils shall be loaded into secured and covered roll-offs for disposal the following day. Appropriate erosion/sedimentation and odor controls shall be implemented.

1.3 WORK INCLUDES

A. Excavating and shoring or bracing sidewalls or utilities, as necessary.

B. Backfilling, consolidation, and compaction as scheduled.

C. Replacement of underground utilities, in kind, as needed.

D. Restoration of pavement and parking lot lighting including electrical conduits and wiring.

1.4 AVAILABLE INFORMATION

A. Existing utility information is provided on the Drawings. The information was obtained for use in assessing utility location but the Contractor may draw his own conclusions therefrom. No responsibility is assumed by TRC for utilities not identified or conditions.

1.5 DEFINITIONS

A. Unsuitable material: Material containing vegetation or organic material, such as mulch, peat, organic silt, topsoil sod, deleterious material, and/or particles greater than 4-inches in diameter, that is not satisfactory for use as determined by TRC. Certain manmade deposits such as broken concrete material may also be determined to be unsuitable material. Unsuitable material includes contaminated and/or hazardous material.

B. Compaction: The tamping and rolling of all fill and backfill placed in uniform horizontal layers not exceeding six inches in thickness after compaction or eight inches of loose lift. Water shall be added in such amounts as necessary to obtain required compaction to a density of not less than 92 percent of maximum dry density as determined by ASTM Designation D1557.

1.6 SUBMITTALS

A. The Contractor shall submit under provisions of Section 01300, the name of imported material suppliers. These suppliers shall provide materials from same source throughout the work. Change of source suppliers shall require approval from TRC. Submitted material shall indicate that the source of backfill material is "certified clean" (i.e., does not contain OHM in concentrations which exceed MCP release thresholds).

B. The Contractor shall submit the manufacturer certificates of compliance for warning and identification tape.

C. The Contractor shall provide the TRC on a daily basis, the results of all compaction monitoring performed that day. The Contractor shall address the actions taken for areas and layers that did not achieve the required density criteria.

1.7 REGULATORY REQUIREMENTS

A. The Contractor shall comply with all excavation, trenching, and related shoring and bracing requirements of Occupational Safety and Health Administration (OSHA) excavation safety standards, 29 CFR Part 1926.650 through 1926.652.

1.8 SOURCE QUALITY CONTROL

A. Inspection and testing will be performed under provisions of Section 01400. Common backfill shall be tested by ASTM D422 once for every 2,000 tons of material.

B. The Contractor shall provide certified analytical testing of backfill to demonstrate that soil does not exceed the limitations for MCP reference/reportable concentrations.

C. If tests indicate materials do not meet specified requirements, the Contractor shall identify an alternative borrow source, test the new material, and submit results to TRC.

1.9 LAYOUT AND GRADES

A. TRC shall layout all lines and establish locations to be excavated in accordance with the Drawings. The Contractor shall establish original grades prior to excavation activities and shall maintain sufficient reference points at all times during construction to properly perform the project.

B. The Contractor shall establish permanent bench marks and replace as directed any, which are destroyed or disturbed. Maintain sufficient reference points at all times during construction to properly perform site regrading.

1.10 QUALITY ASSURANCE

A. Field inspection and testing will be performed by the Contractor under provisions of Section 01400. Classification of all materials will be made by TRC whose decision shall be final and binding on the Contractor.

B. Neither the presence of the TRC nor any observation and testing by TRC shall excuse the Contractor from defects discovered in his Work at that time or subsequent to the testing.

C. Contractor shall perform in-place density testing at a minimum frequency of one test per lift in each excavation but no less than one test per 200 cubic yards of material placed in any one lift. Compaction testing will be performed in accordance with ASTM D1557, D2922, and D3017.

D. Subgrades shall be approved for compactness and material composition prior to placing subsequent lifts. If inspections indicate Work does not meet specified requirements, the work shall be removed, replaced, and compacted at no additional cost to TRC.

PART 2 PRODUCTS

2.1 COMMON BACKFILL

A. Common backfill material shall be soil containing no stone larger than 4-inches and shall be substantially free of organic loam, wood, trash, or other objectionable materials which may be decomposable, compressible or which cannot be properly compacted. Common fill materials shall not contain less than 10 percent nor more than 35 percent by weight of silt and clay. Common fill soils shall be classified as conforming to ASTM D2487 Group Symbol SM, SC, SW, GW, or combinations thereof.

B. Uncontaminated surface soil, excavated for this project, shall be reused provided the grain-size distribution satisfies the specific criteria and the soils are deemed acceptable by TRC.

2.2 SAND

A. Sand shall conform to ASTM C33 for fine aggregate. Sand shall be free of organic material, loam, wood, trash, stones or pebbles or other objectionable material.

2.3 BURIED WARNING AND IDENTIFICATION TAPE

A. Polyethylene plastic and metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3-inch-minimum width, color coded as stated below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED LINE BELOW" or similar wording. Color and printing is to be permanent, unaffected by moisture or soil.

B. Warning tape color codes shall be as follows:

Red:	Electric
Orange:	Telephone or other communication
Blue:	Water system.
Yellow:	Gas.

C. Warning tape for metallic piping shall be acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements indicated above. Minimum thickness of the tape shall be 0.003 inch.

D. Detectable warning tape for non-metallic piping shall be plastic tape conforming to the width, color, and printing requirements indicated above. Minimum thickness of the tape shall be 0.004 inch. The tape shall be manufactured with integral wires, foil backing, or other means of enabling detection by a metal detector when the tape is buried up to 3 feet deep. Encase the metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

PART 3 EXECUTION

3.1 EXAMINATION

A. The Contractor shall be deemed to have inspected the site and satisfied himself as to actual grades and levels and true conditions under which the work will be performed.

B. Bench marks and existing structures shall be protected from damage or displacement from excavation equipment and vehicular traffic.

C. Areas required for execution of Work shall be cleared. The work area shall be free of standing water and shall be dry.

3.2 UTILITIES

A. The Contractor will contact DigSafe at least three days prior to commencing any excavation on the site. In addition, the Contractor will coordinate with TRC and AMETEK to determine the location of underground utilities in the excavation area.

B. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, TRC will be consulted immediately for directions as to procedure. Cooperate with AMETEK and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

C. Do not interrupt existing utilities serving facilities occupied and used by AMETEK or others.

3.3 INSPECTION

A. TRC will examine the areas and conditions under which excavating, filling, and grading are to be performed and notify Contractor of conditions he may find that are detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.

B. Excavation shall proceed to the limits as shown on the Drawings or as determined by TRC, based on field screening and post-excavation sampling and analysis. In general, excavation activities in an area shall first proceed until field screening indicates that cleanup goals have been met. At such time, post-excavation sampling will be performed by TRC and the excavation will be backfilled to prevent nuisance odors. Based on the results of these post-excavation samples, TRC will direct the

Contractor to excavate additional soils or discontinue excavation activities. The Contractor shall protect all areas awaiting post-excavation sample results from access by pedestrians, traffic and potential recontamination.

3.4 DUST/ODOR CONTROL

A. Take appropriate action to check the spread of dust to avoid the creation of a nuisance in the surrounding area. Do not use water if it results in hazardous or objectionable conditions, such as ice, flooding, or pollution. Comply with all dust regulations imposed by local air pollution agencies. As a minimum, at no time shall dust generation be allowed to exceed 1 mg/m^3 at the Contract Limits without implementing appropriate controls.

B. Take appropriate action to mitigate nuisance odors related to the petroleum contamination. Odor suppressing foam or equivalent shall be used to mitigate odors during excavation activities and shall be used in such a manner to promote a clean work environment. In addition, contaminated soil will be transported immediately off-site for proper disposal and the excavation will be backfilled as quickly as possible to mitigate the potential for nuisance odors.

C. If contaminated soil cannot be transported off-site immediately, it shall be stored in a secured, covered roll-off with appropriate erosion/sedimentation controls. It shall be transported off-site the following day for proper disposal in accordance with applicable local, state and federal regulations.

3.5 SURVEYING SUPPORT

A. The Contractor shall provide a survey crew to establish original and restored site grades, and other features so directed by TRC. The survey crew shall be 40-hour health and safety certified in accordance with 20 CFR 1910, part 128.

3.6 GENERAL EXCAVATION

A. The Contractor shall complete all excavation regardless of the type, nature or condition of the material encountered. The Contractor shall be solely responsible for making all excavations in a safe manner.

B. Contractor shall perform all excavation required to complete the Work as shown and specified. This includes all soil, sediment, waste, earth, sand, clay, gravel, hardpan, concrete, boulders not requiring drilling and blasting to remove, decomposed rock, pavements, rubbish, and all other materials within the excavation limits, or as otherwise specified by TRC. Additional removal and off-site disposal of contaminated soils may be required based on post-excavation sampling to be performed by TRC.

C. Excavations shall include earth, sand, clay, gravel, pavements, rubbish and all other materials within the excavation limits. Excavation shall include, but is not limited to, removal, loading, and transportation and off-site disposal of the materials.

D. No on-site material processing or screening system(s) will be allowed due to the possibility of generating objectionable odors or dust at unacceptable levels. On-site segregation and separation of contaminated and uncontaminated materials using conventional construction equipment or manual methods will be allowed as approved by TRC. Appropriate practices to minimize odor and dust generation will be employed during such activities. Dust and odor monitoring shall be conducted by TRC in accordance with the site specific Health and Safety Plan.

E. Where excavation will occur below the ground water table, well points, cofferdams, or other acceptable methods shall be used to permit excavation activities under dry conditions. Dry conditions shall prevail during active work periods until regrading activities are completed. In addition, excavation shall be protected from flooding until backfilling is complete.

F. Stability of Excavations: Slope sides of excavations shall comply with codes and ordinances of agencies having jurisdiction. Shore and brace where sloping is not possible either because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in a safe condition until completion of backfilling.

G. Contractor shall perform excavation in a safe manner, which complies with OSHA regulations.

H. Material Storage: Stockpile excavated uncontaminated surface soil in approved areas, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage. Provide appropriate hay bale or silt fence sediment barriers to prevent erosion and sedimentation. All efforts shall be made to minimize the volume of soil stockpiled on-site.

I. Locate and retain soil materials away from edge of excavations.

J. Dispose of contaminated soil material and waste materials off-site as specified herein. Contaminated soil shall be immediately loaded and transported off-site for proper disposal in accordance with local, state and federal regulations. If uncontaminated soil cannot be transported off-site immediately, it shall be placed in secured, covered roll-off containers with appropriate sedimentation/erosion and odor controls. It shall be transported off-site the following day for disposal in accordance with applicable local, state and federal regulations.

K. TRC shall be notified of unexpected subsurface conditions. Work shall be discontinued in affected areas until notified to resume work by TRC.

M. Grading in the vicinity of excavations shall be properly pitched to prevent water from running into the excavations. Excavations shall be kept free from water during performance of the work under this Contract at no expense to the TRC. Diversion berms and other devices necessary for this purpose shall be built by the Contractor.

N. Excavation shall not be performed when weather conditions or the conditions of the materials are such that, in the opinion of TRC, work cannot be performed satisfactorily.

O. Appropriate measures shall be provided to retain excavation side walls and to ensure that persons working in or near the excavation are protected. Shoring, or bracing may be used to support the walls of excavations and to minimize seepage of groundwater into the excavation. Method, design, construction, and adequacy of any required bracing shall meet the OSHA requirements of 29 CFR Part 1926 and are the responsibility of the Contractor. If an excavation support system is used, the proposed system shall be designed by an engineer registered in the Commonwealth of Massachusetts. The design and construction of the shoring, and bracing system shall provide means for its removal as backfill progresses.

P. All damage related to or caused by the excavation shall be repaired at the expense of the Contractor.

3.7 <u>EXCAVATION NEAR STRUCTURES</u>

A. Excavation may be near existing structures. The Contractor shall furnish, put in place and maintain such bracing as may be required: by Federal, State and local safety requirements to protect adjacent structures from undermining or other damage; to support the sides of excavations; and to prevent any movement which could in any way diminish the width of the excavation below that necessary for proper construction. If TRC is of the opinion that at any points sufficient or proper supports have not been provided, TRC may order additional supports put in, and compliance with such order shall not relieve or release the Contractor from his/her responsibility for the sufficiency of such supports.

Bracing shall be adequate to withstand all pressures to which the structure or trench will be subjected. Any movement or bulging which may occur shall be corrected to provide the necessary clearances and dimensions.

B. The Contractor shall notify TRC if the proposed limits of excavation may interfere with the zone of bearing influence from foundations of structures. The zone of bearing influence shall be within the 45 degree bearing splay of foundations.

3.8 PROTECTION

A. Displaced or loose soil shall be prevented from falling into any excavation. The stability of soil slopes shall be maintained.

B. The Contractor shall provide shoring, bracing, trench boxes, and sheeting where required.

C. The Contractor shall perform all work with utilities in accordance with the procedures outlined by utility companies. Work immediately adjacent to or exposing a utility shall use hand or light equipment for excavation. Uncovered utility lines shall be removed and abandoned or as determined on the Drawings, protected utilities shall be supported during excavating activities. Report damaged utilities immediately to TRC.

3.9 STOCKPILING

A. Clean materials for backfilling shall be stockpiled on-site at locations as indicated on the Drawings. Stockpiled materials shall be of sufficient quantities to meet project schedule and requirements.

B. The clean materials for backfilling may be stockpiled on-site using a base lined with 6 mil. (or higher) gauge polyethylene and covered with 6 mil. (or higher) gauge polyethylene.

C. Direct surface water away from stockpile site to prevent erosion or deterioration of materials, as per Section 02270.

D. Stockpiles shall not exceed 35 feet in height with maximum side slopes of 2:1 (horizontal: vertical). Stockpiles shall be surrounded by silt fences and/or straw bales.

3.10 STOCKPILE CLEANUP

A. Surplus stockpiled materials shall be removed by the Contractor to an off site location designated by the Contractor. The area shall be left in a clean and neat condition. Surface areas shall be graded to prevent free standing surface water.

3.11 PREPARATION

A. Subgrade surfaces shall be proof rolled by making a minimum of four passes over the designated area with compaction equipment accepted by TRC. Subgrade shall be compacted to density requirements for subsequent backfill materials.

B. If, through failure or neglect by the Contractor to conduct the excavation work in a proper manner, the surface of the subgrade is in an unsuitable condition for proceeding with construction, the Contractor shall, at his own expense, remove the unsuitable material and replace it. Failure of the Contractor to control surface or ground water adequately, premature excavation at the work site, or other manifestations of the Contractor's neglect or improper conduct of the work, as determined by TRC, shall be grounds for requiring removal and replacement of unsuitable subgrade without additional compensation.

C. Grading in the vicinity of backfilling shall be properly pitched to prevent water from running into the backfilling. Work areas shall be kept free from water during performance of the work under this Contract. Diversion berms and other devices necessary for this purpose shall be built by the Contractor.

3.12 BACKFILLING - GENERAL

A. The Contractor shall not commence backfilling operations until TRC gives approval. Temporary barricades and/or fencing will be used around all open excavation to insure safety.

B. After the subgrade has been prepared, fill material shall be placed and built-up in successive layers until the required elevations are reached. No fill shall be placed on a frozen surface, nor shall snow, ice, or other frozen material be included in fill. Wet materials containing moisture in excess of the amount necessary for satisfactory placement or compaction shall not be used.

C. All fill shall be brought up in essentially level lifts and shall be placed in levels by standard methods. The method of placement shall not disturb or damage other work. Layers of fill shall not exceed 8 inches in uncompacted thickness before compaction, unless otherwise specified, or as required for proper subgrade stabilization.

D. Filling operations shall continue until the fill has been brought up to the finished slopes, lines, and grades.

E. The entire surface of the work shall be maintained free from ruts and in a condition that will permit construction equipment to travel over any section readily. The top surface of each layer shall be made level or slightly sloped away from the center of the filled area. Fills should be graded to drain and compacted/sealed whenever precipitation is expected.

F. Backfilling shall not be performed when weather conditions or the conditions of the materials are such that, in the opinion of TRC, work cannot be performed satisfactorily.

G. Placement thicknesses and compaction of fill in the work area shall be completed in horizontal layers not exceeding six inches in thickness after compaction or eight inches of loose lift and compacted to at least 92 percent of the maximum dry density as determined by ASTM D1557.

3.13 BURIED WARNING AND IDENTIFICATION TAPE

A. Install tape in accordance with manufacturer's recommendations except as modified herein. Bury tape 12 inches below finished grade.

3.14 MOISTURE CONTROL

A. Moisture in fill materials shall be at or near optimum moisture content. Moisture control shall be within the range of +1 to -3 percent of optimum. This standard shall apply to all compacted fill regardless of the method of compaction used. If TRC determines that the fill material to be used is excessively wet, the Contractor shall dry the material.

B. If, in the opinion of the TRC, additional moisture is required, water shall be applied by sprinkler tanks or other uniform distribution devises. If excessive amounts of water or if rain should cause excessive wetness, the area shall be allowed to dry as provided above.

3.15 BACKFILL - UNDER GROUNDWATER TABLE

A. The Contractor shall backfill the excavation with clean crushed stone backfill to the top of the groundwater table. Crushed stone shall be proof-rolled at the water table.

B. The Contractor shall install the stabilization textile at the groundwater table with the Engineers approval. The stabilization textile shall be installed in accordance with the manufacturer's recommendations.

3.16 COMPACTION

A. Each layer of material shall be compacted by the use of rollers, equipment rubber-tires, or other approved means so as to secure a dense, stable, and thoroughly compacted mass.

B. Areas adjacent to structures or utilities and other areas inaccessible to mobile compaction equipment shall be compacted with suitable approved devices. Compaction by the latter method shall be done in 6-inch layers or lifts sufficient to achieve the compaction specified.

C. No compaction shall be done when the material is too wet. If the compacted surface of the fill layer is determined to be too smooth to provide an adequate bond with the succeeding layer, the layer shall be loosened by scarifying or disced to allow interlocking with the overlying lift.

D. If at any time, TRC judges the degree of compaction being obtained is insufficient, TRC may halt operations and order that a compaction test be taken at their discretion. Tests in each area shall be performed at the Contractor's expense. No more than three tests will be conducted in each area to confirm that adequate compaction has been achieved. Areas found to be deficient in degree of compaction shall be reworked, recompacted, regraded, and retested if required, at the sole expense of the Contractor.

3.17 FINISHED GRADES

A. All areas covered by the project, including excavated and filled areas and adjacent transition areas shall be uniformly graded so that finished surfaces are graded to meet initial grades prior to excavation activities.

B. Grading shall be done by standard methods. Areas adjacent to structures and other areas inaccessible to heavy grading equipment shall be graded by manual methods. Embankments shall be graded at all times to ensure runoff of water.

C. Final grading shall be performed in such manner as to provide proper drainage from the project site. Finished grades shall be pitched to drain away from structures. In no case shall drainage from the project site be so altered or controlled as to result in damage or the potential for damage, to adjacent property, or to any portion of the Work executed under this Contract from erosion or flooding.

END OF SECTION

SECTION 02270

SEDIMENTATION AND EROSION CONTROL

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly, or system, other than those named or described in this Section, shall be determined in accordance with the provisions of the Contract and General Conditions.

1.2 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals necessary to perform all installation, maintenance, removal and area cleanup related to sedimentation control work as shown on the Drawings and as specified herein. The work shall include, but not necessarily be limited to; installation of temporary access ways and staging areas, installation of silt fences/bags and hay bales and a construction entrance, sediment removal and disposal, device maintenance, removal of temporary devices, establishment of final cover and final cleanup.

1.3 SUBMITTALS

A. The Contractor shall submit an O&M Plan for Soil Erosion and Sediment Control measures. O&M Plan shall include installation schedule and maintenance of control measures. Establishment and schedule of permanent site stabilization measures. O&M Plan shall be submitted for TRC approval, 10 days after Notice to Proceed. The Plan shall include technical product literature for all commercial products to be used for sedimentation and erosion control. The O&M Plan shall be revised as necessary until approved by TRC. Contractor shall not proceed with site work until O&M Plan is approved by TRC.

1.4 QUALITY ASSURANCE

A. Be responsible for the timely installation and maintenance of all sedimentation control devices necessary to prevent the movement of sediment from the construction site to off site areas or wetland areas via surface runoff or underground drainage systems. Measures necessary to prevent the movement of sediment off site shall be installed, maintained, removed, and cleaned up at by the Contractor.

1.5 REGULATORY REQUIREMENTS

B. Fines and related costs resulting from failure to provide adequate protection against soil erosion and sedimentation are the obligations of the Contractor.

C. Erosion and sedimentation control measures employed will be subject to approval and inspection by governing agencies having jurisdiction over such work.

D. All erosion and sedimentation control work shall be conducted in accordance with the Erosion and Sedimentation Control Guidelines (MADEP Division of Water Supply).

E. No materials from excavations, stockpiles or site preparation activities shall be deposited within 100 feet of the wetland areas to the east of the site.

1.6 QUALITY ASSURANCE

A. All erosion and sedimentation control work shall comply with applicable requirements of governing authorities having jurisdiction. These specifications are not comprehensive, but rather convey the intent to provide complete slope protection and erosion control for both the AMETEK and adjacent properties.

B. The Contractor shall obtain TRC's acceptance of clearing limits prior to commencing clearing. This shall be done by clearly marking the limits of clearing.

1.7 SCHEDULING AND SEQUENCING

A. All land-disturbing activities shall be planned and conducted in a manner which minimizes off-site sedimentation damage.

B. Erosion control measures shall be removed when the site is permanently stabilized. Proper disposal of erosion and sediment control materials shall be the responsibility of the Contractor.

PART 2 PRODUCTS

2.1 STRAW BALES

A. Straw bales shall consist of straw from acceptable grasses and legumes, free from weeds, reeds, twigs, chaff, debris, other objectionable material or excessive amounts of seeds and grain. It should be free from rot or mold, and the moisture content shall not exceed 15 percent of weight at the time of weighing. The straw shall be securely baled with wire of adequate size to allow for rusting while in use and to permit rehandling when the bale is in a saturated condition. Individual bales shall be of a longitudinal shape not exceeding 100 pounds when baled.

B. Straw bales shall be wire or nylon bound straw bales. Wire or nylon shall be placed horizontally to prevent deterioration of the bindings. Straw bales shall have 2 rebars, steel pickets or 2"x2" stakes placed a minimum of 1-1/2' into the ground. First stake shall be angled toward previously placed straw bale. Gaps shall be filled with loose straw or hay.

2.2 SILT FENCE/BAGS

A. Material characteristics for the silt fence fabric are presented on Table 02100-1.

Table 02100-1
Physical and Mechanical Properties of Geotextiles

Property	Test Method	Required Minimum Value[1]	Unit
Unit Weight[2]	ASTM D3776	5	oz/yd^2
Thickness	ASTM D1777-64	80	mils
Puncture Strength	ASTM D4833	100	lbs
Apparent Opening Size (AOS)	ASTM D4751	Between 70 to 100 (0.21 to 0.150)	sieve size
Grab Strength	ASTM D4632	180	lbs
Grab Elongation	ASTM D4632	50	%
Trapezoidal Tear Strength	ASTM D4533	50	lbs
Mullen Burst Strength	ASTM D3786	290	psi
Permitivity	ASTM D4491-85	0.83	cm/sec
UV Resistance[3] (@ 500 hrs.)	ASTM D4355-84	70	% strength retained

[1]Minimum average roll values (MARV).
[2]For information only, not a required property.
[3]Manufacturer's certification required which states product exceeds required value for typical roll values.

2.3 STONE

A. Stone used for the stabilized construction entrance shall be 1 inch to 2 inch diameter crushed stone.

PART 3 EXECUTION

3.1 STRAW BALE BARRIER INSTALLATION

A. Straw bale barriers shall be installed around catch basins potentially impacted by excavation activities, around all stockpiled clean soil to be used as backfill, and between the work area and the wetlands to the east.

B. Excavation shall be the width of the bale and the length of the proposed barrier to a minimum depth of 4 inches.

C. Bales shall be placed in a single row, lengthwise on proposed line, with ends of adjacent bales tightly abutting one another. In swales, the barrier shall extend to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest bale.

D. Staking shall be accomplished to securely anchor bales by driving at least two stakes or rebars through each bale.

E. The gaps between bales shall be filled by wedging straw to prevent water from channeling between the bales.

F. Any straw bales which become clogged or otherwise deteriorate shall be properly maintained or replaced as necessary by the Contractor.

G. For straw bales installed around catch basins on asphalt paved and concrete surfaces, straw bales shall be securely fastened together with wooden stakes, rebar, wire or other means acceptable to TRC.

3.2 SILT FENCING INSTALLATION

A. The Contractor shall install the pre-manufactured silt fencing in accordance with the manufacturer's recommendations at the locations shown on the Drawings. The silt fence shall remain in place during the duration of the project and shall be removed with the approval of TRC. In addition, silt bags shall be installed in catch basins in accordance with manufacturer's recommendations. The silt fencing shall remain in place for the duration of the project and shall be removed with the approval of TRC.

3.3 TEMPORARY CONSTRUCTION ENTRANCE

A. A temporary construction entrance consisting of a 6-inch layer of stone shall be used to brush dirt off the tires of hauling vehicles. The construction entrance shall remain in place during the duration of the project and shall be removed with the approval of TRC.

3.4 MAINTENANCE AND INSPECTIONS

A. The Contractor shall make daily visual inspections of all sedimentation control devices. If such inspection reveals that additional measures are needed to prevent movement of sediment to offsite areas or into excavations, promptly install additional devices as needed. Sediment controls in need of maintenance shall be repaired promptly.

3.6 REMOVAL AND FINAL CLEANUP

A. Once the site has been fully stabilized against erosion, remove sediment control devices and all accumulated silt. Dispose of silt and waste materials in proper manner. Regrade all areas disturbed during this process and stabilize against erosion with surfacing materials.

END OF SECTION

SECTION 02430

STORM DRAINAGE SYSTEM

PART 1 GENERAL

1.1 CONTRACT REFERENCES

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly, or system, other than those named or described in this Section, shall be determined in accordance with the provisions of the Contract and General Conditions.

1.2 DESCRIPTION

A. Work of this Section includes all labor, materials, equipment and services necessary to complete the Storm Drainage System as shown on the drawings and specified herein, including, but not limited to, the following:

1. Installation of onsite drainage systems, consisting of catch basins, drain inlets, end sections, pipes and all necessary and required accessory items and operations, including connections to existing drainage facilities.

2. Cleaning, testing and repairing of storm drainage system.

1.3 QUALITY ASSURANCE

A. The Contractor shall perform all his operations in accordance with the rules, regulations and ordinances of those governing bodies having jurisdiction.

B. The installation of all drainage structures and pipe within Public R.O.W. and/or Easements, shall conform to the requirements of the agency having jurisdiction.

C. The Contractor shall submit certification from the suppliers insuring that materials are in conformance with this Section of the Project Specifications.

D. Leakage Tests

1. General Requirements

a. The Contractor shall perform all leakage tests on the joint systems in accordance with the requirements specified herein, when indicated on the Drawings, including infiltration and exfiltration tests.

b. All labor, materials and equipment required to perform leakage tests shall be furnished by the Contractor.

c. All water used for exfiltration tests shall be of a quality acceptable to TRC.

d. Prior to acceptance of the pipe type and joints, line or system, the tests and measurements of exfiltration shall be constructed in a manner approved by TRC, and shall apply to the whole system or any portion thereof. All tests shall be made and conducted by the Contractor in the presence of TRC.

e. Sections of pipe tested for infiltration and exfiltration prior to completion of the project shall be subject to additional leakage tests, if warranted in the opinion of TRC.

2. In-Place Methods of Testing

a. If TRC so desires the first section of any line between two manholes shall be tested as soon as possible after backfilling has been completed to at least two (2) feet above to top of the pipe. If such tests appear to be

satisfactory and acceptable, progressive testing of completed sections of the lines may be deferred, at the option of TRC and at the request of the Contractor, until all pipe has been laid, but before final acceptance. However, if permitted, this procedure will not constitute a waiver of any of the tests or the leakage requirements. All tests shall be performed for a minimum period of four (4) hours.

b. Where the crown of the pipe is below the natural groundwater table at the time and place of testing, the pipe shall be tested for infiltration. Suitable watertight plugs shall be Installed and the section of pipe to be tested shall be pumped dry before start of test.

c. Where the crown of the pipe is above the natural water table, the pipe shall be tested for exfiltration by installing necessary plugs, filling pipes and manholes with water and during the test maintaining a static head of water a minimum of two (2) feet above the crown of the pipe.

d. All manholes, catch basins, curb Inlets and other appurtenances to the system shall be tested for watertightness by filling with water and visual inspection of the exfiltration rate.

e. TRC shall be supplied a copy of the test results which shall include amount of leakage and the location of the observed leaks relative to joints, seams, etc. Leakage of the test section shall not exceed 200 gallons per day per mile per inch of nominal pipe diameter.

f. If the test results are outside the above limits, the Contractor shall propose remedial action for approval of TRC. Upon approval and performance of such remedial action the test shall be re-run.

3. Pre-Placement Method of testing

a. Each test section shall include two (2) separately manufactured sections of pipe joined together at the finished ends by the approved jointing method for the project.

b. The pipes shall then be cut, where required, to provide a test section at least ten (10) feet in length. Each open end of the test section shall then be bulkheaded with an appropriate adaptable plate, one (1) of which shall be fitted with a water valve and an air valve and pressure gauge. The bulkhead shall be attached to the pipe sections by an approved method consistent with the type of pipe being tested.

c. Fabrication of the test section shall be performed in the field, and shall be selected at random from the materials delivered to the site. Upon completion of the fabrication, the test section shall be placed vertically and filled with water through the valve in the bulkhead. When the test section has been completely filled with water, the water valve shall be closed and an appropriate source of compressed air attached to the air valve. Air shall be added to the test section until a pressure of 5 p.s.i. Is obtained. The pressure of 5 p.s.i. shall be maintained for a period of eight (8) hours and the points of leakage shall be noted. After eight (8) hours, the pressure shall be released, without expelling water, and the test section filled with measured amounts of water to determine the leakage from the test section.

d. TRC shall be supplied a copy of the test results which shall include amount of leakage and the location of the observed leaks relative to joints, seams, etc. Leakage of the test section shall not exceed 0.1 gallons per day per inch of pipe diameter per lineal feet of laying length between joints.

e. If the test results are outside the above limits, the Contractor shall propose remedial action for approval of TRC. Upon approval and performance of such remedial action the test shall be re-run.

f. Installation of the approved pipe shall include the remedial reassures which were required in the testing of the pipe.

4. Correction of Defective Work

a. Any defects found in the system are to be made good at the expense of the Contractor so as to conform strictly to the Specifications and to the satisfaction of TRC.

b. All repairs shown necessary by the tests are to be performed broken or cracked pipe replaced, all deposits removed, the drain left true to line and grade and entirely clean, free from lumps of cement, protruding gaskets, bulkheads, etc., and ready for use before final acceptance is made.

E. Cleaning and Repair

1. The Contractor shall be required to clean the entire drainage system of all debris and obstructions. This shall include, but not be limited to, removal of all formwork from structures, concrete and mortar droppings, construction debris and dirt. The system shall be thoroughly flushed clean

and the Contractor shall furnish all necessary hose, pumps, pipe and other equipment that may be required for this purpose. No debris shall be flushed into existing storm drains or streams; all debris shall be removed from the system as well as any temporary or permanent detention ponds and disposed of in an approved offsite location.

2. After the system has been cleaned, the Contractor shall thoroughly inspect the system and all repairs shown to be necessary shall be performed at the Contractor's expense and to the complete satisfaction of TRC.

F. Final Inspection

1. Upon completion of the work and before final acceptance by TRC, the entire drainage system shall be subjected to a final inspection in the presence of TRC. The work shall not be considered as complete until the requirements for line, grade, cleanliness, leakage tests and workmanship have been completed to the satisfaction of TRC.

1.4 SUBMITTALS

A. The Contractor shall submit the following material designs for the type specified for review and approval prior to materials being delivered to the site:

1. Reinforced Concrete Pipe
2. Nitrile Gaskets
3. Brick
4. Concrete and Mortar Mixes

B. The Contractor shall submit shop drawings of the following items for the type specified prior to materials being delivered to the Site:

1. Precast Manholes, Catch Basins and Drain Inlets
2. Manhole Frames and Covers
3. Catch Basin and Drain Inlet Frames and Grates
4. Ladder Rungs

1.5 DELIVERY, STORAGE AND HANDLING

A. Storage and Handling of Pipe

1. Storage of pipe on the job shall be in accordance with the pipe manufacturer's recommendations, subject to the approval of TRC.

2. All pipe shall be protected against impact, shock and free fall, and only equipment of sufficient capacity and proper design shall be used in the handling of the pipe. Special care shall be taken to prevent damage to pipe coatings.

B. Damage to Pipe

1. General Requirements

a. Pipe which is defective from any cause, including damage caused by handling, and determined by TRC as

unrepairable, shall be unacceptable for installation and shall be replaced at no cost to TRC as directed by TRC.

b. Pipe that is damaged or disturbed through any cause prior to acceptance of the Work, shall be repaired, realigned or replaced as directed by TRC.

2. Minor Imperfections in Reinforced Concrete Pipe

a. Reinforced Concrete pipe with damage which is the result of minor imperfections in manufacture which do not affect the structural integrity of the pipe may be repaired in the field. Repairs shall be sound, properly finished and cured to the satisfaction of TRC and shall conform to the requirements of these Project Specifications.

1.6 JOB CONDITIONS

A. Excavation and Backfill

1. The provision of Section 02221 of these Project Specifications shall govern all Work under this Section.

B. The installation of all drainage structures and pipe within the Public R.O.W. and/or Easements, shall conform to the requirements of the agency having jurisdiction.

PART 2 PRODUCTS

2.1 STORM DRAIN PIPE, FITTINGS AND JOINTS

A. Concrete Pipe

1. Non-reinforced Concrete Pipe (NCP-G) shall conform to the specifications for Concrete Sewer, Storm Drain and Culvert Pipe," AASHTO Designation M 86. Pipe Joints shall be so designed to utilize watertight nitrile gaskets as a jointing treatment. Non-reinforced Concrete Pipe shall

   only be used for pipes ten (10) inches in diameter and less unless otherwise specified.

2. Reinforced Concrete Pipe (NCP-G) shall conform to the "Specifications for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe", AASHTO Designation M-170. Pipe joints shall be so designed to utilize watertight nitrile gaskets as a jointing treatment. Reinforced Concrete Pipe shall be used for all pipes twelve (12) inches in diameter and larger, unless otherwise specified.

The maximum depth of cover for Concrete Pipe shall conform to the following

MAXIMUM DEPTH OF COVER (FT.)

Class	NCP	RCP
II	9	9
III	13	13
IV	-	18
V	-	24
VI	-	-

3. No lift holes shall be permitted in pipes twenty-four (24) inches and smaller in diameter.

3. All Concrete Pipe shall have a minimum cover of one (1) foot below finished grade or six (6) inches below subgrade. Minimum cover for construction equipment, except that required for subgrade preparation, shall be two (2) feet.

B. Pipe End Sections

1. Reinforced Concrete End Sections shall meet the requirements of AASHTO Designation M170. The flare shall be of the same thickness and materials as the barrel, and shall have steel reinforcement equaling or exceeding the amount for the pertinent size. Connection of end sections to pipe shall be by means of standard joint.

C. Pipe Connections

1. Concrete Pipe

(a) Nitrile gaskets shall conform to ASTM C- 443.

(b) Nitrile Gasket Joint Sealer shall be in accordance with the Specifications for Joints for Circular Concrete Sewer and Culvert Pipe Using Nitrile Gaskets," AASHTO Designation M-198.

2.2 STRUCTURES

A. Brick shall conform to the "Specifications for Sewer and Manhole Brick (made from Clay or Shale)", AASHTO Designation M-91, latest revision, Grade MS.

B. Concrete Block shall be solid block and shall conform to the "Specifications for Concrete Masonry Units for Construction of Catch Basins and Manholes," ASTM C-139, latest revision.

C. Precast Manholes, Catch Basins, Drain Inlets

1. Where called for on the Drawings or approved in writing by TRC, the Contractor may substitute precast manholes, catch basins, and/or drain inlets.

2. Precast Reinforced Concrete Manhole Sections shall conform to the "Specifications for Precast Reinforced Concrete Manhole Sections", AASHTO Designation M-199, latest revision.3. The minimum compressive strength of the concrete used for all precast structures shall be 4,000 p.s.i. Where steps are required in structures, steps shall be installed during the casting of the structures, aligned as specified herein. Joints in the structures shall be tongue and groove joints, formed in such a manner so that a mortar or nitrile seal can be applied.

4. No precast manhole, catch basin or drain inlet shall be fabricated or delivered to the job site until it has been approved by TRC. All structures shall have number and manufacturer's name on each section.

5. Approval for the use of precast structures shall relieve TRC of any additional costs for modification of openings due to line or grade changes, deletion of structures, relocation of structures, or addition or deletion of lines to be connected into the structures, and such additional cost shall be at the Contractor's expense.

D. Manhole Frames and Covers

1. Manhole frames and covers shall be gray cast iron castings, conforming to the requirements of AASHTO Designation M-105, latest revision, Class 30. The castings shall be true to pattern in form and dimensions as specified and shall be free from pouring faults, sponginess, cracks, blowholes and other defects that affect their strength and other characteristics for the intended use. All surfaces shall have a workmanlike finish.

2. All component parts shall fit together in a satisfactory manner and frames and covers shall be of non-rocking design so as to prevent rocking or rattling under traffic. Frames and covers that are warped or rocking, as determined by TRC will be rejected and shall be removed and replaced by the Contractor to the satisfaction of TRC at no cost to TRC.

3. Unless otherwise specified, the word "DRAIN" shall be integrally cast on the cover in raised letters and centered. Letter size shall be two (2) inches.

4. All castings shall be coated with an asphalt paint which shall result in a smooth coating and not be tacky or brittle.

E. Catch Basin and/or Inlet Frames and Grates

1. Catch Basin and/or Inlet Frames and Grates shall be cast iron and/or fabricated steel as specified on the Drawings and in accordance with the following requirements:

   (a) Cast Iron shall be gray cast iron castings conforming to the requirements of AASHTO Designation M-105 latest revision,

   Class 30. All requirements of workmanship and material as specified for manhole castings shall apply herein.

(b) Fabricated Steel shall meet the requirements of AASHTO Designation M-183. Unless otherwise specified, all frames and grates shall be galvanized in accordance with AASHTO Designation M-111.

2. All component parts of the frames and grates shall fit together In a satisfactory manner and frames and grates shall be of a non-rocking design so as to prevent rocking or rattling under traffic. Frames and grates that are warped or rocking, as determined by TRC will be rejected and shall be removed and replaced by the Contractor to the satisfaction of the TRC at no additional cost to TRC.

F. Concrete shall conform to the requirements of Section 03305 of the Project Specifications.

G. Reinforcement

1. Reinforcement shall be new billet stock deformed steel bars conforming to AASHTO Designation Grade 40. Steel wire fabric shall conform to AASHTO Designation M-55. Metal accessories, chairs, ties and other items necessary for proper placement of reinforcing, shall be provided.

2. Reinforcement shall be free from scale, oil, ice and structural defects and shall be stored so as to prevent contact with the ground.

H. Mortar

1. Mortar shall be composed of one (1) part Portland Cement and two (2) parts sand by volume. Hydrated lime not to exceed four (4) pounds of lime to each bag of cement may be added as approved by TRC. Material requirements shall be as follows:

(a) Portland Cement shall conform to the requirements of AASHTO Designation M-85, Type 11.

(b) Hydrated Lime shall conform to the requirements of ASTM C4.

(c) Mortar Sand shall conform to the requirements of AASHTO Designation M-45, except that aggregate shall be no coarser than #8 sieve size.

(d) Water shall be clean and shall not contain any oil, acid, alkali, salts, vegetable matter, organic matter or other deleterious substances. When possible, water shall be from a municipal system.

2. Hand mixing of mortar will be permitted only when, in the opinion of the TRC, the amount of mortar to be used makes machine mixing undesirable. When hand mixing is used, the Ingredients must first be thoroughly mixed dry, in a tight box, after which the proper quantity of clean water shall be gradually added and then the materials shall be hoed or worked until a uniform mixture is secured. Admixtures may be added only with the prior written approval and in the presence of TRC.

3. No greater quantity of mortar is to be prepared than is required for immediate use, and it shall be worked over constantly with hoe or shovel until used. No Mortar shall be retempered, and none shall be used more than one and one-half (1 ½) hours after mixing. All mortar mixture which remains upon stopping work shall be discarded.

I. Steps for Manholes and Inlets

This Specification covers the material requirements for steps for manholes and inlets.

1. General: The minimum design live load, for steps, appurtenances and fastenings, shall be a single concentrated load of 13.5 kN. The live loads imposed by persons occupying the steps shall be considered to be concentrated at such points as will cause the maximum stress in the Structural member being considered.

   Steps shall be designed so a worker's foot cannot slide off the end. The minimum length of the rungs shall be 250 mm.

   Whenever a combination of dissimilar types of metals are used in the manufacture of steps, appurtenances and fastenings, the materials shall be treated to prevent deleterious effects.

2. Materials: Manhole steps shall be fabricated from one of the following:

   (a) Ferrous Metal. Steps shall conform to the following requirements:

   Iron Castings - Class 25A, subsection 715-09.
   Malleable Iron Castings - Grade 35018, subsection 71549. Steel - ASTM A575, Grade M 1020, galvanized in accordance with 71941, Type 1.

   The steps shall have a minimum cross sectional dimension of 25 mm exclusive of any coatings placed on them.

(b) Non-Ferrous Metal. Steps shall conform to the following requirements:

Aluminum Castings - Alloy 356-T6, 715-03.
Wrought Aluminum 6061-T6, 6005-T5, or 6351-T6, 71544.

When aluminum steps are used, the portion of the step which will be in direct contact with cement concrete or concrete mortar, shall be coated with Zinc Chromate Primer conforming to the requirements of subsection 70844 or shall be coated with bituminous material approved by the Materials Bureau.

(c) Reinforced Plastic. Steps shall consist of polypropylene or other plastic material meeting this specification. It may be extruded, cast,

or molded into the standard size and shape manhole steps, having a steel core center for strength and completely covered by the plastic molding for corrosion protection.

The plastic material shall have the following characteristics:

(1) Resistance to Salt and Caustic Solutions. Resistance to the following solutions when submerged for 30 days:

10% Sodium Chloride
10% Hydrochloric Acid
10% Sodium Hydroxide
10% Sulfuric Acid

(2) Flow Point. A flow point of 160°C or greater.

(3) Flexibility. It shall remain flexible over a temperature range of -30° C to + 120° C upon long aging.

(4) Fire Resistance. It shall be non-burning, self-extinguishing, or very slow burning. The steel core shall be not less than 12 mm diameter and shall have the following physical characteristics:

Tensile Yield - Minimum - 275 MPa
Tensile Strength - Minimum - 482 MPa

The plastic step, when cast into a concrete block the proper depth shall withstand a minimum load of 13.5 kN applied on 625 $mm^{(2)}$ area in the center of the step without cracking or breaking the plastic coating, loosening the step in the concrete or permanently deforming the step.

PART 3 EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions where the Storm Drainage System is to be installed and notify TRC of conditions detrimental to the proper and timely completion of the Work. Do not proceed with the Work until unsatisfactory conditions have been corrected by the Contractor in a manner acceptable to TRC.

3.2 GENERAL

A. The Contractor shall install all drainage structures and pipe in the locations shown on the Drawings and/or as approved by TRC. Pipe shall be of the type and sizes specified and shall be laid accurately to line and grade. Structures shall be accurately located and properly oriented.

3.3 PIPE INSTALLATION

A. Laying Pipe

1. Each length of pipe shall be laid with firm, full and even bearing throughout its entire length, in a trench prepared and maintained in accordance with Section 02315 of these Project Specifications. Pipe will be laid upgrade unless otherwise directed by TRC.

2. Bell and spigot pipe shall be laid with the bell end upgrade; tongue and grove pipe shall be laid with groove end upgrade. The pipe shall be joined so that there will be a uniform space all around the pipe. Trimming of the pipe will not be permitted.

3. Every length of pipe shall be inspected and cleaned of all dirt and debris before being laid. Prior to the placing of a length of pipe, the end of the previously laid length shall be carefully and thoroughly wiped smooth and cleaned to obtain an even and close fitting joint.

4. No length of pipe shall be laid until the preceding lengths of pipe have been thoroughly embedded in place, so as to prevent movement or disturbance of the pipe.

B. Full Lengths of Pipe

1. Only full lengths of pipe are to be used In the Installation except that partial lengths of pipe may be used at the entrance to structures where necessary to obtain a proper connection to the structure.

C. Pipe Entrances to Structures

1. All pipe entering structures (e.g. manholes, catch basins, etc.) shall be cut flush with the inside face of the structures, and the cut ends of the pipe and surface of the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges, or imperfections that will impede the flow of water or affect the hydraulic characteristics of the installation.

2. Reinforcing steel shall not be left exposed in cut section of reinforced concrete pipe. The method of cutting and finishing shall be subject to the approval of TRC.

3. Only full sections of pipe shall be used where entering a structure which will be exposed to view, such as endwalls, headwalls, end sections, etc.

4. All pipe connections to structures shall be watertight; the method subject to approval of TRC.

E. Bedding and Backfilling

The type of materials to be used in bedding and backfilling and the method of placement shall conform to the requirements of Section 02221 of these Project Specifications.

F. Protection During Construction

1. The Contractor shall protect the installation at all times during construction, and movement of construction equipment, vehicles and loads over and adjacent to any, pipe shall be performed at the Contractor's risk.

2. At all times when pipe laying is not in progress, open ends of all pipes shall be closed by approved temporary watertight plugs. If water is in the trench when Work is resumed, the plug shall not be removed until the trench has been pumped dry and all danger of water entering the pipe has been eliminated.

D. Tolerance

1. Pipe shall be laid accurately to the line and grade as shown on the Drawings and/or as directed by TRC. Allowable tolerances shall be one-half (½) inch on grade and one (1) inch on line in any section of pipe between structures. Deviations from these tolerances shall be a basis for rejection of the line of pipe by TRC. Any line which has been rejected shall be rebuilt to the correct line and grade by the Contractor at his own expense.

3.4 PIPE JOINTS

A. Jointing Concrete Pipe with Mortar

1. After each length of pipe is laid, the lower portion of the bell shall be filled with mortar, and the succeeding length shall be laid In place so that the Inner surfaces of the abutting lengths are flush. The remainder of the joint shall be completely filled with mortar and sufficient additional mortar used to form a bead around the joint flush with the outside diameter of the bell. The inside of the joint shall be wiped and finished smooth. Joints shall be thoroughly wet before the mortar is placed.

2. Concrete pipe with tongue and groove joints shall be laid so that the inner surfaces of abutting sections are flush. The joints shall then be completely filled with mortar. The inside of the joints shall be wiped smooth and the outside pointed. Joints shall be thoroughly wet before mortar is placed.

B. Jointing Concrete Pipe with Cold Applied Pipe Joint Sealers

1. Bell and spigot pipe or tongue and groove pipe shall be wiped clean and dry before applying the sealer to the pipe joint. Before the pipes are placed in contract with each other, the spigot end or tongue end of the pipe shall be completely covered with an excess of sealer, and then the pipe shall be laid to the established line and grade so that the inside surfaces of abutting pipe are flush.

2. The joints shall then be completely filled with the sealer so as to make a watertight seal. All excess material shall be removed from the inside of the pipe.

C. Jointing Concrete Pipe with Nitrile Gaskets

1. A premolded nitrile gasket shall be used where shown on the Drawings or as specified. The gaskets shall be installed according to the manufacturer's specifications and as approved by TRC.

3.5 END SECTIONS

A. The Contractor shall furnish and install end sections in the locations and of the type and size specified on the Drawings and/or as approved by TRC.

B. The method and manner of installation shall be as specified herein for the installation of pipe.

3.6 MANHOLES, CATCH BASINS, DRAIN INLETS

A. General Requirements

1. All manholes, catch basins, and drain inlets shall be built in accordance with the details and in the locations shown on the Drawings and as specified herein.

2. Structures shall be constructed of brick masonry, precast solid concrete block, cast-in-place Class A Concrete or precast concrete. Precast structures will require shop drawing approval by TRC.

3. No concrete or masonry shall be laid when the temperature is below forty (40) degrees Fahrenheit, or when indications are for lower temperatures within twenty-four (24) hours, unless protection of concrete and masonry is approved by TRC. In this event, Contractor shall take such measures to prevent concrete and masonry from being exposed to freezing temperatures for a period of not less than five (5) days after installation. Approval of the method of protection by TRC shall not relieve the Contractor of his responsibility to protect the masonry from freezing; and any damage to the structure because of freezing shall be corrected by the Contractor at his own expense, to the satisfaction of TRC.

4. All masonry shall be installed by personnel experienced and skilled in this Work, and any person not deemed to be such by TRC shall be removed and replaced by a person so qualified.

5. Manholes, catch basins and drain inlets are to be constructed as soon as the pipe laying reaches the location of the structures. Should the Contractor continue his pipe laying without making provision for completion of the structures, TRC shall have the authority to stop the pipe laying operations until the structure is completed.

6. In constructing manholes, catch basins, and drain inlets, the Contractor shall accurately locate each structure and set accurate templates to conform to the required line and grade. Any structure which is mislocated

or improperly oriented shall be removed and rebuilt in its proper location, alignment and orientation at the Contractor's expense.

7. All manholes, catch basins, and drain inlets located in a low point of a pavement subgrade shall be provided with weep holes as indicated on the Details of the Drawings.

B. Foundations

1. Unless otherwise specified, structures shall be constructed on foundations of Class A Concrete in accordance with Section 03305 of these Project Specifications and all foundations shall rest on firm ground of uniform bearing, as approved by TRC.

C. Masonry

1. All brick or concrete block shall be thoroughly wetted before laying.

2. An masonry shall be laid in full bed of mortar, and all vertical and horizontal joints shall be filled solid with mortar. Vertical joints on each succeeding course shall be staggered. Joints shall be not less than 3/8 inch or more than ½ inch wide. Joints on the inside of the structure shall be neatly struck and pointed.

3. The first course of masonry shall be imbedded in the Concrete foundation immediately after the foundation has been poured.

4. Where specified, the interior surface of the walls shall be painted upon completion with three (3) coats of neat cement grout without sand, applied with an interval of at least 24 hours between applications. The exterior surface of the walls shall be plastered with a one-half (½) inch coat of 1:2 cement mortar.

D. Inverts

1. Brick or smooth concrete invert channels shall be constructed in all manholes and in all catch basins and drain inlets which do not have sumps, to insure a smooth flow of water through the structure.

2. The invert channel shall be constructed to the elevations shown on the Drawings. Channels shall slope smoothly and evenly from the entrance pipe to the outlet pipe.

3. Special care shall be taken in laying brick inverts. Joints shall not exceed three sixteenth (3/16) inch in thickness and each brick shall be carefully

laid in full cement mortar joints on bottom, side and end in one operation; no grouting or working in of mortar after laying of the brick will be permitted.

4. When specifically approved by TRC, split concrete pipe may be used as invert channels. Split pipe for channels will only be considered in those instances where the drain line is of concrete pipe and the major inflow pipe and outflow pipe are of the same size and alignment.

5. Invert channels shall be built for future extensions where shown on the Drawings and/or where directed by TRC.

E. Frames, Covers and Gratings

1. Frames, Covers and/or Gratings for manholes, catch basins and drain inlets shall be of the type and size indicated on the Drawings. Frames shall be well bedded in mortar and shall be set accurately to the correct alignment and grade. In areas to be paved, frames shall be set by using four (4) points of reference, set 90 degrees apart, to insure accurate setting to proposed pavement grade.

2. Where drain inlets are to be located along curb lines or at edge of pavements, sufficient length of proposed curb or edge of pavement adjacent to the structure shall be established prior to construction of the inlet to insure that the structure is correctly located and oriented.

F. Ladder Rungs

1. Ladder rungs shall be installed in all manholes in a ladder-like manner, spaced fifteen (15) inches on center vertically. Rungs shall be set securely In place during the construction of the masonry wall.

2. Ladder rungs shall also be installed in all catch basins and drain inlets greater than five (5) feet in depth unless otherwise specified.

G. Precast Structures

1. Precast structures shall be installed only after shop drawings have been approved.

2. The base unit of the precast structures shall be founded on an approved compacted subgrade. Should the base unit be a slab only, the first riser unit shall be set in a pad of one half (½) inch minimum thick mortar or as recommended by the Manufacturer and approved by TRC. Grout around pipes which protrude through the walls of the structure and on all joints

shall contain "Antihydro", or other approved additive, to insure watertightness. Cement grout shall contain two parts cement to one part sand and additive in accordance with manufacturer's recommendations. Mortar shall be applied to the bottom 1/3 of the opening before the pipe is inserted.

3. The top grade of the precast concrete corbel section shall be set sufficiently below finished grade to permit a maximum of four (4) and a minimum of two (2) courses of eight (8) inch brick to be used as risers to adjust the grade of the casting. Manhole frames shall be set on a grout pad as specified herein.

END OF SECTION

SECTION 02500

PAVING AND SURFACING

PART 1 GENERAL

1.1 CONTRACT REFERENCES

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly, or system, other than those named or described in this Section, shall be determined in accordance with the provisions of the Contract and General Conditions.

1.2 DESCRIPTION

A. The Contractor shall furnish all labor, material, tools, and equipment necessary to install a bituminous concrete cap at location shown on the Drawings.

1.3 WORK INCLUDES

A. Installation of modified crushed stone sub-base under areas to be paved.

B. Supply and installation of bituminous concrete pavement at areas to be paved.

C. Supply and installation of tack coat at the connection of existing and new bituminous concrete.

1.4 RELATED SECTIONS

A. Section 01020 - Special Requirements.

B. Section 01070 - Reference Standards.

1.5 REGULATORY REQUIREMENTS

A. All materials and work shall conform to those specified in the latest edition of the Standards Specifications for Highways and Bridges, Commonwealth of Massachusetts, Highway Department.

B. All work shall comply with the safety rules and regulations of the local and state agencies having jurisdiction. Nothing contained herein shall be construed as permitting work that is contrary to such rules, regulations, and codes.

1.6 ENVIRONMENTAL REQUIREMENTS

A. Asphalt shall not be placed when ambient air or base surface temperature is less than 40 degrees F, or if the surface is wet or frozen.

B. Bituminous mixture shall be placed when temperature is not more than 15 degrees F below bituminous suppliers bill of lading and not more than maximum specified temperature.

PART 2 PRODUCTS

2.1 CRUSHED STONE SUBBASE

A. Crushed stone for subbase material under bituminous pavement shall conform to requirements for Aggregate Base Course M2.01.4 as specified in Section M2 of the reference specification.

2.2 PAVEMENT

A. The pavement shall conform to requirements for Class I Bituminous Concrete Pavement, Type I-1, Section 460 of the reference specification.

2.3 TACK COAT

A. Tack coat shall conform to the requirements for cutback asphalt, M3.02.0 of the reference specification.

PART 3 EXECUTION

3.1 GENERAL

A. All work shall be done by skilled and experienced craftsmen, working under the supervision of a capable foreman. All workmanship shall be of the highest quality and to the complete satisfaction of TRC. All materials shall be applied in accordance with the manufacturer's directions and shall be changed only at the written direction of TRC.

3.2 SUBGRADE PREPARATION

A. Subgrade conditions shall be verified under provisions of Section 01400.

B. The subgrade shall be shaped to true and even lines so as to assure a uniform thickness of the stone base course required under paved areas. Gradients and elevations of subgrade shall be verified as being correct as per Article 3.6 - Tolerances of this Section.

C. Compacted subgrade shall be verified as being dry, thoroughly compacted and stabilized prior to the placing of crushed stone subbase and ready to support paving and imposed loads.

D. The subgrade shall be compacted to densities as specified in Articles 1.6, 1.11, 3.12 and 3.16 - Schedule of Section 02221 - Earthwork prior to the placement of the stone base. Any soft, spongy or yielding subgrade material shall be removed and replaced with suitable material, or otherwise corrected and made stable before construction proceeds. Excavated materials may be stockpiled and reused if approved by TRC.

3.3 CRUSHED STONE SUBBASE

A. The crushed stone subbase shall be thoroughly compacted, homogeneous material conforming to the required thickness prior to placing of surface treatment. TRC will verify that the crushed stone subbase is ready to support paving and imposed loads.

B. Crushed stone shall be compacted to 95 percent of maximum dry density as determined by ASTM D1557. Compaction of the crushed stone shall be in accordance with Section 401.60 of the reference specification.

C. Gradients and elevations of gravel shall be verified as being correct as per Article 3.6 - Tolerances of this Section.

3.4 TACK COAT

A. Tack coat shall be applied to base course in accordance with manufacturer's instructions.

3.5 BITUMINOUS CONCRETE PAVEMENT PLACEMENT

A. Pavement course shall be placed within two hours of placing and compacting base course and to the thickness identified in Article 3.9 - Schedules at the end of this Section.

B. Pavement course placement shall conform to requirements of Section 420.60 of the reference specification.

C. Pavement shall be compacted by rolling to specified density. Pavement shall not be displaced or extruded from position.

D. Pavement shall be hand-compacted in areas inaccessible to rolling equipment.

E. Rolling shall be performed with consecutive passes to achieve even and smooth finish, without roller marks.

F. All finished paving shall conform to the original grade and elevations of the surrounding topography or as changed by TRC due to field conditions.

G. Finished paving surface shall be a uniformly closed, dense and smooth surface. Paved areas shall surface drain completely.

3.6 TOLERANCES

A. Flatness: Maximum variation of 1/4-inch measured with 10 foot straight edge.

B. Scheduled Compacted Thickness: Within 1/4-inch.

3.7 FIELD QUALITY CONTROL

A. Section 01400 - Quality Control: Contractor to provide field inspection and testing.

3.8 PROTECTION OF FINISHED WORK

A. Protect finished Work under provisions of Section 01700.

B. Immediately after placement, protect pavement from mechanical injury until adequate stability has been attained or until surface temperature is less than 140 degrees F.

3.9 SCHEDULES

A. Pavement: Three courses: gravel subbase of 8 inch compacted thickness; pavement course of 2-inch compacted thickness; and, tack coat.

END OF SECTION

SECTION 02940

CONTAMINATED SOIL EXCAVATION

PART 1 GENERAL

1.1 CONTRACT REFERENCES

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly, or system, other than those named or described in this Section, shall be determined in accordance with the provisions of the Contract and General Conditions.

1.2 DESCRIPTION

A. The Contractor shall furnish all labor, material, tools and equipment necessary for excavation, tracking, handling, and temporary storage of contaminated soil, and for transport and disposal of fluids and solids generated during decontamination of vehicles and personnel as part of this Work.

1.3 WORK INCLUDES

A. Excavating and shoring or bracing as necessary.

B. Transportation and Disposal of contaminated soil.

C. Decontamination of equipment and vehicles and disposal of resulting liquid and solids.

D. Backfilling of excavated areas, resulting from the excavation of contaminated soils is part of the Work of Section 02221 - Earthwork.

1.4 RELATED SECTIONS

A. Section 01020 - Special Requirements.

B. Section 01025 - Unit Prices.

C. Section 01070 - Reference Standards.

D. Section 01300 - Submittals.

E. Section 01400 - Quality Control.

F. Section 02100 - Site Preparation.

G. Section 02270 – Sedimentation and Erosion Control.

H. Section 02221 - Earthwork.

I. Section 02601 - Existing Utilities.

1.5 SUBMITTALS

A. TRC shall be responsible for field screening and post-excavation soil sampling and analysis.

B. The Contractor shall submit to TRC all pertinent information relating to the contaminated soil and contaminated water disposal or recycling facilities. Facility acceptance (for soil) shall be granted prior to commencement of excavation activities. The facility information shall include the following:

1. General Information

   a. Facility name
   b. Facility address
   c. Name and title of contact person
   d. Telephone number of contact person
   e. Permit number

2. The facility shall provide a listing of current and valid permits, licenses, letters of approval and other authorizations to operate pertaining to the receipt and management of the water specified in this contract.

C. The Contractor shall submit a decontamination water disposal plan as part of the Work Plan.

D. TRC shall be responsible for all field screening and soil and groundwater sampling for waste characterization and post-excavation sampling. Waste characterization data will be submitted to the Contractor and the Contractor will be responsible for obtaining disposal facility approval. In addition, TRC will be conducting health and safety monitoring in accordance with the Site Specific Health and Safety Plan.

1.6 REGULATORY REQUIREMENTS

A. The Work of this Section shall be performed in accordance with all applicable Federal, State, and local regulations, laws, codes, and ordinances governing the handling, transportation, and disposal of hazardous materials.

B. The Contractor shall obtain all necessary permits and state licenses in conjunction with contaminated soil and water, restricted soil hauling and disposition.

1.7 DEFINITIONS

A. Decontamination Water - Water generated by the Contractor in decontaminating procedures of excavation equipment within contaminated areas.

B. Contaminated Soil - Soils or fills determined by analytical results to contain oil and/or hazardous material at concentrations equal to or greater than a release notification threshold established by 310 CMR 40.0300 and 40.1600.

C. Contaminated Groundwater - Groundwater determined by analytical results to contain any contaminants in excess of MCP reference/reportable concentrations.

1.8 QUALITY ASSURANCE

A. *TRC will be the generator and will sign all Bills of Lading.* Any hazardous waste manifests will be signed by a TRC agent for Lockheed Martin Corporation. The Licensed Site Professional for this project (provided by TRC) will generate the Bills of Lading. All contaminated soil material shall be transported under bills of lading approved by MADEP.

B. TRC will direct the segregation of contaminated soil versus uncontaminated soil and will conduct all necessary sampling and health and safety monitoring. Neither the presence of TRC nor any observation and testing TRC shall excuse the Contractor from defects discovered in his Work.

PART 2 PRODUCTS

2.1 GENERAL

A. The Contractor shall provide all employees and Subcontractor(s) with personal protective equipment and protective clothing consistent with the levels of protection for this Work as indicated in the Site Specific Health and Safety Plan (HASP). TRC will provide on-site health and safety monitoring, in accordance with the HASP

2.2 STORAGE OF EXCAVATED MATERIALS

A. Only new clean backfill or uncontaminated surface soil material shall be stockpiled on-site in accordance with the most recent version of MADEP guidance policies. Contaminated soil shall be loaded and immediately transported off-site for proper disposal.

B. If contaminated soil cannot be immediately transported off-site, it shall be stored in secured, covered roll-off containers for transport off-site the following day. Appropriate sediment/erosion and odor controls must be implemented and disposal shall be done in accordance with applicable local, state and federal regulations.

PART 3 EXECUTION

3.1 GENERAL

A. The Contractor shall perform all contaminated soil excavation work in accordance with TRC's Health and Safety Plan. Contaminated soil excavation work shall include mass excavations and any incidental soil work.

B. The Contractor shall excavate soil to the limits necessary to achieve the required cleanup as directed by TRC.

C. The Contractor shall provide all layout field data, including ties, to TRC. The Contractor shall maintain all required field controls throughout the performance of the Work.

D. All site health and safety controls shall be fully established and in operation prior to beginning any contaminated or potentially contaminated soil excavation. Site controls shall include but not be limited to work zones properly secured, decontamination facilities, and all support equipment and supplies including personal protective equipment. All site controls shall be reviewed by TRC in the field.

3.2 EXCAVATION OF CONTAMINATED MATERIAL

A. Work and decontamination procedures in areas containing contaminated material shall be performed in accordance with standard engineering practices. The contractor shall apply engineering and/or work practice controls as a means of protecting personnel in performance of site-specific tasks. Engineering controls shall be implemented to reduce and maintain employee exposure to at or below safe levels for those tasks demonstrating known or suspected hazards. TRC will be conducting monitoring as required in the site Health and Safety Plan.

B. Contractor shall employ methods necessary to isolate contaminated soils from non-contaminated soils, including benching.

Adequate measures must be taken to minimize dust and nuisance odors.

C. The excavation may include removing additional soils found to contain residual contamination as directed by TRC based on field screening and post excavation sampling and analyses.

D. TRC will be conducting the field screening and post-excavation sampling and analysis.

E. TRC may direct the Contractor to excavate additional soil from areas beyond the designated excavation limits containing residual product based on the field screening and post-excavation analytical results from this sampling. The Contractor shall perform this Work at the unit prices established.

F. The Contractor shall separate excavated contaminated soil as directed by TRC.

3.3 STORAGE OF EXCAVATED MATERIAL

A. Only clean material to be used as backfill can be stockpiled on-site. Soil shall be stockpiled in accordance with this Section and Section 02100, Article 3.7. Haybales shall be place around the stockpile as per Section 02270.

B. Excavated contaminated soil shall be loaded and immediately transported off-site for proper disposal in accordance with applicable local, state and federal regulations.

C. If a roll-off container must be used for temporary storage (described previously in Section 2.2), the roll-off must be properly secured and covered to prevent any infiltration of stormwater or exfiltration of leachate. In addition, a containment dike shall be constructed around the filled soil roll-off containers.

D. Soils shall be suitably dewatered prior to their leaving the site, to prevent free water from developing during transport to the disposal facility.

3.5 EQUIPMENT AND VEHICLE DECONTAMINATION

A. All tools and any equipment used to handle any contaminated material shall be decontaminated prior to leaving the work area and between areas of excavation. This shall include all tools, heavy machinery, and excavation and hauling equipment used during excavation and handling of contaminated material including the tires, tracks, and under carriages of equipment.

B. The Contractor shall construct a decontamination pad to be used to decontaminate equipment and vehicles exiting from contaminated areas. The Contractor shall be responsible for the maintenance and operation of the decontamination station (decontamination pad and wash down equipment) throughout the duration of the work activities. The Contractor shall provide a collection system for the decontamination pad wash water. The Contractor shall collect all wash water resulting from the decontamination process. At the completion of the project, the Contractor shall dismantle and properly dispose of the decontamination pad and resulting contaminants.

C. The minimum design requirements of the decontamination pad are as follows:

1. Pad shall have adequate size to accommodate the width and length of the largest piece of equipment that will be used in contaminated areas.

2. The pad shall be constructed of 40-mil HDPE geomembrane material or 20-mil scrim reinforced HDPE and non-woven geotextile composite and shall have a minimum 24-inch high supported containment berm around the perimeter.

3. Pad shall be sloped to a low point sump to allow for thorough collection of decontamination water.

D. All decontamination water within the decontamination pad shall be collected, pumped to, and contained in an aboveground secure storage tank used for dewatering. Decontamination water shall be treated off-site in accordance with applicable regulations. The Contractor shall have adequate storage facilities to properly contain all decontamination water. The Contractor shall submit a decontamination water collection and disposal plan as part of the Work Plan described in Section 01020.

E. The decontamination pad shall be removed and disposed of following the completion of Work. The pad shall either be disposed of with other contaminated material or disposed of as conventional rubble if the Contractor can substantiate, through analytical testing, that the debris is not contaminated. Disposal of the debris shall only be allowed following the TRC's review of a confirmatory sampling plan. The Contractor shall submit a decontamination pad disposal plan including all proposed sampling and analysis.

END OF SECTION

SECTION 02950

TRANSPORTATION AND DISPOSAL OF CONTAMINATED MATERIAL

PART 1 GENERAL

1.1 CONTRACT REFERENCES

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION

A. The Contractor shall furnish all labor, material, tools and equipment necessary for the transportation and disposal of contaminated materials.

B. The Contractor is required to recycle/reuse contaminated soil at Out-of-State and/or In-State Recycling Facilities or In-State reuse Facilities instead of disposal at any lined landfill if the excavated material is of acceptable physical quality, (proper gradation, minimal amounts of debris) and chemical quality, and the Contractor can identify a facility willing and permitted to accept the material. Facility acceptance for contaminated soil disposal must be given prior to commencement of excavation activities.

C. The Contractor shall submit all of the information required in Article 3.3B of this Section for the recycling/reuse facility.

1.5 SUBMITTALS

A. The Contractor shall submit to TRC for review, as a single submittal, all pertinent information relating to the transport and disposal of materials specified herein, within 14 days after issuance of the Notice to Proceed. The information submitted shall include, as a minimum:

1. Name and address of all contaminated material transporters to be used to complete project.

2. Massachusetts Department of Transportation Transporter Identification Number and expiration date.

3. Proof of permit, license, or authorization to transport contaminated material in all affected states.

4. Soil recycling/asphalt batch information described in Article 3.3.

1.6 <u>DEFINITIONS</u>

A. Out-of-State Recycling Facility - This type of facility shall be state approved or permitted to accept soil that is defined as a hazardous material in 310 CMR 30.00, but is not classified as either a RCRA characteristic waste or RCRA listed waste as defined in 40 CFR Part 261; soil containing PCBs below the facility's permitted level; and all other soil not permitted or unsuitable for in-state disposal or recycling.

B. In-State Recycling Facility - This type of facility shall be approved by the Commonwealth of Massachusetts to accept soil that is classified as petroleum contaminated soil, that would be classified as a hazardous material in 310 CMR 30.00 if not managed under M.G.L. c.21 E and 310 CMR 40.00; and is not classified as a RCRA characteristic waste or RCRA listed waste as defined in 40 CFR Part 261.

C. Material - Soil, pavement, cobblestones, sorptive pads, ballast, railroad ties, rocks, concrete, pipes, and miscellaneous structures and debris.

1.7 <u>REGULATORY REQUIREMENTS</u>

A. The Work of this Section shall be performed in accordance with all applicable Federal, State, and local regulations, laws, codes, and ordinances governing the handling, transportation, and disposal of contaminated material.

B. The Contractor shall obtain all Federal, State and local permits required for the transport and disposal of contaminated soil. The Contractor shall adhere to all permit requirements.

C. The Contractor shall document that the disposal facilities proposed have all certifications and permits as required by Federal, State and local regulatory agencies to receive and dispose of the contaminated soil.

PART 2 PRODUCTS

2.1 <u>GENERAL</u>

A. All Contractor personnel shall wear personal protective equipment and protective clothing consistent with the levels of protection for this Work as indicated in the Site Specific Health and Safety Plan.

PART 3 EXECUTION

3.1 GENERAL

A. TRC will sign all MADEP bills of lading. All soil material shall be transported under MADEP bills of lading regardless of the chemical quality of the soils. TRC will provide LSP Services and generate all Bill of Ladings prior to transport.

3.2 SOIL CHARACTERIZATION

A. Contractor shall be responsible for characterizing the soil for the purpose of obtaining approvals for final disposal of contaminated material. The Contractor shall be responsible for obtaining approval from the disposal facilities.

3.3 SOIL RECYCLING

A. The soil recycling facility shall be permitted pursuant to 310 CMR 30.00 and 310 CMR 19.00 and shall be a hot mix asphalt plant, thermal processing plant or a cold mix emulsion plant. The facility shall be eligible to accept petroleum contaminated soil without MADEP approval provided that levels of contaminants in the soil are below de minimus levels listed below, and specific levels established in the facility's Class A Recycling Permit.

B. The Contractor shall submit to TRC initial approvals or letters of intent and facility information for the recycling facility selected, within 14 Days of issuance of the Notice to Proceed. The facility information shall include the following:

1. General Information

    a. Facility Name

    b. Facility Address

    c. Name of Contact Person

    d. Title of Contact Person

    e. Telephone Number of Contact Person.

    f. Permit Number.

2. The facility shall specify the volume of material that can be accepted from the site on a weekly and a total basis.

3. The facility shall provide written confirmation that they are permitted to accept and will accept the classified soil of the general quality and quantity described by these Specifications.

4. The facility shall provide a listing of all current and valid permits, licenses, letters of approval, and other authorizations to operate that they hold, pertaining to the receipt and management of the soils or materials specified in this Contract.

5. The Contractor shall submit a complete list of the disposal facility's permitted allowable contaminant levels and physical characteristic requirements for contaminated material, and list any required regulatory approvals for individual waste streams.

6. Soil set for asphalt batching shall not exceed any of the maximum contaminant levels presented below.

Facility Maximum Contaminant Levels			
Contaminant	**Hot Mix Asphalt Plant (mg/kg)**	**Thermal Processing Plant (mg/kg)**	**Cold Mix Emulsion Plant (mg/kg)**
Total Arsenic (As)	30	30	30
Total Cadmium (Cd)	30	11	30
Total Chromium	500	500	500
Total Mercury	10	3	10
Total Lead	1,000	1,000	1,000
Total VOCs	30 to 1,800	30 to 1,800	30 to 1,800
TPH	5,000 to 60,000	5,000 to 6,000	5,000 to 60,000
Total PCBs	<2	<2	<2
Total Halogenated VOCs	5	5	5
Listed or Characteristic Hazardous Waste (TCLP)	None	None	None

3.6 <u>WASTE PROFILES AND MANIFESTS</u>

A. TRC shall be responsible for preparing and submitting all waste profile applications and questionnaires. The Contractor shall be responsible for coordination with disposal facilities and all Federal and State Environmental Agencies.

B. TRC shall be responsible for preparing all Bills of Lading with all applicable analytical backup, notification, and control forms. TRC will provide LSP signature for the Bill of Ladings.

C. The Contractor shall provide certified tare and gross weight slips for each load received at the designated facility which shall be attached to each returned bill of lading.

D. TRC will sign all waste profile applications or questionnaires.

E. The Contractor shall submit to TRC, prior to receiving progress payment, documentation certifying that all materials were transported to, accepted, and disposed of, at the selected disposal facility. The documentation shall include the following, as a minimum.

1. Documentation shall be provided for each load from the site to the disposal facility, including all Bills of Lading and any other transfer documentation as applicable.

2. All documentation for each load shall be tracked by the original Bill of Lading that was prepared by TRC.

3.7 TRANSPORT OF CONTAMINATED MATERIAL

A. The Contractor shall not be permitted to transport contaminated materials off-site until all disposal or recycling facility documentation has been received, reviewed, and accepted by TRC.

B. The Contractor shall transport contaminated materials from the site to the disposal or recycling facility in accordance with all United States Department of Transportation (DOT), USEPA, MADEP regulations and other regulations of all affected states.

C. The Hauler(s) shall be licensed in all states affected by transport.

D. The Contractor shall provide to TRC copies of all weight slips, both tare and gross, for every load weighed and disposed of at the accepted disposal facility. The slips shall be tracked by the original Bill of Lading that was prepared by TRC. Progress payments shall only be made upon receipt of these weight slips.

E. The Contractor shall be responsible for ensuring that free-liquid does not develop during transport. "Wet soils" shall not be loaded for transport. The Contractor shall be responsible to properly dispose of any free liquids that may result during transportation.

END OF SECTION

SECTION 03305

CONCRETE

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

A. Work of this Section, as shown or specified, shall be in accordance with the requirements of the Contract Documents.

1.2 WORK INCLUDED

A. Work of this Section includes all labor, materials, equipment and services necessary to complete the Concrete Work and Oil Resistant Coating as shown on the drawings and specified herein.

1.3 RELATED WORK

A. Section 02630 Storm Drainage System

1.4 QUALITY ASSURANCE

A. Concrete work shall strictly adhere to the weather limitations, curing and finishing criteria set forth in this Section of the Project Specifications.

1.5 SUBMITTALS

A. Submit the concrete mix design for the type specified for review and approval prior to any materials being delivered to the site.

PART 2 PRODUCTS

2.1 MATERIALS DEFINITIONS

A. Concrete shall be air-entrained ready-mixed concrete, 3500 psi twenty-eight (28) day compressive strength, and conform to AASHTO Designation M-85 and the following.

All cement shall be Portland Cement, Type I or II, conforming to AASHTO Designation M-85. Cement shall be by an American manufacturer.

B. Fine Aggregate (sand) shall conform to AASHTO Designation M-6 having clear, hard, durable, uncoated grains, free from deleterious substances and shall range in size from fine to coarse within the following percentages by weight:

Passing 3/8" Sieve	100%
Passing No. 4 Sieve	95% – 100%
Passing No. 16 Sieve	45% - 85%
Passing No. 50 Sieve	10% - 30%
Passing No. 100 Sieve	2% - 10%

C. Coarse Aggregate shall conform to AASHTO Designation M-80 and shall be free of deleterious matter or coatings and gradation shall be within the following percentage by weight:

Passing 11/2" Sieve	100%
Passing 1" Sieve	95% – 100%
Passing 2" Sieve	25% - 60%
Passing No. 4 Sieve	0% - 10%

D. Water shall be clean and shall not contain any oil, acid, alkali, salts, vegetable matter, organic matter or other deleterious substances.

E. Oil Resistant Coating shall be Amercoat 66, Polyamide-cured epoxy, as manufactured by Ameron or approved equal.

PART 3 EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions where Concrete Work is to be installed and notify TRC of conditions detrimental to the proper and timely completion of the

Work. Do not proceed with the Work until satisfactory conditions have been corrected by the Contractor in a manner acceptable to TRC.

3.2 <u>INSTALLATION</u>

A. Method of Construction

1. There shall be no less than six (6) sacks of cement per cubic yard. The Concrete shall contain no more than six (6) gallons of water per sack of cement, and shall produce a slump of not more than four (4) inches. Air Content shall be 7% (± 1%).

2. Weather Limitations

(a) Cold Weather Concreting - When the ambient temperature is above 40 degrees F, the plastic concrete shall have a temperature of at least 50 degrees F, at the time of placing. When the ambient temperature is 40 degrees F or below, the plastic concrete shall have a temperature of at least 60 degrees F. Concrete shall not be placed when the ambient temperature is less than 10 degrees F.

Maintenance of at least the minimum temperature shall be accomplished by heating the water or the aggregates, or both, as necessary. Heating methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. Heating shall be in accordance with the ACI 306, Part 2.2 through 2.6.

(b) Hot Weather Concreting - When the ambient temperature reaches 75 degrees F, the plastic concrete shall have a temperature of no more than 90 degrees F, at the time of placing, and one or more of the following precautions shall be followed:

(1) During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 may be required. When air temperature is between 85° F (30° C) and 90° F (32° C), reduce mixing and delivery time from 1.5 hours to 75

minutes, and when temperature is above 90° F (32° C), reduce mixing and delivery time to 60 minutes.

(2) Use a water reducing retarder as per manufacturer's recommendation. When more than one admixture is used, they shall be from the same manufacturer.

(3) Sprinkle coarse aggregate stockpile to cool by evaporation.

(4) Place concrete in compliance with ACI 305 and as herein specified. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90° F (32° C). Mixing water may be chilled, or chopped ice may be used to control temperature provided water equivalent of ice is calculated to total amount of mixing water.

(5) In the case of truck mixing, do not rotate the drum during and after the addition of cement to the mix until mixing water is added at the construction site. This may require reduced loads or the utilization of horizontal type mixers.

(6) Prevent absorption by sprinkling subgrade and wood forms just before placing so that they will not absorb water from the mix.

(7) Erect windbreaks to prevent winds from drying exposed concrete surfaces while they are being finished.

(8) Screed and float concrete as it is placed and start curing immediately.

3. Concrete shall be deposited within thirty (30) minutes after mixing, as nearly as practicable, in its final position to avoid segregation due to rehandling or flowing.

4. Provide proper chutes, troughs and other devices to convey concrete to the various levels. In no case shall concrete be deposited from a height that will separate the aggregates.

5. In placing concrete around reinforcement, care shall be taken to work the concrete well around and into thorough contact with the steel and not disturb the reinforcement. Mechanical vibrators shall be used to insure consolidation, but over-vibrating which may cause segregation shall be avoided.

B. Curing

1. General

a. Comply with all the requirements of ACI 301.

b. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

c. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.

d. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.

2. Curing Methods: Perform curing of concrete by curing and sealing compound, by moist curing, by moisture-retaining cover curing, and by combinations thereof, as herein specified.

a. Provide moisture curing by following methods:

(1) Keep concrete surface continuously wet by covering with water.

(2) Continuous water-fog spray.

(3) Covering concrete surface with specified absorptive cover, thoroughly saturating cover with water and keeping continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent absorptive covers.

b. Provide moisture-cover curing as follows:

(1) Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3" and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

c. Liquid membrane curing meeting the requirements of AASHTO Designation M-148 may be used upon approval of TRC.

C. Finishing

1. As soon as the face forms are removed, all fins and other projections shall be carefully removed and offsets leveled, and rubbed with carborundum where necessary. Pointing and filling voids shall be performed only when approved by TRC.

D. Oil Resistant Coating

1. All concrete surfaces to be coated must contain no additives or hardeners, and should not be treated with sealers or conventional curing compounds containing waxes, silicones, or silicates.

2. Do not use form release agents based on oils, which will deposit a residue on the concrete.

3. All surface preparation and installation shall be in accordance with the manufacturer's recommendations.

END OF SECTION

SECTION 02935

LANDSCAPING

PART I GENERAL

1.1 CONTRACT REFERENCES

A. Attention is directed to the CONTRACT AND GENERAL COMMENTS and all Sections within DIVISION 1 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly, or system, other than those named or described in this Section, shall be determined in accordance with the provisions of the Contract and General Conditions.

1.2 DESCRIPTION

A. The Contractor shall furnish all materials, labor, supervision, tools and equipment necessary to provide temporary and permanent grass vegetative covers in all areas disturbed by the Work.

1.3 WORK INCLUDES

A. Seeding, mulching and fertilizer.

1.4 RELATED SECTIONS

A. Section 01070 - Reference Standards.

B. Section 01300 - Submittals.

C. Section 01400 - Quality Control.

D. Section 02221 – Earthwork.

E. Section 02270 – Sedimentation and Erosion Control.

1.5 DEFINITIONS

A. Weeds: Include Dandelion, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.6 SUBMITTALS

A. Submittals shall be provided under provisions of Section 01300.

B. A manufacturers' Certificate of Compliance to the Specifications shall be supplied with each shipment of seed. These certificates shall include the percentages of purity, weed content, germination of the seed, and also the net weight and date of shipment. If the Contractor is unable to obtain a certificate, the specification information from the seed container shall be submitted.

C. A copy of certificates of analysis for each type of fertilizer shall be submitted prior to application.

D. Certification that the mulch bales contain less than 10 percent weeds.

1.7 QUALITY ASSURANCE

A. Seed mixtures shall be supplied in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.8 REGULATORY REQUIREMENTS

A. The Contractor shall comply with regulatory agencies for fertilizer composition.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Grass seed mixtures shall be delivered and stored in sealed containers. Seed in damaged packaging will not be acceptable.

B. Fertilizer shall be delivered in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.10 SCHEDULING AND SEQUENCING

A. Application of permanent seed shall be performed within one of two planting windows: from April 1 to June 1 or from August 15 to October 15. The actual work shall be done, however, only during periods within these seasons which are normal for such work as determined by weather conditions and by accepted practice in this locality.

B. If permanent seed cannot be planted by October 15, the Contractor shall incorporate winter rye grass into the seed mixture to establish a temporary winter mixture.

C. Planting of either temporary or permanent seed shall commence within 10 days of soil preparation. Once started, the planting operation shall continue until all areas have been planted, except for periods when the soil is too wet to continue the operation. If downtime occurs because of soil conditions, planting shall resume as soon as the soil is suitable for planting.

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Seed mixture: Seed mixture shall be fresh, clean, new crop seed. Grass shall be of the previous year's crop and in no case shall the weed content exceed 15 percent by weight. The seed shall allow for optimal growth and rooting. The mixture shall be furnished in new, clean, sealed and properly labeled containers. Seed which has become wet, moldy otherwise damaged are not acceptable.

2.2 FERTILIZER

A. Fertilizer shall be a complete food recommended for grass, with fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil. The fertilizer shall have the following proportions by weight: Nitrogen 10 percent, phosphorus acid 20 percent, soluble potash 20 percent. The material shall conform to the Association of Official Agricultural Chemists, uniform in composition, dry, free-flowing, and delivered to the site in original, unopened containers bearing the manufacturer's guaranteed analysis.

2.3 ACCESSORIES

A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable.

PART 3 EXECUTION

3.1 EXAMINATION

A. The Contractor shall be deemed to have inspected the site and satisfied himself as to actual grades and levels and true conditions under which the work will be performed.

B. The Contractor shall verify that existing plant life designated to remain is tagged or identified. Trees, plant growth, and features designated to remain as final landscaping shall be protected.

C. Utilities that remain shall be located, identified, and protected from damage.

D. Bench marks, survey control points, and existing structures shall be protected from damage or displacement.

E. The work area shall be free of standing water and shall be dry.

3.2 PREPARATION OF SUBSOIL

A. Subsoil shall be graded to eliminate uneven areas and low spots. Lines, levels, profiles and contours shall be maintained. Changes in grade shall be gradual and slopes shall be blended into level areas.

B. Foreign materials, weeds and undesirable plants and their roots shall be removed.

3.3 LIME AND FERTILIZING

A. Fertilizer and lime shall be applied after smooth raking of topsoil and prior to roller compaction.

B. Fertilizer and lime shall be applied in accordance with manufacturer's instructions. Application rates shall be selected based on soil test results taken at the time of seeding. If soil tests are not taken, the following minimum amounts shall be applied:

1. Lime at 2 tons per acre or 100 pounds per 1,000 square feet.
2. Nitrogen at 40 pounds per acre or 1 pounds per 1,000 square feet.
3. Phosphate at 80 pounds per acre or 2 pounds per 1,000 square feet.
4. Potash at 80 pounds per acre or 2 pounds per 1,000 square feet.

C. Lime and fertilizer shall be mixed thoroughly into the upper 2 inches of soil and lightly watered to aid the dissipation of fertilizer.

3.4 SEEDING

A. Seed shall not be applied at the same time as fertilizer or with same machine used to apply fertilizer. Seeding shall not occur immediately following rain, when ground is too dry, or during windy periods.

B. Seed shall be sowed in accordance with Standard Specifications for Highways and Bridges, Commonwealth of Massachusetts, Highway Department (current edition). Seeding shall be performed using the following application rates:

1. Bird's-foot trefoil with inoculant at 8 pounds per acre.
2. Crown vetch with inoculant at 15 pounds per acre.

3. Creeping red fescue at 20 pounds per acre.

4. Annual ryegrass at 10 pounds per acre.

C. For seeding that occurs after October 15, winter rye grass shall be included in the seed mix as a temporary winter cover. Rye grass shall be applied at a rate of 50 pounds per acre.

D. Areas seeded shall not exceed that which can be mulched on same day. If hydroseeding is not used, then the seeded area shall be rolled with roller not exceeding 112 lbs per foot of width.

E. Mulch shall be applied immediately following seeding and compacting and applied to a thickness of 1/8 inches.

F. Water shall be applied to the seeded areas with a fine spray immediately after each area has been mulched.

3.5 PROTECTION OF FINISHED WORK

A. Finished work shall be protected under provisions of Section 01700. Areas subjected to vehicular traffic during construction shall be reshaped and re-compacted.

3.6 FIELD QUALITY CONTROL

A. Eight weeks after seeding is complete and on written notice from the Contractor, TRC will determine if a satisfactory stand has been established. TRC shall make this determination within 15 days from receipt of notice.

B. If a satisfactory stand has not been established, the Contractor shall immediately replant areas that do not meet satisfactory stand requirements. Should additional replanting be required to meet coverage requirements specified herein, TRC may elect to withhold a portion of the Contractor's payment necessary to replant those remaining areas. The cost of this replanting shall be based on cost estimates from two independent contractors.

END OF SECTION

APPENDIX C

SOIL REMOVAL ESTIMATES

Table C-1: Calculations of Estimated Soil Removal in the Eastern Parking Lot

Depth Interval	Length (feet)	Width (feet)	Square Feet	Cubic Feet	Cubic Yards	Tons
Contaminated Soil Removal						
6-10 feet	175	50	8,750	35,000	1,296	1,944
4-8 feet	58	50	2,900	11,600	430	644
4-10 feet	56	61	3,416	20,500	760	1,140
Totals=				**67,100**	**2,490**	**3,730**
Clean Soil (to be used as backfill)						
0-4 feet	116	50	5,800	23,200	859	1,289
0-6 feet	175	52	9,100	54,600	2,022	3,033
Totals=				**77,800**	**2,880**	**4,330**

APPENDIX D

HEALTH AND SAFETY PLAN

SITE HEALTH AND SAFETY PLAN
LOCKHEED MARTIN FACILITY
50 FORDHAM ROAD
WILMINGTON, MASSACHUSETTS

Volume II

Prepared by:

TRC Environmental Corporation
Boott Mills South
Foot of John Street
Lowell, MA 01852
(978) 970-5600

Revision 1
July 2000

Site Health and Safety Plan
Lockheed Martin Facility
50 Fordham Road
Wilmington, Massachusetts

The material and data in this report were prepared under the supervision and direction of the undersigned.

Gary Ritter, C.I.H.
Corporate Health and Safety Coordinator

Paula Macchiaroli
Project Manager

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VOLUME II

TRC Standard Operating Procedures

1.0 INTRODUCTION AND SCOPE

1.1 Introduction

This Health and Safety Plan (HASP) was developed to protect worker health and safety during implementation of remedial response activities on behalf of Lockheed Martin Corporation at the facility located at 50 Fordham Road in Wilmington, Massachusetts. The site includes one small and three large buildings, a paved parking area, and a wastewater treatment facility.

The proposed work involves the following tasks:

1. Operations and maintenance of the remedial system

2. Ground water and remedial system sampling and analysis

3. Soil excavation

4. Installation of subsurface remedial system

5. Soil and rock drilling and monitoring well installation

1.2 Organization

This HASP is organized as follows:

Section 1: Introduction

Section 2: Key Personnel

Section 3: Chemical Hazards

Section 4: Physical Hazards

Section 5: Standard Air Monitoring Plan

Section 6: Standard Site Controls and Worker Protection

Section 7: Standard Decontamination Procedures

Section 8: Training Requirements

Section 9: Emergency Response Plan

Section 10: Task Specific Hazard Analysis

1.3 Site Identification

Refer to Drawing 1 in the remedial implementation plan for building locations, and other site features.

1.4 Scope

This Health and Safety Plan (HASP) was developed to protect workers at the former GE facility during implementation of remedial response activities. The HASP is based on current Occupational Safety and Health Administration (OSHA) regulations (29 CFR 1910.120), and an evaluation of existing data derived from previous assessment activities. This document is only intended as an aid to employees who perform the tasks identified in this HASP. A discussion of task specific safety procedures is included in Section 9 of this document.

1.5 Site Background

The former Lockheed Martin facility located at 50 Fordham road is an approximately 13 acre parcel of land situated east of Fordham Road and north of Concord Street within an industrial part in Wilmington and North Reading, Massachusetts. General Electric (GE) Company's Aerospace Division occupied the property from 1968 to 1989. GE Aerospace was acquired by Martin Marietta on April 2, 1993 which later became Lockheed Martin Corporation (LMC) on March 15, 1995. AMETEK Aerospace Products, Inc. (AMETEK) is the existing operator of the 50 Fordham Road property. The site (DEP disposal site number 3-0518) has a Tier 1A permit (permit number 83052).

A map of the facility is presented on Drawing 1. Predominant man-made structures include one small and three large buildings (designated Buildings 1, 1A, 2 and 3) situated on the western side of the property; a large paved parking area located on the eastern side of the property; and a wastewater (sewage) treatment facility located north of the parking area.

A variety of investigations were conducted at the 50 Fordham Road site between 1990 and 1992. These investigations indicated the following four major impacted areas on the property;

- Tank Farm Area (soil and groundwater impacted with chlorinated solvents and Stoddard solvent-related BTEX compounds).

- Eastern Parking Lot (unsaturated soil, saturated soil and groundwater impacted with these chlorinated solvents, Stoddard solvent-related BTEX compounds, and a thin layer of separate phase Stoddard solvent on the water table. Impacted groundwater from the Tank Farm appears to extend from the Tank Farm, beneath the Eastern Parking Lot, and off-property in both the bedrock and overburden aquifers).

- Tank K (soil impacted with gasoline-related BTEX compounds).

- Outfall 001 (sediment impacted with total petroleum hydrocarbons and metals).

This HASP has been revised to address remedial response activities consisting of biosparging/SVE system installation, soil excavation/disposal, and deep bedrock groundwater investigation. All field activities will be conducted in accordance with TRC Standard Operating Procedures (SOPs) presented in Volume II.

2.0 KEY PERSONNEL AND ASSIGNMENT RESPONSIBILITIES

2.1 Project Manager

The project manager for this project is Paola Macchiaroli. The project manager has the overall project responsibility for the development, coordination, and implementation of the project field work in a safe manner, and is the central point of contact with regulatory agencies. The project manager is responsible for implementing the steps of the workplan and the HASP, as well as supervising the field team members. In addition, she is responsible for consulting with health and safety coordinator and with the site safety coordinator regarding any changes that may affect the health and safety of the field team members.

2.2 Corporate Health and Safety Coordinator

The corporate health and safety coordinator for the project is Gary Ritter, C.I.H., L.S.P. The health and safety coordinator has the overall responsibility for the development, coordination, and implementation of the HASP and its conformance with TRC's health and safety program. This includes the medical surveillance program, training requirements, monitoring procedures, etc. The health and safety coordinator shall work with the project manager and the site safety coordinator on modifications to the site HASP and will be available for consultation as necessary.

2.3 Site Safety Coordinator

The site safety coordinator (SSC) is responsible for ensuring compliance with the site HASP, including health and safety procedures for work sites, monitoring and recording of conditions, personal protective equipment and clothing, and consulting with the regional health and safety coordinator regarding the HASP. The SSC will also conduct and document attendance at daily safety meetings, perform periodic site inspections, and ensure that subcontractors have received appropriate training.

2.4 Field Personnel

Field personnel are responsible for understanding and adhering to this HASP, and should also be alert to any unsafe conditions or practices which may affect their safety. Any safety deficiencies will be communicated to the site safety coordinator. If personnel safety is threatened, the site safety coordinator, project manager, or regional health and safety coordinator will be contacted immediately.

2.5 Subcontractors and Third Parties

Equipment operators, laborers, and other parties subcontracted by TRC will be responsible for understanding and complying with all site safety requirements. TRC will perform air monitoring and establish decontamination areas. However, subcontractors and third parties engaged in work at this site will be required to provide their own work equipment and personal protective gear. Subcontractors will also be required to provide TRC with documentation that their employees have completed the OSHA-required 40-hour off-site training program and 24 hr. field training (and the annual refresher course, if appropriate) prior to working on this project. Supervisors must also have completed 8 hours of supervisory training before being allowed to manage employees on-site.

This plan will be provided to subcontractors as a hazard communication tool in compliance with 29 CFR 1910.1200. Subcontractors are required to provide their own task specific safety program for their portion of the work. Subcontractors are also required to attend the daily safety meetings.

3.0 CHEMICAL HAZARDS

Previous site investigations have documented the presence of benzene, ethylbenzene, toluene, xylenes (BTEX), chlorinated solvents, gasoline, and Stoddard solvent, a petroleum hydrocarbon.

Table 3-1
Detected Chemicals

Substance	Concentrations (groundwater)	Soil
Trichloroethylene (TCE)	<1 mg/L (ppm)	<1.0 mg/kg
Tetrachloroethylene (PCE)	<1 mg/L (ppm)	2.8 mg/kg (ppm)
Vinyl Chloride	<1 mg/L (ppm)	<1.0 mg/kg (ppm)
1,2-Dichloroethene (1,2-DCE)	<1 mg/L (ppm)	<1.0 mg/kg (ppm)
1,1-Dichloroethene (1,1-DCA)	<1 mg/L (ppm)	<1.0 mg/kg (ppm)
Hydrogen Sulfide	Infrequent detection in some sample headspace	
Carbon Disulfide	Infrequent detection in some groundwater samples	
Stoddard Solvent	Free Phase Liquid	
Gasoline	Sheen	
Benzene	2.3 mg/l (ppm)	2.7 mg/kg (ppm)
Ethylbenzene	2.0 mg/l (ppm)	14.0
Toluene	22.0 mg/l (ppm)	9.3
Xylene	26.0 mg/l (ppm)	94.0

These chemicals are expected to be encountered in trace concentrations in groundwater and adhered to soil particles. Potential worker exposure to these chemicals could occur through inhalation, ingestion, or absorption. Ingestion and absorption will be controlled through the use of personal protective clothing and decontamination procedures. Inhalation hazards will be controlled through the use of engineering controls and respiratory protection.

Stoddard solvent is a mixture of volatile compounds and is also called dry cleaning solvent, mineral spirits, petroleum naptha and spotting naptha. It has a flash point between 102-110 °F and therefore is a Class II combustible liquid. The TLV is 100 ppm and overexposure can damage the kidneys, irritate the eyes and cause narcosis. Response to a PID or FID could vary depending on the manufacturer of the solvent.

MSDS for chemicals brought on-sight are located in Appendix H.

3.1 Acute Health Effects

Table 3-2 summarizes the known health effects of the chemicals encountered at this site. The table includes significant routes of exposure, health effects, and target organs for the pure forms of the chemicals that have been encountered or are suspected to be present on site.

The current permissible exposure limits (PELs) for the detected chemicals are also shown on Table 3-2, as are the NIOSH Recommended Exposure Levels (RELs). PELs are the maximum allowable concentration for an 8-hour work period, while RELs are developed based on a 10-hour work period. The RELs will be used to determine when workers are being exposed to airborne concentrations that may lead to adverse health effects. If these concentrations are exceeded, engineering controls will be implemented to reduce employee exposure. If exposure continues above these levels, employees will be provided with respiratory protection. The inhalation hazard action levels outlined in Section 5.2 are based on the OSHA PELs in Table 3-2.

3.2 Chronic Health Effects

Perchloroethylene and trichloroethylene are suspected human carcinogens, and vinyl chloride and benzene are known human carcinogens. Exposure to these compounds must be kept to an absolute minimum. The maximum detected concentrations (Table 3-1), however, are much lower than the PELs listed in Table 3-2, so occupational overexposure during this project is considered unlikely. All workers must follow the safety procedures included in this document to minimize any exposure potential.

Table 3-2
Health Effects

Chemical Name	CAS Number	Exposure Limits	IDLH Value	Carcinogenicity	Routes of Exposure	Physical Properties	Health Effects
Benzene C_6H_6	71-43-2	REL: 0.1 ppm PEL: 1 ppm STEL: 5 ppm TLV=0.5	500 ppm	YES	Inhalation, absorption, ingestion, and contact	(FP) 12° F (VP) 75 mm (IP) 9.25 eV	**ACUTE:** Irritation to eyes, nose, respiratory system; giddy, headache; nausea; staggered gait; fatigue; abdominal pain **CHRONIC**: Causes anorexia, lassitude, dermatitis, and Leukemia
Carbon Disulfide CS2	75-15-0	REL: 1 ppm PEL: 20 ppm Ceiling: 30 ppm TLV=10	500ppm	N/A	Inhalation and contact	(FP) 22° F (VP) 300 mm (IP) 10.06 eV	**ACUTE**: Dizziness, headache, fatigue, nervousness
1,1 Dichloroethane $CHCl_2CH_3$	75-34-3	REL: 100 ppm PEL: 100 ppm STEL: NA	3,000 ppm	N/A	Inhalation, contact and ingestion	(FP) 22° F (VP) 230 mm (IP) 11.06	**ACUTE**: Central nervous system depression, irritation of upper respiratory tract and skin **CHRONIC**: Liver and kidney damage
1,2 Dichloroethene	107-06-2	REL: 200 ppm PEL: 200 ppm STEL: NA	1,000 ppm	N/A	Inhalation, contact and ingestion	(FP) 36 - 39° F (VP) 180-265 mm (IP) 9.65 eV	**ACUTE**: Inhalation causes nausea, vomiting, weakness, tremor, intestinal cramps, central nervous depression. Liquid causes irritation of eyes and skin. Ingestion causes slight depression to deep narcosis.
Ethylbenzene $CH_3CH_2C_6H_5$	100-41-4	REL: 100 ppm PEL: 100 ppm STEL: 125 ppm	800 ppm	N/A	Inhalation, contact, and ingestion	(FP) 59° F (VP) 7.1 mm (IP) 8.76 eV	**ACUTE**: causes irritation of the eyes, mucous membranes, headaches, dermatitis, narcosis, and coma.
Hydrogen Sulfide H_2S	7783-06-4	Ceiling: 10 ppm TLV=5	100 ppm	N/A	Inhalation and contact	(FP) NA (VP) 20 atm (IP) 10.43 eV	**ACUTE**: Olfactory fatigue, apnea, dizziness, headache, irritation of the eyes, convulsions, coma
TetrachloroethyleneCl_2 $C=CCl_2$	127-18-4	REL: Ca PEL: 100 ppm Ceiling: 200 ppm TLV=25	150 ppm	YES	Inhalation, absorption and , ingestion	(FP) NE (VP) 14 mm (IP) 9.32 eV	**ACUTE**: Vapors can effect central nervous system and cause anesthesia. Liquid may irritate skin after prolonged contact **CHRONIC**: Liver/kidney damage
Toluene $C_6H_5CH_3$ (o;m;p-isomers)	108-88-3	REL: 100 ppm PEL: 200 ppm STEL: 150 ppm TLV=50	500 ppm	N/A	Inhalation, ingestion, and contact	(FP) 40° F (VP) 22 mm (IP) 8.82 eV	**ACUTE**: Fatigue, weakness, confusion, euphoria, dizziness; headache; dilated pupils, nervousness, muscle fatigue; insomnia, dermatitis, photophobia, pubmonary edema

Table 3-2
Health Effects

Chemical Name	CAS Number	Exposure Limits	IDLH Value	Carcinogenicity	Routes of Exposure	Physical Properties	Health Effects
Trichloroethene	79-01-6	REL: Ca PEL: 100 ppm Ceiling: 200 ppm TLV=50	1,000 ppm	N/A	Inhalation, absorption, and ingestion	(FP) 90° F (VP) 50 mm (IP) 9.47 eV	**ACUTE**: Causes irritation of eyes, nose, throat, nausea, blurred vision. Defatting of the skin may cause dermatitis **CHRONIC**: Final disturbance of central nervous system resulting in cardiac failure, damage to the liver and kidneys.
1,1,1 Trichloroethane	71-55-6	REL: NA PEL: 350 ppm	700 ppm	N/A	Inhalation, absorption and ingestion	(FP) NA (VP) 100 mm (IP) 11.0 eV	**ACUTE**: Loss in equilibrium to loss of consciousness, nausea if ingested, dermatitis of skin and slightly irritation to the eyes. **CHRONIC**: Irritation of the skin
Vinyl Chloride CH_2=CHCl	75-01-4	REL: Ca PEL: 1 ppm Ceiling: 5 ppm	NE	YES	Inhalation	(FP) 108° F (VP) 2580 mm (IP) 9.95 eV	**ACUTE**: Weakness, abdominal pain, and gastrointestinal bleeding **CHRONIC**: Bone Degeneration in fingers; jaundice; tingling sensation in hands and feet, and angiosarcoma of liver
Xylene $C_6H_4(CH_3)_2$ (o;m;p-isomers)	1330-20-7	REL: 100 ppm PEL: 100 ppm STEL: 150 ppm	900 ppm	N/A	Inhalation, ingestion and contact	(FP) 90/84/81° F (VP) 7/9/9 mm (IP) 8.56/8.56/8.44 eV	**ACUTE**: Dizziness, excitement, drowsiness, incoordination, staggering, irritation of the eyes, nose, throat; corneal vacuolation; anorexia, nausea, vomiting, abdominal pain, dermatitis.
Stoddard Solvent	8052-41-3	REL: 350 ppm PEL: 500 ppm Ceiling: 1800 ppm	20,000 ppm	N/A	Inhalation, ingestion and contact	(FP) 102-110°F (VP) N/A (IP) N/A	**ACUTE**: Irritation to eyes, nose, throat; dizziness; dermatitis; chemical pneumonia. **CHRONIC**: Kidney damage in animals
Gasoline	8006-61-9	REL: Ca PEL: NA	NE	YES	Inhalation, absorption, ingestion and contact	(FP) 45° F (VP) 38-300 mm (IP) N/A	**ACUTE**: Eye mucous membrane, and skin irritation; dermatis; headache, fatigue, blurred vision, dizziness, confusion, slurred speech, chemical pneumonia. **CHRONIC**: possible liver and kidney damage

Notes:

N/A	Not Available
TWA	Time Weighted Average
STEL	Short Term Exposure Limit, do not exceed for more than 15 minutes
IP	Ionization Potential, in eV
IDLH	Immediately Dangerous to Life or Health
Ca	Possible Carcinogen, keep exposure as low as possible
FP	Flash Point
VP	Vapor Pressure
Ceiling	Ceiling Limit, not to be exceeded
REL	Recommended Exposure Level (NIOSH)
TLV	AGIH Threshold Limit Values

References:
1. Code of Federal Regulations, Title 29, 1910.1000
2. National Institute for Occupation Safety and Health, 1997

Poket Guide to Chemical Hazards, DHHS (NIOSH) Publication

4.0 PHYSICAL HAZARDS

Physical agents that site workers can reasonably be expected to encounter, and mitigation measures to reduce effects of these agents, are discussed below. Other hazards such as weather conditions, insects, poison ivy, and Lyme Disease (Appendix I) will be evaluated daily on an as-needed basis by the SSC.

4.1 Heat Stress

There is a potential for heat stress from the use of protective clothing and climate conditions. One or more of the following procedures may be employed to alleviate potential heat stress problems in the event that site conditions warrant the use of personal protective equipment (PPE), or ambient temperatures exceed 85° F. Heat stress training must be emphasized during the daily safety meetings, and adequate supplies of potable water must be provided to workers each day.

4.1.1 General Precautions

Provide plenty of liquids. To replace body fluids (water and electrolytes) lost because of sweating, use a 0.1 percent saltwater solution, more heavily salted foods, or commercial drink mixes. The commercial mixes may be preferable for those employees on a low sodium diet.

In extremely hot weather, conduct operations in early morning or evening and rotate shifts of workers wearing impervious clothing. Install mobile showers and/or hose-down facilities to reduce body temperature and cool protective clothing.

Ensure that adequate shelter is available for breaks to protect personnel against heat, etc., which can decrease physical efficiency and increase the probability of accidents.

Acclimatization for workers not accustomed to working in elevated temperature environments will be considered and implemented as appropriate.

4.1.2 Heat Stress Monitoring

For monitoring the body's recuperative ability toward excess heat, one or more of the following techniques should be used as a screening mechanism. Monitoring of personnel wearing impervious clothing should commence when the ambient temperature is 70° F or above. Frequency of monitoring should increase as the ambient temperature increases or as slow recovery rates are indicated. When temperatures exceed 80° F, regardless of the use of PPE, workers will be monitored for heat stress after every work period.

Good hygienic standards must be maintained by the employee to aid in the prevention of heat stress illnesses. Frequent change of clothing and daily showering at a minimum should occur with clothing being allowed to dry during rest periods. Persons who notice skin problems should immediately inform their supervisor.

1. Heart rate (HR) should be measured by the radial pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats/minute. If the HR is higher, the next work period should be shortened by 25 percent. The HR is then measured again, once each minute for 2 minutes, (a total of three measurements) after the initial rest period measurement. The HR should decrease by ten beats per minute between each measurement (a total reduction of 20 beats). If the HR does not decrease, the work period should be reduced by 25 percent.

2. Body temperature can be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature (OT) at the beginning of the rest period should not exceed 99° F. If it is greater than 99° F, the next work period should be shortened by 25 percent. OT should be measured again at the end of the rest period to make sure that it has dropped below 99° F.

4.1.3 Effects of Heat Street

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat loading, a number of physical reactions can occur. The severity of these reactions ranges from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to severe (fatal).

Heat-related illnesses include:

- **Heat rash** (also known as prickly heat rash) is caused by continuous exposure to heat and humid air and aggravated by chafing clothes. Heat rash decreases the ability to tolerate heat as well as being a nuisance. Signs are a red prickly-like rash.

  FIRST AID: Employees exhibiting signs of heat rash will be directed to shower and change to clean, dry clothing.

- **Heat cramps** are caused by profuse perspiration with inadequate fluid intake and electrolyte replacement (especially salts). Signs are muscle spasms and pain in the extremities and abdomen and may occur several hours after work has stopped.

  FIRST AID: Employees showing signs of heat cramps will be directed to lie in a cool, shady area, and drink cool fluids. If symptoms persist or worsen the employee will be transported to an emergency facility.

- **Heat exhaustion** is caused by increased stress on various organs to meet increased demands to cool the body. Signs are shallow breathing; pale, cool, moist skin; profuse sweating; dizziness and lassitude.

  FIRST AID: Employees with signs of heat exhaustion will be brought to cool, shady location and given fluids. After recovering, the employee will be dismissed for the day. If victim is unconscious, or conditions persist, the victim will be transported to a hospital.

- **Heat stroke** is the most severe form of heat stress. The body must be cooled immediately to prevent severe injury and/or death. Signs and symptoms are red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and/or coma.

  FIRST AID: HEAT STROKE IS A MEDICAL EMERGENCY. The victim will be brought to a cool area, aggressively treated by removing constricting clothes and applying wet towels or ice packs, and transported without delay to an emergency facility.

4.2 Cold Stress

Ambient air temperatures during site activities may create cold stress for on-site workers. Procedures for recognizing and avoiding cold stress must be followed. Cold stress can range from frostbite to hypothermia. The signs and symptoms of cold stress are listed below.

- **Frostbite** is defined as the actual freezing of one or more layers of skin. In severe cases, organs and structures below the skin can become frozen. Usually, body areas exposed to the most cold, and least body warmth, are affected first. These areas include fingers, toes, ears, and the tip of your nose. Frostbite is characterized by pain and loss of dexterity in the affected limb. The tissue initially appears reddened, but my progress to white, blue, or black.

  FIRST AID: Bring the affected employee indoors and call the local emergency clinic. Rewarming of frost-bitten parts are best left to a medical doctor in a controlled setting.

- **Hypothermia** is the condition that occurs when the body's natural warming mechanisms (muscle activity and shivering) cannot counteract the loss of body heat to the environment. The onset of hypothermia is greatly hastened by being wet. Hypothermia is marked by severe, uncontrollable shivering. The patient will show signs of excessive fatigue, drowsiness, irritability, or euphoria. As hypothermia progresses, the patient will begin to lose consciousness, blood pressure will drop, shivering will cease, and the patient may slip into a coma and possible die.

  FIRST AID: If these symptoms occur, remove the patient to a warm, dry place. If clothing is wet, remove and replace with dry clothing. Keep the patient warm, but not overheated. The patient should be gradually rewarmed to prevent shock. If the patient is conscious and alert, warm liquids should be provided. Coffee and other caffeinated liquids should be avoided because of diuretic and circulatory effects. Notify the emergency clinic; if conditions worsen, the patient loses consciousness, or the patient has an altered mental status have the patient transported to an emergency facility.

4.2.1 General Precautions

The reduction of adverse health effects from cold exposure can be achieved by adopting the following work practices.

- Provide adequate insulating clothing to maintain core temperature at 98.6° F if work is to be performed in air temperatures below 40° F. Wind chill cooling rates and the cooling power of air are critical factors. The higher the wind speed and the lower the air temperature in the work area, the greater the insulation value of the protective clothing should be.

- If the air temperature is 32° F or less, hands should be protected by mittens.

- If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of clothing should be impermeable to water. With more severe work under such conditions, the outer layer should be water repellent, and the outer layer should be changed as it becomes wetted. The outer garments should include provisions for easy ventilation in order to prevent wetting of the inner layer by sweat.

- If available clothing does not give adequate protection to prevent cold injury, work should be modified or suspended until adequate clothing is available, or until weather conditions improve.

- For prolonged work, heated shelters should be available. Workers should be encouraged to use these at regular intervals, with the frequency depending on the severity of the environmental exposure. When entering the shelter, the outer layer of clothing should be removed and the remainder of the clothing loosened to permit heat evaporation, or a change of work clothing should be provided.

- Warm, sweet drinks, such as hot cocoa or soup, should be available at the work site to provide caloric intake and fluid volume. The intake of coffee should be limited because of diuretic and circulatory effects.

- The weight and bulk of cold-weather gear should be included in estimating the required work performance and weights to be lifted in the field.

Workers should be instructed in safety and health procedures regarding cold work environments as part of the pre-work safety meeting. The training program should include instruction in preventing, recognizing, and treating cold stress conditions.

4.3 Noise

The effects of noise include psychological effects (interference with communication by speech, job performance, and safety) and physiological effects, such as temporary and permanent hearing loss.

The factors that affect the degree and extent of hearing loss are intensity or loudness of the noise, type of noise, period of exposure of each day, total work duration, and distance from the noise source.

There is a potential for exposure to loud noise associated with heavy equipment, such as drill rigs. To safeguard workers, all personnel will be provided with disposable earplugs when working around heavy equipment. Table 4-1 summarizes the allowable exposure as a function of sound pressure level, as measured in decibels on the "A" weighting scale.

Table 4-1

Permissible Noise Exposure

Sound Level (dBA)	Hours – Minutes	Hours	Sound Level (dBA)	Hours – Minutes	Hours
90	8 - 0	8.00	103	1 - 19	1.32
91	6 - 58	6.96	104	1 - 9	1.15
92	6 - 4	6.06	105	1 - 0	1.00
93	5 - 17	5.28	106	0 - 52	0.86
94	4 - 36	4.60	107	0 - 46	0.76
95	4 - 0	4.00	108	0 - 40	0.66
96	3 - 29	3.48	109	0 - 34	0.56
97	3 - 2	3.03	110	0 - 30	0.50
98	2 - 38	2.63	111	0 - 26	0.43
99	2 - 18	2.30	112	0 - 23	0.38
100	2 – 0	2.00	113	0 – 20	0.33
101	1 - 44	1.73	114	0 - 17	0.28
102	1 - 31	1.52	115	0 - 15	0.25

As a rule of thumb, you are probably exposed to more than 85 decibels if you have to raise your voice to converse with someone three feet or more from you.

4.4 Blood-Borne Pathogens

Blood-borne pathogens refers to pathogenic microorganisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus, human immunodeficiency virus, Clostridium tetani (tetanus), and Clostridium perfringens (gas gangrene).

The only site personnel who might be exposed to this hazard under normal conditions is the SSC, in the event he or she is required to render first aid to an injured worker while waiting for emergency personnel. The safety officer will be equipped with a first aid kit that contains gloves, surgical mask, and safety goggles to be used whenever contact with bodily fluids is possible. The kit will also be equipped with a CPR mask that has a one-way valve in the event mouth-to-mouth resuscitation of a worker is required. Antibiotic cleansers will be included in the kit, as will special bags for the containment of medical waste.

Any TRC employee who is exposed to bodily fluids during the course of employment will be counseled in bloodborne pathogens by the Area Health and Safety Coordinator, and will be offered a hepatitis vaccine.

4.5 Electrical Hazards

Potential for electrical injury to workers is possible at field work-sites. Caution should be exercised in using small portable electrical equipment and field monitoring equipment. Also be alert to buried and overhead electric lines when conducting site activities. Local "Dig Safe" and/or specific utility companies must be contacted and notified prior to any drilling/excavation activities. Workers would also be alert to locations of overhead utility lines and care should be exercised at all times not to disturb or come in contact with them. ASSUME ALL ELECTRICAL LINES ARE ENERGIZED unless a suitable lockout/tagout procedure has been employed to render the lines safe.

For overhead electrical lines, the minimum clearance to be maintained between the drill rig, hand auger sections, or any other equipment, and the electrical lines is shown in Table 4-2 below. When using portable powered equipment, care must be used to make sure the power cord cannot be stepped on, cut, or tripped over. All powered equipment should utilize ground flow interrupt (GFI) circuits.

Table 4-2

Electrical Clearance

Nominal Voltage of Line	Minimum Clearance (feet)
Up to 50,000	10
Over 50,000 - 75,000	11
Over 75,000 – 125,000	13
Over 125,000 – 175,000	15
Over 175,000 – 250,000	17
Over 250,000 – 370,000	21
Over 370,000 – 550,000	27
Over 550,000 – 1,000,000	42

All stored energy must be dissipated prior to removing any piece of equipment. Energy is not only electrical energy, but also positional, rotational, kinetic, hydraulic, or pneumatic energy.

- Disconnect the equipment from the power source and lock out the power source to prevent activation.
- Disconnect to block equipment so that moving parts are firmly fixed in place.
- If possible, lower all raised portions to ground level, or block it so it cannot fall.
- Block or disconnect all hydraulic or pneumatic pistons or cylinders.

4.6 Fire or Explosion

Explosion or fire may occur where fuel, oxygen, and heat combine. The chemical contaminants identified to date for this site are low concentrations in soil, and are not expected to volatilize enough to provide for an explosive environment. If the PID indicates organic vapors exceeding 1,000 ppm (0.1 percent), a combustible gas indicator will be brought to the site to monitor for fire or explosion hazards. If the concentration exceeds 10 percent of the lower explosive levels (LEL), work will be stopped and the area evacuated until vapor concentrations are reduced.

Also, smoking by workers presents a potential for causing explosion or fire; therefore, no smoking is permitted at field work-sites.

4.7 Lifting Hazards

Field operations often require that physical labor tasks be performed. All employees should utilize proper bending and lifting procedures. Whenever an object is to be lifted, the employee should bend at the knees and lift the object using the legs. Additionally, an employee should not attempt to lift bulky or heavy objects (over 30 pounds) without assistance.

4.8 Equipment Safety

Certain tasks anticipated at this site will include the use of powered tools and equipment. The following safety procedures will be adhered to when using this type of equipment.

4.8.1 Hand Tools

- All power cords must be in good condition with no cracking or fraying.
- Power cords must be rated for the appropriate current.

- Ensure all safety guards are in place.
- Ground flow interrupt circuits should be used with portable equipment.
- Hearing protection must be worn when using powered equipment.
- All tools should be carefully passed by hand, not tossed or thrown.
- Do not use damaged tools.
- Keep all tools cleaned and stored in an orderly manner when not in use.
- When coring, breaking, or chipping asphalt or concrete, wear safety glasses and require all others around you to wear safety glasses.
- When using a hand auger, wear work gloves and boots.

4.8.2 Heavy Equipment

Prior to operating heavy equipment, adequate site cleaning will be performed, if necessary. Care will be taken to provide a safe working area. Work will commence only when tree limbs, unstable ground, or site obstructions do not cause adverse operating conditions.

Before using any equipment, walk completely around the equipment to check for hazards. Make sure the equipment is on solid, level ground. Pay particular attention to overhead hazards and consult Table 4-2 to determine the minimum distance from overhead power lines to the closest point on the rig.

Do not drive the equipment from one location to another with the mast in the raised position. Before raising the mast, all equipment and personnel (with the exception of the operator) should be cleared from the areas to the rear and sides of the mast. The operator should announce the mast is being raised prior to raising it. No personnel will be allowed on equipment while it is operating. An exclusion zone (Section 6.1.2) will be established around the drill rig to prevent unauthorized personnel from approaching.

Other safety work procedures:

- All excavation location should be examined by the utility locator prior to digging or drilling.
- Equipment should only be operated by qualified personnel.
- No person should be within ten feet of operating equipment.

- No passengers are allowed on heavy equipment unless a seat and seatbelt is available for their use.
- Top speed limit on the job site will be 10 miles per hour.

4.9 Excavation Safety

A qualified subcontractor will be retained by TRC if any excavations must be conducted on the site. The subcontractor will provide an excavation safety plan. TRC personnel shall not enter the excavation.

OSHA regulations pertaining to worker safety around excavations are presented in Appendix F.

4.10 Confined Spaces

Confined spaces are any location where access or egress is restricted, such as pits, vaults, tanks, vessels, etc. As each space is unique, a confined space entry plan must be prepared individually for any space that must be entered. No confined space entry is anticipated for this scope of work. If the scope of work changes and an entry is required, contact the HSC to prepare a revision to this HASP and a site-specific confined space entry plan.

4.11 Drilling Safety

A qualified subcontractor will be retained by TRC for borehole drilling and monitoring well installations. All drilling activities will be conducted consistent with International Drilling Federation Guidelines (Appendix F).

4.12 Recovered Product Storage

Recovered product is to be stored in 55-gallon steel drums, drums are not to be filled more than ½ during freezing weather, in use drums are to be bonded and grounded during liquid transfer. Drums are to be labeled using the NFPA label with a Health Rating of 1, a Flammability Rating of 2 and Reactivity of 1. All sources of ignition (electrical, vehicles) are to be kept a minimum of 30 feet away. The storage shed should be passively vented, labeled and access restricted. A grounding strip should be installed and attached to a ground, which consists of a copper rod driven 6 feet into the ground or structural steel. A secondary collection container and spill clean-up material should be used during liquid transfer to collect spills.

<u>**Inspection**</u>

All drums should be inspected each site visit and noted in the site log. Hazardous waste labeling should be completed with as applicable. Full drums should be removed promptly and Bill-of Lading/manifests completed.

5.0 AIR MONITORING PLAN

During the course of this investigation, the possibility exists that site workers will be exposed to airborne concentrations of the chemicals that have been detected at this facility. To protect workers, the following methods will be employed to measure the concentration of organic vapors in the work area.

5.1 Equipment

5.1.1 Volatile Organic Compound Gases and Vapors

Decisions to upgrade or downgrade the protective equipment worn by workers at the site should be based on solid knowledge of the hazards present. Total Organic Vapor (TOV) concentrations at the site will be measured with a Photo Ionization Detector (PID) to evaluate inhalation hazards. The PID measures organic vapors by using an ultraviolet lamp to ionize organic compounds in the air stream. The ionized compounds are then measured and converted to a reading as parts per million of organic vapor in air.

The PID will be calibrated prior to the start of each shift using a field calibration standard gas. The PID will not respond to different organic vapors with the same sensitivity. The Action Levels (see Section 5.2) for this project have deliberately been chosen to be lower than most of the PEL's in Table 3-2 to account for response factors of the instrument.

The concentrations of individual organic compounds can be quantified with colorimetric detector tubes. The detector tubes operate by drawing a fixed amount of the air to be sampled through a glass tube, where it reacts with a reagent and produces a stain that can be read as concentration in air. It is important to read the instructions for each different tube prior to use, as cross contamination is often encountered.

The pump should be checked for leaks before each use by inserting a sealed tube and squeezing the bellows. If the pump holds pressure for one minute, no leaks are present. If the pump leaks it must be replaced. Break the tips off the appropriate tube, and follow the package instructions on how to obtain a sample.

5.1.2 Explosion Hazard

A combustible gas indicator (CGI) (a.k.a., LEL meter) will be used to monitor the possible presence of explosive gases (e.g., methane) or vapors where appropriate. The CGI will be an "inherently safe instrument" approved for Class 1 Division 1 locations. Equipment calibration will be performed daily before startup of work per manufacturer instructions. The alarm will be set to 10 percent of the LEL at which point work shall be stopped. Continued work in this atmosphere will not take place without the approval of the DHSO and HSC and the appropriate PPE and intrinsically safe equipment. If feasible, calibration gas to be used will be specific to the combustible gases suspected to be present.

5.1.3 Dust Monitoring

Dust monitoring will be conducted during excavation and intrusive activities (i.e. drilling). Personal and area monitoring will be performed continuously in areas where dust generating operations are being conducted. Results will be recorded at 15-minute intervals. The alarm will be set at 10 milligrams per cubic meter (mg/m^3). If no alarm conditions are recorded and no visible dust is present, dust monitoring may be reduced or discontinued at the discretion of the DHSO.

5.1.4 Hydrogen Sulfide Monitoring

Hydrogen Sulfide will be monitored continuously during operations in the lagoon areas. Hydrogen Sulfide will be measured utilizing a battery operated meter which detects hydrogen sulfide levels in the parts per million (ppm) range. The meter is calibrated so that the alarm will sound at any hydrogen sulfide readings at or above 2.5 ppm. As previously discussed, work shall stop. Continued work in this atmosphere will require an upgrade to Level B PPE, subject to the approval of the DHSO and HSC.

5.2 Action Levels

Measured concentrations of particulates and organic vapors will be entered onto an air monitoring form included in Appendix A and the site logbook. Action levels are presented in Table 5-1 and conservatively based on a potential exposure to vinyl chloride. If the concentrations of various chemicals exceed the action level, site personnel will evaluate the area or be equipped with suitable respiratory protection.

Table 5-1

Action Levels

Instrument	Action Level	Level of Protection
PID (sustained reading for five minutes in breathing zone)	> 1 ppm	Collect sample and analyze with colorimetric tube (vinyl chloride). If vinyl chloride present, evacuate area or upgrade to Level B
	< 5 ppm	D
	5-20 ppm	C
	>20 ppm	Evacuate area and let area ventilate, contact HSC
LEL/O_2 Meter	<10% LEL	Modified D
	>10% LEL	Evacuate area and let area ventilate, contact HSC
	<19.5% O_2	Level B required, or evacuate area and let area ventilate, contact HSC

Table 5-1 Action Levels		
Instrument	**Action Level**	**Level of Protection**
	19.5% < O_2 < 23.5%	Modified D
	>23.5% O_2	Evacuate area and let area ventilate, contact HSC
H_2S Meter	<5 ppm	Modified D
	>5 ppm	Level B required, or evacuate area and let area ventilate, contact HSC

Note that this table is superseded if, at any time, a detector tube indicates that a substance is present at or above its PEL, after taking into account the accuracy of the tube as stated in its instructions. Action levels may be modified upon the consent of the CHSC.

5.3 Personnel Responsibilities

The Health and Safety Coordinator (HSC) and the Site Safety Coordinator (SSC) shall be responsible for determining whether additional exposure monitoring/sampling is needed to supplement the equipment and methods described above. A revised sampling plan will then be developed by the HSC and implemented by the SSC.

The SSC shall ensure that appropriate air monitoring equipment is available for use prior to the start of any work. The SSC will perform site air monitoring during the course of the project. The SSC shall also ensure that monitoring instruments are used only by persons who have had prior training and experience in their operation, calibration and care, and who understand their limitations. The SSC shall also ensure that the instruments are properly calibrated and recharged regularly, and that the proper operation of the instruments are checked daily. Calibration data should be included on the form in Appendix A.

6.0 SITE CONTROLS

This section identifies the methods that will be implemented by TRC to reduce worker exposure to the chemical and/or physical hazards identified at this project location. Protective methods can be classified as engineering controls or personal protective equipment.

6.1 Engineering Controls

Engineering controls include all measures designed to minimize the possibility of allowing an inhalation hazard to occur. ·Engineering controls are to be the first step in reducing worker exposure at this site.

6.1.1 Dust Control

Significant amounts of dust are not expected during this investigation. In general, subsurface soil has enough moisture to prevent dust generation. If visible dust is generated, water will be used for suppression.

6.1.2 Control Zones

To control access to potentially impacted areas, the Site Safety Coordinator will establish limited access control zones as follows.

Exclusion Zone

No one will be allowed in the work area unless they are equipped with the personnel protective equipment he SSC has deemed necessary and they have read this Safety Plan.

Contamination Reduction Zone

A CRZ will be established outside the exclusion zone. No personnel or equipment will be allowed to leave the CRZ without first being decontaminated in accordance with Section 7. The CRZ can either extend around the entire hot zone if space permits, or it can just be located at the access control points.

Personnel assisting workers with decontamination must be utilizing personal protective equipment (PPE) of the same type as the workers in the exclusion zone. In any situation where contaminated soils are present, the minimum protective equipment will be Tyvek coveralls and nitrile gloves. If the possibility of contact with impacted liquid or product exists, the minimum personal protective equipment will be nitrile gloves, and poly coated Tyvek.

Support Zone

The support zone consists of the remainder of the site area. No possibility of exposure to toxic contaminants is expected in this area, and no special protective methods will be needed. All workers in the support zone, however, will need to comply with standard job site safety requirements.

6.1.3 Forced Ventilation

In the event that vapors exceed the permissible limits, explosive-proof blowers may be used to disperse the vapors and lower the concentrations. Periodic monitoring will be increased to document the effectiveness of the ventilation.

6.1.4 Material Control

All solid and liquid materials generated during this project will be handled as per the Work Plan and Sampling Plan. This will include taking appropriate steps to ensure that potentially impacted material is contained and does not pose a threat of spreading to clean areas of the site.

6.2 Personal Protective Equipment

When engineering controls are not effective or feasible, workers shall be required to use the following protective equipment. Any workers using respiratory protection equipment must be currently medically certified to do so, and have passed a qualitative fit test within the preceding year.

Based on the results of previous investigations at the site, EPA Level D PPE will be initially used on all tasks identified in Section 1.1. PPE Levels will be upgraded based on the air monitoring levels in Table 5-2.

6.2.1 Level D Protection

EPA Level D Personal Protective Equipment is acceptable for areas with no inhalation hazard, or where the hazard has been demonstrated to be below the action levels. Level D protection will include:

- Worker overalls or other suitable work clothes,
- Safety boots with steel toe and shank,
- Hard hat,
- Safety glasses, and
- Face shield or goggles if a splash hazard is present.

Modified Level D protection consisting of Nitrile gloves and Tyvek overalls are to be used when handling samples of impacted soil. Nitrile gloves with latex inner gloves and an impermeable splash suit are to be used when handling liquid materials or samples.

6.2.2 Level C Protection

Level C Protection is suitable for use when limited concentrations of the chemicals of concern are present. Level C will consist of the following equipment:

- Tyvek coveralls or equivalent when working with solid materials,
- Poly coated Tyvek coveralls when handling contaminated liquids,
- Safety boots with steel toe and shank,
- Safety glasses or goggles,
- Hard hat,
- Nitrile gloves with latex inner gloves, and
- Half-or Full-face Air Purifying Respirator (APR) with organic vapor cartridges and dust prefilters. Half face respirators provide protection up to 10 times the action level. Full face respirators provide protection up to 50 times the action level.

APR's may only be used in non-IDLH atmospheres, and assuming that appropriate cartridges are available for use. APR cartridges are to be replaced at the beginning and mid-point of each shift and whenever breakthrough is noted. Breakthrough is any indication of an unusual taste, odor, or sensation.

6.1.1 Level B Protection

If the inhalation hazards exceed the safe use limitations of the air purifying respirator equipment (any contaminant greater than 50 times its PEL), or IDLH conditions exist, the following protective equipment will be employed.

- Tyvek coveralls or equivalent when working with solid materials,
- Poly coated Tyvek when working with liquid materials,
- Safety boots with steel toe and shank,
- Hard hat,
- Nitrile gloves with latex inner gloves, and

- Pressure-demand (positive pressure) full-face, self-contained breathing apparatus (SCBA) or airline respirator with escape SCBA operated in positive pressure mode.

7.0 DECONTAMINATION PROCEDURES

The following procedures will be implemented to minimize the spread of contaminants at this site.

7.1 Worker Decontamination

Anyone exiting a designated exclusion zone will do so through an access control point. The worker will proceed into the contamination reduction zone. Under no circumstances is dust to be shaken off equipment or clothing. The decontamination will proceed as follows:

1. Wash and rinse any hand tools that will be leaving the CRZ.

2. Remove disposable clothing by rolling it down the body. Place clothing in appropriate waste receptable.

3. Remove and dispose of gloves.

4. Remove respirator. Dispose of filters in waste receptacle. Clean and rinse respirator prior to storage.

5. Remove and dispose of any inner gloves.

6. Proceed immediately to wash facility and wash hands and face. If work has concluded for the day, the worker should completely shower as soon as practical.

7.2 Heavy Equipment Decontamination

Prior to exiting the exclusion zone, all heavy equipment that was in contact with contaminated soil or water will be steam cleaned by workers in Level D equipment with splash protection equipment. All rinsate must be collected and appropriately disposed of.

8.0 TRAINING REQUIREMENTS

This section identifies the minimum training requirements for workers at this site, and identifies site-specific training requirements and site contingency plans.

8.1 Initial Training

At the time of assignment to this project, field personnel shall have completed at least 40 hours of off-site instruction in the health and safety issues involved in hazardous substance site work. Additionally, site personnel must have a minimum of 3 work days (24 hours) of actual field experience under the direct supervision of a trained, experienced supervisor. Employees who can show by documentation of work experience and/or training that they have had the equivalent to the stated requirements shall be considered as meeting these initial training requirements. Each site worker must sign and date a Personal Acknowledgement (see Appendix D) stating that he or she has read and understood this HASP. Site supervisors must complete an additional eight hours of supervisory training. The SSC must keep copies of training certificates at the job site.

The SSC or his designate must conduct and document (see Appendix B) a tailgate safety meeting at the beginning of daily field activities, whenever new personnel arrive at the site, as site conditions change, or as needed.

Since this project may require the use of full-face cartridge respirators, all TRC field team members must be fit tested for the use of such respirators. Fit testing must have been performed within the past year of the field activity. Fit test records shall be filed with the DHSO and with the Corporate Health and Safety Officer. All TRC field personnel are responsible for the proper care and maintenance of their assigned full-face respirator.

In addition, prior to conducting any activities in Level B PPE, on-site dry runs shall be performed to the satisfaction of the DHSO, Site Manager, and the assigned Level B Monitor.

8.2 Site Specific Training

All TRC employees will attend an initial and follow-up safety briefings. The briefings will discuss the work to be completed, task assignments, the contents of this HASP, site hazards, and hazard mitigation methods. Follow-up briefings will be conducted when site conditions change, revisions are made to this HASP, or when new employees are introduced to the site.

8.3 Medical Surveillance

All employees who are required to work in potentially contaminated areas for 30 or more days per year shall be medically monitored in accordance with 29 CFR 1910.120. The monitoring will consist of a baseline exam, annual exams, and an exit exam.

Employees potentially exposed to noise levels above an 8-hour time weighted average of 85 decibels will participate in a hearing conservation program. The program will include annual audiograms to determine any hearing loss, as well as training on loss prevention.

9.0 EMERGENCY RESPONSE PLAN

The site safety coordinator will be responsible for maintaining a clean job site free from hazards and providing safe egress from the site. Cones and/or barricades and high visibility surveyor tape will be utilized for traffic control, if needed, and for limiting access to hazardous and restricted areas.

Prior to work startup, emergency medical procedures and lines of communication will be established. The fire department, ambulance service, project personnel, and directions to the nearest hospitals with an emergency room are identified in Table 9-1. Communications will be with a mobile phone located on site.

A vehicle shall be available on site during work activities to transport injured personnel to the identified emergency medical facilities. The designated route to those facilities are described in Table 9-1. Telephone numbers and locations for emergency room assistance shall be posted at the site.

At a minimum, one site worker will be capable of rendering standard first-aid and cardiopulmonary resuscitation (CPR). A first-aid kit and adequate supply of fresh water will be available at the work site.

9.1 Emergency Procedures

Emergency phone numbers (see Table 9-1) will be posted for the fire department, ambulance service, and nearest emergency medical clinic/hospital. The fastest route to the clinic/hospital, along with emergency telephone numbers, shall be prominently posted in the work area (see Figure 1). The site safety coordinator will be the lead person in emergency situations.

All TRC personnel on the job site will work with a 'buddy' system. At least one other worker will be with you at all times.

In the event an evacuation is necessary, it will be requested by the SSC. All workers should immediately leave the area and assemble in the parking lot. Announcement of the situation will be through word of mouth. If the work area is too large for this method of work, automobile horns or a portable air horn will be used to signal the emergency.

Emergency procedures, including evacuation routes and staging areas, will be determined at the first site safety meeting.

9.2 Incident Follow-up

Should an accident occur, the site safety coordinator, or his designate, will immediately notify the project manager, complete an accident report (see Appendix C), and investigate the cause. Any recommended hazard control measures must be discussed with the site coordinator and meet with his approval prior to implementation. Any chemical exposures or occupational injuries and illnesses shall also be reported to the site safety coordinator and recorded. Any fatality, serious injury, or illness occurring on the job will be immediately reported to OSHA. Records of all site accidents and first aid treatments will be maintained by the project manager or site safety coordinator. Additionally, records of recordable work place injuries and illnesses are routinely maintained at TRC office for at least 5 years, as required by OSHA.

<table>
<tr><th colspan="3">Table 9-1
Emergency Assistance Information</th></tr>
<tr><th>Contact</th><th>Phone Number</th><th>Hospital Directions</th></tr>
<tr><td>Local Police</td><td>911</td><td rowspan="6">WINCHESTER HOSPITAL
4 Highland Avenue,
Winchester:

From 93 south, take the Montvale Ave./Woburn Exit, Exit 36. Take a right onto Montvale Ave. Take a left at the lights onto Washington Street. At the next set of lights, take a left onto Forest Street. Take the second right onto Highland Ave., the Hospital is 1,000 yards up on the left.</td></tr>
<tr><td>Fire Department</td><td>911</td></tr>
<tr><td>Ambulance</td><td>911</td></tr>
<tr><td>Local Hospital:
Winchester Hospital</td><td>(781) 729-9000</td></tr>
<tr><td>Corporate H&S Manager
Gary Ritter</td><td>(860) 298-6256</td></tr>
<tr><td>Project Manager:
Paola Macchiaroli</td><td>(978) 656-3582</td></tr>
<tr><td colspan="3">Urgent Care (i.e., sutures, broken bones) can be provided by the Wilmington Regional Health Center located at 500 Salem Street, Route 62, Wilmington, (978) 657-3910. <u>THEY DO NOT</u> provide emergency services.</td></tr>
</table>

Boott Mills South
Foot of John Street
Lowell, MA 01852
(978) 970-5600

FORMER GE SITE
WILMINGTON/NORTH READING, MASSACHUSETTS

FIGURE 1
HOSPITAL ROUTE

Date: 6/00 | Project No. E9202

E9202/EPL/RIP/hospital

10.0 TASK SPECIFIC HAZARD ANALYSIS

This section includes a discussion of specific hazards and procedures to mitigate those hazards for each of the tasks to be conducted as part of this project. Table 10-1 summarizes the anticipated tasks and hazards.

Table 10-1

Task Hazard Analysis

Task	Potential Hazards	Preventive Measures	Initial Level of Protection
Drilling wells and sample subsurface soils during drilling	Utilities, heavy equipment, potential chemical exposure, heat and cold stress, noise.	See Sections 4.1, 4.2, 4.3, 4.5, 4.6, 4.8, 4.9, 5, 6, and 7.	D
Recovery System O&M and NPDES and groundwater sampling	Potential chemical exposure, heat and cold stress.	See Sections 4.1, 4.2, 5, and 6.	D
Soil excavation	Utilities, heavy equipment, large open excavations, potential chemical exposure, heat and cold stress, noise.	See Sections 4.1, 4.2, 4.3, 4.5, 4.6, 4.8, 4.9, 5, 6, and 7.	D
Dewatering and recovery of NAPL from excavations	Large open excavations, potential chemical exposure, heat and cold stress, noise.	See Sections 4.1, 4.2, 4.3, 4.5, 4.6, 4.8, 4.9, 5, 6, and 7.	D
Treatment of groundwater	Potential chemical exposure, heat and cold stress, noise.	See Sections 4.1, 4.2, 4.3, 5, and 6.	D
Stockpiling and off-site transportation of soil	Heavy equipment, potential chemical exposure, heat and cold stress, noise.	See Sections 4.1, 4.2, 4.3, 4.5, 4.6, 4.8, 4.9, 5, 6, and 7.	D
Sampling soil from stockpiles and excavations	Potential chemical exposure, heat and cold stress.	See Sections 4.1, 4.2, 5, and 6.	D

TRC STANDARD OPERATING PROCEDURE NO. 001

GROUND WATER SAMPLING

Prepared by: ______________________ 10/22/99

Adam Balogh, P.G. — Date

Reviewed by: ______________________ 10/22/99

Dale Weiss, P.G., Senior Hydrogeologist — Date

Approved by: ______________________ 10/25/99

Peter Spawn, Program Manager — Date

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ATTACHMENTS

Attachment A Field Data Record Ground Water

Attachment B Field Data Record Well Development

TRC STANDARD OPERATING PROCEDURE NO. 001
GROUND WATER SAMPLING

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in ground water sampling activities. This SOP details equipment and sampling procedures for sampling from monitoring wells, residential drinking water wells, and industrial water supply wells. This SOP conforms to "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and " "Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells (U.S. EPA, July 30, 1996, Rev. 2)."

1.1 Objective

The objective of ground water sampling is to obtain a representative sample of water from the ground water aquifer. This requires that the water sample being collected is representative of true ground water as opposed to stagnant water which is contained in the well casing and associated plumbing.

1.2 Equipment

The following equipment should be used when sampling a monitoring well. Site specific conditions may warrant the use of additional equipment.

- Water level measuring device
- Submersible pump with low-flow capabilities, equipped with Teflon or polyethylene 78 bn tubing
- Water Parameter instrument and flow-through cell (must include: pH, temperature, conductivity, oxidation reduction potential and dissolved oxygen)
- Turbidity meter
- Sample containers
- Field Logbook and/or Field Data Record for ground water
- Traffic Reports
- Chain of Custody forms
- Custody seals
- Sample preservative kit (includes preservatives for each specific analysis)
- Sample labels
- Sample tags
- Packing tape
- Zip-lock bags
- Packing materials

- Shipping coolers
- Trip blanks (if applicable)
- Temperature cooler indicator blanks
- Ice or "blue ice"

2.0 PROCEDURES

Equipment and procedures for sampling three types of wells are described below, including

- Monitoring wells;
- Residential drinking water wells; and
- Industrial water supply wells.

2.1 Ground Water Sampling of Monitoring Wells

The following procedure should be used for collecting a ground water sample from a monitoring well.

1. Prior to collecting water samples, place a waterproof sample label on each sample container. Include the following information on each label:

   a. TRC Project No.: __________ (e.g., 2850-N61-22)

   b. Project Name: __________ (e.g., XYZ Corporation)

   c. Sample ID.: X-GW-MW10-41893

      Where X - Site initials (e.g., XYZ Site)
      GW - Ground Water Sample
      MW10 - Well Designation
      41893 - Sampling Date

   d. Analysis required: ________ (e.g., TOC)

   e. Preservative: _________ (e.g. ICED, pH<2 H_2SO_4)

   f. Collection Time: _________ (e.g., 0930)

g. Collection Date: _________ (e.g., 4-18-93)

h. Initials of Sampler: _______ (e.g., GLD)

Fill in the information with a water proof ink pen ***before*** sample collection. This will prevent difficulty in filling out a wet label. Cover the label with clear cellophane tape.

2. On the groundwater field data record note the physical condition of the well, including damage, deterioration, and signs of tampering.

3. Unlock the protective cap on the well.

4. Open the well cap. Note any unusual odors, sounds, or difficulties in opening the well. Record organic vapor reading with a suitable organic vapor screening device, if applicable.

5. Gently lower a decontaminated water level measuring device into the well to determine the static water level.

6. Measure the depth to the bottom of the well and the inside diameter of the well casing, if unknown.

7. Initiate purging. Slowly lower the pumping equipment (submersible pump) so that the intake is located at the midpoint of the well screen. If the water level is lower than the top of the well screen, position the pump intake at the midpoint of the standing water. The intake should be at least 1 foot above the bottom of the well to minimize mobilization of settled sediment, the risk of the pumping suction being broken, or the entrainment of air in the sample.

   As described above, lower the pump to the appropriate depth within the well. Commence purging at the slowest possible rate and slowly increase the speed until discharge occurs. Measure the flow rate using a plastic graduated cylinder and time piece. Adjust the pump speed to maintain flow rate that is less than the recharge rate. Monitor the draw down to ensure that none occurs. Continue to monitor the water level during the purging and sampling. Note any flow rate adjustment(s). Under no circumstances should the well be pumped dry and once pumping is begun, it should not be interrupted until the entire sample volume has been collected. Collect all purge water in a bucket.

8. Initially, turbidity may be elevated. Once visual estimates indicate that turbidity has decreased to a measurable range, begin monitoring indicator parameters: temperature, pH, specific conductance, dissolved oxygen (DO), turbidity, and oxidation/reduction potential (ORP). Monitor these parameters as frequency as possible (approximately every 3 to 5 minutes or as appropriate).

Stop purging when pH and specific conductance have stabilized and turbidity is 5 NTU's or less. Parameters are considered to have stabilized if, over three consecutive readings, all of the following criteria are met.

- pH ± 0.1 unit
- specific conductance and temperature within 3%
- turbidity within 10% for values greater than 1 nephelometric turbidity units (NTU)
- DO ± 10%
- ORP ±10 mv
- However, if parameters do not stabilize, or turbidity remains greater than 5 NTUs, technical judgement will be used to ascertain when sampling should be commenced.

The flow rate will be reduced to minimize aeration of the water and a sample will be collected directly for volatile organic compounds (VOCs). A "test" vial will be collected first to determine the amount of preservative (HCL) needed to reduce the pH to less than 2. The pH of the test sample will be determined, then HCl will be incrementally added to the sample until the pH is less than 2. The volume of HCl added to the test vial will be recorded and that amount used in each of the remaining sample vials. If the test vial effervesces, no preservatives will be added to the VOC fraction of the sample.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. All flow cells will be shaded from direct sunlight to minimize the potential for out gassing It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help ensure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing; (2) insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values."

9. Fractions of the ground water sample should be collected in the following order:

   1. Volatile organic compounds (VOCs);
   2. Semivolatile organic compounds (SVOCs);
   3. Unfiltered inorganic compounds;
   4. Filtered inorganic compounds; and
   5. Water quality parameters.

   During sample collection, allow the water to flow directly down the side of the sample container without allowing the tubing the touch the inside of the sample container or lid, in order to minimize aeration and maintain sample integrity.

   Samples for volatile organics will be collected first, and the sample vial must contain no air bubbles after it has been capped; ensure this by turning the vial upside down and tapping it lightly. If any bubbles are observed, discard the sample and collect a new sample. Fill the remaining sample containers at least 3/4 full for all other analyses.

10. Preserve the samples in accordance with "40 CFR Part 136, EPA Regulations on Test Procedures for the Analysis of Pollutants."

   Measure and record the final water level, temperature, pH, specific conductance, DO, turbidity, and ORP readings. After measuring for final indicator parameters, cease pumping and disassemble the purging and sampling equipment.

   - Replace the protective/locking cover on the well and lock the outer casing (if present).

   - Dispose of all purged water according to the procedures described in Appendix H.

   To ensure that representative ground water samples are collected, ground water will be removed from each well until in-situ ground water parameters stabilize and a turbidity of less than 5 NTUs is achieved. If stabilization of in-situ parameters is not achieved, a maximum of five well volumes will be removed prior to sampling. Ground water will be removed from the wells utilizing a submersible pump. In circumstances where access via pump is not possible (i.e., a narrow diameter well mouth) a dedicated teflon or stainless steel bailer will be used. The method of purging the wells will depend on the well construction, depth, and rate of recharge. All monitoring wells will be permitted to recharge before ground water samples are collected.

11. Wrap the sample containers in a resealable plastic bag, place them into a shipping container, cool to 4°C with ice packs and complete the chain-of-custody form. Pad the samples with bubble wrap and/or vermiculite packing as necessary.

12. Detail in the field logbook the sample location, ID, and time. The TRC field data record for ground water (attached) should be used to record the following:

- Volume of each sample
- Sample identification Number
- Sample location
- Time and date sample was taken
- Personnel performing the task
- Volume of water removed
- Purging time
- Field parameters such as pH, temperature, conductivity, turbidity oxidation reduction potential and dissolved oxygen
- Sampling method
- Analytical parameters
- Preservation method and amount of preservative added
- Chain-of-custody information such as laboratory contract number or CLP number

2.2 Ground Water Sampling of Residential Drinking Water Wells and Industrial Supply Wells

The following procedure should be used for collecting a ground water sample from a residential well.

1. Every effort should be made to locate a suitable sampling point which is not positioned after any type of filtration or water treatment system. This will typically be an outside tap. If such a non-filtered or non-treated sample cannot be obtained, an effort will be made to disconnect the filtration/treatment system prior to sample collection after owner permission is received. If the sampling tap has an aerator device, the aerator will be removed prior to sampling.

2. The amount of static water volume contained in the well system (i.e., inside well casing, storage tank, plumbing) will be calculated. The volume of the static water column will be calculated using the following equation.

$$V = d^2 h(0.0408)$$

where: V = volume of static water column (gallons)

d = diameter of the well (inches)

h = height of the static water column (feet)

(0.0408) = unit conversion factor

3. At a minimum, the volume of the holding tank will be purged prior to sample collection. If the well is not used regularly, one to three well system volumes will be purged if the well recharges quickly and it is feasible to dispose of a large volume of water. Temperature, pH, dissolved oxygen, oxidation reduction potential and conductivity of the water will be monitored periodically. When these indicator parameters have stabilized within 10 percent, the well will be sampled.

   Purged water should be disposed, at a minimum, twenty-five feet downgradient of the well. If purge water cannot be disposed of on site, it should be containerized in 55-gallon drums.

4. The flow rate of the tap will be reduced to minimize aeration of the water and a sample will be collected directly from the tap for volatile organic compounds (VOCs). A "test" vial will be collected first to determine the amount of preservative (HCL), needed to reduce the pH to less than 2. The pH of the test sample will be determined, then HCl will be incrementally added to the sample until the pH is less than 2. The volume of HCl added to the test vial will be recorded and that amount used in each of the remaining sample vials. If the test vial effervesces, no preservatives will be added to the VOC fraction of the sample.

5. The flow rate will then be increased, and the remaining fractions will be collected in the following order:

   1. Semivolatile organic compounds (SVOCs);
   2. Unfiltered inorganic compounds;

3. Filtered inorganic compounds; and
4. Water quality parameters.

All fractions of ground water samples will be preserved in the field in accordance with "40 CFR Part 136, EPA Regulations on Test Procedures for the Analysis of Pollutants."

6. Wrap the sample containers in a resealable plastic bag, place them into a shipping container, cool with ice packs to 4□C, and complete the chain-of-custody form. Pad the samples with bubble wrap and vermiculite packing as necessary.

7. Detail in the field logbook or ground water sample collection form, the following information:
   - Sample identification Number
   - Sample location
   - Volume of water removed
   - Purging time
   - Field parameters such as pH, temperature, conductivity and turbidity
   - Sampling method
   - Analytical parameters
   - Preservation method and amount of preservative added
   - Chain-of-custody information such as laboratory contract number or CLP number.

2.3 Duplicate Ground Water and Residential/Industrial Supply Well Sampling

The following procedures should be used for collecting duplicate ground water and residential/industrial supply well samples:

1. For quality control purposes, each duplicate sample will be submitted to the laboratory as a "blind" duplicate sample, in that a non-existing sampling point will be assigned in labeling the duplicate. All labeling procedures used for ground water sampling will be employed and all parameters measured will also be recorded. Since the duplicate is collected simultaneously to the actual sample, a "blind" sample time, within one hour of 7the actual time, will also be assigned. The actual source and collection time of the duplicate sample will be recorded in the field book.

2. Each duplicate sample will be collected simultaneously with the actual sample. At the coincident step in the sampling procedures that the VOC containers are filled and sealed, the duplicate sample VOC containers will also be filled and sealed. Following the order of collection specified for each set of containers (VOCs, SVOCs, unfiltered inorganic

compounds, and filtered inorganic compounds), the duplicate sample containers will be filled simultaneously with each parameter.

3. All collection and preservation procedures outlined for ground water and residential/industrial supply well sampling will be followed for each duplicate sample.

TRC

Field Data Record Ground Water

Project:	Project No.:	Date/Time:	Sheet ___ of ___
Contractor Personnel:		TRC Personnel:	

Sample No.: Well Location:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

Protective Casing Stick-up (from ground) ______ ft.

Riser Stick-up (from ground) ______ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch ☐ ______

Well Depth ____ ft. ☐ top of riser ☐ top of casing ☐ ______ ☐ measured ☐ historical

Water Depth ____ ft.

Height of Water Column ____ ft. x ☐ .16 gal/ft (2 in.) ☐ .65 gal/ft (4 in.) ☐ 1.5 gal/ft (6 in.) ☐ __ gal/ft (__ in.)

Volume of Water in Well = ______ gallon(s)

______ Total gallons to purge

[Vol. = $r^2h(0.163)$]

PID SCREENING MEAS.

Background	
Well Mouth	

WELL MATERIAL ☐ PVC ☐ SS ☐ ______

FIELD WATER QUALITY MEASUREMENTS

Purge Volume (gal)							
pH (Std. Units)							
Eh (millivolts)							
Conduct. (µmhos/cm)							
Temp. (C)							
Turb. (NTU)							
DO (mg/l)							

Sample Description

Clear ☐ Turbid ☐

Color ______

Odor ______

Other ______

SAMPLE EQUIP./DECON.	PURGE	SAMPLE
Peristaltic Pump	☐	☐
Submersible Pump	☐	☐
Bailer	☐	☐
Waterra	☐	☐
PVC/Silicon Tubing	☐	☐
Teflon/Silicon Tubing	☐	☐
Air Lift	☐	☐
In-line Filter	☐	☐
Pressure Vacuum Filter	☐	☐
Measuring Tape	☐	☐
______	☐	☐

EQUIPMENT ID

DESCRIPTION OF DECON. PROC.

DECON. FLUID USED	
Tap Water	☐
Alconox	☐
Tap Water	☐
HNO_3 (1 or 10%)	☐
Tap Water	☐
Methanol	☐
Hexane	☐
Acetone	☐
Air Dry	☐
DI Water	☐
Air Dry	☐
None	☐

ANALYTICAL PARAMETERS	Filtered (circle)	Preservation Method	Volume Required	Time of Collection	CLP Sample #	CLP Case #
☐ TCL Volatiles	YES NO	4° C	2x40 mL			
☐ BNA Extractables	YES NO	4° C	4x1 L Amb GL			
☐ PCBs/Pesticides	YES NO	4° C				
☐ TAL Metals	YES NO	HNO_3/4° C	1 L PL			
☐ Cyanide	YES NO	NaOH/4° C	1 L PL			
☐ ______	YES NO					

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Signed: ______________

Rev: 8 July 1991

TRC

Field Data Record Well Development

Project: Project No.: Date/Time: Sheet ___ of ___

TRC Personnel:

Well Identification:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

PID SCREENING MEAS.

Background	
Well Mouth	

Protective Casing Stick-up (from ground) ______ ft.

Riser Stick-up (from ground) ______ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch ☐ ______

WELL MATERIAL ☐ PVC ☐ SS ☐ ___

Well Depth ___ ft. ☐ top of riser ☐ top of casing ☐ ________ ☐ measured ☐ historical

Water Depth ___ ft.

Height of Water Column ___ ft. x ☐ .16 gal/ft (2 in.) ☐ .65 gal/ft (4 in.) ☐ 1.5 gal/ft (6 in.) ☐ __ gal/ft (__ in.)

Volume of Water in Well = ______ gallon(s)

______ Total gallons to purge

[Vol. = $r^2h(0.163)$]

FIELD WATER QUALITY MEASUREMENTS

Purge Volume (gal)										
pH (Std. Units)										
Eh (millivolts)										
Conduct. (µmhos/cm)										
Temp. (C)										
Turb. (NTU)										
DO (mg/l)										
Purge Volume (gal)										
pH (Std. Units)										
Eh (millivolts)										
Conduct. (µmhos/cm)										
Temp. (C)										
Turb. (NTU)										
DO (mg/l)										

EQUIPMENT	PURGE	SAMPLE
Peristaltic Pump	☐	☐
Submersible Pump	☐	☐
Bailer	☐	☐
Waterra	☐	☐
PVC/Silicon Tubing	☐	☐
Teflon/Silicon Tubing	☐	☐
Air Lift	☐	☐
In-line Filter	☐	☐
Pressure Vacuum Filter	☐	☐
Measuring Tape	☐	☐
________	☐	☐

EQUIPMENT ID

____

____

____

____

DESCRIPTION OF DECON. PROC.

DECON. FLUID USED	
Tap Water	☐
Alconox	☐
Tap Water	☐
HNO3 (1 or 10%)	☐
Tap Water	☐
Methanol	☐
Hexane	☐
Acetone	☐
Air Dry	☐
DI Water	☐
Air Dry	☐
None	☐

AF-206b

Signed: ________________

Rev: 8 July 1991

TRC STANDARD OPERATING PROCEDURE NO. 002

SURFACE SOIL SAMPLING

Prepared by: ______________________ 10/22/99
Adam Balogh, P.G. — Date

Reviewed by: ______________________ 10/22/99
Dale Weiss, P.G., Senior Hydrogeologist — Date

Approved by: ______________________ 10/25/99
Peter Spawn, Program Manager — Date

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1.1 Objective 1
1.2 Equipment 1

2.0 PROCEDURES 2
2.1 Sampling Procedure 2

ATTACHMENT A

Sample Log Sheet

TRC STANDARD OPERATING PROCEDURE NO. 002
SURFACE SOIL SAMPLING

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the logistics, collection techniques, and documentation requirements for collecting surface soil samples.

1.1 Objective

The objective of surface soil sampling is to obtain a representative sample of soil for laboratory analysis of contaminants of concern at a given site. This objective requires that the sample be both free of unsuitable material and be of sufficient quantity and quality for analysis by the selected analytical method.

1.2 Equipment

The following equipment is needed for surface soil sampling:

- Boots, latex gloves, chemical resistant gloves, appropriate level of personal protection.

- Sample containers - one (1) liter glass jar with a Teflon lined cap or two (2) 8 oz. glass jars with Teflon lined caps (per sample). Samples to be analyzed for VOCs will be collected by the USEPA 5035 method using the following glassware: (a) "high level" analysis – one (1) 40 ml VOA vial pre-preserved with 15 ml of methanol; or, (b) "low level" analysis – one (1) 40 ml VOA vial pre-preserved with 15 ml of methanol, and two (2) 40 ml VOA vials pre-preserved with 5 ml of sodium disulfate. All samples submitted for VOC analysis will include one small (40 ml to 4 oz) container, to allow the laboratory to record the moisture/dry-weight characteristics. Should conditions allow, VOC samples may be collected with Encore samplers, rather than methanol – preserved glassware.

- Samples collected for VOC analysis with the use of Encore samplers will be containerized as follows: (a) for high level VOC analysis, one 25-gram Encore sampler will be provided to the laboratory; and, if appropriate, (b) for low level VOC analysis, two 5-gram Encore samplers will be provided to the laboratory. Samples will be collected directly into the Encore samplers, capped and sealed, and delivered to the laboratory within 7 days of collection.

- Stainless steel spoon or spatula.

- Wooden stakes and spray paint (highly visible).

- Field logbook and/or TRC Sample Log Form (Form AF-212).
- Sample bottle labels.
- Chain-of-custody forms (TRC or EPA, as necessary).
- Hand auger.
- Stainless steel trowel/shovel.
- Stainless steel mixing bowl.
- Disposable syringe.
- Digital Scale (accurate to +/- grams).
- Encore sampling containers, if conditions allow.
- Indelible marking pens.

2.0 PROCEDURES

2.1 Sampling Procedure

The following procedure should be used for surface soil sampling.

1 All surface debris should be removed prior to sampling including wood, paper, sod, gravel, and trash.

2 Identify the sample location and mark with a stake, flagging, or similar marker.

3 Collect the soil using a stainless steel shovel, hand auger, trowel and/or spatula. Avoid collection of larger pieces of material (cobbles, larger rocks).

4 A pre-cleaned stainless steel spoon or spatula should be used to take the soil sample and fill the sample containers except in the case of a sample for VOC analysis, which are collected using and an open barrel disposable syringe. Care should be taken to avoid sampling anything but soil. Stones, gravel, or vegetation should be removed from the sample since these materials will not be analyzed.

5 For VOC analysis prior to collecting the sample, USEPA method 5035 specific volumes of preservative (methanol and sodium bisulfate) will be added to sterilized 40 ml containers. Each pre-preserved container will then be weighed prior to sample collection, and the container/preservative weight will be recorded on the chain of custody. A digital scale capable of +/- 0.1 gram(s) accuracy will be used to weigh the sample containers.

6 If a sample for VOC is desired it will be collected first using an open barrel, disposable syringe. VOC samples should **never** be homogenized or composited.

7 The end of syringe barrel will be covered.

8 For a Low Level Analysis the soil will be extruded into a prepreserved VOA vial containing a stir bar, sodium bisulfate (5 ml) and distilled water.

9 If the sample is collected for high level volatile analysis, the sample will be extruded into a VOA vial containing Purge and Trap grade methanol (15 ml).

10 The syringe will be filled with undisturbed soil of the following volumes: 5 grams of soil for low-level analysis (added to the soil of sodium bisulfate); and/or 15 grams of soil for high level analysis (added to the 15 ml of methanol).

11 Any particles of grains present on the container rim or cap will be removed to ensure an adequate seal of the vial. The VOA vial will be capped quickly and label with sample IDs, date, and time of collection. The container/preservative/sample will then be weighed and that post-collection weight will also be recorded on the chain of custody. The objective sample weights(5g for low-level analysis, and 15 g for high level analysis) will be achieved (+/- 10%) with the use of the digital scale. Should insufficient sample volume be added to the preserved container, a stainless-steel spatula will be used to add a small portion of sample until the target weight is achieved (or exceeded with 10%).

12 In the event that a field screening technique (instrument reading, visual staining of the soil, or olfactory observation) indicates the presence of VOCs or hydrocarbons, note the observations or instrument readings in the field logs).

13 Collect additional material for the remaining parameters by collecting the sample with the stainless steel spoon and transferring the soil into a stainless steel bowl. Homogenize the sample by mixing the sample within the bowl using the stainless steel spoon prior to filling the remaining sample containers.

14 Record the sample location, ID and time in the field logbook. Complete the TRC Sample Log Sheet (attached) with the following:

- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was taken
- Personnel performing the task
- Visual or sensory description of the sample
- Brief sediment descriptions (color, texture, appearance)
- Weather conditions during sampling
- Runoff conditions
- Other pertinent observations
- Soil description
- Weights of preserved VOC containers before and after sample collection.

Label each sample container with the following information:

a. TRC Project No.:________(e.g., 2850-N61-22)

b. Project Name:____(e.g., XYZ Corporation)

c. Sample ID.: X-SS 12 - 41884 - 3"-6"

Where: X - site initials (e.g., XYZ Site)
SS - Surface Soil
12 - Sampling Location
41884 - Date
3"-6" - Depth of Sample

d. Analysis Required:_______(e.g., METALS)

e. Preservative:_______(e.g., ICED)

f. Collection time:______(e.g., 1415)

g. Collection date:______(e.g., 4-18-84)

h. Initials of collector:______(e.g., FWJ)

After the samples have been collected, the sampling location will be marked with wooden stakes colored with highly visible spray paint in order to identify the sample location for surveying purposes.

Wrap the sample containers in a resealable plastic bag, place them into a shipping container, cool with ice packs and complete the chain-of-custody form. Pad the samples with bubble wrap and/or vermiculite packing as necessary.

2.2 Duplicate Surface Soil Collection

The following procedures should be used for collecting duplicate surface soil samples:

1. For quality control purposes, each duplicate sample will be submitted to the laboratory as a "blind" duplicate sample, in that a non-existing sampling point will be assigned in labeling the duplicate. All labeling procedures used for surface soil sampling will be employed. Since the duplicate is collected simultaneously to the actual sample, a "blind" sample time, within one hour of the actual time, will also be assigned. The actual source and collection time of the duplicate sample will be recorded in the field book.

2. Each duplicate sample will be collected simultaneously with the actual sample. At the coincident step in the sampling procedures that the VOC containers are filled and sealed, the duplicate sample VOC containers will also be filled and sealed. Following the order of collection specified for each set of containers (VOCs, SVOCs, unfiltered inorganic compounds, and filtered inorganic compounds), the duplicate sample containers will be filled simultaneously with each parameter.

3. All collection and preservation procedures outlined for surficial soil sampling will be followed for each duplicate sample.

TRC

Sample Log Sheet

Project:	Project No.:	Date/Time:	Sheet ___ of ___
Contractor Personnel:		Alliance Personnel:	

Sample No.: ____________________

Depth/Interval Sampled: ____________

Sample Type: Grab, Composite or Both (circle)

Media: (circle)
Surface Soil
Subsurface Soil
Other __________
Sediment
Surface Water
Ground Water

Sketch of Sample Location

Field Screening Information:

Type of Meter:

Other Field Measurements:

Observations:

SAMPLE COLLECTION EQUIPMENT:

- Hand Auger ☐
- Core Sampler ☐
- Spatula/Spoon ☐
- Bowl (stainless) ☐
- Split-spoon (2" or 3") ☐

OTHER:

- Trowel ☐
- Shelby Tube ☐
- Dredge Sampler ☐
- Kemmerer ☐
- Extended Arm ☐
- Bailer ☐
- Backhoe ☐
- Van Dorn Bottle ☐

DECONTAMINATION PROCEDURE:

DECON. FLUID	USED	DESCRIPTION:
Tap water	☐	
Alconox	☐	
Tap water	☐	
HNO_3 (1 or10%)	☐	
Tap Water	☐	
Methanol	☐	
Hexane	☐	
Acetone	☐	
Air Dry	☐	
DI Water	☐	
Air Dry	☐	
None	☐	

ANALYTICAL PARAMETERS	Filtered (circle)	Preservation Method	Volume Required	Time of Collection	CLP Sample	CLP Case#
☐ TCL Volatiles	YES NO					
☐ BNA Extractables	YES NO					
☐ PCBs/Pesticides	YES NO					
☐ TAL Metals	YES NO					
☐ Cyanide	YES NO					
☐ ________	YES NO					

AF-212

Rev: 8 July 1991

Signed: ____________________

TRC STANDARD OPERATING PROCEDURE NO. 003

SURFACE WATER &
SEDIMENT SAMPLING

Prepared by: Adam Balogh, P.G. — Date: 10/22/99

Coordinated by: Dale Weiss, P.G., Project Manager — Date: 10/22/99

Approved by: Peter Spawn, Program Manager — Date: 10/25/99

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2.3 Sediment Sampling Procedure 5

ATTACHMENT A TRC Sample Log Sheet

TRC STANDARD OPERATING PROCEDURE NO. 003
SURFACE WATER AND SEDIMENT SAMPLING

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the logistics, collection techniques, and documentation requirements for collecting surface water and sediment samples. The SOP conforms with "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of surface water and sediment sampling is to obtain a representative sample of these media for laboratory analysis of contaminants of concern at a given site. This objective requires that the sample be both free of unsuitable material and be of sufficient quantity and quality for analysis by the selected analytical method.

1.2 Equipment

The following equipment is needed for surface water and sediment sampling:

Surface Water Sampling

- Boots, waders, latex gloves, chemical resistant gloves, appropriate level of personal protection.
- Sample containers (40 milliliter VOA vials, 1 liter amber glass jars and 1 liter plastic bottles).
- Wooden stakes and highly visible spray paint.
- Kemmerer bottle, Van Doru bottle or sterile sampler (if required). The sampler employed will be manufactured of stainless steel, Teflon, or glass.
- Waterproof field logbook and/or TRC Sample Log Form.
- Sample bottle, labels (TRC or EPA, as necessary).
- Chain-of-custody forms (TRC or EPA, as necessary).
- Boat (if needed).

Sediment Sampling

- Boots, waders, latex gloves, chemical resistant gloves, appropriate level of personal protection.

- Dedicated stainless steel spoons (2 tablespoon size), hand auger, or ponar dredge (for river/stream sediments).
- Indelible markers
- Digital scale (accurate to +/- 0.1 grams)
- Disposable sampling syringe
- Encore sampling containers (if conditions allow)
- Stainless-steel mixing bowl
- Stainless-steel spatulas or spoons.
- Dedicated Teflon spoons (if required).
- Sample containers; one (1) liter glass jar with a Teflon lined cap or two (2) 8 oz. Glass jars with Teflon lined caps (per sample). Samples to be analyzed for VOCs will be collected by the USEPA 5035 method using the following glassware: (a) "high level" analysis – one (1) 40 ml VOA vial pre-preserved with 15 ml of methanol; or (b) "low level" analysis 15 ml of methanol and two (2) 40 ml VOA vials pre-preserved with 5 ml of sodium bisulfate. All samples submitted for VOC analysis will include on small (40 ml to 4 oz) container, in order to allow the laboratory to record the moisture/dry-weight characteristics. Should conditions allow, VOC samples may be collected with Encore samplers, rather than methanol – preserved glassware.
- Samples collected for VOC analysis with the use of Encore samplers will be containerized as follows: a. for high level VOC analysis, one 25-gram Encore sampler will be provided to the laboratory; and, two 5-gram Encore samplers will be provided to the laboratory. Samples will be collected directly into the Encore samplers, capped and sealed, and delivered to the laboratory within 7 day of collection.
- Wooden stakes and highly visible spray paint.
- Waterproof field logbook and/or TRC Sample Log Form.
- Sample bottle labels (TRC or EPA, as necessary).
- Chain-of-custody forms (TRC or EPA as necessary).

2.0 PROCEDURES

2.1 Order of Samples

If both stream sediment and water samples are to be collected concurrently, the water samples should be taken first in order to avoid introducing sediment into the water column from sediment collection activities.

In flowing streams or runoff channels, samples should be collected first from the furthest point downstream. The remaining samples will be taken while proceeding upstream.

2.2 Surface Water Sampling Procedure

The person collecting the samples in most cases will have to enter the water body. For flowing streams this will necessitate the donning of boots or waders, and wearing of latex inner gloves and chemical resistant outer gloves. All samples in flowing water bodies will be taken facing upstream. Samples taken from small lakes or ponds should be taken from a boat using a Kemmerer or Van Dorn bottle. Samples taken from standing puddles, pools, and drainage ditches should be taken without disturbing the sediments. This may be accomplished by the use of a remote sampler, e.g., a sample bottle held on a long pole with a gimballed yoke.

The sampling procedure for surface water is as follows.

1. Prior to collecting any water samples, place a waterproof sample label on each container following this system:

   a. TRC Project No.: _____ (e.g., 2850-N61-22)

   b. Project Name: ______ (e.g., XYZ Corporation)

   c. Sample ID X-SW-10 41884

      Where X-site initials (e.g., XYZ Site)
      SW-surface water
      10-sampling location
      41184-date

   d. Analysis required: ______ (e.g., TOC)

   e. Preservative:______(e.g., ICED pH<2 H_2SO_4)

   f. Collection Time:______(e.g., 0930)

   g. Collection date: _____ (e.g., 4-11-84)

   h. Initials of collector______(e.g., GLD)

   Fill in the information with a waterproof ink pen before sample collection. This will prevent difficulty in filling out a wet label.

2. Determine the amount of preservative required for each type of sample, prior to collection of samples at a given location. Collect an aliquot of sample in the

appropriate container, and slowly add preservative until the pH as indicated by pH paper, is at the specified level. Place the same amount of preservative in the remaining sample containers.

3. Face upstream; wearing gloves, take clean, wide-mouth container and submerge it.

4. Take the filled jar and fill pre-preserved volatile organic vials before filling any other containers. Slightly over-fill the vial and screw on the cap. Then turn the vial upside down and tap lightly to check for air bubbles. Air bubbles of any size should not be present as they can introduce significant error in the analysis of the sample. If any air bubbles are present, empty the vial and repeat the process.

5. Using the same wide-mouth container as a scoop, continue to fill the remaining pre-preserved sample bottles. Where samples are to be submitted for dissolved metals and/or cyanide, and field filtration is required, 500 ml of water collected from the sampling point will be filtered in the field using a portable pump and sterile, dedicated filtration devices. The filtered sample will be preserved subsequent to the filtration.

6. Gently mix all samples and check for proper preservation with indicator paper (i.e., pH paper).

7. The temperature, pH, dissolved oxygen, oxidation reduction potential and conductivity of the sampled water should be determined immediately after sample collection. Where possible, field measurements of these parameters will be measured in-site, rather than from a sample container. These measurements should not be taken from any sample bottles being sent to the analytical laboratory for chemical analysis.

8. Wrap the sample containers in a resealable plastic bag, place them into a shipping container, cool with ice packs and complete the chain-of-custody form. Pad the samples with bubble wrap and vermiculite packing as necessary.

9. Detail in the field logbook the sample location, ID, and time. Complete the TRC Sample Log Sheet (attached) with the following:

- Sample identification number
- Location of the sample (sketch of the sample point)
- Time and date sample was taken
- Personnel performing the task
- Visual or sensory description of the sample (color, odor, turbidity, etc.)
- Weather conditions during sampling
- Runoff conditions

- Other pertinent observations

10. Place a spray painted wooden stake at the edge of the stream or near the sample point with the sample number on it. The stake will be located by survey for inclusion on a site map.

11. Field investigation requiring more than one sampling event should include the use of a Master Sample Log and a Field Chemistry Logbook. At the end of each day, all samples shall be recorded in the Master Logbook Calibration of field instruments and field chemistry measurements such as pH shall be recorded in the field chemistry logbook.

2.3 Sediment Sampling Procedure

The following procedure will be followed for sediment sampling.

1. Select a sample location that is representative of sediment depositional areas. This might mean a sandbar in the middle of a stream, the inside corner of a stream bed in a meander, or a deep pool where water velocities are reduced.

2. Place a waterproof sample label on the glass container which specifies the following:

   - TRC Project No.
   - Project Name
   - Sample ID
   - Analysis Required
   - Preservative
   - Collection Time
   - Collection Date
   - Initials of the collector

   Record the information with a waterproof ink pen prior to collecting the sample.

3. For VOC analysis prior to collecting the sample, USEPA method 5035 specific volumes of preservative (methanol and sodium bisulfate) will be added to sterilized 40 ml containers. Each pre-preserved container will then be weighed prior to sample collection, and the container/preservative weight will be recorded on the chain of custody. A digital scale capable of +/- 0.1 gram(s) accuracy will be used to weight the sample containers.

4. Use either a pre-cleaned dedicated stainless steel spoon or Teflon coated

spoon (that will fit inside the sample jar), to collect the sample except for samples for VOC analysis which will be collected using an open barrel, disposable syringe.

5. All samples should be taken within the top 6 inches of the stream bed. Remove any vegetation debris (leaves, roots, bark) along with any large stones from the sample so that only the finer soil material is collected. Samples should be obtained using the appropriate sampling device lauger, core barrel, shovel or ponar dredge

6. Excess liquids collected along with the sediment sample will be allowed to decant from the (auger or dredge) sampler prior to sample containerization.

7. Sediment samples for VOC analysis shall be collected directly from the dredge/auger sampling device using an open barrel, disposable syringe.

8. The syringe will be filled with undisturbed soil of the following volumes: 5 grams of soil for low-level analysis (added to the 5 ml of sodium bisulfate); and/or 15 grams of soil for high level analysis (added to the 15 ml of methanol).

9. The end of the syringe barrel will be covered.

10. For high level VOC analysis, the soil will be extruded from the syringe into a preserved VOA vial, containing "purge and trap" grade methanol (15 ml).

11. For low level VOC analysis, the soil will be extruded from the syringe into a preserved VOA vial, containing sodium bisulfate (5 ml), a stir bar, and distilled water.

12. Any particles or grains present on the container rim or cap will be removed to ensure an adequate vial seal. The VOA vial will be capped quickly and labeled with Sample identification numbers, date and time of collection. The container/preservative/sample will then be weighed and that post-collection weight will also be recorded on the chain of custody. The objective sample weights (5 g for low-level analysis, and 15 g to high level analysis) will be achieved (+/- 10%) with the use of the digital scale. Should insufficient sample volume be added to the preserved container, a stainless-steel spatula will be used to add a small portion of sample until the target weight is achieved (or exceeded within 10%).

13. In the event that a field screening technique (instrument reading, visual staining of the soil, or olfactory observation) indicates the presence of VOCs or hydrocarbons, note the observations or instrument readings in the field logs.

14. Once the VOC fraction has been acquired, obtain sample material for the other parameters to be analyzed.

    - Detail in the field logbook the sample location, ID, and time. Complete the TRC Sample Log Sheet (attached) with the following:
    - Sample identification number
    - Location of the sample (sketch of the sample point)
    - Time and date sample was taken
    - Personnel performing the task
    - Visual or sensory description of the sample
    - Brief sediment description (color, texture, appearance)
    - Weather conditions during sampling
    - Run off conditions
    - Other pertinent observations

15. Place a wooden stake at the edge of the stream or near the sample point with the sample number on it. This stake will be located by survey for inclusion on a site map.

In the event that a duplicate or split sample is required, a composited sediment sample will be collected. Compositing will be performed by collecting enough sample for two containers and then placing the sample into a precleaned stainless steel basin and mixing it thoroughly with a stainless steel spoon. After mixing the sample, it should be equally divided between sample containers. Note that samples for VOCs will **not** be composited, but will be composed of separate samples collected immediately adjacent to each other.

2.3 Duplicate Surface Water and Sediment Sampling

The following procedures should be used for collecting duplicate surface water and sediment samples:

1. For quality control purposes, each duplicate sample will be submitted to the laboratory as a

"blind" duplicate sample, in that a non-existing sampling point will be assigned in labeling the duplicate. All labeling procedures used for surface water and sediment sampling will be employed and all parameters measured will also be recorded. Since the duplicate is collected simultaneously to the actual sample, a "blind" sample time, within one hour of the actual time, will also be assigned. The actual source and collection time of the duplicate sample will be recorded in the field book.

2. Each duplicate sample will be collected simultaneously with the actual sample. At the coincident step in the sampling procedures that the VOC containers are filled and sealed, the duplicate sample VOC containers will also be filled and sealed. Following the order of collection specified for each set of containers (VOCs, SVOCs, unfiltered inorganic compounds, and filtered inorganic compounds), the duplicate sample containers will be filled simultaneously with each parameter.

3. All collection and preservation procedures outlined surface water and sediment sampling will be followed for each duplicate sample.

TRC

Sample Log Sheet

Project: Project No.:

Date/Time:

Sheet ___ of ___

Contractor Personnel:

TRC Personnel:

Sample No.: ______________________

Depth/Interval Sampled: ____________

Sample Type: Grab, Composite or Both (circle)

Media: (circle)
Surface Soil Sediment
Subsurface Soil Surface Water
Other __________ Ground Water

Sketch of Sample Location

Field Screening Information:

Type of Meter:

Observations:

Other Field Measurements:

SAMPLE COLLECTION EQUIPMENT:

- Hand Auger ☐
- Core Sampler ☐
- Spatula/Spoon ☐
- Bowl (stainless) ☐
- Split-spoon (2" or 3") ☐
- OTHER:
- Trowel ☐
- Shelby Tube ☐
- Dredge Sampler ☐
- Kemmerer ☐
- Extended Arm ☐
- Bailer ☐
- Backhoe ☐
- Van Dorn Bottle ☐

DECONTAMINATION PROCEDURE:

DECON. FLUID	USED	DESCRIPTION:
Tap water	☐	
Alconox	☐	
Tap water	☐	
HNO_3 (1 or10%)	☐	
Tap Water	☐	
Methanol	☐	
Hexane	☐	
Acetone	☐	
Air Dry	☐	
DI Water	☐	
Air Dry	☐	
None	☐	

ANALYTICAL PARAMETERS	Filtered (circle)	Preservation Method	Volume Required	Time of Collection	CLP Sample	CLP Case#
☐ TCL Volatiles	YES NO					
☐ BNA Extractables	YES NO					
☐ PCBs/Pesticides	YES NO					
☐ TAL Metals	YES NO					
☐ Cyanide	YES NO					
☐ __________	YES NO					

AF-212

Rev: 8 July 1991

Signed: ______________________

TRC STANDARD OPERATING PROCEDURE NO. 004

EQUIPMENT DECONTAMINATION PROCEDURES

Prepared by: ______________________ 10/22/99
Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/22/99
Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/25/99
Peter Spawn, Program Manager Date

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TRC STANDARD OPERATING PROCEDURE NO. 004
EQUIPMENT DECONTAMINATION PROCEDURES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for decontamination of field equipment used in hazardous waste investigations. The SOP conforms to "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of equipment decontamination is to remove potential contaminants from a sampling device or item of field equipment prior to and between collection of samples for laboratory analysis and limit personnel exposure to residual contamination that may be present on used field equipment.

1.2 Equipment

The following equipment may be utilized when decontaminating equipment. Site-specific conditions may warrant the use or deletion of items from this list.

- Alconox, liquinox or other non-phosphate concentrated laboratory grade soap;
- Deionized Water;
- Pump Sprayer;
- 1-Pint Squeeze bottle filled with pesticide-grade hexane;
- 1-Pint Squeeze bottle filled with pesticide-grade methanol;
- 1-Pint Squeeze bottle filled with ten (10) percent nitric acid;
- 1-Pint Squeeze bottle filled with one (1) percent nitric acid;
- Five large plastic wash basins (24 inches by 30 inches by 6 inches deep);
- Two coarse scrub brushes;
- Small wire brush;
- Aluminum foil;
- Polyethylene sheeting;
- Two large capacity barrels;
- All necessary personal protective equipment (gloves, eyewear, tyveks);
- Extra quantities of above listed liquids; and

- 4 inch Schd 40 PVC pipe 4 feet in length with an end cap for decowing Pump and associated tubing (if needed).

2.0 PROCEDURES

2.1 General

The following procedures should be used for decontaminating field equipment. Procedures will vary with equipment used and potential contaminants present at the site.

2.2 Procedure for Soil Sampling Equipment

Soil sampling equipment, such as split spoon samplers, shovels, augers, trowels, spoons, and spatulas will be cleaned using the following procedure.

1. Lay out sufficient polyethylene sheeting on the ground or floor to allow placement of the five plastic wash basins and an air drying area. Place wash basins on the polyethylene sheeting.

2. Fill the first wash basin with potable tap water. Add sufficient soap powder or solution to cause suds to form in the basin. Do not use an excessive amount of the soap or rinsing the soap residue off the equipment will be difficult.

3. Using a clean coarse scrub brush, wash the sampling equipment in the soap solution in the first basin, removing all dirt. Allow excess soap to drain off the equipment when finished.

4. Rinse the equipment with tap water in the second basin, using a coarse scrub brush or pressure sprayer to aid in the rinse, if necessary.

5. If the equipment is being used to sample for metals, rinse the equipment with nitric acid in the third basin. A 10 percent solution is used on stainless steel equipment. A one percent solution is used on all other equipment. If no metals sampling is being performed, this step may be omitted.

6. Spray down the equipment in the third basin, using deionized water.

7. Spray down the equipment in the fourth basin, using pesticide-grade methanol, if sampling for organic compounds is to be performed. If oily, a two-step process using methanol, followed by hexane should be used to remove both water soluble and non-

soluble compounds. If no samples for organic compounds are being collected, this step may be omitted.

8. Allow the equipment to completely air dry on clean polyethylene sheeting.

9. Rinse the equipment in the fifth basin, using deionized water.

10. Allow the equipment to completely air dry on clean polyethylene sheeting.

11. Reassemble equipment, if necessary, and wrap completely in clean, unused aluminum foil, shiny side out for transport. Re-use of equipment on the same day without wrapping in foil is acceptable.

12. Allow spent cleaning solutions in the trays to evaporate into the air. If evaporation is not possible, all spent cleaning solutions shall be drummed for disposal along with any other contaminated fluids generated during the field investigation.

13. Record the decontamination procedure in the field logbook or on appropriate field form.

14. If step 8, rinsing with organic solvents, was performed, check the equipment for the presence of residual solvents with a photoionization or flame ionization detector prior to use. If a detection occurs, disassemble the equipment and allow to air dry until no readings are observed, then re-rerinse with deionized water.

Note that if temperature or humidity conditions preclude air drying equipment, sufficient spares should be available so that no item of sampling equipment need be used more than once. Alternatively, the inability to air dry equipment completely prior to reuse should be noted in the field logbook. In this case, additional rinses with deionized water should be used and recorded.

2.3 Procedure for Ground Water Sampling Equipment

Ground water sampling equipment, such as bailers and stainless steel cord will be cleaned using the following procedure.

1. Lay out sufficient polyethylene sheeting on the ground or floor to allow placement of the five plastic wash basins and room for air drying and place wash basins on the sheeting.

2. Fill the first wash basin with potable tap water. Add sufficient soap powder or solution to cause suds to form in the basin. Do not use an excessive amount of soap or rinsing the soap residue off the equipment will be difficult.

3. Wash the sampling equipment in the soap solution in the first basin, removing all residues. Allow excess soap to drain off the equipment when finished.

4. Rinse the equipment with tap water in the second basin.

5. If the equipment is being used to sample for metals, rinse the equipment with nitric acid in the third basin. A 10 percent solution is used on stainless steel equipment. A one percent solution is used on all other equipment. If no metals sampling is being performed, this step may be omitted.

6. Spray down the equipment in the third basin, using deionized water.

7. Spray down the equipment in the fourth basin, using pesticide-grade methanol, if sampling for organic compounds is to be performed. If oily, a two-step process using methanol, followed by hexane should be used to remove both water soluble and non-soluble compounds. If no organic compounds sampling is being performed, this step may be omitted.

8. Allow the equipment to completely air dry on clean polyethylene sheeting.

9. Rinse the equipment in the fifth basin, using deionized water.

10. Allow the equipment to completely air dry on clean polyethylene sheeting.

11. Reassemble equipment, if necessary, and wrap completely in clean, unused aluminum foil, shiny side out for transport. Re-use of equipment on the same day without wrapping in foil is acceptable.

12. Allow spent cleaning solutions in the trays to evaporate into the air. If evaporation is not possible, all spent cleaning solutions shall be drummed for disposal along with any other contaminated fluids generated during the field investigation.

13. Record the decontamination procedure in the field logbook or appropriate field form.

14. If step 8, rinsing with organic solvents, was performed, check the equipment for the presence of residual solvents with a photoionization or flame ionization detector prior to use. If a detection occurs, disassemble the equipment and allow to air dry until no readings are observed. Re-rinse with deionized water.

Note that if temperature or humidity conditions preclude air drying equipment, sufficient spares should be available so that no item of sampling equipment need be used more than once.

Alternatively, the inability to air dry equipment completely prior to reuse should be noted in the field log. In this case, additional rinses with deionized water should be used and recorded.

2.4 Procedure for Oversized Equipment

Outsized equipment, such as submersible pumps, will be cleaned using the following procedure.

1. Fill two clean barrels with tap water.

2. Add sufficient concentrated soap to one barrel to form a thin layer of soap suds.

3. Immerse the pump in the soap containing barrel and start pump. Circulate the soap solution through the pump and feed discharge into a waste disposal drum or into the municipal sewage disposal system.

4. Immerse the pump in the barrel filled with clean tap water and start pump. Circulate the water through the pump and feed discharge into a waste disposal drum. Run the pump until no soap residue is visible in the discharge.

5. Deionized water should then be run through the pump and used to rinse all submersible parts and hoses.

6. Record the decontamination procedure in the field logbook or appropriate field form.

2.5 Procedure for Measuring Equipment

Measuring equipment, such as pressure transducers or water level indicators, will be cleaned using the following procedure.

1. Fill two clean basins with tap water.

2. Add sufficient concentrated soap to one basin to form a thin layer of soap suds.

3. Immerse the device in the soap containing basin and gently agitate. Scrub device if it is soiled. Do not submerse any electrical connectors or take up reels, only that portion of the device in contact with potentially contaminated water.

4. Immerse the device in the basin containing the rinse water and gently agitate. Do not submerse any electrical connectors or take up reels, only that portion of the device in contact with contaminated water.

6. Spray rinse equipment with deionized water.

7. Allow the equipment to air dry.

8. Record the decontamination procedure in the field logbook or appropriate field form.

TRC STANDARD OPERATING PROCEDURE NO. 005

SOIL DESCRIPTION PROCEDURE

Prepared by: ______________________ 10/22/99
Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/22/99
Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/25/99
Peter Spawn, Program Manager Date

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ATTACHMENT A

TRC Boring Log

TRC STANDARD OPERATING PROCEDURE NO. 005
SOIL DESCRIPTION PROCEDURE

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the method for describing soil samples in test pits, soil borings, and soil grab samples. The SOP conforms to "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of soil sample description is to provide geological information useful for the purpose of hydrogeological or geotechnical evaluation of a site. This objective requires a soil description method that is based upon widely accepted geological criteria.

1.2 Equipment

The following equipment may be necessary during soil description activities:

- Sand grading chart
- Field logbook
- Folding Ruler or Yard Stick
- Portable table
- Polyethylene sheeting
- Hand lens
- Deionized water in squeeze bottle
- Required personal protective equipment (gloves, boot, eye wear, hard hat, etc.)
- Air monitoring equipment (as required)
- Duct tape
- Boring logs (if applicable)

2.0 PROCEDURES

2.1 General

The general description of a soil sample should be in the following order:

1. Color
2. Density
3. Moisture content
4. Geologic modifiers or classifications
5. Major constituent - capitalized
6. Minor Constituent
7. Geologic description (in parentheses)

Example: Tan, loose wet stratified medium SAND, little fine sand, trace coarse sand, trace silt (glacial outwash)

When logging a soil sample collected from a split spoon when more than one soil material is present in the split spoon, describe each one separately, using an additional line(s) on the boring log form. Start the description from the top of the split spoon, and log each change in stratigraphy in sequence to the bottom of the spoon. Provide an interval or length (i.e., 0-5 ft.:) at the beginning of each separate sequence description, followed by a colon. Draw a line below the bottom of the complete sample description.

2.2 Color

The main color value should be stated, along with an appropriate modifier. For example

- light brown
- dark brown
- reddish brown
- brown

The presence of mottling should be included in the description, where present. For example:

- Gray, slightly mottled, dense, damp, poorly sorted angular fine to medium SAND, some silt, trace angular coarse sand, trace clay (lodgement glacial till).

2.3 Density

In borings, density should be based on the sum of the middle two 6-inch blow counts of a two foot split spoon or the last two 6-inch blow counts of an 18-inch split spoon. Professional judgement should be used when applying the density modifier. If high blow counts are due to the presence of a cobble, boulder or large piece of gravel that impedes forward progress of the split spoon, density should based upon the character of the material in the split spoon, if any, or omitted from the description. A notation should be made in the sample description when this situation occurs. Appropriate modifiers are described in the following table.

Granular Soils		Cohesive Soils	
Blows/ft	**Density**	**Blows/ft**	**Density**
0-4	very loose	<2	very soft
4-10	loose	2-4	soft
10-30	medium dense	4-8	medium stiff
30-50	dense	8-15	stiff
>50	very dense	15-30 >30	very stiff hard

In test pits, density is subjective and should be based upon the ease of excavation. The above adjectives for granular and cohesive soils should be used in the description.

2.4 Moisture content

Moisture content should be described using the following modifiers:

- **Dry** - no moisture.
- **Moist** - very slight moisture content, no visible water droplets.
- **Wet** - saturated.

2.5 Geologic Modifiers

Sedimentological descriptions aid in the geologic classification of a soil material. Appropriate modifiers include:

- **Stratification** - the presence of alternating layers of non-cohesive materials of different grain sizes.
- **Lamination or varves** - the presence of alternating very thin layers of fine materials, such as silt and clay.

- **Sorting** - A geological term used to describe how close in size the grains in a sample are to each other. For example, a well sorted sample contains grains of similar size; a poorly sorted sample contains grains of many sizes.

- **Grading** - An engineering term used to describe the range in grain sizes present in a sample. For example, a narrowly graded sample contains grains of similar size; a widely graded sample contains grains of different sizes.

- **Angularity or rounding** - Geological terms that are used to describe the general appearance of visible grains in the soil sample. Useful in determining the origin and depositional environment of a material. Water transported materials may be rounded. Glacial tills will be more angular.

2.6 Grain-size scales

Grain size classification should be based on an accepted classification system such as, the Unified System. The predominate grain size should be listed in the soil description in all capital letters.

Boulder	> 300 mm
Cobble:	75 - 300 mm,
C. Gravel:	19 - 75 mm,
F. Gravel:	4.75 - 19 mm,
C. Sand:	2.0 - 4.75 mm,
M. Sand:	0.425 - 2.0 mm,
F. Sand:	0.075 - 0.425 mm
Silt:	0.002 - 0.075 mm
Clay:	<0.002 mm

2.7 Proportions

For geologic description, proportions of grain sizes will be based upon the following nomenclature:

- Trace: 0-10%
- Little: 10-20%
- Some: 20-35%

- And: 35-50%

The major soil sample constituent is always capitalized and listed first.

Minor constituents also include ancillary materials such as mica flakes, dark minerals, or naturally occurring organic matter, such as humus, peat, or other vegetative material.

TRC

Project/Client	Project No.	Boring No.	Sheet
		Well No.	___ of ___
Location Description		TRC Geologist	

Drilling Contractor/Foreman	Drill Rig Make/Model	Auger/Drive Casing Size/Type

Sampler Description	Drilling Method	Coordinates X= Y=	
Filter Seal Amount/Type:	Drill Bit/Auger Diameter:	Ref. El.:	
Sand Pack Amount/Type:	Hammer Weight/Fall:	Riser Stick Up:	
Screen Length/Type:	Water Table Depth:	Surface Elevation:	
Riser Length/Type:	Total Depth:	Date Start:	Date Finish:

Depth	Sample Number	Blows/ RQD	Pen/Rec Core Rec	Sample Description	Strati-graphic Description	Field Testing	Lab Sample Number	Well Construction

Granular Soils

Blows/ft	Density
0-4	v. loose
4-10	loose
10-30	m. dense
30-50	dense
>50	v. dense

Proportions

trace 0-10% some 20-35%
little 10-20% and 35-50%

Cohesive Soils

Blows/ft	Density
>2	v. soft
2-4	soft
4-8	m. stiff
8-15	stiff
15-30	v. stiff
>30	hard

Grain Size (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. sand	2.0-0.43 mm
c. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Notes

A-??

TRC

Project/Client	Project No.	Boring No.	Sheet
		Well No.	___ of ___
Location Description		TRC Geologist	

Depth	Sample Number	Blows/ RQD	Pen/Rec Core Rec	Sample Description	Strati-graphic Description	Field Testing	Lab Sample Number	Well Construction

Granular Soils

Blows/ft	Density
0-4	v. loose
4-10	loose
10-30	m. dense
30-50	dense
>50	v. dense

Proportions

trace	0-10%	some	20-35%
little	10-20%	and	35-50%

Cohesive Soils

Blows/ft	Density
>2	v. soft
2-4	soft
4-8	m. stiff
8-15	stiff
15-30	v. stiff
>30	hard

Grain Size (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. sand	2.0-0.43 mm
c. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Notes

AF-280

TRC STANDARD OPERATING PROCEDURE NO. 006

SOIL AND ROCK BORING

Prepared by: Adam Balogh, P.G. — Date: 11/8/99

Reviewed by: Dale Weiss, P.G., Project Manager — Date: 11/8/99

Approved by: Peter Spawn, Program Manager — Date: 11/8/99

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Attachment A Boring Log
Attachment B TRC Rock Core Log

TRC STANDARD OPERATING PROCEDURE NO. 006
SOIL AND ROCK BORING

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for recording subsurface conditions in soil borings during site hydrogeological and geotechnical investigations. The SOP conforms to "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of borings is to provide samples for description and characterization of subsurface conditions, and obtain samples for geotechnical and chemical analyses, often prior to installation of a monitoring well. This objective requires the use of consistent procedures for documenting observations and collecting samples.

2.0 PROCEDURES

2.1 Predrilling Requirements

When conducting borings in an industrial facility, TRC will contact all utilities or industrial facility personnel necessary to receive clearance to drill at specified locations. The names of the personnel authorizing clearance will be documented in the field logbook. The exact location of each boring shall also be reviewed by responsible plant personnel to ensure that the area is free of the facility-owned buried utilities.

Dig-safe will be contacted prior to drilling in public areas. Drilling locations shall be no closer than 25 feet to overhead utilities. The appropriate utility companies will be contacted to provide insulation of utility lines prior to commencement of drilling activities.

The supervising geologist/engineer shall record the name of the drilling firm and the names of the driller and his assistant(s). The date, project location, project number, and weather conditions shall be recorded as well.

An accurate time log of drilling activities shall be kept. This log shall be kept in the field logbook and shall include at a minimum, the following:

- Time driller and rig arrive on site
- Time drilling begins

- Any delays in the drilling activities and the cause of such delays
- Time drillers go off site
- Down time (those periods when drilling activities cease due to equipment malfunctions, weather, ordered stoppages)

2.2 Test Boring Method

Test borings can be conducted by a variety of drilling methods. The more commonly employed test boring techniques may be classified in to six groups, based on the method used in displacing or removing subsurface material during the advancement of the borehole. The six drilling techniques are: displacement boring, wash boring, percussion drilling, rotary drilling, auger boring, and continuous sampling. The quality of the information obtained from the various boring methods varies greatly with the character of the subsurface geologic conditions, and careful consideration should be given in selecting the desired method. It may be necessary to employ more than one boring method to advance a particular borehole. The drilling techniques used on any particular project will be selected by the project manager and/or project geologist. In general, the wash rotary, and auger boring are most common and described below.

2.2.1 Wash Boring

This method involves advancing casing, as required, and washing-out the soil to the bottom of the casing with a chopping bit to the desired sampling depth. The casing can e advanced by either spinning or hammering (pounding) the casing with a 300 pound hammer. The borehole may be stabilized with the casing, water, or drilling mud, and open samplers, such as the split-or solid-spoon type are driven into the undisturbed soil at the bottom of the borehole.

This method is most commonly used in soils which do not contain large cobbles and boulders, or cemented horizons. The wash boring method involves the introduction of drilling water and/or drilling mud to the borehole. The use of these materials and this method should be avoided whenever possible in conducting environmental investigations. The introduction of drilling fluids can alter the chemical composition of the groundwater adjacent to the borehole, and may have an adverse effect on groundwater quality analyses on groundwater samples from monitoring wells installed in the completed borehole.

If it is necessary to use this technique to advance a borehole, the field geologist should determine the source and quality of the drilling water to be used in the boring process. The field geologist should not authorize the use of on-site or nearby groundwater or surface water bodies as the source of the drilling water, unless the proposed source has been sampled and analyzed for the full suite of contaminants considered likely to be present in the groundwater or surface water bodies as the source of the drilling water, unless the proposed source has been sampled and analyzed for the full suite of contaminants considered likely to be present in the groundwater beneath the site. In all cases where drilling water or drilling mid are used to advance a borehole, the field geologist should obtain an adequate sample of the drilling fluid for potential analysis, at the discretion of the project manager and quality assurance/quality control (QA/QC) officer.

2.2.2 Rotary Drilling

This method is a variation of the wash boring technique, utilizing a rotary drill bit, rather than a chopping bit. It is employed primarily in advancing and cleaning the borehole to the required sampling depth, and is used in conjunction with air, water, or mud to bring the cuttings to the ground surface. This is the method generally preferred for exploratory test borings in the geo-technical consulting industry. This method is commonly used in environmental investigations when test borings are expected to encounter dense tills and coarse granular deposits (such as gravels), or are expected to terminate at depths exceeding thirty feet below the ground surface.

The primary disadvantage of this technique for environmental investigations is the introduction of drilling water or drilling mud. The use of air rotary drilling rigs is usually not appropriate for environmental investigations unless filters are used because the cuttings brought to the ground surface are ejected into the air adjacent to the drilling rig. Air born contaminated soil could pose a health risk to workers at the site and nearby residents.

2.2.3 Auger Borings

This method involves advancing helical solid-flight or hollow-stemmed augers, with large mobile equipment. This is a fast method for advancing the borehole, without the use of drilling muds, in partially saturated or unsaturated material above the groundwater table. Conventional sampling procedures are employed (split-spoon sampler). Some disturbance of the natural soil is caused by the advancing augers. Auger borings are primarily used for environmental investigations because they are cost effective and do not involve the introduction of drilling fluids and muds to the subsurface environment.

Auger borings are difficult to advance below the groundwater table in granular soils due to the vertical pressure exerted by the groundwater following into the void created by the auger. This condition is commonly referred to as "running sands" or "blowing sands" in the drilling industry. "Running sands" can be counteracted with limited success by maintaining a constant hydraulic head in hollow-stemmed augers during the sampling operations. However, the constant head technique is not very effective when drilling more than approximately ten feet below the water table in granular soils.

Augers are difficult, and sometimes impossible, to advance to depths of greater than thirty feet in dense tills or coarse granular deposits (such as gravel).

Solid stem augers are not recommended for environmental investigations because soil samples can not be obtained from discrete depth intervals. Soil samples from solid stem auger borings are typically collected from the surface of the auger flights as the cuttings are brought to the ground surface.

Slotted, hollow-stemmed augers are commonly used in environmental investigations when vertical profiling of a water bearing unit is desired. The slotted lead auger is advanced to a pre-determined depth below the groundwater table, and water within the auger is purged with a pump to draw "undisturbed" formation water into the auger. A sample of the groundwater is obtained for analysis and the auger is advanced to the next groundwater sampling interval.

2.3 Borehole Stabilization

2.3.1 Casing

Driving steel pipe or casing provided the most reliable and practical method of advancing a borehole to the required depth. Table 1 summarizes the numerous sizes and types of casing available. The borehole is advance by constant blows of a drive hammer (typically 300 pounds, falling over a distance of 24 inches) upon a drive head which is attached to the casing. As the blows to drive the casing are constant, supplementary information may be obtained in the soil resistance by counting the casing blows and the resulting penetration. Casing blows are typically recorded for each foot of penetration of the casing. The casing can also be spun to the desired depth.

The casing is driven/spun in five-foot increments, with representative soil samples being obtained on a continuous basis or at the completion of each five-foot drive (depending upon the project specifications). After the casing is seated at the required depth, the borehole must be cleaned-out prior to obtaining a soil sample. In soft or loose soils, stability of the borehole is increased by keeping the casing filled with water or drilling fluids.

2.3.2 Drilling Mud

Drilling mud is a fluid employed to stabilize an encased borehole, or to improve sample quality and minimize soil disturbance in cased holes. Drilling mud may be prepared from any native clay or from several commercially available products. Employing mud in a boring makes identification of the cuttings more difficult and hinders groundwater level observations.

The use of drilling mud is typically avoided when conducting environmental investigations. The use of drilling mud can reduce the permeability of the walls of the borehole, and therefore, lead to erroneous water level measurements. Additionally, the use of muds introduces foreign material to the subsurface environment which is not completely removed upon completion of the boring. The results of chemical analyses conducted on soil samples from boreholes advanced with drilling mud may not be representative of the natural (undisturbed) formation. Water samples obtained from wells installed in these boreholes may contain contaminants or parameters which were not originally present in the groundwater prior to the use of the drilling mud.

Under no circumstances, should drilling mud be prepared with local or on-site clays. If the use of drilling mud is required to advance the boring, the mud should be prepared with commercially available clays, and samples of the mud mixture should be analyzed for the contaminants of concern.

The basic mud mixture employed in the drilling industry is bentonite and fresh water (approximately 6 percent bentonite by weight: 50 pounds of bentonite per 100 gallons of water). Attapulgite clay is commonly used and will mix with salt water to prevent flocculation. Weight additives such as pulverized barite, hematite, galena, or other heavy minerals may be added to the mixture to increase the specific gravity in troublesome soils or under artesian conditions. The precise ingredients and their puoportions in the mixture must be recorded for future reference, particularly when groundwater from wells installed in there borings is to be tested for dissolved metals and pH. Attention must be given to the particular group of contaminants exceed to be present in the groundwater beneath the site.

2.3.3 Hollow-stemmed Augers

Hollow-stemmed augers are advanced hydraulically into the overburden to the required sampling depth. The auger acts as a casing during the advancement of the borehole. A removable center plug allows passage of the sampling equipment (typically a split-spoon sampler) to the required depth. Augers are usually in five-foot sections. Some disturbances of the sampling zone may be created during the augering operation.

Drillers commonly dislike using the center plug and often attempt to complete the boring without using one. However, the center plug should always be used to prevent soil from entering the auger. If a center plug is not used, the split-spoon sampler may not be located at the desired sampling depth due to the presence of soil inside the auger.

2.4 Borehole Cleaning

Thorough and careful cleaning of the borehole is mandatory for obtaining representative, undisturbed samples. Careful measurement of tool length is required. The washing operation should not usually extend below the bottom of the casing (cohesive soils would be an exception). Special bits that deflect the wash water outward or upward should be employed, and only enough wash water should be pumped down the hole to bring the cuttings to the surface. Special shielded auger cleanouts should be employed in cohesive soils prior to obtaining undisturbed piston samples.

Where details of subsurface conditions are necessary, soil sampling shall be conducted using a split-spoon penetration sampler, driven with a 140 pound hammer with a free-fall of 30 inches. This is a standard method of soil sampling as described in ASTM Designation D 1586. If necessary, the length of the hammer shaft will be measured and marked, to ensure a minimum drop of 30 inches. This technique should be conducted as follows:

1. The split-spoon sampler (spoon) consists of a 2-inch (outside diameter) by 1-3/8 inch (inside diameter), 18-inch to 24-inch length, eat-treated, case-hardened steel head, split-spoon, and shoe assembly. Split-spoon or split-tube samplers are the most generally accepted method for obtaining representative, undisturbed soil samples.(refer to Figure 1)

   The head is vented to prevent pressure buildup during sampling and must be kept clean. A steel ball watercheck valve is located in the head to prevent downward water pressure from acting on the sample. Removal of the watercheck frequently causes sample loss.

2. The drive rods which connect the spoon to the drive head should have a stiffness equal to or greater than that of the A-rod. In order to maintain only minimal rod deflection, on exceptionally deep holes, it may be preferable to use N-rods. The size of the drive rods must be kept constant throughout a specific exploration program, as the energy absorbed by the rods will vary with the size and weight of the rod employed. This is most important in geotechnical investigation

3. The drive head consists of a guide rod to give the drop hammer (140 pounds) free fall in order to strike the anvil attached to the lower end of the assembly. The guide rod must be at least 3.5 feet in length to insure the correct hammer drop.

4. The drop hammer used in determining SPT resistance must weigh 140 pounds and have a 2.5 inch diameter hole through the center, for passage of the drive head guide rod.

5. The hammer is raised with a rope activated by the drill rig cathead; no more than 2 turns of the rope should be allowed on the cathead. A 30 inch hammer drop is mandatory for proper SPT determination. Extreme care must be exercised to produce consistent results.

Automatic trip hammers are commercially available which insure the 30 inch free-fall drop. When presentation of the soil structure is critical (such as in liquefaction studies), the automatic trip hammer should be employed.

6. Attach the split-spoon sampler to the drill rods and lower the assembly to the bottom of the borehole.

   Measure the drill rod stickup to determine if "eave" or "blow-up" of the stratum has occurred. Note any penetration of the sampler into the stratum under the weight of the rods. The 140 pound hammer is raised 30 inches above the drivehead anvil and then allowed to free fall and strike the anvil. This procedure is repeated until the sampler has penetrated the full length of the sampler (18 to 24 inches depending on the sampler) into the stratum at the bottom of the borehole.

7. The number of blows of the hammer required for each 6 inch penetration is counted and recorded on the test boring log. A penetration rate of 100 blows per foot is normally considered "refusal"; however, this criterion may be varied depending upon the desired information. The penetration resistance (N) is determined by adding the second and third 6 inch resistance blow counts together. When other sizes and types of sampling and drive equipment are employed, ASTM reference tables may be used in converting the obtained blow count to the accepted SPT value.

8. The sampler is then withdrawn from the borehole, preferably by pulling on the rope. If the sampler is difficult to remove from the stratum, it may be necessary to remove it by hitting the drive head upward with short, light hammer strokes. Remove the sampler from the bottom of the borehole slowly to minimize disturbance. Keep the casing full of water during the removal operation.

9. Careful measurement of all drilling tools, samplers, and casing must be exercised during all phases of the test boring operations, to insure maximum quality and recovery of the sample.

10. The split-spoon is opened and carefully examined, noting all soil characteristics, color seam, disturbance, etc. A representative sample is selected and preserved in a screw-top, glass jar and properly labeled. In the event that more than one soil type is encountered in the split-spoon, each soil type should be preserved in a separate jar.

11. The supervising geologist/engineer shall record, at a minimum, the weight of the hammer, the length of the split spoon sampler, and the number of hammer blows on the spoon per 6 inches of penetration. Upon removal of the sampler, the earth materials shall be logged in accordance with TRC SOP No. 005, Soil Sample Description.

When the number of blow counts exceeds 50 per 6 inches, the split spoon sampling shall be terminated and the number of blow per tenths of foot (for the last one-half foot) shall be recorded and noted as sampler refusal.

12. If a sample is to be retained, a pre-cleaned stainless steel or teflon coated spoon will be used to take the soil sample and fill the sample containers.

    After the samples have been collected, and the borehole has been backfilled with cement/bentonite or cement, the approximate location of the boring will be marked with an oak stake colored with highly visible spray paint. The boring number will also be written on the stake to identify the sample location for surveying purposes.

2.5 Logging Bedrock Cores

Rock Coring is a method to obtain bedrock samples for geologic classification, facilitate their performance of permeability tests, and install groundwater monitoring wells within bedrock formations.

The supervising geologist/engineer on a drilling program is responsible for logging and recording geologic and geotechnical information from rock cores.

There is no universal core barrel or drilling equipment for rock coring. The geologic and topographic conditions, in addition to the requirements of the project will dictate the type of equipment to be employed on any specific project. The following factors lead to good production:

1. Insure a level and stable drilling platform before commencing boring.

2. Insure that the drill stem remains as nearly vertical as possible. On deep core holes, true alignment of the casing is critical. The driller may elect to use a heavy drilling mud instead of casing to support the borehole walls; this procedure is not acceptable for environmental investigations.

3. Upon encountering boring refusal at the soil/bedrock interface, the casing should be firmly seated on the rock and thoroughly washed out before inserting the diamond-bit core barrel.

4. Inspect the selected core barrel and bit for wear, general cleanliness, and free movement of all parts. Reject any core barrel or bit that appears unsatisfactory. Upon selecting a

satisfactory core barrel and bit, mount the core barrel and bit assembly on the drilling rods and lower it into the borehole until the bit touches the bedrock surface.

5. Pump drill fluid down the drill rods and observe a return flow before commencing drilling operations.

6. Carefully measure all length of rods, core barrel, and stick-up through all phases of the drilling to insure accurate depth determination.

7. The diamond-bit core barrel should be started in the hole and the rock drilled in continuous 5-foot length intervals (runs) until the required depth is reached.

8. Drill with minimal vertical pressure and rotation. Most rigs are equipped with a selection of gear ratios and a variable hydraulically-controlled feed mechanism. Driller expertise in selecting the correct combination of speed and feed rate is invaluable.

9. Water return should be no more than what is just sufficient to bring the borehole cuttings to the surface.

10. Record the drilling time per foot, type of bit, estimate of bit wear, drill rig R.P.M.,and feed pressure.

11. Upon completing each 5 foot core run, the core barrel is spun and lifted to break the core at the bottom of the run. After the ore is broken off it should be withdrawn, labeled, and stored in an approved core box.(Refer to SOP # 5009) Cores should be carefully handled to ensure their proper identification and placement in correct order. Care should be taken to recover as large a percentage of unbroken core as possible.

12. Carefully place the rock core in the core box with wooden partitions so that the cores from each boring will be kept separate. The core should always be placed in the core box in book fashion with the top of the run at the upper left corner and the remaining core placed sequentially from left to right and from the top left corner to the lower right corner. Place a wooden partition at the beginning and end of each core run. The core should fit snugly in the box so that it will not roll or slide and suffer additional breakage. The wooden blocks should be labeled with the Run Number and depths of the beginning and end if each run.

    Each core box should only contain cores from a single boring. Never place the core from more than one test boring in a core box. In addition, wherever core is lost due to the presence of a cavity or large discontinuity (open or filled), a spacer should be placed in the proper position tn the core box. The spacer should be labeled with the depth range and thickness of the missing core, and the reason for the missing core (e.g., cavity, large joint, etc.).

13. Carefully examine and classify the rock, and measure the recovery and RQD in percent. Record all information on the core boring report.

14. If 100% recovery was not obtained, sound the borehole to determine if the missing core still remains in the bottom of the borehole.

15. Always terminate each boring with 100% recovery, in order to insure that appropriate knowledge is available of there materials.

16. The core box should be marked on the top and two ends with the client's name, site identification, boring number, depth range, and box number.

17. The core barrel and drilling tools must be steam-cleaned or washed upon completion of the bore hole to preclude cross contamination between successive bore holes.

18. Wash water used during the core drilling should not be re-circulated to the bore hole if possible.

2.5.1 Wireline Drilling

The procedures for wireline drilling are also the same as for conventional rock coring, with the exception that the core barrel is designed so that the inner core barrel can be raised in a wireline without removing the entire drill string, outer core barrel, and bit. The drilling rig must be equipped with a wireline hoist.

2.5.2 Oriented Core

If precise spatial orientation of rock bedding, foliation, and discontinuities are required, it is recommended that the Christensen Diamond Products Series D-3, NWD-3 core barrel, or equivalent, be employed.

2.5.3 Shotcore Drilling

Shotcore drilling is usually employed to produce large-diameter rock core (2 to 6 feet and larger). The core is cut by the abrasive action of chilled steel shot fed to a rotating steel bit. Shotcoring procedures are as follows:

1. Lower the assembled shotcore barrel to the bedrock surface.

2. Drop one or two handfuls of chilled shot down the center rod. Connect the bit to the drilling spindle and slowly turn by hand with a pipe wrench. A "gritty" feeling indicates that the shot is beneath the bit.

3. Lift the bit off the bottom and introduce the fresh water supply. When water return appears at the surface, lower the bit to the bedrock surface.

4. Drill feed must be manual with only enough downward pressure to follow the bit. This is an abrasive action and too much shot will wear the core barrel and too little will not core the rock. Driller expertise and careful attention are absolutely critical in successful shotcore drilling.

5. Regulate water flow so that it just allows the cuttings and slivers sf steel to be carried over the top of the casing. Add additional shot as required.

6. A good flow of muddy slurry to the surface indicates that the rock is being drilled.

7. If water return is clear, but contains fine particles of steel, this is an indication that an excess of shot has been used. Flush the hole and start again.

8. Record the drilling rate and reface the bit shoe after every withdrawal by squaring up the face with a hammer.

9. To recover the core, a hard, uniformly-graded pea gravel is fed into the center rod as it is slowly rotated so the gravel is "grouted" between the core and the core barrel, and the entire unit is pulled to the surface. On occasion, it may be necessary to remove the core barrel and drill a small diameter hole in the center of the core while it is still in the hole, then drive a casing retriever into the core before retrieval is possible.

2.5.4 Preservation of Rockcore

The following information shall be included in a rock core run log:

- The depth and length of the core run.
- The coring rate, down pressure, and torque and rotation speed. This information can be obtained from the driller.
- The color of the core wash water. Any changes, loss of return water, or gain of return water will be noted.
- The recovery of the core run recorded as length of rock recovered over the length of the core run.

- The Rock Quality Designation (RQD) of the run. RQD is reported as the sum of inches of all naturally fractured rock core pieces larger than four inches over the total number of inches in the run. The length of the piece will be determined by the distance between naturally occurring fractures.
- The rock type(s) and their location in the core run, rotating color, mineralogy, texture, fossil content, effervescence in HCL, and any other data of geologic significance.
- Any structure in the core, including fractures, clay seams, vugs, bedding, fissility, and any other data of geologic or geotechnical significance.

Rock cores shall be stored in a core box in the exact sequence in which they were removed from the ground. Core runs will be separated by wooden blocks clearly marked with the depth of the run. The top of the core box shall be marked with the project name, location, project number, boring number, and the depths of the core runs in that box. The front and one end of the core box shall be marked with project name, boring number, and depths of the core runs in that box. All core pieces shall be oriented in the box as they fit together. A black and white stripe shall be drawn down the length of the core, so that core orientation can easily be determined.

2.6 Photographing Soil and Rock Samples from Borings

If soil samples are to be photographed this should occur while still in the split spoon. If smearing of the sample has occurred, a fresh exposure can be made by scraping with a pen knife or other similar object. The spoon and sample should be placed in a good light, preferably against a solid colored background. A ruler for scale and a tag identifying the sample should be placed in the picture. The identifier tag must have the sample number, depth and project name or number written so as to be legible in the photograph. Any photographs taken must be recorded in the field logbook.

Rock core samples are photographed in the wooden core box. The rock should be wetted to enhance the color and textural changes in the rock. Due to the relatively large size of most core boxes, the photographer (when possible) should stand up on a chair, tail gate, car bumper or other perch in order to photograph the box from directly above, and get the entire box in the camera's field of view. The photograph must include a ruler for scale and an identifier tag indicating the project name and number, the boring number, the date, and the depths of the various core runs.

TRC

Project/Client	Project No.	Boring No.	Sheet ___ of ___
		Well No.	
Location Description		TRC Geologist	

Drilling Contractor/Foreman	Drill Rig Make/Model	Auger/Drive Casing Size/Type
Sampler Description	Drilling Method	Coordinates X= Y=
Filter Seal Amount/Type:	Drill Bit/Auger Diameter:	Ref. El.:
Sand Pack Amount/Type:	Hammer Weight/Fall:	Riser Stick Up:
Screen Length/Type:	Water Table Depth:	Surface Elevation:
Riser Length/Type:	Total Depth:	Date Start: Date Finish:

Depth	Sample Number	Blows/ RQD	Pen/Rec Core Rec	Sample Description	Strati-graphic Description	Field Testing	Lab Sample Number	Well Construction

Granular Soils

Blows/ft	Density
0-4	v. loose
4-10	loose
10-30	m. dense
30-50	dense
>50	v. dense

Proportions

trace	0-10%	some	20-35%
little	10-20%	and	35-50%

Cohesive Soils

Blows/ft	Density
>2	v. soft
2-4	soft
4-8	m. stiff
8-15	stiff
15-30	v. stiff
>30	hard

Grain Size (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. sand	2.0-0.43 mm
c. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Notes

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TRC

Project/Client	Project No.	Boring No.	Sheet
		Well No.	___ of ___
Location Description		TRC Geologist	

Depth	Sample Number	Blows/ RQD	Pen/Rec Core Rec	Sample Description	Strati-graphic Description	Field Testing	Lab Sample Number	Well Construction

Granular Soils

Blows/ft	Density
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4-10	loose
10-30	m. dense
30-50	dense
>50	v. dense

Proportions

trace 0-10% some 20-35%
little 10-20% sand 35-50%

Cohesive Soils

Blows/ft	Density
>2	v. soft
2-4	soft
4-8	m. stiff
8-15	stiff
15-30	v. stiff
>30	hard

Grain Size (USCS)

silt/clay	<0.08 mm
f. sand	0.43-0.08 mm
m. sand	2.0-0.43 mm
c. sand	4.8-2.0 mm
f. gravel	19-4.8 mm
c. gravel	75-19 mm
cobble	300-75 mm
boulder	>300 mm

Notes

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TRC

Rock Core Log

Project:	Project No.	Date/Time	Sheet ___ of ___
Contractor Personnel:		TRC Oversight Personnel:	
Boring Well Number:	Driller/Equipment:	Elevation: ______ Orientation: ______ Time Start: ______ Time Finish: ______	

Depth	Comments: Tests, Instrumentation, Coring Rate and Smoothness, Coring Fluid Loss	Core Run Length and Recovery (%)	Core Loss Zone	Box Number	Discontinuities: RQD	Discontinuities: Fractures Per Foot	Discontinuities: Description (Tightness, Planarity, Smoothness, Filling, Staining, Orientation)	Lithology: Mineralogy, Classification, Color, Grain Size, Alteration, Cementation, Hardness, Weathered State	Graphic Log

AF-207 Rev: 30 May 1991

TRC STANDARD OPERATING PROCEDURE NO. 007

TEST PIT LOGGING PROCEDURES

Prepared by: ______________________ 10/22/99

Adam Balogh, P.G. — Date

Reviewed by: ______________________ 10/22/99

Dale Weiss, P.G., Project Manager — Date

Approved by: ______________________ 10/25/99

Peter Spawn, Program Manager — Date

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ATTACHMENT A

Test Pit Log

TRC STANDARD OPERATING PROCEDURE NO. 007
TEST PIT LOGGING PROCEDURES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for completing and logging test pits during field investigations at hazardous and non-hazardous waste sites. This procedure is consistent with "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objectives

The objectives of completing test pits are to document subsurface conditions, investigate anomalous magnetic readings, observe subsurface geology, identify the vertical extent of contamination, confirm depth to bedrock, complete drum removal activity, conduct percolation tests, obtain subsurface soil samples and identify potential subsurface conduits for ground water flow and potential contaminant migration.

1.2 Equipment

The following list of equipment includes the necessary items to be used by TRC personnel during the conduct of test pits. Subcontractor personnel typically provide and operate all excavation and steam cleaning equipment. Site-specific conditions may warrant the use of additional or deletion of items from this list.

- Electronic water level indicators;
- Measuring tape with weight (0.1 foot increments);
- Any necessary personal protective equipment (hardhat, gloves, eyewear, tyvek suits, boots, etc);
- Air Monitoring instruments as required (Hnu, OVM, etc.);
- Field logbook;
- Test pit log sheets;
- Oil/water interface probe;
- Camera; and
- Sampling materials (jars, bowls, spoons, etc.).

2.0 PROCEDURES

The following procedures should be used during the conduct of test pitting. Procedures may vary depending on the equipment used, excavation requirements, sampling strategy and contaminants present at the site. Site specific conditions may warrant the use of stringent air monitoring, personal protective equipment and potentially substantial access constraints. These are defined in the site-specific health and safety plan.

1. The scope of the investigation, objectives, potential contaminants, spoils pile segregation and health and safety plan should be reviewed with all subcontractor personnel prior to initiation of the test pitting activity. All intended hand signals to be used during the excavation should be reviewed and understood between the personnel directing the operation and the equipment operator. One individual will be designated to direct the operator, and record the geology and observations. The second individual will conduct continuous air monitoring and recording, photography, and sample collection, storage and documentation.

2. Initiate the excavation in approximate one to two foot loose lifts. Observations of visual contamination, buried containers or potential conduits should be recorded and operations suspended while photos and measurements to a location of interest within the pit are made and recorded.

3. Once the excavation has been completed to the desired depth, the soil should be logged as described in SOP No. 5. If samples from specific layers for geologic description are desired, the bucket should be used to gain samples from the edges of the pit in the desired location.

4. The dimensions of the final test pit should be measured and recorded. A sketch of the test pit and any unusual features should be completed on the test pit log sheet. Photographs of at least one side of the pit or any features should be taken and recorded in the field logbook. The depth to water should be measured from a location on the side of the pit at the original grade.

5. Locations within the pit desired for laboratory analysis should be obtained with the bucket. Samples for volatile organic analysis should be filled immediately from available material and additional aliquots withdrawn from the center of the bucket, homogenized in a stainless steel bowl and placed in the required sample jars. All sample jars should be pre-labeled, wiped off, documented and stored.

6. Backfill and return the excavated area to the original grade. Make certain the subcontractor packs down the backfilled soil and does not leave any surface holes or other hazards when completed.

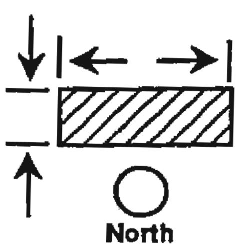
7. Stake, label, and flag the test pit location for future reference or surveying.

8. If segregation of contaminated soil has occurred, the disposition of these soils should be in accordance with the site-specific work plan and applicable guidance. Frequently these are not backfilled into the original pit, but the pit is backfilled with DOT approved fill. In addition, lining of the pit with polyethylene sheeting, mounding, covering of the excavation, and surrounding the excavation with gravel to direct surface runoff away may be required.

TRC Test Pit Log	Project: Project No.:	Date/Time:	Sheet ___ of ___
	Contractor Personnel:	TRC Personnel:	
Equipment/Contractor Used:	Location:	Test Pit Number:	
Reach/Capacity:	Total Depth:	Piezometer Installed? Yes No	
Depth to Ground Water:	Weather:	Elevation: Top of Pit ________	

Depth	Sample Number	Stratigraphic Description	REMARKS:

TEST PIT PLAN



Vol. = _____ cu. yd.

PROPORTIONS USED

Trace (TR).	0 - 10%
Little (LI.)	10 - 20%
Some (SO.)	20 - 35%
And	35 - 50%

GRAIN SIZE

Boulder	>203 mm	>8 in.
Cobble	76 - 203 mm	3 - 8 in.
C. Gravel	19 - 76 mm	3/4 - 3 in.
F. Gravel	4.75 - 19 mm	3/16 - 3/4 in.
C. Sand	2.0 - 4.75 mm	5/64 - 3/16 in.
M. Sand	0.4 - 2.0 mm	1/64 - 5/64 in.
F. Sand	0.075 - 0.4 mm	
Silt	0.002 - 0.075 mm	
Clay	<0.002 mm	

TRC STANDARD OPERATING PROCEDURE NO. 008

IN-SITU PERMEABILITY (SLUG) TESTS

Prepared by: Adam Balogh, P.G. — Date: 10/22/99

Reviewed by: Dale Weiss, Project Manager, TRC — Date: 10/22/99

Approved by: Peter Spawn, Program Manager — Date: 10/25/99

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ATTACHMENT A

TRC Slug Test Data Sheet

TRC STANDARD OPERATING PROCEDURE NO. 008
IN-SITU PERMEABILITY (SLUG) TESTS

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in in-situ permeability (slug) testing activities. This SOP details equipment and testing procedures for monitoring wells screened above and below the water table in high or low permeability confined or unconfined aquifers. This SOP conforms to "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," the RCRA Ground Water Monitoring Draft Technical Guidance (EPA/530-R-93-001), and other pertinent technical publications.

1.1 Objective

The objective of slug testing is to obtain an order of magnitude estimate of aquifer hydraulic conductivity in the immediate vicinity of the tested well. This objective requires knowledge of aquifer geology and well geometry, as well as the collection of sufficient test data to allow estimation of aquifer hydraulic characteristics.

2.0 PROCEDURES

Equipment and procedures for conducting three types of slug tests are described below, including:

- rising or falling head tests in wells screened below the water table;
- rising head tests in wells screened across the water table; and
- pneumatic rising head tests in highly transmissive sand and gravel aquifers.

2.1 Rising or Falling Head Tests

2.1.1 Equipment

The following equipment are necessary to perform a rising or falling head slug test in a monitoring well. Site specific conditions may warrant the use of additional equipment.

- Water level measuring device
- Bailer
- Slug bar
- Rope or wire
- Slug test data form

- Field logbook
- Electronic data logger
- Pressure transducer and conductor cable
- Stop watch or watch with a built-in timer
- Duct tape
- Well completion diagrams

The slug bar may be constructed of solid or hollow plastic, such as PVC or metal such as aluminum or steel (depending upon the chemical environment in the well). If hollow, the slug bar will be filled with silica sand or other inert material to add weight. The slug bar should be of sufficient size to cause a minimum of two feet of displacement in a well. For a two-inch diameter well, the slug bar should be no more than 1.5 inches in diameter and a minimum of 3.6 feet long. For a four-inch diameter well, the slug bar should be no more than 3 inches in diameter and a minimum of 3.6 feet long. The slug bar should be securely fastened to a nylon rope or wire.

A standard sampling or well development bailer may be used in place of the slug bar, as long as the volume of water displaced by the bailer will be sufficient to change the water level in the well a minimum of two feet. If the bailer is to be used for a falling head test, it should be filled with analyte-free water so that the bailer will not have any buoyancy.

2.1.2 Falling-Head Test Procedure

The following procedure should be utilized for conducting a falling head slug test. The test should not be performed in any well where the screen extends above the water table.

1. Note the physical condition of the well, including damage, deterioration, and signs of tampering.

2. Open the well cap. Note any unusual odors, sounds, or difficulties in opening the well. Record organic vapor reading with a suitable organic vapor screening device.

3. Lower a decontaminated water level measuring device into the well to determine the static water level.

4. Measure the depth to the bottom of the well and the inside diameter of the well casing.

5. If using a pressure transducer connected to a data logger, lower the pressure transducer into the well to a sufficient depth in the well so that the transducer will be below the maximum depth reached by the slug bar.

6. Secure the pressure transducer to the side of the well using duct tape. The transducer cable should lie flat along the side of the well riser, so that disturbance by the slug bar will be minimized. Do not bend the transducer cable or a kink will develop in the cable that will cut off the pressure equalization vent tube in the cable, which will prevent the transducer from operating.

7. Allow the pressure transducer to temperature equilibrate a minimum of 15 minutes before connecting it to the data logger and starting the test.

8. Allow the water level in the well to recover to static level after emplacement of the pressure transducer, prior to starting the test.

9. Determine the distance from the top of the well riser to the water surface in the well and add one foot to this length. The resulting length is the amount of wire or rope needed so that the slug bar or bailer will be submerged a minimum of one foot when it is placed in the well. A loop should be placed in the rope or wire at this length and a strong metal rod or wooden stick placed and secured through the loop. If the bottom of the well is less than this length added to the length of the slug bar or bailer, the length of the rope or wire should be adjusted so that the slug bar will be no less than one foot above the top of the pressure transducer when the bar is dropped in the well.

10. If using a data logger, program it to record logarithmically, with a maximum time interval of no more than one minute between readings. Set the data logger to record relative change in head only, not absolute head.

11. If depth readings are to be recorded manually (this procedure is recommended only in aquifers suspected of having low hydraulic conductivity, less than 5 feet per day), readings should be taken every 10 seconds for the first minute of the test, every 30 seconds for the first 5 minutes and every minute until 10 minutes. Thereafter, readings may be taken every 5 minutes for the duration of the test. If the well has not recovered within one hour, readings may be taken every 0.5 hour until six hours and at one hour intervals thereafter. This process will require two people during the first 10 minutes of the test, a person to act as time keeper/data recorder and a person to measure depth to water.

12. Place the slug or bailer in the well until the bottom of the displacement device is no more than 6 inches above the water level in the well. The person holding the device should be holding the rope or wire by the rod or stick.

13. To start the test, the person holding the slug bar will signal the person operating the data logger and rapidly lower the device into the well until the stick or rod is resting on the well riser. The slug bar should not be dropped. The data logger is started as soon as the slug bar is lowered.

14. The test will be run until the well has recovered to 90 percent of static water level. If 90 percent recovery has not occurred within 12 hours, the test may be stopped. Field conditions and time constraints may warrant stopping the test in less than 12 hours.

15. All equipment (pressure transducer and cable, water level measurement device and slug bar or bailer) shall be decontaminated before repeating the test in another well.

16. Download the data logger to a computer or to hard copy to ensure that the data is not inadvertently lost. If the data were recorded manually, calculate the relative change in head by subtracting the recorded depths to water from initial static water level and record the absolute value of that change, for each time-depth data pair.

2.1.3 Rising-Head Test Procedure

The following procedure should be utilized for conducting a rising head slug test. Note, the test may be started after completion of a falling head test in a well screened below the water table (described in Section 2.1.2). The steps are essentially the same as those for a falling head test, except that the test is started only after a displacement device has been placed in the well and the water level in the well has recovered back to static conditions.

1. Note the physical condition of the well, including damage, deterioration, and signs of tampering.

2. Unlock the protective cap on the well.

3. Open the well cap. Note any unusual odors, sounds, or difficulties in opening the well. Record organic vapor reading with a suitable organic vapor screening device.

4. Lower a decontaminated water level measuring device into the well to determine the static water level.

5. Measure the depth to the bottom of the well and the inside diameter of the well casing.

6. If using a pressure transducer connected to a data logger, lower the pressure transducer into the well to a sufficient depth in the well so that the transducer will be below the maximum depth reached by the slug bar.

7. Secure the pressure transducer to the side of the well using duct tape. The transducer cable should lie flat along the side of the well riser, so that disturbance by the slug bar will be minimized. Do not bend the transducer cable or a kink will develop in the cable that will cut off the pressure equalization vent tube in the cable, which will prevent the transducer from operating.

8. Allow the pressure transducer to temperature equilibrate a minimum of 15 minutes before connecting it to the data logger and starting the test.

9. Allow the water level in the well to recover to static level after emplacement of the pressure transducer, prior to starting the test.

10. Determine the distance from the top of the well riser to the water surface in the well and add one foot to this length. The resulting length is the amount of wire or rope needed so that the slug bar or bailer will be submerged a minimum of one foot when it is placed in the well. A loop should be placed in the rope or wire at this length and a strong metal rod or wooden stick placed and secured through the loop. If the bottom of the well is less than this length added to the length of the slug bar or bailer, the length of the rope or wire should be adjusted so that the slug bar will be no less than one foot above the top of the pressure transducer when the bar is placed in the well.

11. Lower slug into well.

12. If using a data logger, program it to record logarithmically, with a maximum time interval of no more than one minute between readings. Set the data logger to record relative change in head only, not absolute head.

13. If depth readings are to be recorded manually (this procedure is recommended only in aquifers suspected of having low hydraulic conductivity, less than 5 feet

per day), readings should be taken every 10 seconds for the first minute of the test, every 30 seconds for the first 5 minutes and every minute until 10 minutes. Thereafter, readings may be taken every 5 minutes for the duration of the test. If the well has not recovered within one hour, readings may be taken every 0.5 hour until six hours and one hour thereafter. This process will require two personnel during the first 10 minutes of the test, a person to act as time keeper/data recorder and a person to measure depth to water.

14. To start the test, the person holding the rope or wire attached to the slug bar will signal the person operating the data logger and rapidly remove the device from the well. The slug bar should be removed rapidly but smoothly so that water sloshing in the well is minimized. The data logger is started as the slug bar is removed.

15. The test will be run until the well has recovered to 90 percent of static water level. If 90 percent recovery has not occurred within 12 hours, the test may be stopped. Field conditions and time constraints may warrant stopping the test in less than 12 hours.

2.2 Pneumatic Rising Head Tests

2.2.1 Equipment

The following equipment should be utilized when conducting a pneumatic rising head slug test. Site specific conditions may warrant the use of additional equipment.

- Water level measuring device
- Slug test data sheet
- Field logbook
- Electronic data logger
- Pressure transducer(s) and conductor cable
- Stop watch or watch with a built-in timer
- Duct tape
- Pressure tight "tree" assembly
- Short length (6-inches) of flexible rubber hose whose inside diameter is the same as the outside diameter of the well riser
- Two 2- or 4-inch diameter hose clamps
- Compressor or compressed air tank with hose and appropriate adapters

The pressure-tight "tree" assembly is a device placed on the top of the well that will accomplish the following:

- form a pressure seal between the well and the atmosphere;
- allow the injection of compressed air into the well via an air hose connected to a compressor or compressed air tank;
- provide a pressure-tight passage for a pressure transducer cable and a water level meter; and
- allow for rapid well depressurization.

The tree is illustrated in Figure 2.2.1-1. If the top of the riser is threaded, the device may be screwed onto the riser, if the threads are wrapped with teflon tape. If the threaded end of the riser has been cut off, a slip coupling will need to be placed over the base of the tree and the top of the riser. A small length of flexible rubber hose the same inside diameter as the outside diameter of the coupling will be slipped over the coupling and secured in place with tightly closed hose clamps to form a pressure tight seal between the riser and the well.

The simplest method for providing access for the pressure transducer cable and the water level meter is to use a standard large diameter laboratory black rubber cork with a hole through the cork's axis that has been slit half way through along that axis, as illustrated in Figure 2.2.1-1. The cork can be firmly placed into the top of the tree to form a pressure tight seal.

The tree will have a standard ball valve with an inside valve orifice diameter no less than the diameter of the well riser as shown in Figure 2.2.1-1. In addition, a standard swage-lock fitting or quick-connect coupling will be attached to the side of the tree to act as a compressed air inlet port.

2.2.2 Procedure

The following procedure should be used for conducting a pneumatic rising head slug test. The test may not be run in any well screened across the water table.

1. Note the physical condition of the well, including damage, deterioration, and signs of tampering.

2. Unlock the protective cap on the well.

3. Open the well cap. Note any unusual odors, sounds, or difficulties in opening the well. Record organic vapor reading with a suitable organic vapor screening device.

4. Check for any holes in the side of the riser. The test cannot be conducted in any well that is not air tight.

5. Lower a decontaminated water level measuring device into the well to determine the static water level.

6. Measure the depth to the bottom of the well and the inside diameter of the well casing.

7. Install the test tree to the top of the well, either by screwing it in to existing threads or by using a slip coupling adapter. Make sure the seal to the riser head is pressure tight.

8. Lower the pressure transducer into the well through the top of the tree to at least 10 feet below the water table. The pressure transducer should be rated no less than 30 pounds per square inch.

9. Allow the pressure transducer to temperature equilibrate a minimum of 15 minutes before connecting it to the data logger and starting the test.

10. Turn on and lower the water level indicator into the well through the top of the tree to five (5) feet below the water table. If the water table is less than five feet from the top of the well screen, place the indicator no less than two feet above the screen. Turn off the indicator.

11. Secure the transducer cable and the water level meter and tape in place to the top of the tree with the cork described in Section 2.2.1. Insert the transducer cable into the hole in the rubber lab cork via the slit and place the water level indicator tape flat in the slit. Place the cork firmly in the top of the tree so that no gaps are left in the cork. Place small strips of duct tape over the assembly to ensure that the seal is air tight. During this procedure, do not bend the transducer cable or a kink will develop in the cable that will cut off the pressure equalization vent tube in the cable. Such kinks will prevent the transducer from operating.

12. Connect the pressure transducer to the data logger and program the data logger to record logarithmically, with a maximum time interval of no more than one minute between readings. Set the data logger to record relative change in head only, not absolute head.

13. Connect the air hose to the compressed air supply or compressor and the tree. Make sure the ball valve is securely closed.

14. Turn on the water level indicator and start feeding compressed air in to the well. When the water level in the well has been depressed sufficiently, the water level indicator submergence tone will stop sounding.

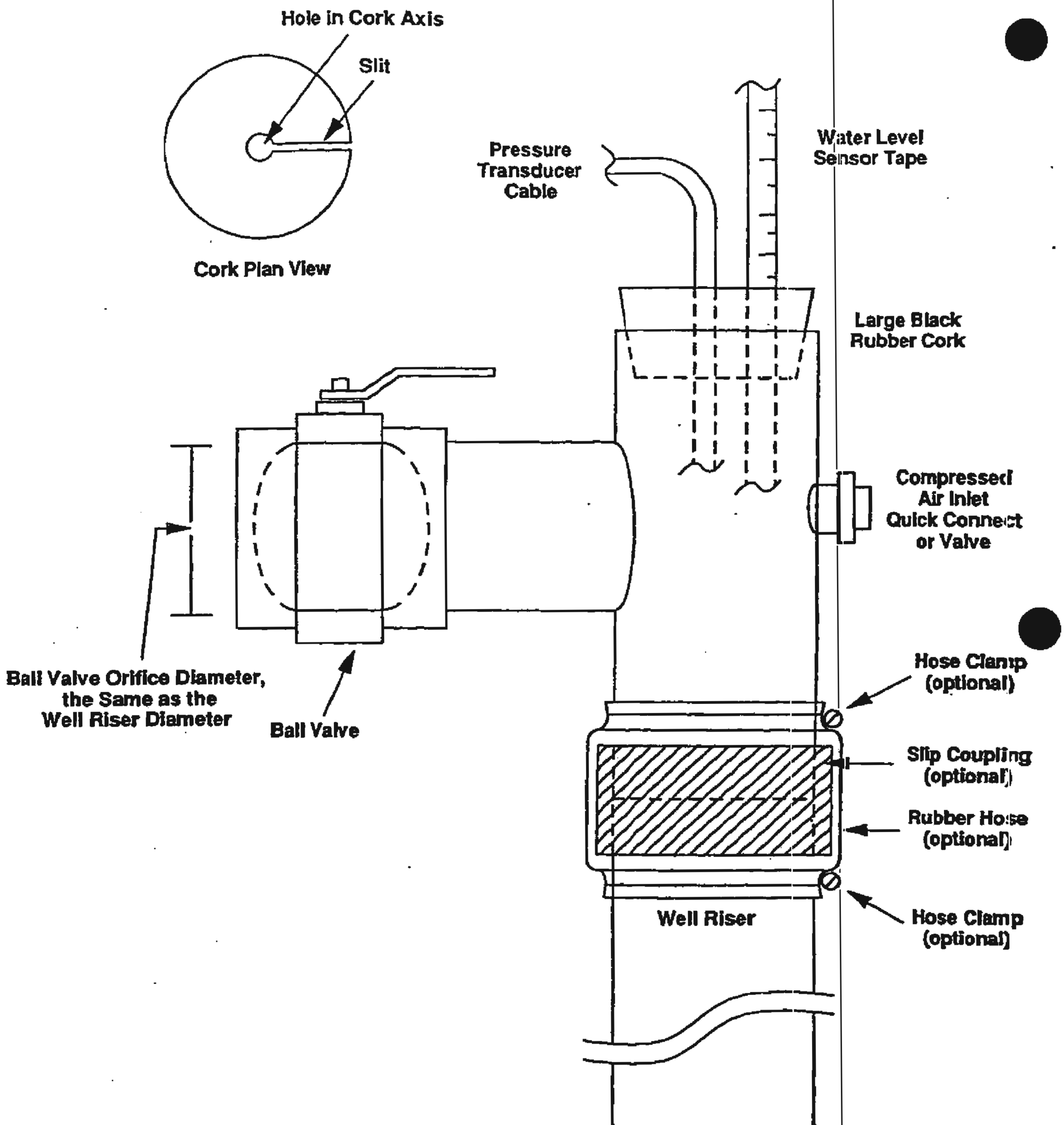
15. Open the ball valve and activate the data logger simultaneously. The ball valve should be opened as quickly as possible.

16. In highly permeable aquifers the water level in the well should recover to pre-test static water levels within a few seconds. Full recovery should be accomplished in no more than one minute. If the data logger is the type that cannot be read until the test has run at least ten minutes, do not stop the test until a minimum of 90 percent recovery can be confirmed by interrogating the data logger.

17. All equipment (pressure transducer and cable, water level measurement device and displacement device) should be decontaminated before repeating the test in another well.

18. Download the data logger to a computer or to hard copy to ensure that the data is not inadvertently lost.

19. Complete the TRC slug test data sheet (attached) with all pertinent data.



TRC SOP No. 008

Pneumatic Slug Test Pressure Tree Assembly Schematic.

TRC

Slug Test Data Sheet

Project:	Project No.:	Date/Time:	Sheet ___ of ___
Contractor Personnel:		TRC Personnel:	

Well No.:	Weather:

WELL DATA:
(attach well construction form and well log if available)

Well Diameter: ____________________

Filter Pack Diameter: ____________________
(same as auger/drive casing diameter)

Depth to Water: ____________________

From Top of: __________ Riser __________ Ground.

Depth to Top of Screen: ____________________

Depth to Bottom of Screen: ____________________

Screen Slot Size: ____________________

AQUIFER INFORMATION:

Aquifer Material: ____________________

____

Confined: _____ Unconfined: _____ Perched _____

Aquifer Thickness (est.) ____________________

SLUG TEST METHOD

Withdrawal: __________ Volume: __________

Addition: __________ Volume: __________

Slug Bar: __________ Dimensions: L ____ W ____

Bailer: __________ Dimensions: L ____ W ____

Calculate Volume of Slug Bar/Bailer:

____

____

TEST DATA

Time Started: ____________________

Time Completed: ____________________

Elapsed Time: ____________________

Water Level at Test Completion: ____________________

Comments:

TEST MEASUREMENT INFORMATION

Recording Method: ____________________

____

Transducer Size (ex. 10 psi): ____________________

Transducer Depth: ____________________

Data Logger Model: ____________________

Data Logger Test Number: ____________________

Recording Type: Linear _____ Log _____

Maximum Time Step: ____________________

Obtain Field Print of Data? Y _____ N _____

(Note: allow time for water level to equilibrate once transducer has been introduced)

TRC STANDARD OPERATING PROCEDURE NO. 009

GROUND WATER MONITORING
WELL INSTALLATION

Prepared by: ______________________ 10/22/99
Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/22/99
Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/25/99
Peter Spawn, Program Manager Date

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2.3 Monitoring Well Installation 4

ATTACHMENT A

Monitoring Well Construction Summary

TRC STANDARD OPERATING PROCEDURE NO. 009
GROUND WATER MONITORING WELL INSTALLATION

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the construction, installation, and development of ground water monitoring wells. The SOP conforms to "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of a ground water monitoring well is to collect representative ground water samples and obtain information on aquifer hydraulic head. A secondary objective is to obtain aquifer hydrologic data from the well. These objectives require that the well be installed and developed using suitable materials, equipment, and procedures.

2.0 PROCEDURES

2.1 Preparation

Prior to the initiation of field work the project manager, field hydrogeologist, or field technical lead (site manager) will secure the services of a qualified drilling contractor. A contract between TRC and the drilling contractor will be executed before mobilization. The drilling contractor must meet the following requirements:

- have the appropriate licenses and registrations;
- have the proper equipment available to perform the type of drilling required; and
- have personnel who are OSHA-trained to work on hazardous waste sites and are willing to participate in the appropriate medical monitoring for the site.

Before the start of field tasks, the field hydrogeologist or field technical lead is responsible for coordinating the following items with the drilling contractor personnel.

- familiarizing the contractor with the objectives of the investigation.

- providing and reviewing of a copy of the project work plan with the contractor;
- providing and reviewing of a copy of the project health and safety plan with the contractor; and
- performing a daily health and safety review with the contractor.

Compliance with all state and federal requirements is required prior to the installation of monitoring wells. The field hydrogeologist or project manager is responsible for obtaining all required permits. These permits may include, but are not limited to the following:

- notification and approval to drill/install a monitoring well;
- registration of the well;
- permit for water withdrawals;
- well abandonment when the project is completed; and
- State specified dig-safe permits.

2.2 Materials

In general, all well materials (other than filter sand, seals, and grout) will be cleaned with a high pressure, hot water wash, rinsed with deionized water, and sealed in plastic bags. Decontamination and bagging can be conducted by the manufacturer, prior to delivery to the site. Alternatively, the contractor or TRC may decontaminate the materials at an off-site location and deliver them to the site in a protective wrap.

2.2.1 Well Screens

Monitoring well screens will typically consist of two-inch diameter, flush-threaded, schedule 40, polyvinyl chloride (PVC), machine-cut slotted screen. Other materials or sizes may be specified in the work plan as required by site conditions or local regulations. If the well is to be used for in-situ hydraulic conductivity testing as well as ground water sampling, wire-wrap type screen construction is recommended over machine-slotted screen, to increase screen open area and ensure that the screen does not inhibit the flow of water into or out of the well. The screen slot size should be selected to retain a minimum of 90 percent of the filter pack material.

2.2.2 Riser and End Caps

Monitoring well riser and end caps will consist of two-inch diameter, flush-threaded, schedule 40, poly vinyl chloride (PVC). Other materials or sizes may be specified in the work plan as required by site conditions or local regulations. The top cap will have a small hole drilled through it to allow the passage of air, unless the well is to be installed at ground level. In that case, the top of the well shall be sealed with an expansion cap, to prevent the inflow of runoff into the well.

2.2.3 Filter Pack

A filter pack will be required in any formation other than coarse sand and gravels containing less than ten percent fines (silts and clays) by weight. In such formations, the use of an artificial sand pack may be optional. The purpose of the filter pack is to inhibit the flow of fines into the well screen, allowing production of ground water optimal for ground water quality analyses.

Where an artificial filter pack is required the filter material shall be composed of a washed, graded, commercially-produced silica sand. The uniformity coefficient (C_u) of the filter pack will be no less than one and no more than two, to prevent segregation of the filter material when it is installed in the well. The grain size of the filter pack shall be no less than 3 and no more than 6 times the D_{30} (passing) of the finest geologic unit in which the well is to be screened. A multiplier of 3 shall be used if the formation is fine and uniform and 6 if the formation is coarse and non-uniform. The D_{30} grain size of the formation should be determined by laboratory sieve grain-size analysis. If laboratory grain-size analysis cannot be performed, a variety of sand packs should be available, based upon known geological information of the site. Based upon field estimates of grain size distribution, a sand pack will be selected that matches the above criteria.

2.2.4 Seal

The seal will consist of bentonite clay pellets, chips, donut or slurry, sufficient to form a two foot thick seal above the filter pack. The selection of the form of bentonite clay will depend upon the project budget, location of the top of the filter pack relative to the water table. The seal will be hydrated with potable analyte-free water.

2.2.5 Grout

The annular space above the bentonite seal and the ground surface shall be grouted with a mixture of 95 percent Portland concrete or equivalent, and 5 percent bentonite grout, mixed with potable water to the specifications of the concrete manufacturer.

2.2.6 Surface Protective Casing

The surface casing shall consist of galvanized steel or steel coated with a rust-proofing coating. The surface casing shall have a hinged cap with provision for a lock. The base of the casing, at the point where it shall extend above the concrete pad, shall have a small weep hole drilled through the casing to prevent the build-up of precipitation or ice between the steel casing and well riser.

2.3 Monitoring Well Installation

Boreholes to be completed as monitoring wells will be advanced and logged in accordance with TRC SOPs No. 005 (Soil Description Procedure) and No. 006 (Soil Boring Logging). Equipment used to advance the boring and install the monitoring well will be decontaminated prior to the start of the boring using the procedures in SOP No. 004. All well materials that do not appear to be factory cleaned and sealed or those that have become open during shipment to the site will be steam cleaned prior to use at the site.

2.3.1 Procedures

Monitoring wells will be installed by the drilling subcontractor under the direction of a qualified TRC geologist or engineer. Monitoring wells will be installed using the following general procedures which may be dependent on the site specific requirements.

1. The construction details of the well to be installed will be provided to the driller, including well material, screen length, slot size, riser length, depth of the well, sandpack, bentonite seal, grouting requirements, and surface well completion.

2. All well materials will be inspected to ensure that they are clean prior to installation.

3. Sections of screen and riser will be threaded together and lowered into the borehole. Centralizers may be used in deeper wells to ensure proper well placement within the borehole.

4. The selected well packing materials will be introduced into the annulus in a manner so as to ensure an adequate well pack and seal. The thickness of each layer of well pack material will be measured with a weighted string and recorded. All augers or casing will be removed sequentially during sand pack installation and the well will remain at the desired depth during auger or casing withdrawal.

5. The bentonite seal installation technique will vary with the depth of the water table. The appropriate type of bentonite (pellets, chips, or slurry) will be selected to suit the objectives of the installation program. In general, the seal will be installed above the sandpack so that a thickness of two to three feet is installed. Bentonite seals in shallow wells installed across the water table will be hydrated and allowed to swell prior to the emplacement of a cement-bentonite grout mixture.

6. A cement-bentonite grout will be emplaced to fill the annulus of the boring. Dependent on the depth of the well and water table, the grout may be tremied into the desired location. The grout mixture (percentage of cement to bentonite) will be recorded and will be in accordance with the work plan or recommended guidance and Section 2.2.5 of this SOP. The grout will be pumped into the boring around the well materials to the surface. If necessary, after solidification of the grout and settling occurs, the grout may need to be topped of with additional grout mixture. The need for additional grout will be based on the intended surface completion for the well.

7. Depending on the location of the well, flush mounted road boxes or steel protective casings with locking cap will be recommended and cemented in place as described in Section 2.2.6 above. Once completed, the well will be locked and allowed to settle prior to well development.

8. All information concerning the well installation details will be recorded on a TRC Well Construction Diagram.

TRC

Monitoring Well Construction Summary

MW-

Project: ______ No.: ______

Client: ______ Date Completed: ______

Location: ______

Boring Contractor: ______ Method: ______

TRC Geologist: ______

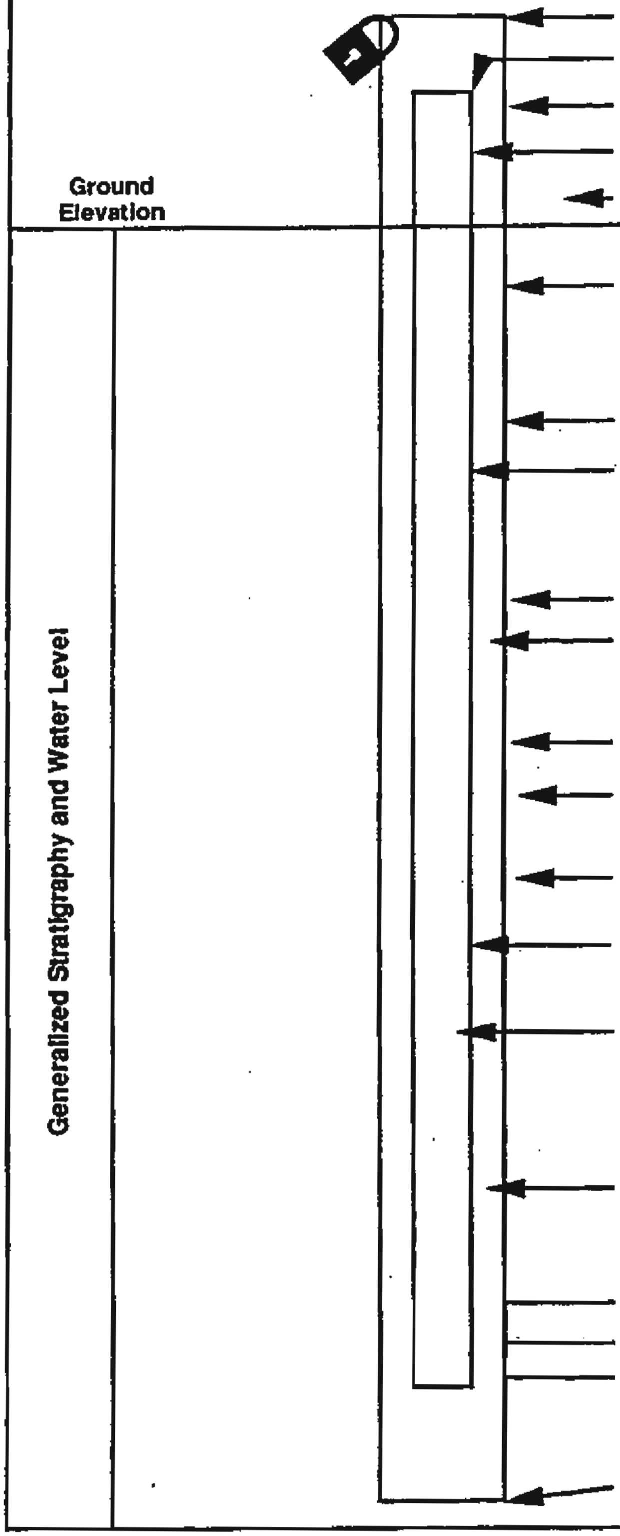
Reference Elevation: ______

Elev. Ground Surface: ______

Depth to Ground Water: ______

Development Date: ______

Development Method: ______



Elevation top of protective casing: ______

Elevation of top riser pipe: ______

Stick-up of protective casing: ______

Stick-up of riser pipe: ______

Type of surface seal: ______

I.D. of protective casing: ______

Type of protective casing: ______

Depth bottom of protective casing ______

Riser pipe I.D. ______

Type of riser pipe: ______

Borehole diameter: ______

Type of backfill: ______

Elevation/depth top of seal: ______

Type and thickness of seal: ______

Depth top of filter pack: ______

Elevation/Depth top of screen: ______

Type of screen: ______

Slot size: ______

I.D. of screen ______

Type of filter/sand pack: ______

Elevation/depth bottom of screen: ______

Elevation/depth bottom of well: ______

Elevation/depth bottom of filter pack: ______

Type of backfill below observation well: ______

Elevation/depth of borehole: ______

BL/2

TRC STANDARD OPERATING PROCEDURE NO. 010

GROUND WATER MONITORING WELL DEVELOPMENT

Prepared by: ______________________ 10/25/99

Adam Balogh, P.G., Project Manager — Date

Reviewed by: ______________________ 10/25/99

Dale Weiss, P.G., Senior Hydrogeolist — Date

Approved by: ______________________ 10/25/99

Peter Spawn, Program Manager — Date

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ATTACHMENT A

Field Data Record Well Development

TRC STANDARD OPERATING PROCEDURE NO. 010
GROUND WATER MONITORING WELL DEVELOPMENT

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the development of ground water monitoring wells. The SOP conforms to "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/0001)," and other pertinent technical publications.

1.1 Objectives

Monitoring well development is completed in order to establish a good hydraulic connection between the well screen and the surrounding aquifer, settle the sandpack and formation from drilling, and removal of the fine particles (silt) from the water column and sandpack in order to obtain ground water samples that are representative of the aquifer in which the well is installed.

2.0 PROCEDURE

2.1 Equipment

The complete list of required equipment is presented below. Site specific conditions may warrant the addition or deletion of some equipment.

- Watterra system
- Centrifugal pump and hosing
- pH Meter
- Conductivity meter
- Turbidity meter
- Plastic beaker or jar
- Bailer and cord
- Field logbook
- Well development logsheet
- Large capacity DOT-approved containers (if required)
- Two, five-gallon buckets
- Deionized water spray bottle
- Surge-block
- Submersible pump

2.2 Procedures

Well development will be completed on monitoring wells after the grout, annular seals, and protective casings are stable (i.e., 48 hours after installation).

1. Consult the monitoring well completion diagram and boring logs to determine the well construction geometry (depth and length of screen), air monitoring results, material screened, and depth to water. If potable water has been used during well installation, the estimated amount of water lost to the formation during the drilling process should be removed prior to the initiation of well development to ensure the removal of fresh formation water during the development process.

2. Select the appropriate device and tubing to complete development. The apparatus selected should be capable of surging the entire length of the well screen and be equipped with enough discharge tubing and water withdrawal capability to complete well evacuation to the surface and into containers if required.

3. Measure the static water level in the well using SOP No. 012, and determine the amount of standing water in the well (well volume). Record the air readings, water level, and calculated single well volume.

4. Using the appropriate length of dedicated or decontaminated hosing/tubing and the selected pumping apparatus, insert the equipment into the well.

5. Initiate water removal from the well and record the initial field water quality measurements of pH, temperature, conductivity, and turbidity on the well development form. Record any odors, water color, increases in air monitoring results or other observations in the field log book or on the well development form.

6. Continue to evacuate the well while surging the water in the well screen into and out of the sandpack. Using a plastic beaker or jar to collect purged water, conduct and record the field water quality parameters as in No. 5 above with each successive well volume as well as any additional observations. Rinse measurements probes with deionized water between successive measurements and rinse with the purged water prior to the measurement of each well volume. Water should be withdrawn from the well until three (3) successive measurements of field water quality measurements vary by less than ten (10) percent of the instrument's scale. During this procedure, the water clarity and turbidity should be closely monitored. Typically, following initially turbid results, turbidity values will decrease with the removal of subsequent well volumes; however, stabilization of the turbidity values in silty aquifers may be difficult. Well development should proceed until turbidity values have stabilized to within ten (10) percent.

7. Once all the development criteria have been satisfied, remove the apparatus from the well and complete decontamination of the apparatus and probes using SOP No. 004.

TRC

Field Data Record
Well Development

Project: Project No.: | Date/Time: | Sheet ___ of ___

TRC Personnel:

Well Identification:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

Protective Casing Stick-up (from ground) ______ ft.

Riser Stick-up (from ground) ______ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch ☐ ______

WELL MATERIAL ☐ PVC ☐ SS ☐ ___

Well Depth ___ ft. ☐ top of riser ☐ top of casing ☐ ______ ☐ measured ☐ historical

Water Depth ___ ft.

Height of Water Column ___ ft. x ☐ .16 gal/ft (2 in.) ☐ .65 gal/ft (4 in.) ☐ 1.5 gal/ft (6 in.) ☐ __ gal/ft (__ in.)

Volume of Water in Well = ______ gallon(s)

______ Total gallons to purge

[Vol. = $r^2 h(0.163)$]

PID SCREENING MEAS.

Background	
Well Mouth	

FIELD WATER QUALITY MEASUREMENTS

Purge Volume (gal)										
pH (Std. Units)										
Eh (millivolts)										
Conduct. (µmhos/cm)										
Temp. (C)										
Turb. (NTU)										
DO (mg/l)										
Purge Volume (gal)										
pH (Std. Units)										
Eh (millivolts)										
Conduct. (µmhos/cm)										
Temp. (C)										
Turb. (NTU)										
DO (mg/l)										

EQUIPMENT	PURGE	SAMPLE
Peristaltic Pump	☐	☐
Submersible Pump	☐	☐
Bailer	☐	☐
Waterra	☐	☐
PVC/Silicon Tubing	☐	☐
Teflon/Silicon Tubing	☐	☐
Air Lift	☐	☐
In-line Filter	☐	☐
Pressure Vacuum Filter	☐	☐
Measuring Tape	☐	☐
______	☐	☐

EQUIPMENT ID

______
______
______
______

DESCRIPTION OF DECON. PROC.

DECON. FLUID USED	
Tap Water	☐
Alconox	☐
Tap Water	☐
HNO_3 (1 or 10%)	☐
Tap Water	☐
Methanol	☐
Hexane	☐
Acetone	☐
Air Dry	☐
DI Water	☐
Air Dry	☐
None	☐

Signed: ______________

TRC STANDARD OPERATING PROCEDURE NO. 011

GENERAL PUMPING TEST PROCEDURES

Prepared by: Adam Balogh, P.G. — Date: 10/22/99

Reviewed by: Dale Weiss, P.G., Project Manager — Date: 10/9/99

Approved by: Peter Spawn, Program Manager — Date: 10/25/99

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Attachments

Attachment A Pump Test Data Sheet
Attachment B Pump Testing Monitoring

TRC STANDARD OPERATING PROCEDURE NO. 011
GENERAL PUMPING-TEST PROCEDURES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods and general procedures for conducting pumping tests in monitoring wells.

1.1 Objective

The objectives of pumping tests include identifying aquifer properties of recharge, drawdown, storativity, transmissivity, specific and sustained yield, and aquifer boundaries. Knowledge of these aspects are essential aids in the understanding of aquifer characteristics for the configuration of remediation or ground water supply systems.

1.2 Equipment

The following equipment may be used during the conduct of an aquifer pumping test. Site-specific conditions may warrant addition to, or deletion of items from this list.

- Field logbook or pump test log
- Water level indicators
- Pressure transducers
- Data logging equipment
- Field printer
- Lap-top computer
- Duct tape
- Alconox, liquinox, or other non-phosphate concentrated laboratory grade soap
- Deionized Water
- Submersible pump with flow regulator and foot valve
- Generator
- Heavy duty extension cords
- Polyethylene sheeting
- Large capacity barrels (alternately holding tanks); frac tanks will be onsite
- Necessary personal protective equipment (gloves, eyewear, tyvek suits)
- Portable radios
- Well completion logs
- Well keys
- Flow meter/graduated bucket
- Stopwatch

2.0 PROCEDURES

The following general procedures should be used for conducting a pumping test. Alterations of these general procedures may be necessary in order to accommodate site specific conditions and data requirements.

Aquifer pumping tests should follow the set-up procedures listed below in order to consistently record the desired data as accurately as possible.

1. Determine the appropriate lengths of transducer cables based on the distances from pumping to observation wells. Based on the well geometries, determine the appropriate pressure-rated transducer, number of logging channels needed, required pump hosing length, pump capacity and type, minimum and maximum anticipated pumping rates. Identify the test control location and create a pre-test schematic of where the wells are, depth of transducer and pump settings, where the water will be discharged or containerized, and how the test can be implemented efficiently before going into the field.

2. Conduct decontamination of all downhole test equipment and wrap all equipment in polyethylene sheeting or bags. These should be dedicated and labeled for the intended wells.

3. Following any required air monitoring, measure water levels in all of the wells to be monitored during the test. Record the water levels in the logbook or on the pump test log. It is recommended that the water levels be monitored for a period of time prior to the test to identify any trends of rising or falling water levels due to nearby supply wells, tidal influence or surface water bodies.

4. Set and secure the pump in the pumping well at the planned depth and allow for stabilization of the displaced water level caused by insertion. The generator should be filled with gasoline at a remote down-wind location and extension cord run to this location. Record the pump depth in the logbook or on the pump test log. Monitor the water level in the pumping well to ensure that static levels are attained.

5. Secure the transducers with duct tape in the desired wells at the planned depths as identified in the pre-test schematic. Set all transducers in the wells for a minimum of two hours to allow for adaption to ground water temperature and cable stretch. The transducer in the pumping well should be set above the pump. Run all of the transducer cables to the test control location and connect them to the data logger in the desired channel(s). Record the transducer depths in the logbook or on the pump test log.

6. While the transducers are becoming stable, programming of the data logger for each channel should be completed with the specific parameters for each transducer. Scale

factors, linearity, offset, well ID, reference level, and type of reading (surface or top of casing) should be selected. These parameters are specific to each transducer and data logger and are usually clearly identified on the wheel and cable for each transducer.

7. The data logger should be programmed to collect readings at the desired interval(s) for the entire duration of the test including recovery. The test should be programmed to allow for logging of water levels during the drawdown and recovery stages using the logarithmic option recommended with most data loggers. The actual log scale can also be modified to suit the needs of the test if desired. The data logger should be programmed to start prior to initiation of pumping the well. Record the programmed duration in the logbook or on the pump test log.

8. Once the test equipment is ready, the entries, well IDs, and parameters for each channel should then be double checked for accuracy. The connections to all channels should be checked by communication with each individual transducer.

9. The startup of the pump should be synchronized with the logging of water level data. The rate of pumping should be set at the desired rate. The rate should be stabilized as quickly as possible to promote accurate data analysis. Direct the discharge to the appropriate containers, if required, or to a location outside of the anticipated cone of influence. The pumping rate should be measured and recorded routinely during initial pumping to confirm that the rate is stable. All adjustments to the rate should be recorded. Record the actual start time and pumping rate of the test in the logbook or on the test log.

10. Monitor the channels of the data logger to read the transducers. Look for drawdown in the pumping well to confirm operation. Monitor the transducers in the observation wells to confirm their operation. Manual measurement of the water levels should be performed periodically to confirm the accuracy of the transducer data.

11 Increase pumping rates at the required frequency.

12. If a recovery test also planned, shut down the pump, record the time and allow the water level in the pumping well to recover to 90 percent of static levels while the transducer and data logger collect the recovery data.

13. Once the test is completed, remove, and decontaminate all downhole equipment.

TRC

Pump Test Data Sheet

Project:	Project No.:	Date/Time:	Sheet ___ of ___
Contractor Personnel:		Alliance Personnel:	

Weather:

Well No.: __________ Pumping Well ☐ Observation Well ☐

Distance from Pumping Well: ______________

Well Diameter: _______ Static Water Level: _____

Well Depth: ________________

Screen Size: ________________

Depth Top of Screen: ______ Depth Bottom of Screen: _____

Calculate Volume of Water in Pumping Well:
[VOL = $\pi r^2 L \times 7.48$ gal/ft^3]

Note: r = Radius (ft)
L = Length of Saturated zone in well (ft)

DISCHARGE INFORMATION:

Well Discharge Rate: ______________________

Discharge Rate Measurement Method: __________

____

Was rate checked throughout test Y ___ N ___

If yes, note variations:

TEST DATA:

Time Drawdown Test Started: ______________________

Time Recovery Started: ______________________

Time Recovery Completed: ______________________

Elapsed Time: ______________________

Approximate distance and location of discharge outlet from observation/monitoring well: ______________________

____

% Recovery Achieved: ______________________

DRAWDOWN MEASUREMENT INFORMATION:

Recording Method: ______________________

____

Transducer Size (ex. 10 psi): ______________

Transducer Depth: ______________________
(Allow Time for water level to equilibrate)

Data Logger Model: ______________________

Data Logger Test Number: ______________

Recording Type: Linear ______ Log ______

Maximum Time Step: ______________________

Obtain Field Print of Data? Y _______ N _______

DIAGRAM OF PUMP TEST SET UP:

Comments:

TRC

Pump Testing Monitoring Well Data

Client	Project	Project #	Sheet ___ of ___	
Site	Location	Alliance Personnel:	Date/Time	

Test Start Clock Time: ________ Elapsed Time: ________	Channel #:____ XD psi:____ XD Depth: ____ Radius: ____ Well#:____ Static W.L.: ____	Channel #:____ XD psi:____ XD Depth: ____ Radius: ____ Well#:____ Static W.L.: ____	Channel #:____ XD psi:____ XD Depth: ____ Radius: ____ Well#:____ Static W.L.: ____	Channel #:____ XD psi:____ XD Depth: ____ Radius: ____ Well#:____ Static W.L.: ____	Channel #:____ XD psi:____ XD Depth: ____ Radius: ____ Well#:____ Static W.L.: ____	Channel #:____ XD psi:____ XD Depth: ____ Radius: ____ Well#:____ Static W.L.: ____	Channel #:____ XD psi:____ XD Depth: ____ Radius: ____ Well#:____ Static W.L.: ____	Channel #:____ XD psi:____ XD Depth: ____ Radius: ____ Well#:____ Static W.L.: ____

TRC STANDARD OPERATING PROCEDURE NO. 012

WATER LEVEL MEASUREMENT PROCEDURES

Prepared by: ______________________ 10/22/99

Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/22/99

Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/25/99

Peter Spawn, Program Manager Date

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TRC STANDARD OPERATING PROCEDURE NO. 012
WATER LEVEL MEASUREMENT PROCEDURES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for conducting water level measurements in monitoring wells during field investigations at hazardous and non-hazardous waste sites. This procedure is consistent with "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of water level measurements is to gain accurate measurements of the depth of ground water for use during well installation, in the recording of data for the preparation of ground water elevation contour maps, purge volume calculations during ground water sampling, slug tests, packer tests, and pump tests.

1.2 Equipment

The following list of equipment may be utilized during the conduct of water level measurements. Site-specific conditions may warrant the use of additional or deletion of items from this list.

- Electronic water level indicators
- Steel tape and chalk
- Tap Water
- Alconox, liquinox or other non-phosphate concentrated laboratory grade soap
- Deionized Water
- Pump Sprayer
- Pint Squeeze bottles
- Any necessary personal protective equipment (gloves, eyewear, tyvek suits)
- Air Monitoring instruments as required (Hnu, OVM, etc.)
- Field logbook and monitoring form
- Well keys
- Previous measurement data (if available)
- Oil/water interface probe
- Precision ruler
- Plunker on tape

2.0 PROCEDURES

The following procedures should be followed during the conduct of water level measurements. Procedures may vary depending on the equipment used and contaminants present at the site.

Site specific conditions may warrant the use of stringent air monitoring and potentially more significant decontamination scenarios.

1. Record the condition of the well (protective casing, concrete collar, lock in place etc.).

2. Put on latex or other sterile gloves. Stand upwind of the well; unlock and open the well. If a vented cap is present, conduct well mouth air monitoring from the vent. If a non-vented well cap is present, remove the cap and monitor the well mouth immediately. Record all pertinent air monitoring results (sustained, dissipating, background, odor).

3. Identify the previous measuring point marking or notch on the riser or casing (if present). Record this location in the field logbook or on the water level monitoring form.

4. Using a previously decontaminated water level indicator, turn on the meter, check the audible indicator, reel the electronic probe into the well riser (with the increments visible) slowly until the meter sounds, grasp the tape with hand, withdraw the tape and lower it again slowly until the sound is again audible. Check the depth to water on the tape and make a mental note of the depth to within .01 feet. Lower the probe again slowly and repeat the measurement for accuracy. Record the depth to water from the measuring point in the field logbook or on the water level monitoring form.

5. Procedures utilized during water level measurements where free phase petroleum products are floating on the water table should be modified to include the use of the oil/water interface probe. The procedures during the use of this probe should be implemented similarly and by manufacturers' specifications. Through the use of this probe, product thickness can be determined.

6. Decontaminate the probe and any obviously soiled tape.

TRC STANDARD OPERATING PROCEDURE NO. 013

GENERAL SURVEY PROCEDURES

Prepared by: ______________________ 10/22/99
Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/22/99
Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/25/99
Peter Spawn, Program Manager Date

Recycled Paper

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TRC STANDARD OPERATING PROCEDURE NO. 013
GENERAL SURVEY PROCEDURES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for conducting general surveys of monitoring wells and site features during field investigations at hazardous and non-hazardous waste sites. This procedure is consistent with "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of conducting surveys is to obtain accurate locations and elevations for incorporation into the preparation of ground water elevation contour maps, site contour maps, and site plans or figures. Horizontal locations should be accurate to one foot and vertical locations should be accurate to .01 foot. All traverse loops should close within a ratio of 1:30,000.

1.2 Equipment

The following list of equipment may be utilized during site surveys. Site-specific conditions may warrant the use of additional or deletion of items from this list.

- Theodolite
- Automatic Level
- Tripod
- Stadia Rod (graduated in 0.01 feet)
- Electronic distance meter (EDM)
- Prisms and targets
- Compass
- Plum-bob
- Folding engineers rule (graduated in 0.01 feet)
- Steel tape (graduated in 0.01 feet)
- Any necessary personal protective equipment (boots, gloves, eyewear, tyvek suits)
- Air Monitoring instruments as required (Hnu, OVM, etc.)
- Field log book
- Calculator
- Local bench mark datum
- Previous measurement data (if available)

- Surveying nails (PKs)
- Stakes and tacks
- Flagging and/or marking paint
- Permanent markers and/or lumber crayons
- Portable radios
- Traffic cones, safety vests
- Hammer, chisel, axe, knife, saw, shovel

2.0 PROCEDURES

2.1 Procedures for conducting relative elevation surveys (level loop)

The following procedures should be utilized during the conduct of relative elevation surveys. Procedures may vary depending on the equipment used, features to be surveyed, and contaminants present at the site. Site specific conditions may warrant modifications to these procedures and certain sites will require a licensed surveying subcontractor. This SOP is intended for use on small areas where only relative elevations are required and can be conducted by qualified TRC personnel. A comprehensive will require more stringent procedures to be established on a project by project basis.

1. For monitoring well elevation surveys, follow the map or plan of locations in a logical order.

2. Record the condition of the well (protective casing, concrete collar, lock in place etc.).

3. Identify the previous measuring point marking or notch on the riser or casing (if present). Record this location in the field logbook and provide it to the subcontractor or other rod person.

4. Set-up and level the instruments to be used during the survey.

5. Measure the instrument height above the bench mark elevation (temporary or permanent).

6. Begin the level-loop to the desired locations and record all measurements in the field book. Instruct the subcontractor (or other) to record the elevation of the top of the protective casing, the top of PVC riser at the measuring point notch or marking (if present) and the ground surface to within 0.01 foot. Shots which are greater than 500 feet in distance should be avoided due to the potential for error. To promote accuracy, the stadia rod should be swayed back and forth slowly by the rod person and the surveyor should record the lowest measurement. The loop should be closed at the

starting point (bench mark) within +/- 0.05 feet of the original elevation per foot of length of level loop not exceeding +/- 1.0 foot.

7. Replace the vented cap, lock the well and continue the level loop.

2.2 Relative Traverse Surveys

The following procedures should be utilized during the conduct of traverse surveys. Procedures may vary depending on the equipment used and the features to be surveyed. Site specific conditions may warrant modifications to these procedures. This SOP is intended for use on small areas where only relative locations of site features are required and can be conducted by qualified TRC personnel.

1. Establish the traverse loop to be surveyed.

2. Set-up and level the surveying instrument (transit, theodolite) over a reference stake and center cross-hairs of the optical plumb on a tack in the center of the stake. Set the internal verniers to zero degrees. Conduct a back-sight on an established benchmark. Measure the instrument height above the bench mark elevation, unlock the horizontal vernier and turn the instrument clock-wise (towards a positive angle) to the desired location. Record the measurements in the field book. The prism mounted on a tripod, staff or a stadia rod should be set and held by the rod person in the middle of the object of interest. After all shots are completed at this location, set a stake (hub) or PK nail (if in asphalt or concrete) in the ground at the next desired survey station. Avoid shots which are greater than 500 feet in distance unless an electronic distance meter is being utilized.

3. Set-up and level the instrument over the next station and center the cross-hairs of the optical plumb on a tack in the center of the stake. Repeat step No. 2 except the back sight will be to the former reference station stake instead of a bench mark. The final station should be sighted into the original bench mark. The traverse should close within a ratio of 1:30,000 feet. Horizontal locations should be accurate to within +/- one (1) foot.

TRC STANDARD OPERATING PROCEDURE NO. 014

PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

Prepared by: ______________________ 10/22/99
Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/22/99
Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/22/99
Peter Spawn, Program Manager Date

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TRC STANDARD OPERATING PROCEDURE NO. 014
PACKAGING AND SHIPPING OF ENVIRONMENTAL SAMPLES

1.0 INTRODUCTION

1.1 Objective

Proper packaging and shipping is necessary to ensure the protection of the integrity of environmental samples shipped for analysis

The objective of this standard operating procedure (SOP) is to establish packaging and shipping requirements and guidelines for environmental sample shipping.

1.2 Required Equipment

- Coolers with return address of TRC office written on inside lid
- Heavy-duty plastic bags
- Plastic zip-top bags, small and large
- Plastic electrical tape
- Fiber tape
- Duct tape
- Vermiculite and/or packing peanuts
- Bubble Wrap (optional)
- Ice
- Chain-of-Custody seals
- Completed Chain-of-Custody record or CLP custody records if applicable
- Completed Bill of Lading

The term "Environmental Sample" refers to any sample that has less than reportable quantities of any hazardous constituents according to Department of Transportation (DOT) 49 CFR - Section 172.

2.0 PROCEDURES

The following steps must be followed when packing for shipment by air:

1. Select a sturdy cooler in good repair. Secure and tape the drain plug (inside and outside) with fiber or duct tape.

2. Be sure the caps on all bottles are tight (will not leak); check to see that labels and chain-of-custody records are completed properly.

3. Place all bottles in separate and appropriately sized plastic zip-top bags and close the bags. Up to three VOA vials may be packed in one bag. Bottles may be wrapped in bubble wrap. Optional, place three to six VOA vials in a quart metal can and then fill the can with vermiculite. It is preferable to place glass sample bottles and jars into the cooler vertically. Due to the strength properties of a glass container, there is much less chance for breakage when the container is packed vertically rather then horizontally.

4. Place two to four inches of packing peanuts or vermiculite into the bag in the cooler and then place the bottles and cans in the bag with sufficient space to allow for the addition of more packing peanuts or vermiculite between the bottles and cans.

5. Put ice in large plastic zip-top bags (double bagging the zip-tops is preferred) and properly seal. Place these ice bags on top of, or between, the samples. Fill all remaining space between the bottles or cans with packing peanuts or vermiculite. Securely fasten the top of the large garbage bag with tape (preferably duct tape).

6. Place the completed Chain-of-Custody Record or the CLP Traffic Report Form (if applicable) for the laboratory into a plastic zip-top bag, tape the bag to the inner side of the cooler=s lid, and then close the cooler.

7. Fiber tape shall be wrapped around each end of the cooler two times, and completed Chain-of-Custody seals affixed to the top opposite sides of the cooler half on the fiber tape so that the cooler cannot be opened without breaking the seal. Complete two more wrap arounds with fiber tape; place clear tape over custody seals.

8. The shipping containers must be marked ATHIS END UP@ and arrow labels which indicate the proper upward position of the container should be affixed to the cooler. A label containing the name and address of the shipper shall be placed on the outside of the container. Labels used in the shipment of hazardous materials (such as Cargo Only Air Craft, Flammable Solids, etc.) are not permitted to be on the outside of the container used to transport environmental samples and shall not be used.

TRC STANDARD OPERATING PROCEDURE NO. 015

STEP-TEST PROCEDURES

Prepared by: ______________________ 10/22/99

Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/22/99

Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/25/99

Peter Spawn, Program Manager Date

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Attachment A Pump Test Data Sheet
Attachment B Pump Testing Monitoring

TRC STANDARD OPERATING PROCEDURE NO. 011
GENERAL STEP-TEST PROCEDURES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods and general procedures for conducting step-pumping tests in monitoring wells.

A step-drawdown test is similar to a constant-rate test except that the pumping rate is systematically increased in a series of several steps of equal duration. The basic requirements of the constant-discharge test should be maintained for each step, including maintaining a constant pumping rate during each step of the test, and obtaining frequent water-level measurements in the pumping well and observation wells.

Generally, step-drawdown tests are conducted during a single day with each pumping step consisting of a 1-hour to 2-hour period. Consistent time intervals permit easy comparison of the drawdown data. It is desirable, but not critical, that the water level in the pumping well be allowed to recover to its static condition before starting the next discharge step of the test.

Step-drawdown tests are used to determine the specific capacity of a pumping well, optimum pumping rates, and the percentage of turbulent and laminar flow occurring at a pumping well. Under ideal, laminar-flow conditions, the drawdown in a pumping well is directly proportional to the discharge (Driscoll, 1986). If the flow is not entirely laminar, meaning that some turbulent flow also occurs, the drawdown will be proportional to the discharge rate raised to some power. Analytical equations have been developed to estimate the percentage of laminar versus turbulent flow from pumping wells (Driscoll, 1986). From such analyses a long-term test discharge rate can be selected that will avoid excessive turbulent flow.

1.1 Objective

The objectives of step-tests include identifying aquifer properties of recharge, drawdown, storativity, transmissivity, specific and sustained yield, and aquifer boundaries. Knowledge of these aspects are essential aids in the understanding of aquifer characteristics for the configuration of remediation or ground water supply systems.

1.2 Equipment

The following equipment may be used during the conduct of step-tests. Site-specific conditions may warrant addition to, or deletion of items from this list.

- Field logbook or pump test log
- Water level indicators
- Pressure transducers
- Data logging equipment
- Field printer
- Lap-top computer
- Duct tape
- Alconox, liquinox, or other non-phosphate concentrated laboratory grade soap;
- Deionized Water;
- Submersible pump with flow regulator and foot valve
- Generator
- Heavy duty extension cords
- Polyethylene sheeting
- Large capacity barrels (alternately holding tanks);
- Necessary personal protective equipment (gloves, eyewear, tyvek suits);
- Portable radios
- Well completion logs
- Well keys
- Flow meter/graduated bucket
- Stopwatch

2.0 PROCEDURES

The following general procedures should be used for conducting step-tests. Alterations of these general procedures may be necessary in order to accommodate site specific conditions and data requirements.

Step-tests should follow the set-up procedures listed below in order to consistently record the desired data as accurately as possible.

1. Determine the appropriate lengths of transducer cables based on the distances from pumping to observation wells. Based on the well geometries, determine the appropriate pressure-rated transducer, number of logging channels needed, required pump hosing length, pump capacity and type, minimum and maximum anticipated pumping rates.

Identify the test control location and create a pre-test schematic of where the wells are, depth of transducer and pump settings, where the water will be discharged or containerized, and how the test can be implemented efficiently before going into the field.

2. Conduct decontamination of all downhole step-test equipment using the procedures identified in SOP No. 4 and wrap all equipment in polyethylene sheeting or bags. These should be dedicated and labeled for the intended wells.

3. Following any required air monitoring, measure water levels in all of the wells to be monitored during the test following the procedures identified in SOP No. 12. Record the water levels in the logbook or on the pump test log. It is recommended that the water levels be monitored for a period of time prior to the test to identify any trends of rising or falling water levels due to nearby supply wells, tidal influence or surface water bodies.

4. Set and secure the pump in the pumping well at the planned depth and allow for stabilization of the displaced water level caused by its insertion. The generator should be filled with gasoline at a remote down-wind location and extension cord run to this location. Record the pump depth in the logbook or on the pump test log. Monitor the water level in the pumping well to ensure that static levels are attained.

5. Secure the transducers with duct tape in the desired wells at the planned depths as identified in the pre-test schematic. Set all transducers in the wells for a minimum of two hours to allow for adaption to ground water temperature and cable stretch. The transducer in the pumping well should be set above the pump. Run all of the transducer cables to the test control location and connect them to the data logger in the desired channel(s). Record the transducer depths in the logbook or on the pump test log.

6. While the transducers are becoming stable, programming of the data logger for each channel should be completed with the specific parameters for each transducer. Scale factors, linearity, offset, well ID, reference level, and type of reading (surface or top of casing) should be selected. These parameters are specific to each transducer and data logger and are usually clearly identified on the wheel and cable for each transducer.

7. The data logger should be programmed to collect readings at the desired interval(s) for the entire duration of the test including recovery. The test should be programmed to allow for logging of water levels during the drawdown and recovery stages using the logarithmic option recommended with most data loggers. The actual log scale can also

be modified to suit the needs of the test if desired. The data logger should be programmed to start prior to initiation of pumping the well. Record the programmed duration in the logbook or on the pump test log.

8. Once the test equipment is ready, the entries, well IDs, and parameters for each channel should then be double checked for accuracy. The connections to all channels should be checked by communication with each individual transducer.

9. The startup of the pump should be synchronized with the logging of water level data. The rate of pumping should be set at the desired rate. The rate should be stabilized as quickly as possible to promote accurate data analysis. Direct the discharge to the appropriate containers, if required, or to a location outside of the anticipated cone of influence. The pumping rate should be measured and recorded routinely during initial pumping to confirm that the rate is stable. All adjustments to the rate should be recorded. Record the actual start time and pumping rate of the test in the logbook or on the pump test log.

10. Monitor the channels of the data logger to read the transducers. Look for drawdown in the pumping well to confirm operation. Monitor the transducers in the observation wells to confirm their operation. Manual measurement of the water levels should be performed periodically to confirm the accuracy of the transducer data.

11. Increase pumping rates at the required frequency.

12. If a recovery test also planned, shut down the pump, record the time and allow the water level in the pumping well to recover to 90 percent of static levels while the transducer and data logger collect the recovery data.

13. Once the test is completed, remove, and decontaminate all downhole equipment.

TRC

Pump Test Data Sheet

Project: Project No.:

Date/Time:

Sheet ___ of ___

Contractor Personnel:

Alliance Personnel:

Weather:

Well No.: __________

Pumping Well ☐
Observation Well ☐

Distance from Pumping Well: ____________

Well Diameter: ______ Static Water Level: _____

Well Depth: ________________

Screen Size: ________________

Depth Top of Screen:______ Depth Bottom of Screen:_____

Calculate Volume of Water in Pumping Well:
[VOL = $\Pi r^2 L \times 7.48$ gal/ft^3]

Note: r = Radius (ft)
L = Length of Saturated zone in well (ft)

DISCHARGE INFORMATION:

Well Discharge Rate: ____________________

Discharge Rate Measurement Method: ____________

____

Was rate checked throughout test Y ___ N ___

If yes, note variations:

TEST DATA:

Time Drawdown Test Started: ____________________

Time Recovery Started: ____________________

Time Recovery Completed: ____________________

Elapsed Time: ____________________

Approximate distance and location of discharge outlet from observation/monitoring well: ____________________

____

% Recovery Achieved: ____________________

DRAWDOWN MEASUREMENT INFORMATION:

Recording Method: ____________________

____

Transducer Size (ex. 10 psi): ______________

Transducer Depth: ____________________
(Allow Time for water level to equilibrate)

Data Logger Model: ____________________

Data Logger Test Number: ______________

Recording Type: Linear ______ Log ______

Maximum Time Step: ____________________

Obtain Field Print of Data? Y ______ N ______

DIAGRAM OF PUMP TEST SET UP:

Comments:

TRC

Pump Testing Monitoring Well Data

Client	Project	Project #	Sheet ___ of ___
Site	Location	Alliance Personnel:	Date/Time

Test Start Clock Time: __________ Elapsed Time: __________	Channel #:_____ XD psi:_______ XD Depth: _____ Radius: _______ Well#:________ Static W.L.: ____	Channel #:_____ XD psi:_______ XD Depth: _____ Radius: _______ Well#:________ Static W.L.: ____	Channel #:_____ XD psi:_______ XD Depth: _____ Radius: _______ Well#:________ Static W.L.: ____	Channel #:_____ XD psi:_______ XD Depth: _____ Radius: _______ Well#:________ Static W.L.: ____	Channel #:_____ XD psi:_______ XD Depth: _____ Radius: _______ Well#:________ Static W.L.: ____	Channel #:_____ XD psi:_______ XD Depth: _____ Radius: _______ Well#:________ Static W.L.: ____	Channel #:_____ XD psi:_______ XD Depth: _____ Radius: _______ Well#:________ Static W.L.: ____	Channel #:_____ XD psi:_______ XD Depth: _____ Radius: _______ Well#:________ Static W.L.: ____

AF-[illegible]

TRC STANDARD OPERATING PROCEDURE NO. 016

JAR HEADSPACE ANALYTICAL SCREENING PROCEDURE

Prepared by: ______________________ 10/22/99

Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/22/96

Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/25/99

Peter Spawn, Program Manager Date

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TRC STANDARD OPERATING PROCEDURE NO. 016
JAR HEADSPACE ANALYTICAL SCREENING PROCEDURE

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods for conducting water level measurements in monitoring wells during field investigations at hazardous and non-hazardous waste sites. This procedure is consistent with "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of jar headspace screening is to gain accurate field measurements from soil or ground water media encountered during boring, soil sampling, or ground water sampling.

1.2 Equipment

The following list of equipment may be utilized during the conduct of water level measurements. Site-specific conditions may warrant the use of additional or deletion of items from this list.

- Photo ionization detector (PID) or flame ionization detector (FID)
- Aluminum Foil
- Clean jars (approximately 500 ml or larger - jars less than 8 oz. capacity should not be used) or one-gallon resealable plastic bags.
- Field logbook

2.0 PROCEDURES

The following procedures should be followed. Note that for soil samples, a resealable plastic bag may be substituted for clean jars.

1. Record the sample characteristics and identity in logbook.

2. Put on latex or other sterile gloves. Fill half-full two clean glass jars with the sample to be analyzed. Quickly cover each open top with one sheet of clean aluminum foil (shiny side up) and subsequently apply screw caps to tightly seal the jars.

3. Allow headspace development for at least 10 minutes. <u>Vigorously shake jars for 15 seconds both at the beginning and end of the headspace development period.</u> Where ambient temperatures are below 32°F (0°C), headspace development should be within a heated vehicle or building.

4. Subsequently to headspace development, remove screw lid/expose foil seal. Quickly puncture foil seal with instrument sampling probe, to a point about one-half of the headspace depth. Exercise care to avoid uptake of water droplets or soil particulates.

   As an alternative, syringe withdrawal of a headspace sample with subsequent injection to instrument probe or septum-fitted inlet is acceptable contingent upon verification of methodology using a test gas standard.

5. Following probe insertion through foil seal and/or sample injection to the probe, record highest meter response as the jar headspace concentration. Using foil seal/probe insertion method, maximum response should occur between 2 and 5 seconds. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case headspace data should be discounted.

6. The headspace screening data from both jar samples should be recorded and compared; generally, replicate values should be consistent to plus or minus 20 percent.

7. PID and FID field instruments shall be operated and calibrated to yield "total organic vapors" in ppm (v/v) as benzene. PID instruments must be operated with an appropriate eV (+/-) lamp source. Operation, maintenance, and calibration shall be performed in accordance with the manufacturer's specifications. For jar headspace analysis, instrument calibration shall be checked/adjusted no less than once every ten analyses, or daily, whichever is greater.

8. Instrumentation with digital (LED/LCD) displays may not be able to discern maximum headspace response unless equipped with a "maximum hold" feature or strip-chart recorder. Deviations, departures and/or additions to the above procedures should be consistent with 310 CMR 40.0017. In such cases, compelling technical justification must be presented and documented by the methodology proponent.

TRC STANDARD OPERATING PROCEDURE NO. 017

GENERAL PACKER TEST PROCEDURES

Prepared by: ______________________ 10/25/99
Adam Balogh, P.G. Date

Reviewed by: ______________________ 10/25/99
Dale Weiss, P.G., Project Manager Date

Approved by: ______________________ 10/25/99
Peter Spawn, Program Manager Date

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FIGURES

Figure 1 Schematic of Mechanical Packer Pressure Test and Related Equipment 10

Attachment A

Pressure of Test Form

TRC STANDARD OPERATING PROCEDURE NO. 017
GENERAL PACKER TEST PROCEDURES

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the methods and general procedures for conducting Packer tests in monitoring wells. This SOP conforms to "A Compendium of Superfund Field Operations Methods" (EPA/540/P-87/001), and other pertinent technical publications.

Packer tests may be performed during the advancement of the borehole or after drilling is completed. Packer tests are usually conducted in NQ/NX-size (3-inch) boreholes, but can be conducted in boreholes of a larger size. The test involves placing expandable packers, either mechanical or pneumatic, in a borehole. A pneumatic packer assembly is preferred because it is easier to use and provides a more positive seal. A section of the borehole, usually five feet in length, is sealed off with the packers. Water is then pumped through the zone between the packers at a known pressure. The rate of flow into the formation is measured with a flow meter. The permeability of the test zone is calculated using the data obtained in the test.

1.1 Objective

The objective of a Packer Test is to identify the permeability of a specific zone in a bedrock borehole. Knowledge of this is essential in understanding aquifer characteristics for the configuration of remediation or ground water supply systems.

1.2 Equipment

The following equipment may be used during the conduct of a Packer test. Site-specific conditions may warrant addition to, or deletion of items from this list.

- Field logbook or Packer test log
- Water level indicators
- Pressure transducers
- Data logging equipment
- Field printer
- Lap-top computer
- Duct tape
- Alconox, liquinox, or other non-phosphate concentrated laboratory grade soap;
- Deionized Water;
- Submersible pump with flow regulator and foot valve
- Generator

- Heavy duty extension cords
- Polyethylene sheeting
- Large capacity barrels (alternately holding tanks);
- Necessary personal protective equipment (gloves, eyewear, tyvek suits);
- Portable radios
- Well completion logs
- Well keys
- Flow meter/graduated bucket
- Stopwatch

2.0 PROCEDURES

The following methodology should be used to conduct a bedrock packer test.

1. Flush the borehole with clean water to remove cuttings. Measure the depth of the borehole, and check for caving. Be sure that an adequate reserve of water is available to avoid running out of water during a test.

2. Determine the test zone. The test section length should be a minimum of 5 times the diameter of the borehole. Avoid placing the packer in a zone of fractured rock or in the bottom of the casing because leakage will occur. Keep the rock core or drilling logs handy to refer to during the test.

3. Maintain the test pressures below what is commonly referred to as the Maximum Water Pressure (Pmax). This should avoid the chance of hydrofracturing (loosening) the rock mass. Pmax is determined by the following formula:

   $Pmax = (H_1)(1 \text{ psi/ft})$
   where H_1 = depth in feet from ground surface to the bottom of the upper packer
   (Note: in highly fractured rock this should not exceed 0.75 psi/ft)

During test operations the water pressures are observed at the gauge. The Maximum Gauge Pressure (Gpmax) is calculated by the following formula:

$Gpmax = (H_1 + H_3)\ (1 \text{ psi/ft}) - H_1 - H_2)\ (.43 \text{ psi/ft})$
Where
H_1 = depth in feet from ground surface to the bottom of the upper packer
H_2 = depth in feet from ground surface to the static water level
H_3 = height in feet of pressure gauge above ground surface

The depth and height variables (H_1, H_2 and H_3) are shown on Figure 1.

When significant flow rates are encountered during the test the gauge pressure may need to be increased to compensate for system pressure loss due to frictional head loss. This is an unusual situation.

4. To ensure that the packer system is not leaking, test it prior to the start of the actual permeability test. This can be done by installing the packer in a piece of steel casing and conducting the test as if it were being done in the borehole. The water pressure must not exceed the Packer Inflation Pressure (see Step #5, below). Calibration for a particular test assembly can be obtained on site by laying the system out on the ground and pumping water through the system while collection the data as if the test were being performed in-situ. Check the hose for leaks. Check the water meter to assure that it is working properly.

5. Determine the Packer Inflation Pressure (PIP), by performing the following steps:

Step 1 - Establish Minimum Inflation Pressure (MIP) (i.e., the pressure required to inflate the packers in the casing so that they can no longer be pushed or pulled through the casing).

Step 2 - Establish the Static Head Pressure (Ps) i psi at the test depth by the following calculation:

$$Ps = (H_1 - H_2)\ (0.43 \text{ psi/ft})$$

Where,

H_1 and H_2 are as above

Step 3 - make sure the Packer Inflation Pressure (PIP) equals the Minimum Inflation Pressure (MIP) plus the Static Head Pressure plus the Maximum Gauge Pressure (Gpmax) of the test zone between the packers. This is sometimes written as follows:

$$PIP = MIP + Ps + Gpmax$$

6. Determine the static water level in the borehole prior to the installation of the packer.

7. Assemble and install the packer equipment in the borehole. Measure each rod to top of coupling as it goes into the hole. Be sure rods are tightened to prevent leakage at the joints; teflon tape may be helpful. Number the rods for easy tracking of the packer location for sequential tests. Lower the equipment to the location of the deepest test. Figure 1 depicts a configuration for a packer test.

8. Before performing the first test, bleed air out of the lines by forcing water through the packer system assembly before the packers are inflated. Inflate both packers to the required packer pressure. Double packers are usually spaced five feet apart, but spacing can be varied to meet specific test requirements.

9. Before starting the test, review the Packer Test Data Sheets (Figure 3) and record the following:

- Test number
- Test section (i.e. length)
- Hole size
- Height of pressure gauge above ground surface
- Ground surface elevation
- Depths to rock surface, ground water, bottom of boring, bottom of upper packer, and to top of lower packer

10. Conduct the bedrock packer test in three stages:

Step 1 - ½ Gpmax

Pump water into the system and record observations of gauge pressure and water meter at 30-second intervals for at least three to five minutes after a constant rate of flow is reached.

Step 2 - Full Gpmax

Pump water into system and record observations of gauge pressure and water meter at 30-second intervals for at least three to five minutes after a constant rate of flow is reached.

Step 3 - Full Gpmax plus 20 psi increase on the Packer Inflation Pressure

Increase Packer Inflation Pressure by 20 psi. Pump water into the system and record observations of gauge pressure and water meter at 30-second intervals for at least three to five minutes after a constant rate of flow is reached. The results of Steps 2 and 3 should be similar. If they are not, Step 3 should be repeated, increasing the Packer Inflation Pressure by an additional 20 psi. This is done to check for leakage past the packers.

For all test steps, record water levels in the casing during the test. If the water level rises or bubbles appear during the test, the packers may not be sealed and the test results may be suspect. Measurements of doubtful accuracy must be noted, along with a description of the questionable aspects. If possible, testing should be continued until accurate data is obtained. It may be necessary to move the packer assembly a short distance to obtain an adequate seal.

11. If leakage of water from the packed section into the surrounding rock is so great that the Gpmax cannot be reached, run the pump at its full capacity with the bypass valve closed. Record the volume of water pumped into the test section and the associated pressure readings at timed intervals. This data will give a minimum value of the rock permeability.

12. Upon completion of the test, deflate the packers and move to the next test depth. Complete log sheet (see Figure 2).

13. The same test methodology may be used with a single packer. Single packer tests are conducted either as the borehole is advanced or after the entire borehole has been completed. With this test configuration the bottom of the borehole takes the place of the second packer.

3.0 PROBLEMS AND POSSIBLE SOLUTIONS

There are a number of possible problems that may develop while performing a bedrock packer test. Several of the most common problems and their possible solutions are outlined below.

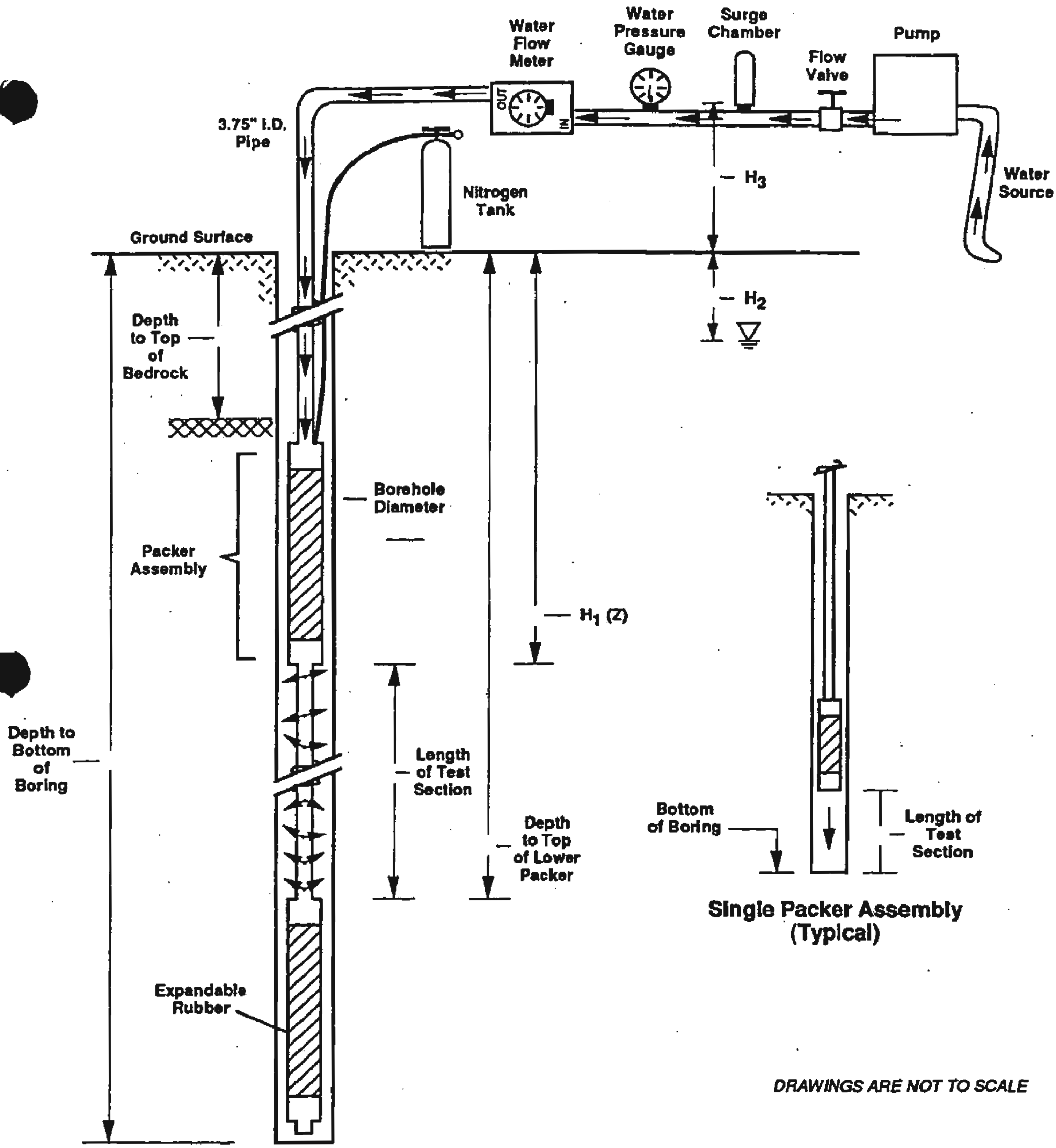
1. Packers move up out of the hole at the start of the test.
Occasionally, particularly in low permeability rocks, the packer assembly may lift out of the hole due to the water pressure. Observers should stay clear of the top of the borehole to avoid injury. It may be helpful to deflate and re-inflate the packers to obtain a more positive seal in the borehole. Also, the rig drive head can be placed over the top of the swivel to help to hold the packers in place during the testing.

2. Excessive amounts of water are pumped into the formation.
In certain types of hydrogeologic or contaminant investigations, large quantities of water should not be pumped into the aquifer as this may impact local ground water quality and movement. If this is a concern, packer tests should be avoided. Alternatively, falling or rising head tests may be performed or geophysical borehole data may be obtained.

3. The packers jam in the borehole.
Packers may become caught in the borehole for two reasons: 1) caving of the formation around the packers, or 2) failure of the packers to deflate. In the latter case, it is generally advisable to re-inflate and deflate the packers a second time to try to remedy the problem. Forcibly removing the packers from the hole should be avoided as they may become permanently lodged or damaged. In some instances it may be helpful to pump water through the system to help lubricate the equipment for removal. Packer tests in soft, broken or cavernous formations should always be attempted with great caution.

4. Water meter malfunction.
Water meters are sensitive instruments and are subject to malfunctions due to clogging by debris or mechanical failure. It is important to check the water meter prior to use to be certain that it is working properly. Generally, it is best to place the water meter in a horizontal position, particularly for low flow measurements. It is also important to determine what the units of the meter dial are prior to use, as they are often poorly marked. Discharging water from the meter

into a container of known volume (e.g., 5-gallon bucket or a 55-gallon drum) and comparing this to the metered volume provides a reasonably accurate check.



Double Packer Assembly and Associated Apparatus (Typical)

Maximum Gauge Pressure (GPMax)

$GPMax = (H_1 + H_3)$ (1 psi/ft.) - $(H_1 - H_2)$ (.43 psi/ft)

H1 = depth in feet from ground surface to the bottom of the upper packer

H2 = depth in feet from ground surface to the static water level

H3 = height in feet of pressure gauge above ground surface

AF-223 B

TRC

Pressure Test Form

Boring No.	Ground Elevation
Date Start:	Date Finished:
Time Start:	Time Finished:

Project: Project No.:

Location:

TRC Personnel:

Contractor Personnel:

Driller:

	Packer System	Water Meter	Pressure Gauge	Surge Chamber
Type				
Mfg.				
Model No.				

M.G.P = (0.566 to 1.0) (Z)
Computed Max. Gauge Press. (M.G.P.) ______
Computed Internal Friction ______
Rock Type ______
Hole Size ______
Recovery (%) ______
RQD (%) ______

Depths (measured from ground surface in feet)
to Top of Rock ______
to Bottom of Boring ______
to Water Table (H_2) ______
to Top of Lower Packer ______
to Bottom of Upper Packer (Z) (H_1) ______
Length of Test Section ______
Height of Water Pressure Gauge Above Ground Surface (H_3) ______

GAUGE PRESS. ______ PACKER INFL'T'N PRESS. ______			GAUGE PRESS. ______ PACKER INFL'T'N PRESS. ______			GAUGE PRESS. ______ PACKER INFL'T'N PRESS. ______			GAUGE PRESS. ______ PACKER INFL'T'N PRESS. ______			GAUGE PRESS. ______ PACKER INFL'T'N PRESS. ______		
Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow	Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow	Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow	Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow	Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow
Remarks:			Remarks:			Remarks:			Remarks:			Remarks:		

Single ☐
Double ☐

Test Configuration:
Fill Out Diagram on Back

Rev. F[illegible]y 16, 1993

TRC

Pressure Test Form

Boring No.	Ground Elevation
Date Start:	Date Finished:
Time Start:	Time Finished:

Project: Project No.:

Location:

TRC Personnel:

Contractor Personnel:

Driller:

	Packer System	Water Meter	Pressure Gauge	Surge Chamber
Type				
Mfg.				
Model No.				

M.G.P = (0.566 to 1.0) (Z)
Computed Max. Gauge Press. (M.G.P.) ______
Computed Internal Friction ______
Rock Type ______
Hole Size ______
Recovery (%) ______
RQD (%) ______

Depths (measured from ground surface in feet)
to Top of Rock ______
to Bottom of Boring ______
to Water Table (H_2) ______
to Top of Lower Packer ______
to Bottom of Upper Packer (Z) (H_1) ______
Length of Test Section ______
Height of Water Pressure Gauge Above Ground Surface (H_3) ______

GAUGE PRESS. ______ | GAUGE PRESS. ______ | GAUGE PRESS. ______ | GAUGE PRESS. ______ | GAUGE PRESS. ______
PACKER INFL'T'N PRESS. ______ | PACKER INFL'T'N PRESS. ______ | PACKER INFL'T'N PRESS. ______ | PACKER INFL'T'N PRESS. ______ | PACKER INFL'T'N PRESS. ______

Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow	Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow	Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow	Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow	Elapsed Time (min.)	Flow Reading (gal.)	Δ Flow

Remarks:

Single ☐
Double ☐

Remarks:

Remarks:

Remarks:

Remarks:

Test Configuration:
Fill Out Diagram on Back

TRC STANDARD OPERATING PROCEDURE NO. 018

SAMPLE CHAIN OF CUSTODY

Prepared by: _______________ 10/25/99

Adam Balogh, P.G. — Date

Reviewed by: _______________ 10/25/99

Dale Weiss, Senior Hydrogeologist — Date

Approved by: _______________ 10/25/99

Peter Spawn, Program Manager — Date

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TRC STANDARD OPERATING PROCEDURE NO. 018
SAMPLE CHAIN OF CUSTODY

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the documentation requirements for collecting samples. The SOP conforms to "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

Sampling handling is an important part of the field investigation program since samples that are incorrectly handled can affect the quality of data. Sample handling begins at the collection of the samples and continues until the sample has been analyzed. Described in this section are sample preservation requirements for the samples, sample custody, and documentation protocols.

2.0 SAMPLE CUSTODY

An overriding consideration essential for the validation of environmental measurement data is the necessity to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration. Evidence of the sample traceability from collection to shipment, laboratory receipt, and laboratory custody (until proper sample disposal and the introduction of field investigation results as evidence in legal proceedings when pertinent) must be documented. A sample is considered to be in a person's custody if the sample is:

- In a person's actual possession
- In view after being in a person's possession
- Locked so that no one can tamper with it after having been in physical custody
- In a secured area, restricted to authorized personnel

The field team leader (or designee) is responsible for overseeing and supervising the implementation of proper sample custody procedures in the field. The field team leader or designee are also responsible for ensuring sample custody until the samples have been transferred to a courier or directly to the laboratory. Once received by the laboratory, the samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

2.1 Chain-of-Custody

The chain-of-custody procedures are initiated in the field immediately following sample collection. The procedures consist of: (1) preparing and attaching a unique sample label and tag (RAS analyses only) to each sample collected, (2) completing the traffic report/chain of custody (TR/COC) form for RAS analyses and the COC for DAS analyses, and (3) preparing and packing the samples for shipment. The standard operating procedures for the DAS program, including procurement of analytical services, sample tracking, and overall management of the program can be found in EPA's Regional Sample Control Center Guidance for the CLP and DAS (1996b), which contains the current guidelines that are applicable to this section.

2.1.1 Sample Labels

Field personnel are responsible for uniquely identifying and labeling all samples collected during a field investigation program. All labeling must be completed in indelible/waterproof ink and securely affixed to the sample container.

For RAS analyses, all sample bottles will be labeled with both a label and an EPA-CLP sample number designated for RAS analyses. Similarly, for all DAS analyses, sample bottles will be labeled with a label and a DAS sample number. The label typically contains the following information:

- Unique sample identification number
- Sample location/description number
- Type of analysis to be performed
- Sample volume, container type, and the type of chemical preservation used
- Sampling date and time
- Sampler's initials

The RAS sample number is a unique number that identifies each sample analyzed through the CLP system. The DAS sample number is also a unique number; however, DAS samples are not routed through the EPA-CLP process, but are generated and tracked through the analytical services work assignment. Both the RAS and DAS sample numbers are preprinted on adhesive labels. The RAS sample number labels are provided by the Regional Sample Control Center (RSCC) for EPA Region I, and DAS sample number labels are provided by the DAS Laboratory/Tracking Coordinator. It is the field personnel's responsibility to assign the RAS or DAS sample number correctly, transcribe it accurately on the appropriate documentation, place the labels on the correct bottles, and transcribe it accurately to the bottle tag.

The RAS sample number label contains the following information:

- An alpha-numeric sample identification number as assigned by the RSCC.
- Type of analysis to be performed

The DAS sample number label will contain only an alpha-numeric sample identification number as assigned by the Laboratory/Tracking Coordinator and can be used for any type of DAS analyses. If a sample number is used but there are additional sample stickers with that number remaining, the extra stickers will be destroyed. Unused numbers may be retained for future use. An attempt should be made to use the numbers consecutively to avoid confusion. An example of the RAS and DAS sample number labels are shown in Figure 1.

2.1.2 Sample Tags

Field personnel are responsible for tagging all samples that are collected and submitted for RAS analyses. An EPA-CLP sample tag must be completed in indelible/water-proof ink and securely attached to each sample container. The EPA-CLP sample tag contains the following information:

- Project Code (work assignment number)
- Unique sample identification number (also called the station location)
- Sampling date and time
- Designate: composite or grab sample
- Preservative: yes or no
- Type of analysis to be performed
- Signature of the person packaging the sample
- RAS sample number
- Case number

An example of an EPA-CLP sample tag is shown in Figure 2. Sample tags are not necessary for samples submitted for DAS analyses.

For each sampling event, a case number is assigned by the EPA Contract Laboratory Analytical Support Services (CLASS) contractor for RAS samples and by the Laboratory/Tracking Coordinator for DAS samples. Although the DAS case number is assigned by the Laboratory/Tracking Coordinator, the RSCC is notified of the assigned case number and the anticipated number of samples to be collected prior to sample collection, and a Region I summary form is submitted to the RSCC. From this point on the tracking of DAS samples is the responsibility of the Project Chemist.

The RAS case number is five digits in length. The DAS case number is a four digit number followed by an assigned letter. The case number allows for tracking of samples and maintains site confidentiality. No reference to the site name will be shown on paper work.

2.1.3 Custody Seal

Custody seals will be secured across the shipping container to ensure content integrity. The seals contain both the date and the signature of the person affixing them and must be completed in indelible/waterproof ink. An example of a custody seal is shown in Figure 2.

2.1.4 Traffic Report/Chain of Custody and Chain of Custody

For inorganic and organic analyses, TR/COCs (Figures 3 and 4, respectively) must be completed for each sample set submitted for RAS analyses. COC (Figure 5) must be completed for each sample set submitted for DAS analyses. These forms are maintained as a record of sample collection, transfer, shipment, and receipt by the laboratory. These forms also contain pertinent information concerning sampling locations, dates, and times; signatures of at least one sampling team member; types of samples collected along with a unique sample identification number; the number of samples collected and shipped for analysis in each lot; the project name and number; and the name of the laboratory to which the samples are being sent. They must be completed to ensure proper transfer of custody from the time of sample collection to analysis. The appropriate copies must be sent to the CLASS contractor, RSCC, and the laboratory.

2.1.5 Transfer of Custody

Samples will be accompanied by an approved and completed TR/COC or COC form during each step of custody transfer and shipment. When physical possession of samples is transferred, both the individual relinquishing the samples and the individual receiving them will sign, date, and record the time on the COC form. In the case of sample shipment by an overnight courier, a properly prepared air bill (Figure 6) will serve as an extension of the TR/COC or COC form while the samples are in transit.

At the start of business the day following shipment, field personnel will either notify the CLASS contractor or RSCC of RAS sample shipments, by telephone. This notification enables the CLASS contractor to track the shipment of samples from the field to the laboratory and ensure timely receipt of the samples at the laboratory. The following information should be reported to the CLASS contractor and documented:

- Field Team Person's name, phone number, and EPA region
- Case number of the project
- Batch numbers (dioxin only)
- Exact number(s), matrix(ces), and concentration(s) of samples shipped
- Laboratories to which samples were shipped
- Analyses required

- Carrier name and air bill number(s) for the shipment
- Method of shipment (e.g., overnight)
- Date of shipment
- Information on completions, changes, delays, continuations, etc., pertinent to the Case and sampling project

If the RAS sample shipment is made after 5:00 p.m. eastern standard time (EST), the CLASS contractor will be notified at the start of business the next day (8:00 a.m. EST). The CLASS contractor will also be notified by 3:00 p.m. EST Friday for RAS sample shipments that will be received at the laboratory on Saturday. Appropriate copies of the TR/COC must be sent to the RSCC and CLASS contractor to document collection of RAS samples to be analyzed through the EPA CLP system. Upon completion of a sampling event, copies of all TR/COC and a copy of the appropriate data quality objectives (DQO) summary form (Figure 7) will be sent to the following addresses:

Ms. Christine Clark
US EPA Region I OEME
60 Westview Street
Lexington, MA 02173
(781) 860-4615

Ms. Nicole Coene
U.S. EPA CLASS / Dyn Corp.
Information & Engineering Tech. Inc.
200 Edmund Halley Drive
Reston, VA 20191-3436
703-264-0330

2.2 Sample Packaging and Shipping

Following sample collection, all samples will be brought to an on-site location for batching and paperwork checks. At this central location, like sample types are matched (i.e., solids, liquids, etc.) with similar sample types from all sample locations. Labels and logbook information are checked to ensure there is no error in sample identification. The samples are packaged to prevent breakage and/or leakage, and the shipping containers are labeled in accordance with the Department of Transportation (DOT) regulations for transport.

All samples will be shipped directly to the laboratories via an overnight carrier. For each sample shipment to a specific laboratory, an overnight air bill must be properly completed. In order to ensure the safe and secure delivery of all collected samples to the laboratories, packaging and shipping procedures have been developed so that resulting shipment will comply with applicable DOT regulations for air or surface transportation.

MAJR51 - TOTAL METALS

MAJR51 - CYANIDE

DAM470

FIGURE 1 RAS and DAS Sample Number Label Examples

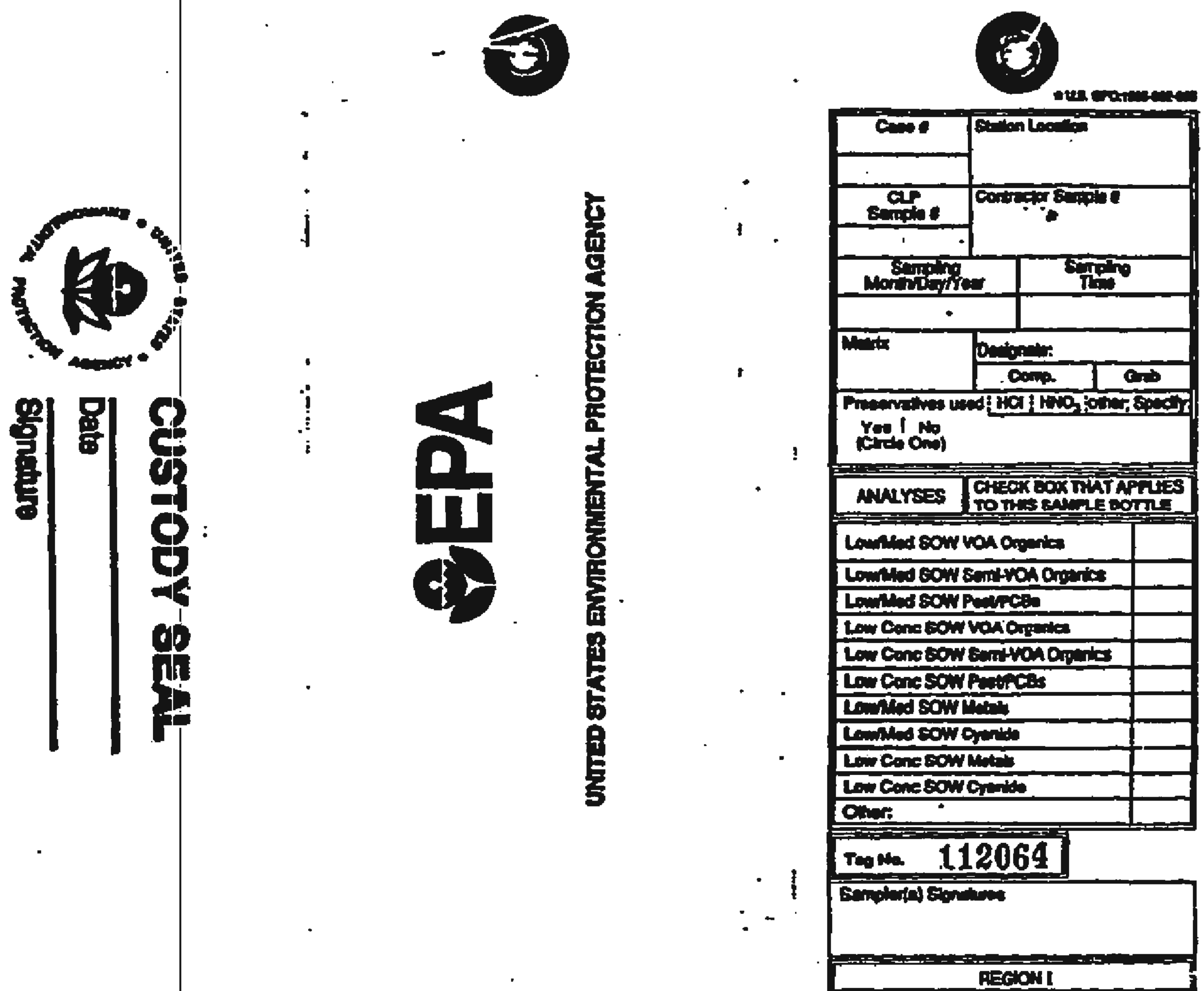

FIGURE 2. RAS Tag and COC Seal

FIGURE 3 Inorganic COC

United States Environmental Protection Agency
Contract Laboratory Program Sample Management Office
PO Box 818 Alexandria, VA 22313
703-557-2490 FTS 557-2490

Inorganic Traffic Report & Chain of Custody Record

(For Inorganic CLP Analysis)

SAS No. (if applicable)

Case No.

1. Project Code | Account Code | 2. Region No. | Sampling Co. | 4. Date Shipped | Carrier

Regional Information | Sampler (Name) | Airbill Number

Non-Superfund Program | Sampler Signature | 5. Ship To

Site Name

City, State | Site Spill ID

3. Type of Activity: Lead: SF, PRP, ST, FED; Pre-Remedial: PA, SSI, LSI; Remedial: RIFS, RD, RA, O&M, NPLD; Removal: CLEM, REMA, REM, OIL, UST

ATTN:

6. Preservative (Enter in Column D)
1. HCl
2. HNO3
3. NaOH
4. H_2SO_4
5. $K_2CR_2O_7$
6. Ice only
7. Other (Specify)
N. Not preserved

7. Sample Description (Enter in Column A)
1. Surface Water
2. Ground Water
3. Leachate
4. Rinsate
5. Soil/Sediment
6. Oil (High only)
7. Waste (High only)
8. Other (Specify)

CLP Sample Numbers (from labels)	A Enter # from Box 7	B Conc. Low Med High	C Sample Type: Comp./Grab	D Preservative from Box 6	E - RAS Analysis: Metals Total	Metals Dissolved	Cyanide	Low Conc. only: Metals	Low Conc. only: Fluoride	pH	High only: Conduc-tivity	F Regional Specific Tracking Number or Tag Numbers	G Station Location Number	H Mo/Day/Year/Time Sample Collection	I Sampler Initials	J Corresp. CLP Org. Samp. No.	K Enter Appropriate Qualifier for Designated Field QC: B = Blank, S = Spike, D = Duplicate, PE = Perform. Eval., — = Not a QC Sample

Shipment for Case complete? (Y/N) | Page 1 of ____ | Sample used for a spike and/or duplicate | Additional Sampler Signatures | Chain of Custody Seal Number

CHAIN OF CUSTODY RECORD

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks Is custody seal intact? Y/N/none	

Split Samples ☐ Accepted (Signature)
☐ Declined

EPA Form 9110-1 (Rev. 5-91) Replaces EPA Form (2075-6), previous edition which may be used

DISTRIBUTION:
Green - Region Copy Pink - SMO Copy White - Lab Copy for return to Region Yellow - Lab Copy for Return to SMO

SEE REVERSE FOR ADDITIONAL STANDARD INSTRUCTIONS

I 353899

FIGURE 4 Organic COC

EPA United States Environmental Protection Agency
Contract Laboratory Program

Organic Traffic Report & Chain of Custody Record
(For Organic CLP Analysis)

SAS No. (if applicable)	Case No.

1. Project Code	Account Code	2. Region No.	Sampling Co.	4. Date Shipped	Carrier
Regional Information		Sampler (Name)		Airbill Number	
Non-Superfund Program		Sampler Signature		5. Ship To	
Site Name		3. Purpose*			
City, State	Site Spill ID			ATTN:	

3. Purpose*
- Lead: SF, PRP, ST, FED
- Early Action: CLEM, PA, REM, RI, SI, ESI
- Long-Term Action: FS, RD, RA, O&M, NPLD

6. Matrix (Enter in Column A)
1. Surface Water
2. Ground Water
3. Leachate
4. Field QC
5. Soil/Sediment
6. Oil (High only)
7. Waste (High only)
8. Other (Specify in Column A)

7. Preservative (Enter in Column D)
1. HCl
2. HNO3
3. NaHSO4
4. H2SO4
5. Ice only
6. Other (Specify in Column D)
N. Not preserved

CLP Sample Numbers (from labels)	A Matrix (from Box 6) Other:	B Conc. Low Med High	C Sample Type: Comp./Grab	D Preservative (from Box 7) Other:	E RAS Analysis VOA	BNA	Pest/PCB	High only ARO/TOX	F Regional Specific Tracking Number or Tag Numbers	G Station Location Identifier	H Mo/Day/Year/Time Sample Collection	I Corresponding CLP Inorganic Sample No.	J Sampler Initials	K Field QC Qualifier B = Blank S = Spike D = Duplicate R = Rinsate PE = Perform. Eval. — = Not a QC Sample

Shipment for Case Complete? (Y/N)	Page ___ of ___	Sample(s) to be Used for Laboratory QC	Additional Sampler Signatures	Chain of Custody Seal Number(s)

CHAIN OF CUSTODY RECORD

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks Is custody seal intact? Y/N/none	

DISTRIBUTION: Blue - Region Copy; White - Lab Copy for Return to Region; Pink - SMO Copy; Yellow - Lab Copy for Return to SMO

EPA Form 9110-2

SEE REVERSE FOR ADDITIONAL STANDARD INSTRUCTIONS
*SEE REVERSE FOR PURPOSE CODE DEFINITIONS

358561

AEI-8713-3 REV. 3/93

FIGURE 5 COC

CHAIN OF CUSTODY RECORD

Project Name ____________________
Project No.: ____________________
Sampling Date(s): ____________________
Laboratory: ____________________
Laboratory P.O. #: ____________________
Shipping Airbill No.: ____________________
Shipping Date(s): ____________________
Shipper's Name: ____________________

Sample Code	Sampled Date	Container Size	Container G/P	MATRIX: Aqueous	Organic Solvent	Ash/Soil/Sediment	Acidic	Basic	Other	Source Description	ANALYSIS: Trace Metals*	Mercury	Hexavalent Chromium	HCl	Cl2	Particulate Matter	PCDD/PCDF	Semi-Volatile Organics	Volatile Organics	Physical Parameters*					Comments

Relinquished by:	Date/Time:	Relinquished by:	Date/Time:
Received by:	Date/Time:	Received by:	Date/Time:

REMARKS (*):

№ 02538

WHITE — LABORATORY YELLOW — LABORATORY COPY PINK — OFFICE COPY GOLD — FIELD COPY

TRC
TRC Environmental Corporation

FIGURE 6 Fed EX Airbill

FedEx. USA Airbill FedEx Tracking Number 806923456477 Form I.D. No. 0200 **Sender's Copy**

1 From (please print and press hard)

Date 4/27/99 Sender's FedEx Account Number 0021-0354-0

Sender's Name TODD D. MAJER Phone 978 990-5600

Company TRC ENVIRONMENTAL

Address Boott Mills South, Foot of John St. Dept/Floor/Suite/Room

City Lowell State MA ZIP 01852

2 Your Internal Billing Reference Information (Optional) (First 24 characters will appear on invoice) 02136-0200-01162

3 To (please print and press hard)

Recipient's Name Beverly Kilgore Phone 256 534-9800

Company SENTINEL, INC

Address 2800 Big Wallace Ave, Suite L3 Dept/Floor/Suite/Room

(To "HOLD" at FedEx location, print FedEx address here) (We Cannot Deliver to P.O. Boxes or P.O. ZIP Codes)

☐ Check here if residence

City Huntsville State AL ZIP 35805

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For WEEKEND Delivery check here ☐ Saturday Delivery ☐ NEW Sunday Delivery

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Questions?
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The World On Time.

4a Express Package Service Packages under 150 lbs.

☒ FedEx Priority Overnight ☐ FedEx Standard Overnight ☐ FedEx First Overnight ☐ FedEx 2Day ☐ FedEx Express Saver

4b Express Freight Service Packages over 150 lbs.

☐ FedEx Overnight Freight ☐ FedEx 2Day Freight ☐ FedEx Express Saver Freight

(Call for delivery schedule. See back for detailed descriptions of freight services.)

5 Packaging ☐ FedEx Letter ☐ FedEx Pak ☐ FedEx Box ☐ FedEx Tube ☒ Other Pkg.

6 Special Handling

Does this shipment contain dangerous goods? ☐ No ☐ Yes ☐ Yes

☐ Dry Ice ☐ Cargo Aircraft Only

7 Payment

Bill to: ☒ Sender ☐ Recipient ☐ Third Party ☐ Credit Card ☐ Cash/Check

FedEx Account No.

Credit Card No. Exp. Date

Total Packages	Total Weight	Total Declared Value	Total Charges
1	54	$ .00	$

8 Release Signature Sign to authorize delivery without obtaining signature.

Your signature authorizes Federal Express to deliver this shipment without obtaining a signature and agrees to indemnify and hold harmless Federal Express from any resulting claims.

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RETAIN THIS COPY FOR YOUR RECORDS

EPA-NE - DQO SUMMARY FORM

Page____ of____

...urrent Form should be completed for each sampling event. Refer to Attachment A for instructions on completing this form, Attachment B for a complete list of parameter codes and Attachment C for an example of a completed form.

EPA Program: TSCA CERCLA RCRA DW NPDES CAA
Other:______
Projected Date(s) of Sampling______
EPA Site Manager______
EPA Case Team Members______

Site Name______
Site Location______
Assigned Site Latitude/Longitude______
CERCLA Site/Spill Identifier No. 01 ______ (Include Operable Unit)
Phase: ERA SA/SI pre-RI RI (phase I, etc.) FS RD RA post-RA
(circle one) Other:______

QAPP Title and Revision Date______

Approved by:______ Date of Approval:______
Title of Approving Official:______ Organization*:______
*If other than EPA, record date approval authority was delegated:______

EPA Oversight Project (circle one) Y N
Confirmatory Analysis for Field Screening Y N
Are comparability criteria documented? Y N
Type of EPA Oversight (circle one) PRP or FF Other:______
If EPA Oversight or Confirmatory: % splits______

a.	Matrix Code[1]								
b.	Parameter Code[2]								
c.	Preservation Code[3]								
d.	Analytical Services Mechanism								
e.	No. of Sample Locations								
	Field QC:								
f.	Field Duplicate Pairs								
g.	Equipment Blanks								
h.	VOA Trip Blanks								
i.	Cooler Temperature Blanks								
j.	Bottle Blanks								
k.	Other:______								
l.	PES sent to Laboratory								
	Laboratory QC:								
m.	Reagent Blank								
n.	Duplicate								
o.	Matrix Spike								
p.	Matrix Spike Duplicate								
q.	Other:______								

Site Information
Site Dimensions______
List all potentially contaminated matrices______
Range of Depth to Groundwater______
Soil Types: Surface Subsurface Other:______
Sediment Types: Stream Pond Estuary Wetland Other:______ Expected Soil/Sediment Moisture Content: High Low

...hen multiple matrices will be sampled during a sampling event, complete Sections 3-10 for each matrix. Matrix Code[1]______

Data Use (circle all that apply): Site Investigation/Assessment; Nature and Extent of Contamination; Engineering Design; Post-Remedial Action (quarterly monitoring); PRP Determination; Human and/or Ecological Risk Assessment; Remedial Action; Removal Action; Remediation Alternatives; Other:______

FIGURE 7 pg 1 DQO

6. Summarize DQOs: ______________________________

Complete Table if applicable

COCs	Action Levels	Analytical Method Quantitation Limits

7. Sampling Method (circle technique) Bailer Low flow pump (Region I method: Yes No) Peristaltic Pump
Positive Displacement Pump Faucet or Spigot Other: ____________
Split Spoon Dredge Trowel Other: ____________

Sampling Procedure (SOP name, No., Rev. #, and date) ______________________
List Background Sample Locations ______________________
Circle: Grab or Composite
"Hot spots" sampled: Yes No

8. Field Data (circle) ORP pH Specific Conductance Dissolved O_2 Temperature Turbidity
Other: ______________________

9. Analytical Methods and Parameters

Method title/SOP name	Method/SOP Identification number	Revision Date	Target Parameters (VOA, SV, Pest/PCB, Metals, etc.)

10. Validation Criteria (circle one) 1. Region I, EPA-NE Data Validation Functional Guidelines for Evaluating Environmental Analyses, Part II, III or IV
2. Other Approved Validation Criteria: ______________________
Validation Tier (circle one) I II III Partial Tier III: ______________________
Company/Organization Performing Data Validation ______________________ (Prime or Subcontractor (circle one))

11. Company Name: ______________________ Contract Number ______________________
Contract Name (e.g. START, RACS, etc.) ______________________ Work Assignment No. ______________________
Person Completing Form/Title ______________________ Date of DQO Summary Form Completion ______________________

Matrix Codes[1] - Refer to Attachment B, Part I
Parameter Codes[2] - Refer to Attachment B, Part II

Preservation Codes[3]

1.	HCl to pH ≤ 2	7.	$K_2Cr_2O_7$
2.	HNO_3	8.	Freeze
3.	$NaHSO_4$	9.	Room Temperature (avoid excessive heat)
4.	H_2SO_4	10.	Other (Specify)
5.	Cool @ 4°C (± 2°)	N.	Not preserved
6.	NaOH		

- To supplement Matrix Codes and/or Parameter Codes contact the QA Unit

FIGURE 7 pg 2 DQO

TRC STANDARD OPERATING PROCEDURE NO. 019

DATA VALIDATION

Prepared by: Adam J Balogh — 11/9/99
Adam Balogh, P.G. — Date

Reviewed by: Dale Weiss — 11/8/99
Dale Weiss, P.G., Project Manager — Date

Approved by: Peter Spawn — 11/8/99
Peter Spawn, Program Manager — Date

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Attachment B

Data Validation Memo Transmittal

Attachment C

Data Package Transmittal for Data Validation

TRC STANDARD OPERATING PROCEDURE NO. 019
DATA VALIDATION

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in the procedures for conducting data validations. This procedure is consistent with "A Compendium of Superfund Field Operations Methods (EPA/540/P-87/001)," and other pertinent technical publications.

1.1 Objective

The objective of data validation is to assess and qualify the acceptability and usability of analytical data.

2.0 PROCEDURES

The following procedure should be followed.

The data validation will be conducted by a primary reviewer who has responsibility for completing the validation report within schedule and budget. The validation report will be reviewed by a validation reviewer, who will verify the accuracy of the validation report using the attached guidelines and review checklist. Both validators will sign the validation letter report.

It is the responsibility of each validator to review the SAP/QPjP and SOW prior to starting a validation. Questions or comments regarding the scope of the validation are to be answered by the Project Manager.

1. **Primary data validator** to receive analytical data package, COC forms, field notes, PE scores from Project Manager

2. **Project manager** to assign primary validator with budget and schedule information. Primary validator to inform Validation Reviewer of schedule and budget. Primary validator performs validation as indicated in SAP/QPjP and SOW.

3. If data are missing from analytical data package, then the **primary validator** will prepare a memo stating data needed from laboratory and submit it to project manager/project chemist. Project manager/project chemist will contact appropriate personnel to resolve problem.

4. **Primary data validator** creates validation report with 2 signature lines.

5. **Primary validator** submits validation report, worksheets, raw data package, electronic data tables and validation report to validation reviewer.

6. **Validation Reviewer** reviews validation per Validation Review Guidelines and Checklist.

7. **Validation Reviewer** to provide comments to primary validator. Primary validator addresses comments.

8. When report is complete, **validation reviewer** signs validation letter and completes Data Quality Assessment Form (DQAF), if necessary. Return validation report, raw data package, checklist, and DQAF to Primary validator.

9. **Primary validator** create cover letter on TRC letterhead to accompany validation report delivery under Project Manager's name.

10. **Laboratory coordinator and/or primary validator** update data tracking system and deliver within schedule and budget to Project Manager.

ATTACHMENT A
VALIDATION REVIEW
GUIDELINES AND CHECKLIST

VALIDATION REVIEW GUIDELINES AND CHECKLIST

1. Validation reviewer to receive from Project Manager and review SAP/QAPjP.
2. Validation reviewer to receive schedules from primary reviewer.
3. Validation reviewer to receive data validation report and raw data package.
4. Validation reviewer to review using checklist below.
5. Validation reviewer coordinates correction of any discrepancies or errors with primary validator.
6. Once validation report is accurate and correct, review is complete.
7. Validation reviewer completes Data Quality Assessment Form, if necessary.
8. Return signed validation letter and report to primary validator for delivery to Project Manager.

Complete	Activity	Comments
	Check accuracy of every value of each analyte summary table	
	Check accuracy of Case # and SDG on Cover sheet and in validation forms	
	Verify that all necessary attachments are present and complete	
	Review data package QC results against DV worksheet and validation report	
	Review data usability section of report	

ATTACHMENT B
DATA VALIDATION MEMO TRANSMITTAL

DATA VALIDATION MEMO TRANSMITTAL

Date: ______________________

To: ______________________

From: ______________________

Site: ______________________

Charge No.: ______________________

Package Case No.: ______________________

Parameter(s): ______________________

____

____

____

Electronic Deliverables:

	File Name	File Location
Memo		
Data Summary Tables		
Other		

Hard Copy Deliverables:

	Included (Y/N)	Completed (Y/N)	Proofed (Y/N)	Comments
Memo				
Data Summary Tables				
I/ORDA Form				
Worksheets				
PE Scores				
Field Notes				
CSF Audit				
DQO Summary Form				

TRC STANDARD OPERATING PROCEDURE NO. 020

SOIL VAPOR SURVEY

Prepared by: ______________________________ ____________________
Adam Balogh, P.G. Date

Reviewed by: ______________________________ ____________________
Dale Weiss, P.G., Senior Hydrogeologist Date

Approved by: ______________________________ ____________________
Peter Spawn, Program Manager Date

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ATTACHMENTS

Attachment A Soil Vapor Survey Data Summary/PID

Attachment B Soil Vapor Summary Data Summary/GC

TRC STANDARD OPERATING PROCEDURE NO. 020
SOIL VAPOR SURVEY

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) was prepared to direct TRC personnel in soil vapor survey activities. This SOP details equipment and sampling procedures for sampling subsurface vapors. This SOP conforms to "Interim Final RCRA Facility Investigation (RFI) (EPA/530/SW-89-031)".

1.1 Objective

The objective of soil vapor sampling is to obtain a representative sample of vapor from the subsurface. This requires that the soil vapor sample being collected is representative of true soil vapor as opposed to stagnant or dilute vapor.

1.2 Equipment

The following equipment should be used when sampling a monitoring well. Site specific conditions may warrant the use of additional equipment.

- Steel road and hammer or hand auger or KV Associates tool
- Sampling device (i.e., Summa Canister, tedlar bag and Orsat lung sample or direct-read PID/FID)
- Field Logbook Soil Vapor Survey Data Forms
- Traffic Reports
- Chain of Custody forms
- Custody seals
- Sample labels
- Sample tags
- Packing tape
- Packing materials
- Shipping coolers/boxes

2.0 PROCEDURES

Equipment and procedures for sampling two types of sampling are described below, including

- Shallow (up to 6-feet deep); and
- Deep (more than 6-feeet deep).

2.1 Shallow (Up to 6-Feet Deep)

- Select sampling locations based on soil data and existing monitoring data.
- Penetrate soil to desired depth. A steel rod ½ to ¾-inch diameter and a heavy hammer are sufficient. A bar punch equipped with insulated handles is better for numerous holes. It is a small, hand operated pile driver with a sliding weight on the top. Hand augers may also be used.
- Insert inert (e.g., Teflon) tubing to bottom of hole. Tubing may be weighted or attached to a small diameter stick to assure that it gets to the bottom of the hole. Tubing should be perforated along bottom few inches to assure gas flow.
- Close top of hole around tubing using a gas impervious seal.
- Readings may be taken immediately after making the barhole.
- Attach meter or sampling pump and evacuate hold of air-diluted gases before recording gas concentrations or taking samples.
- When using a portable meter, begin with the most sensitive range (0-100 percent by volume of the lower explosive limit (LEL) for methane). If meter is pegged, change to the next least sensitive range to determine actual gas concentration.
- Tubing shall be marked, sealed, and protected if sampling will be done later.
- If results are erratic the hole should be plugged and further readings taken a few minutes later.
- Detail in logbook the sample location, ID, and time. The TRC Soil Vapor Survey Summary Form (Attachment A and B) should be used to record:
  - Instrument(s) used and calibration procedure

  - Sample ID and depth
  - Description of soil cover
  - Reading or measurement

- Monitoring should be repeated a day or two after probe installation to verify readings.

2.2 Deep (More Than 6-Feet Deep)

- Same general procedures as above.

- Use portable power augers or truck-mounted augers.

- For permanent monitoring points, use rigid tubing (e.g., Teflon).

- Detail in logbook the sample location, ID, and time. The TRC Soil Vapor Survey Summary Form (Attachment A and B) should be used to record:

  - Instrument(s) used and calibration procedure
  - Sample ID and depth
  - Description of soil cover
  - Reading or measurement

CAUTION

- When using hand powered equipment, stop if any unusually high resistance is met. This resistance could be from a gas pipe or an electrical cable.

- Before using powered equipment, confirm that there are no underground utilities in the location(s) selected.

- Use non-sparking equipment and procedures and monitor for methane explosive limits.

APPENDIX A

AIR MONITORING FORM

AIR MONITORING RECORD

Project: ______________________________ Date: ____________________

Location: ____

Technician performing monitoring: _____________________________________

Instrument Data

Instrument No.	Type & Model	Serial No.
1		
2		
3		

Field Calibration Data

Instrument No.	Calibration Gas & Conc.	Calibration Time	Verification Time	Verification Time	Verification Time
1					
2					
3					

Air Monitoring Data

Time	Instrument No.-Type	Concentration	Notes

APPENDIX B

TAILGATE SAFETY MEETING FORM

FIELD SAFETY MEETING FORM

Date:________________ Time:______________ Job Number:__________________

Client:__________________ Address:______________________________________

Site Location:____

Scope of Work:____

Safety Topics Presented

Protective Clothing/Equipment: ____

Chemical Hazard ____

Physical Hazard: ____

Special Equipment: ____

Other: ____

Emergency Procedures: ____

Hospital Address and Route: ____

Attendance Record

Names: ____

____

____

____

APPENDIX C

INJURY/ACCIDENT FORMS

DEPARTMENT OF INDUSTRIAL ACCIDENTS — DEPARTMENT FR
600 WASHINGTON STREET, BOSTON, MASSACHUSETTS 02111

EMPLOYER'S FIRST REPORT OF INJURY

(To be filed only for those injuries resulting in five lost work days.)

Please print or type legibly. Incorrect, illegible or incomplete forms will be returned.

FOR OFFICE USE DO NOT WRITE IN COLUMN

Stamped Date Received:

Board Number

E ______

V ______

R ______

I. EMPLOYEE DATA

1. First Name Initial Last Name
2. Social Security Number
3. Home Address (No. & Street, City, State, Zip Code)
4. Home Tel. #
5. Marital Status ☐ Single ☐ Married
6. Sex ☐ Male ☐ Female
7. Date of Birth (MM/DD/YY)
8. No. of Dependents

9a. Regular Occupation

9b. Occupation when injured (if different)

9c. No. of days on non-regular job when injured.

10. How long in your employ? yrs. ____ mos. ____
11. If a juvenile, was an employment certificate or permit on file? ☐ Yes ☐ No

II. EMPLOYER DATA

12. Employer Name
13. E.I.N. NUMBER
14. Office Address (No. & Street, City, State, Zip Code)
15. Telephone #
16. Name and Address of Insurance Company (not agent) providing your Workers' Compensation Coverage
17. Nature of Business or Article Manufactured
18. Industry (S.I.C.) Code

III. EMPLOYEE WAGE DATA

19. Piece or Hourly Worker ☐ Piece ☐ Hourly
20. Hourly Wage $ ____
21. # Hours worked per day ____
22. Days worked per week ____
23. Provide estimated value of meals furnished the employee each week and estimated weekly value of any lodging, fuel, etc. furnished: $ ____
24. Gross Aver. Weekly Wage $ ____

IV. OCCUPATIONAL INJURY OR ILLNESS DATA

25. Date of Injury (MM/DD/YY) / /
26. Was injured paid in full for this day? ☐ Yes ☐ No
27. Date Disability began (MM/DD/YY)
28. Date of Fifth Work Day Lost (MM/DD/YY) / /
29. Estimated length of Disability in days ____ days
30. Injury Type Code ____
31. Primary Body Part Code ____
32. Secondary Body Part Code ____
33. Other injury descriptors (Check all that apply):
    a. Injury direct result of a single accident ☐
    b. Injury resulted from cumulative condition ☐
    c. Injury represents a chronic/recurring disease ☐
    d. Injury resulted from toxic/hazardous substance ☐
34. Address or Location where injury/illness occurred.
35. On employer's premises? ☐ Yes ☐ No
36. Employee's Department ____
37. If injured has returned to work
    a. Date of Return (MM/DD/YY) / / b. Weekly Wage $ ____ c. At what occupation? ____
38. To whom and when was injury/illness reported?
39. If injured has died (MM/DD/YY) enter date of death / /
40. Name and Address of Witnesses:
41. Name and Address of Physician
42. Name and Address of Hospital

V. ACCIDENT INFORMATION

43. Describe fully how accident/injury occurred.

Signed by ____________ Title ____________ Date ____________

Please file original with the D.I.A., copies to both insurer and employee within five days, excluding Sundays and holidays, from date in box #28. Fa[ilure to] comply with reporting requirements may result in a fine.

Injury Type and Body Part codes are listed on revers[e]

APPENDIX D

PERSONAL ACKNOWLEDGEMENT

PERSONAL ACKNOWLEDGEMENT

A component of the Health and Safety Plan (HASP), designed to provide personnel safety during this subsurface investigation requires that you receive training as described in the HASP (Section 8) prior to working at the site. Additionally, you are required to read and understand the HASP. When you have fulfilled these requirements, please sign and date this personal acknowledgement:

Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date
Name (Printed)	Signature	Date

APPENDIX E

MSDS FOR STODDARD SOLVENT

ATSDR ToxFAQs

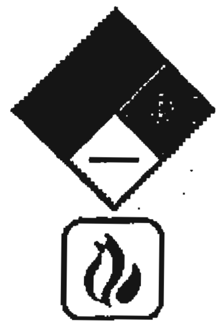
Stoddard Solvent

CAS# 8052-41-3

September 1996

Stoddard Solvent
There is no molecular representation since this substance is a mixture of many compounds.

ChemFinder



NFPA Label Key

Agency for Toxic Substances and Disease Registry

This fact sheet answers the most frequently asked health questions about Stoddard solvent. For more information, you may call the ATSDR Information Center at 1-800-447-1544. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

SUMMARY: Exposure to Stoddard solvent occurs mainly in the workplace. People who breathe Stoddard solvent can experience headaches; dizziness; and eye, skin, or throat irritation. This substance has been found in at least 7 of the 1,430 National Priorities List Sites identified by the Environmental Protection Agency (EPA).

What is Stoddard solvent?
(Pronounced stod'ard sol'vent)

Stoddard solvent is a colorless, flammable liquid that smells and tastes like kerosene. It will turn into a vapor at temperatures of 150–200 ° C.

Stoddard solvent is a petroleum mixture that is also known as dry cleaning safety solvent, petroleum solvent, and varnoline; its registered trade names are Texsolve S® and Varsol 1®. It is a chemical mixture that is similar to white spirits.

Stoddard solvent is used as a paint thinner; in some types of photocopier toners, printing inks, and adhesives; as a dry cleaning solvent; and as a general cleaner and degreaser.

Use of trade names is for identification only and does not imply endorsement by the Agency for Toxic Substances and Disease Registry (ATSDR), the Public Health Service, or the U.S. Department of Health and Human Services (DHHS).

What happens to Stoddard solvent when it enters the environment?

Because Stoddard solvent is a mixture of many chemicals, these chemicals may react differently in the environment. Some of these chemicals can:

- be broken down by sunlight or other chemicals in the air;
- attach to particles in soil or water;
- sink down to the sediment in water; and
- be broken down by microorganisms in water, soil, or sediment.

It is not known whether Stoddard solvent will build up in plants or animals living in contaminated soil or water, but some of the chemicals that make up Stoddard solvent might build up in these situations.

How might I be exposed to Stoddard solvent?

- Using products containing Stoddard solvent such as a paint or paint thinner, and breathing the vapors, or getting the vapors in your eyes
- Breathing contaminated air where Stoddard solvent is manufactured, used, or spilled
- Breathing contaminated air at or near hazardous waste sites
- Drinking or bathing in contaminated water
- Ingesting contaminated soil or water near waste sites containing Stoddard solvent
- Touching contaminated soil or water

How can Stoddard solvent affect my health?

Animal testing is sometimes necessary to find out how toxic substances might harm people or to treat those who have been exposed. Laws today protect the welfare of research animals and scientists must follow strict guidelines.

Most of the information on the health effects of Stoddard solvent comes from studies in which it is breathed; there are fewer studies of exposure to the eyes or skin.

Exposure to Stoddard solvent in the air can affect your nervous system and cause dizziness, headaches, or a prolonged reaction time. It can also cause eye, skin, or throat irritation.

Rats, cats, and dogs that breathed in large amounts of Stoddard solvent for several hours suffered seizures. Breathing Stoddard solvent has caused bronchitis in guinea pigs, but neither seizures nor bronchitis has been reported when humans breathed it. The effects of swallowing Stoddard solvent are not known.

It is not known whether Stoddard solvent can cause birth defects or affect reproduction.

How likely is Stoddard solvent to cause cancer?

The **International Agency for Research on Cancer (IARC)** has determined that Stoddard solvent is not classifiable as to its carcinogenicity to humans.

Very few studies have been located that study the carcinogenic effects of Stoddard solvent in humans or animals.

Is there a medical test to show whether I've been exposed to Stoddard solvent?

There is no routinely used test to show whether you have been exposed to Stoddard solvent. Because Stoddard solvent is a mixture of many chemicals, some of these chemicals can be detected in your breath, blood, urine, and fat. However, the tests cannot tell you if you have been exposed to the specific mixture of chemicals found in Stoddard solvent. They also cannot tell whether you will suffer any health effects.

Has the federal government made recommendations to protect human health?

The **Occupational Safety and Health Administration (OSHA)** has set a maximum exposure limit of 500 parts of Stoddard solvent per 1 million parts of air (500 ppm) for an 8-hour workday, 40-hour workweek.

The **National Institute for Occupational Safety and Health (NIOSH)** recommends that the average workplace air levels not be more than 60 ppm in workplace air for a 10-hour workday, 40-hour workweek.

Glossary

Carcinogenicity:
  Ability to cause cancer
CAS:
  Chemical Abstracts Service
Ingesting:
  Taking food or drink into your body
PPM:
  Parts per million
Sediment:
  Mud and debris that have settled at the bottom of a body of water

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 1995. Toxicological profile for Stoddard solvent. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

For more information, contact

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333
Phone: 1-800-447-1544
Fax: 404-639-6359

U.S. Department of Health and Human Services
Public Health Service
Agency for Toxic Substances and Disease Registry

Link to ToxFAQs Home Page

Link to ATSDR Science Corner

Link to ATSDR Home Page

Please reduce your browser font size for better viewing and printing.

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 202-483-7616

MSDS *Material Safety Data Sheet*

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

J.T.Baker

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

STODDARD SOLVENT

MSDS Number: S6588 --- *Effective Date: 12/08/96*

1. Product Identification

Synonyms: White spirits; Mineral spirits type I; Petroleum distillate
CAS No.: 8052-41-3
Molecular Weight: Not applicable to mixtures.
Chemical Formula: > 65% C10 or higher hydrocarbons
Product Codes: V110

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Stoddard Solvent	8052-41-3	98 - 100%	Yes

3. Hazards Identification

Emergency Overview

DANGER! HARMFUL OR FATAL IF SWALLOWED. AFFECTS CENTRAL NERVOUS SYSTEM. MAY AFFECT KIDNEYS. FLAMMABLE LIQUID AND VAPOR. HARMFUL IF INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT.

J.T. Baker SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 1 - Slight
Flammability Rating: 2 - Moderate
Reactivity Rating: 0 - None
Contact Rating: 1 - Slight
Lab Protective Equip: GOGGLES; LAB COAT; VENT HOOD; PROPER GLOVES; CLASS
Storage Color Code: Red (Flammable)

Potential Health Effects

Inhalation:
Effects are typically those of most hydrocarbons, dizziness and euphoria leading to unconsciousness in severe cases. Vapors also irritate the respiratory tract. Symptoms may include coughing, difficult breathing and chest pain. A central nervous system depressant.

Ingestion:
Fatal dose for humans estimated at 3-4 oz, but ingestion of much smaller amounts may cause lung edema and possible death because of aspiration into lungs.

Skin Contact:
The defatting action of this solvent may lead to soreness, inflammation and, possibly, dermatitis.

Eye Contact:
Vapors may be irritating at concentrations of 450 ppm and above (15 minutes exposure) and contact with the liquid solvent can be painful and possibly damaging to eye tissues.

Chronic Exposure:
Chronic exposure may lead to central nervous system complications, blood changes (aplastic anemia, a rare occurrence that is potentially fatal), and dermatitis. Animal studies have indicated the potential for liver and kidney damage.

Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired kidney function may be more susceptible to the effects of the substance.

---

4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Ingestion:

Aspiration hazard. If swallowed, vomiting may occur spontaneously, but DO NOT INDUCE. If vomiting occurs, keep head below hips to prevent aspiration into lungs. Never give anything by mouth to an unconscious person. Call a physician immediately.

Skin Contact:
Immediately flush skin with plenty of soap and water for at least 15 minutes. Remove contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.

Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

---

5. Fire Fighting Measures

Fire:
Flash point: 38C (100F) CC Autoignition temperature: 232 - 260C (450 - 500F) Flammable limits in air % by volume: lel: 0.8; uel: ca. 6 Flammable. This liquid is near its lower flammability limit at room-temperature. Flash point may range between 38-40 C. Contact with strong oxidizers may cause fire.

Explosion:
Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Sealed containers may rupture when heated. Sensitive to static discharge.

Fire Extinguishing Media:
Water spray, dry chemical, alcohol foam, or carbon dioxide. Direct stream of water can scatter and spread flames.

Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Water spray may be used to keep fire exposed containers cool.

---

6. Accidental Release Measures

Ventilate area of leak or spill. Remove all sources of ignition. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Use non-sparking tools and equipment. Collect liquid in an appropriate container or absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! If a leak or spill has not ignited, use water spray to disperse the vapors, to protect personnel attempting to stop leak, and to flush spills away from exposures. J. T. Baker SOLUSORB(tm) solvent adsorbent is recommended for spills of this product.

7. Handling and Storage

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from incompatibles. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment, including explosion proof ventilation. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product. Do Not attempt to clean empty containers since residue is difficult to remove. Do not pressurize, cut, weld, braze, solder, drill, grind or expose such containers to heat, sparks, flame, static electricity or other sources of ignition: they may explode and cause injury or death.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
-OSHA Permissible Exposure Limit (PEL): 500 ppm (TWA) -ACGIH Threshold Limit Value (TLV): 100 ppm (TWA)

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details. Use explosion-proof equipment.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, a half-face organic vapor respirator may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece organic vapor respirator may be worn up to 50 times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-face piece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:
Rubber or neoprene gloves and additional protection including impervious boots, apron, or coveralls, as needed in areas of unusual exposure.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:
Clear, colorless liquid.

Odor:
Kerosene-like.

Solubility:
Insoluble in water.

Density:
0.79

pH:
No information found.

% Volatiles by volume @ 21C (70F):
100

Boiling Point:
156 - 202C (313 - 396F)

Melting Point:
No information found.

Vapor Density (Air=1):
4.8

Vapor Pressure (mm Hg):
ca. 5 @ 25C (77F)

Evaporation Rate (BuAc=1):
ca. 0.08

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.

Hazardous Decomposition Products:
Carbon dioxide and carbon monoxide may form when heated to decomposition.

Hazardous Polymerization:
Will not occur.

Incompatibilities:
Strong acids, strong oxidizers.

Conditions to Avoid:
Heat, flames, ignition sources and incompatibles.

11. Toxicological Information

No LD50/LC50 information found relating to normal routes of occupational exposure.
Investigated as a tumorigen.

--------\Cancer Lists\--

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Stoddard Solvent (8052-41-3)	No	No	None

12. Ecological Information

Environmental Fate:
No information found.

Environmental Toxicity:
No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: PETROLEUM DISTILLATES, N.O.S. (STODDARD SOLVENT)
Hazard Class: 3

UN/NA: UN1268
Packing Group: III
Information reported for product/size: 20L

International (Water, I.M.O.)

Proper Shipping Name: PETROLEUM DISTILLATES, N.O.S. (STODDARD SOLVENT)
Hazard Class: 3.3
UN/NA: UN1268
Packing Group: III
Information reported for product/size: 20L

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\--------

Ingredient	TSCA	EC	Japan	Australia
Stoddard Solvent (8052-41-3)	Yes	Yes	No	Yes

--------\Chemical Inventory Status - Part 2\--------

Ingredient	Korea	--Canada-- DSL	--Canada-- NDSL	Phil.
Stoddard Solvent (8052-41-3)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\--------

Ingredient	-SARA 302- RQ	-SARA 302- TPQ	------SARA 313------ List	------SARA 313------ Chemical Catg.
Stoddard Solvent (8052-41-3)	No	No	No	No

--------\Federal, State & International Regulations - Part 2\--------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Stoddard Solvent (8052-41-3)	No	No	No

Chemical Weapons Convention: No   TSCA 12(b): No   CDTA: No
SARA 311/312: Acute: Yes   Chronic: Yes Fire: Yes Pressure: No
Reactivity: No   (Pure / Liquid)

Australian Hazchem Code: 3[Y]E
Poison Schedule: S5

WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: 3 Flammability: 2 Reactivity: 0

Label Hazard Warning:
DANGER! HARMFUL OR FATAL IF SWALLOWED. AFFECTS CENTRAL NERVOUS SYSTEM. MAY AFFECT KIDNEYS. FLAMMABLE LIQUID AND VAPOR. HARMFUL IF INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT.

Label Precautions:
Keep away from heat, sparks and flame. Avoid breathing vapor. Keep container closed. Use only with adequate ventilation. Wash thoroughly after handling. Avoid contact with eyes, skin and clothing.

Label First Aid:
Aspiration hazard. If swallowed, vomiting may occur spontaneously, but DO NOT INDUCE. If vomiting occurs, keep head below hips to prevent aspiration into lungs. Never give anything by mouth to an unconscious person. Call a physician immediately. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. Get medical attention.

Product Use:
Laboratory Reagent.

Revision Information:
Pure. New 16 section MSDS format, all sections have been revised.

Disclaimer:
****

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Prepared by: Strategic Services Division

APPENDIX F

OSHA EXCAVATION REGULATIONS

ENFLEX Federal and State Regulations, April 2000

DATABASES | JURISDICTIONS | SEARCH | CONTENTS

Hide Document Profile | Previous in Jurisdiction | Next in Jurisdiction

Citation: Title 29, Part 1926
Jurisdiction: Federal **Document Date:** August 9, 1994 **Page Count:** 4
Section Title: 1926.651 Specific Excavation Requirements (Integrated)
Subject Terms: health & safety, employee, inspection, design, safety, construction, operating, compliance
Source: Integrated Document

§ 1926.651 Specific excavation requirements.

(a) Surface encumbrances. All surface encumbrances that are located so as to create a hazard to employees shall be removed or supported, as necessary, to safeguard employees.
(b) Underground installations.
(1) Walkways shall be provided where employees or equipment are required or permitted to cross over excavations. Guardrails which comply with § 1926.502(b) shall be provided where walkways are 6 feet (1.8 m) or more above lower levels.
(2) Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation. When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law), or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used.
(3) When excavation operations approach the estimated location of underground installations, the exact location of the installations shall be determined by safe and acceptable means.
(4) While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees.
(c) Access and egress --
(1) Structural ramps.
(i) Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.
(ii) Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.
(iii) Structural members used for ramps and runways shall be of uniform thickness.
(iv) Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.

(v) Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.
(2) Means of egress from trench excavations. A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.
(d) Exposure to vehicular traffic. Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.
(e) Exposure to falling loads. No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with § 1926.601(b)(6), to provide adequate protection for the operator during loading and unloading operations.
(f) Warning system for mobile equipment. When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade shall be away from the excavation.
(g) Hazardous atmospheres --
(1) Testing and controls. In addition to the requirements set forth in subparts D and E of this part (29 CFR 1926.50 - 1926.107) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:
(i) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.
(ii) Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with subparts D and E of this part respectively.
(iii) Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas.
(iv) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.
(2) Emergency rescue equipment.
(i) Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.
(ii) Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a life-line securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.
(h) Protection from hazards associated with water accumulation.
(1) Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.
(2) If water is controlled or prevented from accumulating by the use of water removal equipment, the

water removal equipment and operations shall be monitored by a competent person to ensure proper operation.
(3) If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to runoff from heavy rains will require an inspection by a competent person and compliance with paragraphs (h)(1) and (h)(2) of this section.
(i) Stability of adjacent structures.
(1) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations, support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.
(2) Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:
(i) A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or
(ii) The excavation is in stable rock; or
(iii) A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or
(iv) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.
(3) Sidewalks, pavements, and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.
(j) Protection of employees from loose rock or soil.
(1) Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary on the face to stop and contain falling material; or other means that provide equivalent protection.
(2) Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet (.61 m) from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.
(k) Inspections.
(1) Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.
(2) Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.
(l) Fall protection.
(1) Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails shall be provided.
(2) Adequate barrier physical protection shall be provided at all remotely located excavations. All wells, pits, shafts, etc., shall be barricaded or covered. Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., shall be backfilled.

[As amended at 59 FR 40672, Aug. 9, 1994]

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Section Title: 1926.652 Requirements for Protective Systems (Integrated)
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§ 1926.652 Requirements for protective systems.

(a) Protection of employees in excavations.
(1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:
(1) Excavations are made entirely in stable rock; or
(ii) Excavations are less than 5 feet (1.52 m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.
(2) Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.
(b) Design of sloping and benching systems. The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (b)(1); or, in the alternative, paragraph (b)(2); or, in the alternative, paragraph (b)(3), or, in the alternative, paragraph (b)(4), as follows:
(1) Option (1) -- Allowable configurations and slopes.
(i) Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.
(ii) Slopes specified in paragraph (b)(1)(i) of this section, shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this subpart.
(2) Option (2) -- Determination of slopes and configurations using Appendices A and B. Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be determined in accordance with the conditions and requirements set forth in appendices A and B to this subpart.
(3) Option (3) -- Designs using other tabulated data.
(i) Designs of sloping or benching systems shall be selected from and be in accordance with tabulated data, such as tables and charts.
(ii) The tabulated data shall be in written form and shall include all of the following:
(A) Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;
(B) Identification of the limits of use of the data, to include the magnitude and configuration of slopes determined to be safe;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.
(iii) At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.
(4) Option (4) -- Design by a registered professional engineer.
(i) Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under paragraph (b) of this section shall be approved by a registered professional engineer.
(ii) Designs shall be in written form and shall include at lest the following:
(A) The magnitude of the slopes that were determined to be safe for the particular project;
(B) The configurations that were determined to be safe for the particular project; and
(C) The identity of the registered professional engineer approving the design.
(iii) At lest one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Secretary upon request.
(c) Design of support systems, shield systems, and other protective systems. Designs of support systems shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:
(1) Option (1) -- Designs using appendices A, C and D. Designs for timber shoring in trenches shall be determined in accordance with the conditions and requirements set forth in appendices A and C to this subpart. Designs for aluminum hydraulic shoring shall be in accordance with paragraph (c)(2) of this section, but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with appendix D.
(2) Option (2) -- Designs Using Manufacturer's Tabulated Data.
(i) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.
(ii) Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.
(iii) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Secretary upon request.
(3) Option (3) -- Designs using other tabulated data.
(i) Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.
(ii) The tabulated data shall be in written form and include all of the following:
(A) Identification of the parameters that affect the selection of a protective system drawn from such data;
(B) Identification of the limits of use of the data;
(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.
(iii) At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.
(4) Option (4) -- Design by a registered professional engineer.
(i) Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include the following:
(A) A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and
(B) The identity of the registered professional engineer approving the design.
(iii) At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Secretary upon request.
(d) Materials and equipment.
(1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.
(2) Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.
(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.
(e) Installation and removal of support --
(1) General.
(i) Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.
(ii) Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.
(iii) Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.
(iv) Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.
(v) Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.
(vi) Backfilling shall progress together with the removal of support systems from excavations.
(2) Additional requirements for support systems for trench excavations.
(i) Excavation of material to a level no greater than 2 feet (.61 m) below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.
(ii) Installation of a support system shall be closely coordinated with the excavation of trenches.
(f) Sloping and benching systems. Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.
(g) Shield systems --
(1) General.
(i) Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.
(ii) Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.
(iii) Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

(iv) Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

(2) Additional requirement for shield systems used in trench excavations. Excavations of earth material to a level not greater than 2 feet (.61 m) below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

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Section Title: Appendix A to Subpart P Soil Classification (Integrated)
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Appendix A to Subpart P -- Soil Classification

(a) Scope and application --
(1) Scope. This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.
(2) Application. This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in § 1926.652(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in § 1926.652(c), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.
(b) Definitions. The definitions and examples given below are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653-85 and D2488; The Unified Soils Classification System, The U.S. Department of Agriculture (USDA) Textural Classification Scheme; and The National Bureau of Standards Report BSS-121.
"Cemented soil" means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-size sample cannot be crushed into powder or individual soil particles by finger pressure.
"Cohesive soil" means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.
"Dry soil" means soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.
"Granular soil" means gravel; sand, or silt, (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be

molded when moist and crumbles easily when dry.
"Layered system" means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.
"Moist soil" means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.
"Plastic" means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.
"Saturated soil" means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.
"Soil classification system" means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.
"Stable rock" means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.
"Submerged soil" means soil which is underwater or is free seeping.
"Type A" means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (sf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:
(i) The soil is fissured; or
(ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or
(iii) The soil has been previously disturbed; or
(iv) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or
(v) The material is subject to other factors that would require it to be classified as a less stable material.
"Type B" means:
(i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or
(ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.
(iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.
(iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
(v) Dry rock that is not stable; or
(vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.
"Type C" means:
(i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or
(ii) Granular soils including gravel, sand, and loamy sand; or
(iii) Submerged soil or soil from which water is freely-seeping; or
(iv) Submerged rock that is not stable, or
(v) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.
Unconfined compressive strength" means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

"Wet soil" means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

(c) Requirements --

(1) Classification of soil and rock deposits. Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) Basis of classification. The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods of soil classification and testing such as those adopted by the American Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) Visual and manual analyses. The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) Layered systems. In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) Reclassification. If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) Acceptable visual and manual tests.

(1) Visual tests. Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(ii) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(iii) Observe the side of the opened excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(iv) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(v) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(vi) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(vii) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) Manual tests. Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(i) Plasticity. Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/8-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of 1/8-inch thread can be held on one end without tearing,

the soil is cohesive.
(ii) Dry strength. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissered.
(iii) Thumb penetration. The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488 -- "Standard Recommended Practice for Description of Soils (Visual - Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.
(iv) Other strength tests. Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shear-vane.
(v) Drying test. The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:
(A) If the sample develops cracks as it dries, significant fissures are indicated.
(B) Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as a unfissured cohesive material and the unconfined compressive strength should be determined.
(C) If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

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Appendix B to Subpart P -- Sloping and Benching

(a) Scope and application. This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in § 1926.652(b)(2).
(b) Definitions.
"Actual slope" means the slope to which an excavation face is excavated.
"Distress" means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and ravelling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.
"Maximum allowable slope" means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).
"Short term exposure" means a period of time less than or equal to 24 hours that an excavation is open.
(c) Requirements --
(1) Soil classification. Soil and rock deposits shall be classified in accordance with appendix A to subpart P of part 1926.
(2) Maximum allowable slope. The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.
(3) Actual slope.
(i) The actual slope shall not be steeper than the maximum allowable slope.
(ii) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least 1/12 horizontal to one vertical (1/2H:1V) less steep than the maximum allowable slope.
(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the

maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with § 1926.651(i).
(4) Configurations. Configurations of sloping and benching systems shall be in accordance with Figure B-1.

Table B-1. -- Maximum Allowable Slopes

Soil or Rock Type	Maximum Allowable Slopes (H:V){1} for Excavations less Than 20 Feet Deep{3}
Stable Rock	Vertical (90°)
Type A{2}	3/4:1 (53°)
Type B	1:1 (45°)
Type C	1-1/2:1 (34°)

{1} Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
{2} A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°).
{3} Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

ENFLEX Note: For a copy of the following figures, please call the ENFLEX Hotline at (800)544-3118:
FIGURE B-1.1: EXCAVATIONS MADE IN TYPE A SOIL;
FIGURE B-1.2: EXCAVATIONS MADE IN TYPE B SOIL;
FIGURE B-1.3: EXCAVATIONS MADE IN TYPE C SOIL;
FIGURE B-1.4: EXCAVATIONS MADE IN LAYERED SOILS.

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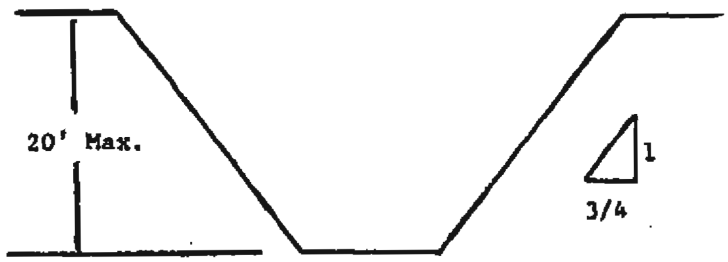
Figure B–1

Slope Configurations

(All slopes stated below are in the horizontal to vertical ratio)

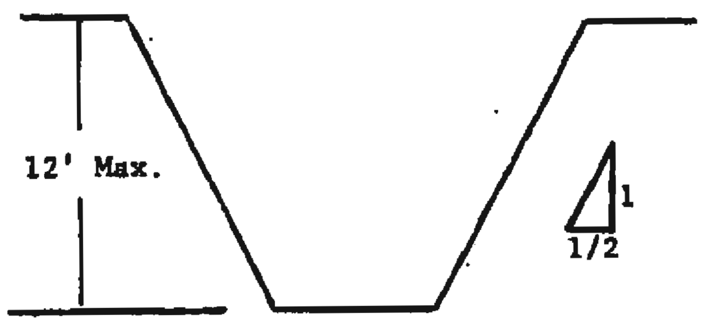
B–1.1 Excavations made in Type A soil.

1. All simple slope excavation 20 feet or less in depth shall have a maximum allowable slope of ¾:1.



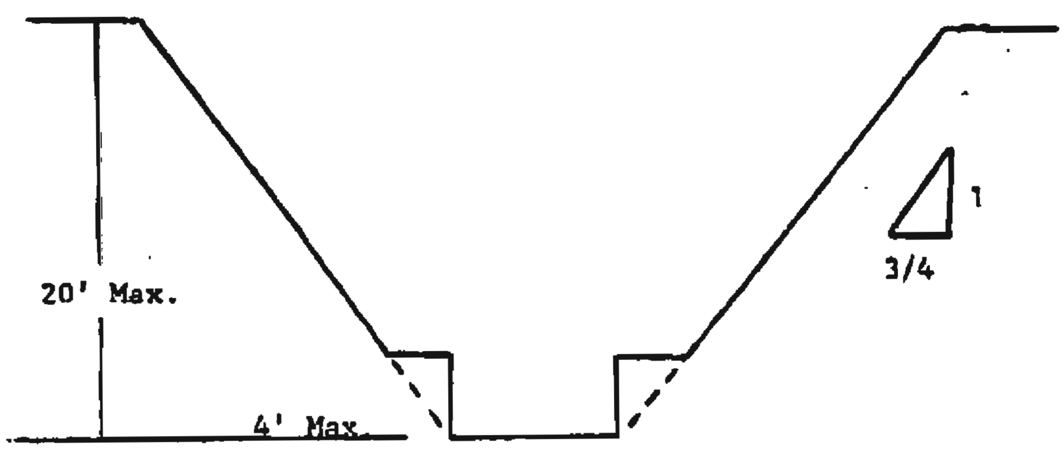
SIMPLE SLOPE—GENERAL

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of ½:1.

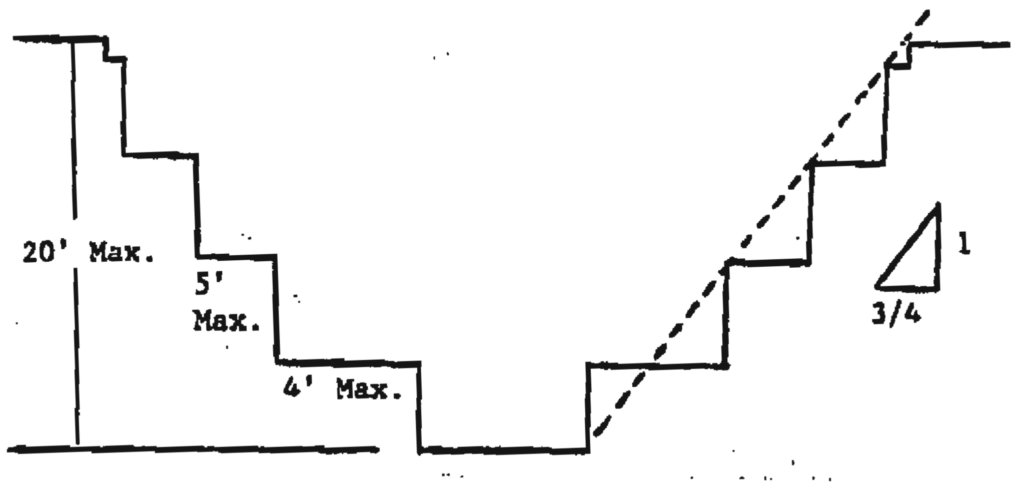


SIMPLE SLOPE—SHORT TERM

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of ¾ to 1 and maximum bench dimensions as follows:

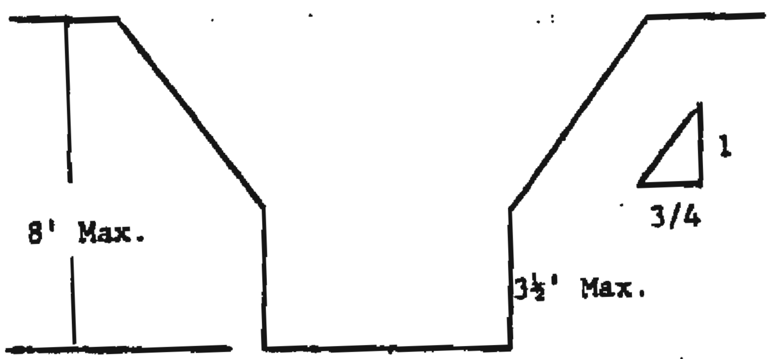


SIMPLE BENCH



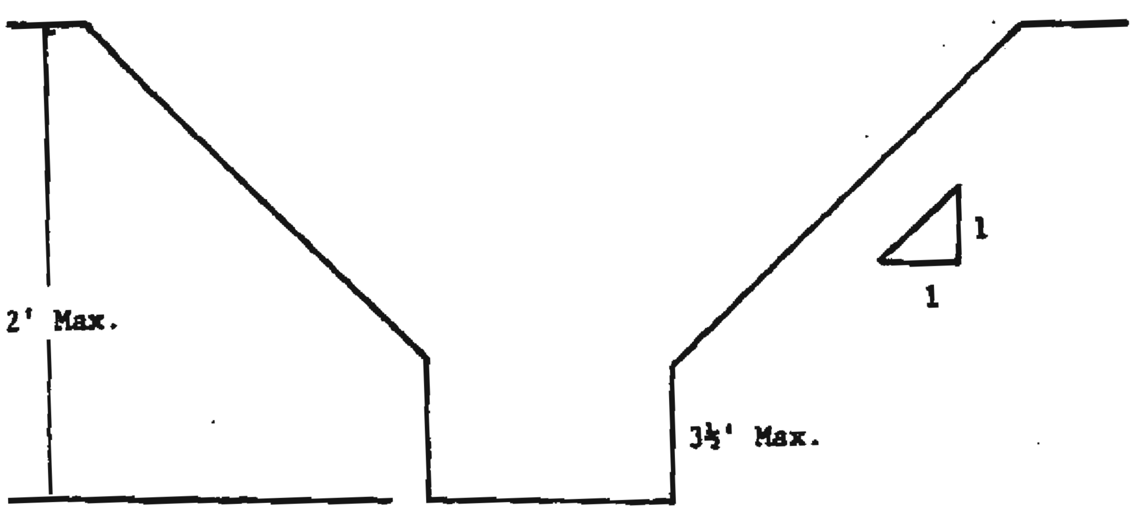
MULTIPLE BENCH

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 3½ feet.



UNSUPPORTED VERTICALLY SIDED LOWER PORTION—MAXIMUM 8 FEET IN DEPTH

All excavations more than 8 feet but not more than 12 feet in depth which unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3½ feet.



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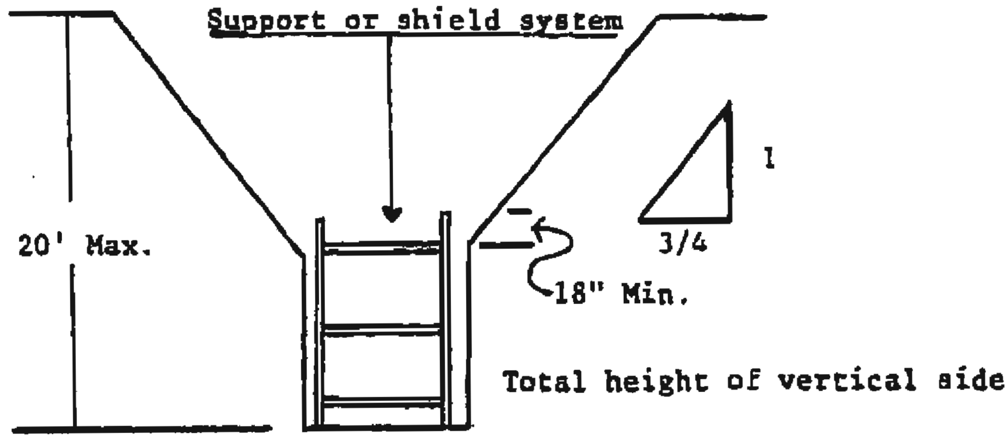
UNSUPPORTED VERTICALLY SIDED LOWER PORTION—MAXIMUM 12 FEET IN DEPTH

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of ¾:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

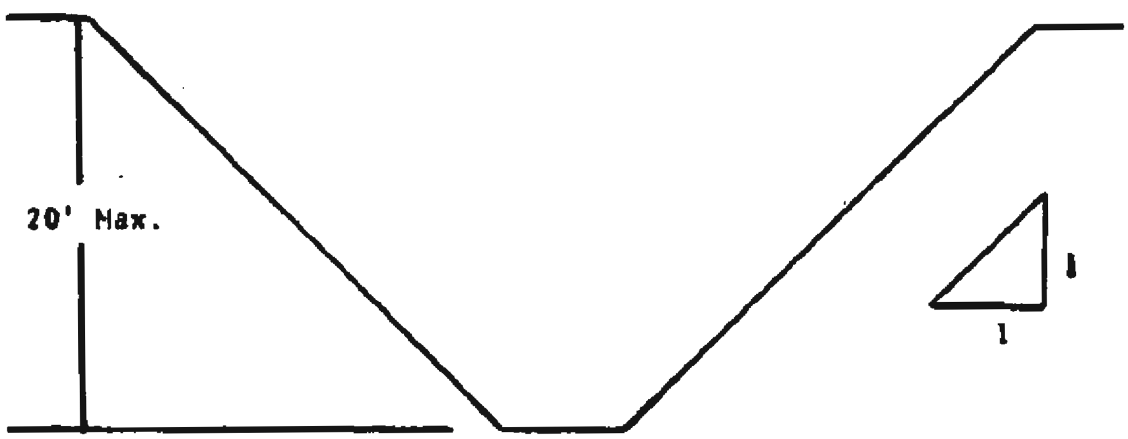


SUPPORTED OR SHIELDED VERTICALLY SIDED LOWER PORTION

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under § 1926.652(b).

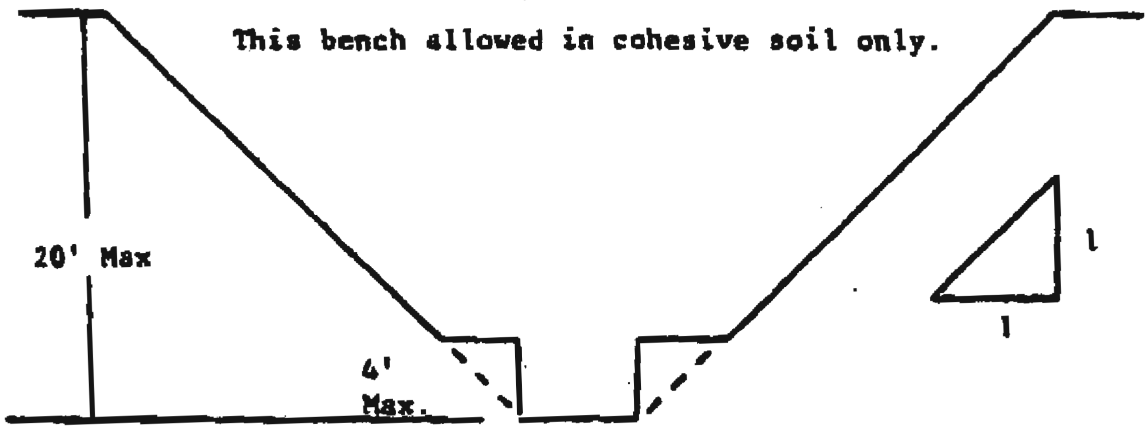
B-1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

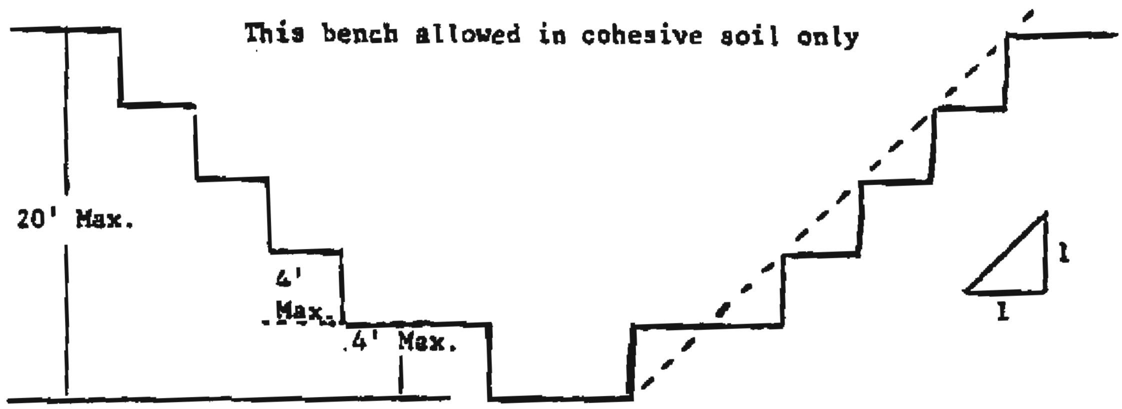


SIMPLE SLOPE

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

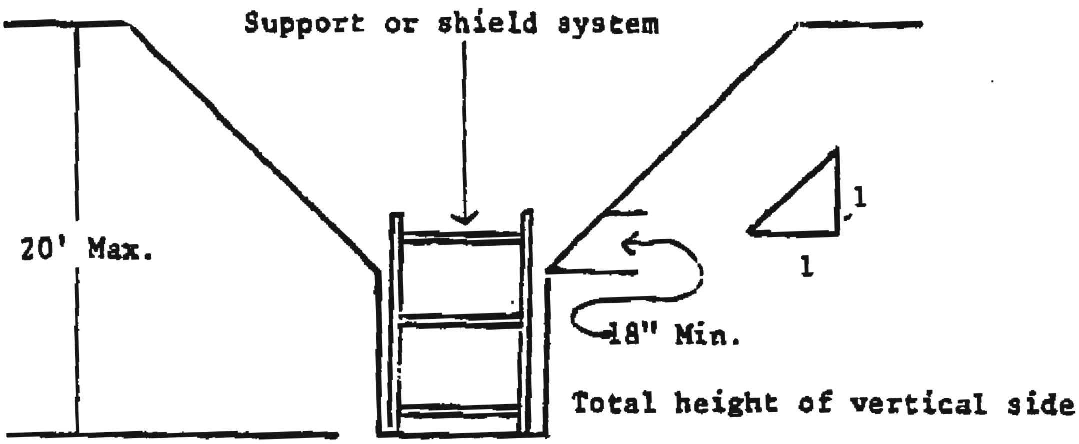


SINGLE BENCH



MULTIPLE BENCH

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.



VERTICALLY SIDED LOWER PORTION

4. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

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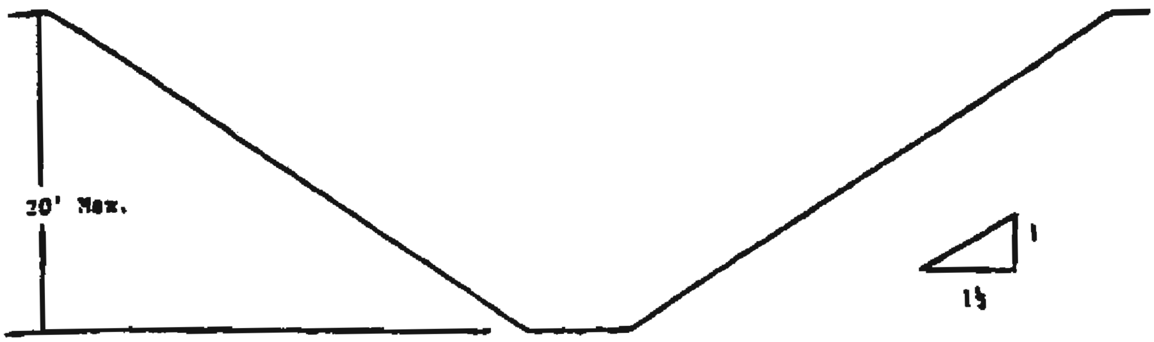
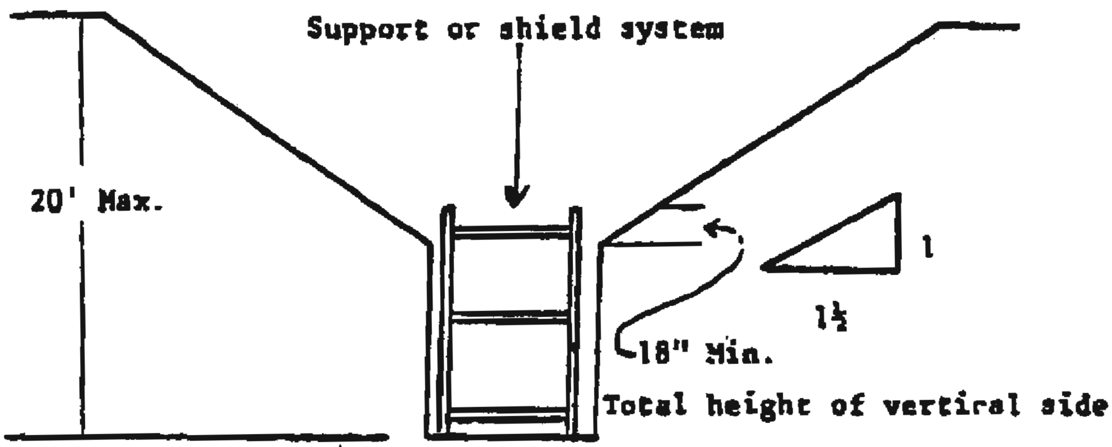
B–1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1½:1.



Simple Slope

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½:1.

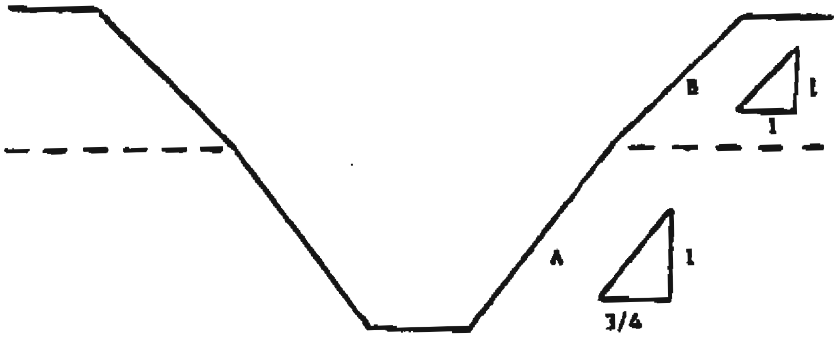


Vertical Sided Lower Portion

3. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

B–1.4 Excavations Made in Layered Soils

1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



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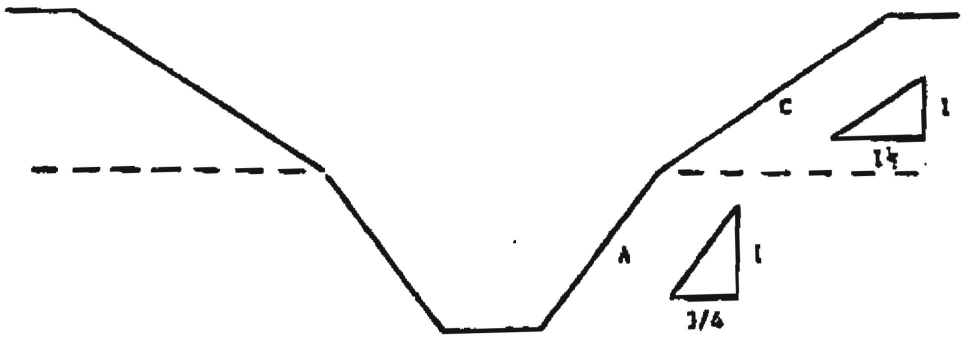
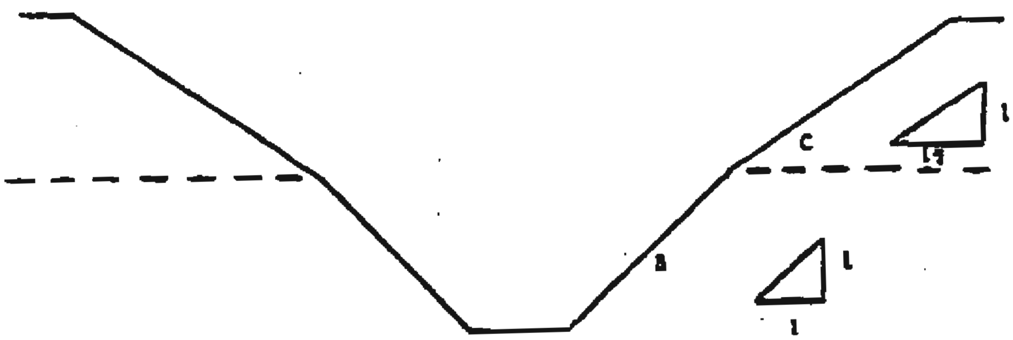


C OVER A



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Section Title: Appendix C to Subpart P Timber Shoring for Trenches (Integrated)
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Source: Integrated Document

Appendix C to Subpart P -- Timber Shoring for Trenches

(a) Scope. This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with § 1926.652 (c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in § 1926.652(b) and § 1926.652(c).
(b) Soil Classification. In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.
(c) Presentation of Information. Information is presented in several forms as follows:
(1) Information is presented in tabular form in Tables C-1.1, C-1.2, and C-1.3, and Tables C-2.1, C-2.2 and C-2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.
(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.
(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.
(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.
(5) Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in paragraph (g) of this Appendix.
(d) Basis and limitations of the data.
(1) Dimensions of timber members.
(i) The sizes of the timber members listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific

sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.
(ii) The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under § 1926.652(c)(3), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.
(2) Limitation of application.
(i) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in § 1926.652(c).
(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with § 1926.652.
(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.
(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.
(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.
(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.
(e) Use of Tables. The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.
(f) Examples to Illustrate the Use of Tables C-1.1 through C-1.3.
(1) Example 1.
A trench dug in Type A soil is 13 feet deep and five feet wide.
From Table C-1.1, for acceptable arrangements of timber can be used.

Arrangement #1

Space 4 x 4 crossbraces at six feet horizontally and four feet vertically.
Wales are not required.
Space 3 x 8 uprights at six fee horizontally. This arrangement is commonly called "skip shoring."

Arrangement #2

Space 4 x 6 crossbraces at eight feet horizontally and four feet vertically.

Space 8 x 8 wales at four feet vertically.
Space 2 x 6 uprights at four feet horizontally.

Arrangement #3

Space 6 x 6 crossbraces at 10 feet horizontally and four feet vertically.
Space 8 x 10 wales at four feet vertically.
Space 2 x 6 uprights at five feet horizontally.

Arrangement #4

Space 6 x 6 crossbraces at 12 feet horizontally and four feet vertically.
Space 10 x 10 wales at four feet vertically.
Spaces 3 x 8 uprights at six feet horizontally.
(2) Example 2.
A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement #1

Space 6 x 6 crossbraces at six feet horizontally and five feet vertically.
Space 8 x 8 wales at five feet vertically.
Space 2 x 6 uprights at two feet horizontally.

Arrangement #2

Space 6 x 8 crossbraces at eight feet horizontally and five feet vertically.
Space 10 x 10 wales at five feet vertically.
Space 2 x 6 uprights at two feet horizontally.

Arrangement #3

Space 8 x 8 crossbraces at 10 feet horizontally and five feet vertically.
Space 10 x 12 wales a five feet vertically.
Space 2 x 6 uprights at two feet vertically.
(3) Example 3.
A trench dug in Type C soil is 13 feet deep and five feet wide.
From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #1

Space 8 x 8 crossbraces at six feet horizontally and five feet vertically.
Space 10 x 12 wales at five feet vertically.
Position 2 x 6 uprights as closely together as possible.
If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #2

Space 8 x 10 crossbraces at eight feet horizontally and five feet vertically.
Space 12 x 12 wales at five feet vertically.

Position 2 x 6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) Example 4.

A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.

Space 8 x 10 crossbraces at six feet horizontally and five feet vertically.

Space 12 x 12 wales at five feet vertically.

Use 3 x 6 tight sheeting.

Use of Tables C-2.1 through C-2.3 would follow the same procedures.

(g) Notes for all Tables.

1. Member sizes at spacings other than indicated are to be determined as specified in § 1926.652(c), "Design of Protective Systems."
2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.
3. All spacing indicated is measured center to center.
4. Wales to be installed with greater dimension horizontal.
5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.
6. Trench jacks may be used in lieu of or in combination with timber crossbraces.
7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

ENFLEX Note: The following tables are wider than your screen. Please scroll right to see the entire table.

Table C-1.1. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type A P(a) = 25 x H + 72 psf (2 ft Surcharge)

	Size (actual) and Spacing of Me								
	Cross Braces							Wales	
		Width of Trench (Feet)							
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)	Ve spa (fe
5	Up to 6	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	-
To	Up to 8	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	-

10	Up to 10	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	8 x 8	4
	Up to 12	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4
10	Up to 6	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	-
To	Up to 8	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4
15	Up to 10	6 x 6	6 x 5	6 x 6	6 x 8	6 x 8	4	8 x 10	4
	Up to 12	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	10 x 10	4
15	Up to 6	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	6 x 8	4
To	Up to 8	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	8 x 8	4
20	Up to 10	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	4	8 x 10	4
	Up to 12	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	4	10 x 10	4
Over 20	See Note 1								

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* Mixed oak or equivalent wi|th a bending strength not less than 850 psi.
** Manufactured members of |equivalent strength may be substituted for wood.

Table C-1.2. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type B P(a) = 45 x H + 72 psf (2 ft Surcharge)

	Size (actual) and Spacing of Me							
	Cross Braces							Wales
		Width of Trench (Feet)						
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)
5	Up to 6	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	5	6 x 8
To	Up to 8	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	8 x 10
10	Up to 10	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	10 x 10
	See Note 1							
10	Up to 6	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	8 x 8
To	Up to 8	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 10
15	Up to 10	8 x 8	8 x 8	8 x 8	8 x 8	6 x 10	5	10 x 12

Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)
	See Note 1							
15	Up to 6	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	8 x 10
To	Up to 8	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x 12
20	Up to 10	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12
	See Note 1							
Over 20	See Note 1							

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* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Table C-1.3. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type C P(a) = 80 x H + 72 psf (2 ft Surcharge)

	Size (actual) and Spacing of Me							
	Cross Braces							Wales
		Width of Trench (Feet)						
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)
5	Up to 6	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	8 x 10
To	Up to 8	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x 12
10	Up to 10	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12
	See Note 1							
10	Up to 6	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x 12
To	Up to 8	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12
15	See Note 1							
	See Note 1							
15	Up to 6	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12
To	See Note 1							
20	See Note							

	1 See Note 1
Over 20	See Note 1

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* Mixed Oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.1. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type A P(a) = 25 x H ± 72 psf (2 ft Surcharge)

	Size (S4S) and Spacing of Membe								
	Cross Braces							Wales	
		Width of Trench (Feet)							
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)	Ve spa (fe
5	Up to 6	4 x 4	4 x 4	4 x 4	4 x 4	4 x 6	4	Not Req'd	No Re
To	Up to 8	4 x 4	4 x 4	4 x 4	4 x 6	4 x 6	4	Not Req'd	No Re
10	Up to 10	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	8 x 8	4
	Up to 12	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	8 x 8	4
10	Up to 6	4 x 4	4 x 4	4 x 4	6 x 6	6 x 6	4	Not Req'd	No Re
To	Up to 8	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	6 x 8	4
15	Up to 10	6 x 6	6 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4
	Up to 12	6 x 6	6 x 6	6 x 6	6 x 6	6 x 6	4	8 x 10	4
15	Up to 6	6 x 6	6 x 6	6 x 6	6 x 6	6 x 6	4	6 x 8	4
To	Up to 8	6 x 6	6 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4
20	Up to 10	6 x 6	6 x 6	6 x 6	6 x 6	6 x 8	4	8 x 10	4
	Up to 12	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	8 x 12	4
Over 20	See Note 1								

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* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.2. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type B P(a) = 45 x H + 72 psf (2 ft Surcharge)

	Size (S4S) and Spacing of Membe							
	Cross Braces							Wales
		Width of Trench (Feet)						
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)
5	Up to 6	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	5	6 x 8
To	Up to 8	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	5	8 x 8
10	Up to 10	4 x 6	4 x 6	6 x 6	6 x 6	6 x 8	5	8 x 10
	See Note 1							
10	Up to 6	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	8 x 8
To	Up to 8	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 10
15	Up to 10	6 x 8	6 x 8	8 x 8	8 x 8	8 x 8	5	10 x 12
	See Note 1							
15	Up to 6	6 x 8	6 x 8	6 x 8	6 x 8	8 x 8	5	8 x 10
To	Up to 8	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 12
20	Up to 10	8 x 8	8 x 8	8 x 8	8 x 8	8 x 8	5	12 x 12
	See Note 1							
Over 20	See Note 1							

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* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.3. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type C P(a) = 80 x H + 72 psf (2 ft Surcharge)

	Size (S4S) and Spacing of Membe							
	Cross Braces							Wales
		Width of Trench (Feet)						
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)
5	Up to 6	6 x 6	6 x 6	6 x 6	6 x 6	8 x 8	5	8 x 8
To	Up to 8	6 x 6	6 x 6	6 x 6	8 x 8	8 x 8	5	10 x 10
10	Up to 10	6 x 6	6 x 6	8 x 8	8 x 8	8 x 8	5	10 x 12
	See Note 1							
10	Up to 6	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 10
To	Up to 8	8 x 8	8 x 8	8 x 8	8 x 8	8 x 8	5	12 x 12
15	See Note 1							
	See Note 1							
15	Up to 6	8 x 8	8 x 8	8 x 8	8 x 10	8 x 10	5	10 x 12
To	See Note 1							
20	See Note 1							
	See Note 1							
Over 20	See Note 1							

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* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

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Section Title: Appendix C to Subpart P Timber Shoring for Trenches (Integrated)

Subject Terms: health & safety, employee, maintenance, design, safety, construction, operating, compliance

Source: Integrated Document

Appendix C to Subpart P -- Timber Shoring for Trenches

(a) Scope. This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with § 1926.652 (c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in § 1926.652(b) and § 1926.652(c).
(b) Soil Classification. In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.
(c) Presentation of Information. Information is presented in several forms as follows:
(1) Information is presented in tabular form in Tables C-1.1, C-1.2, and C-1.3, and Tables C-2.1, C-2.2 and C-2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.
(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.
(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.
(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.
(5) Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in paragraph (g) of this Appendix.
(d) Basis and limitations of the data.
(1) Dimensions of timber members.
(i) The sizes of the timber members listed in Tables C-1.1 through C-1.3 are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific

sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.
(ii) The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under § 1926.652(c)(3), and are referred to The Corps of Engineers, The Bureau of Reclamation or data from other acceptable sources.
(2) Limitation of application.
(i) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in § 1926.652(c).
(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with § 1926.652.
(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.
(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.
(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.
(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.
(e) Use of Tables. The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the crossbraces, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.
(f) Examples to Illustrate the Use of Tables C-1.1 through C-1.3.
(1) Example 1.
A trench dug in Type A soil is 13 feet deep and five feet wide.
From Table C-1.1, for acceptable arrangements of timber can be used.

Arrangement #1

Space 4 x 4 crossbraces at six feet horizontally and four feet vertically.
Wales are not required.
Space 3 x 8 uprights at six fee horizontally. This arrangement is commonly called "skip shoring."

Arrangement #2

Space 4 x 6 crossbraces at eight feet horizontally and four feet vertically.

Space 8 x 8 wales at four feet vertically.
Space 2 x 6 uprights at four feet horizontally.

Arrangement #3

Space 6 x 6 crossbraces at 10 feet horizontally and four feet vertically.
Space 8 x 10 wales at four feet vertically.
Space 2 x 6 uprights at five feet horizontally.

Arrangement #4

Space 6 x 6 crossbraces at 12 feet horizontally and four feet vertically.
Space 10 x 10 wales at four feet vertically.
Spaces 3 x 8 uprights at six feet horizontally.
(2) Example 2.
A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement #1

Space 6 x 6 crossbraces at six feet horizontally and five feet vertically.
Space 8 x 8 wales at five feet vertically.
Space 2 x 6 uprights at two feet horizontally.

Arrangement #2

Space 6 x 8 crossbraces at eight feet horizontally and five feet vertically.
Space 10 x 10 wales at five feet vertically.
Space 2 x 6 uprights at two feet horizontally.

Arrangement #3

Space 8 x 8 crossbraces at 10 feet horizontally and five feet vertically.
Space 10 x 12 wales a five feet vertically.
Space 2 x 6 uprights at two feet vertically.
(3) Example 3.
A trench dug in Type C soil is 13 feet deep and five feet wide.
From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement #1

Space 8 x 8 crossbraces at six feet horizontally and five feet vertically.
Space 10 x 12 wales at five feet vertically.
Position 2 x 6 uprights as closely together as possible.
If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement #2

Space 8 x 10 crossbraces at eight feet horizontally and five feet vertically.
Space 12 x 12 wales at five feet vertically.

Position 2 x 6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.
(4) Example 4.
A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.
Space 8 x 10 crossbraces at six feet horizontally and five feet vertically.
Space 12 x 12 wales at five feet vertically.
Use 3 x 6 tight sheeting.
Use of Tables C-2.1 through C-2.3 would follow the same procedures.
(g) Notes for all Tables.
1. Member sizes at spacings other than indicated are to be determined as specified in § 1926.652(c), "Design of Protective Systems."
2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.
3. All spacing indicated is measured center to center.
4. Wales to be installed with greater dimension horizontal.
5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.
6. Trench jacks may be used in lieu of or in combination with timber crossbraces.
7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

ENFLEX Note: The following tables are wider than your screen. Please scroll right to see the entire table.

Table C-1.1. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type A P(a) = 25 x H + 72 psf (2 ft Surcharge)

	Size (actual) and Spacing of Me								
	Cross Braces							Wales	
		Width of Trench (Feet)							
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)	Ve spa (fe
5	Up to 6	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	-
To	Up to 8	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	-

10	Up to 10	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	8 x 8	4
	Up to 12	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4
10	Up to 6	4 x 4	4 x 4	4 x 6	6 x 6	6 x 6	4	Not Req'd	-
To	Up to 8	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4
15	Up to 10	6 x 6	6 x 5	6 x 6	6 x 8	6 x 8	4	8 x 10	4
	Up to 12	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	10 x 10	4
15	Up to 6	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	6 x 8	4
To	Up to 8	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	8 x 8	4
20	Up to 10	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	4	8 x 10	4
	Up to 12	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	4	10 x 10	4
Over 20	See Note 1								

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* Mixed oak or equivalent wi|th a bending strength not less than 850 psi.

** Manufactured members of |equivalent strength may be substituted for wood.

Table C-1.2. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type B P(a) = 45 x H + 72 psf (2 ft Surcharge)

	Size (actual) and Spacing of Me							
	Cross Braces							Wales
		Width of Trench (Feet)						
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)
5	Up to 6	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	5	6 x 8
To	Up to 8	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	8 x 10
10	Up to 10	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	10 x 10
	See Note 1							
10	Up to 6	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	8 x 8
To	Up to 8	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 10
15	Up to 10	8 x 8	8 x 8	8 x 8	8 x 8	6 x 10	5	10 x 12

	See Note 1							
15	Up to 6	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	8 x 10
To	Up to 8	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x 12
20	Up to 10	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12
	See Note 1							
Over 20	See Note 1							

----

* Mixed oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.

Table C-1.3. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type C P(a) = 80 x H + 72 psf (2 ft Surcharge)

	Size (actual) and Spacing of Me							
	Cross Braces							Wales
		Width of Trench (Feet)						
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)
5	Up to 6	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	8 x 10
To	Up to 8	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x 12
10	Up to 10	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12
	See Note 1							
10	Up to 6	8 x 8	8 x 8	8 x 8	8 x 8	8 x 10	5	10 x 12
To	Up to 8	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12
15	See Note 1							
	See Note 1							
15	Up to 6	8 x 10	8 x 10	8 x 10	8 x 10	10 x 10	5	12 x 12
To	See Note 1							
20	See Note							

	1 See Note 1
Over 20	See Note 1

---

* Mixed Oak or equivalent with a bending strength not less than 850 psi.
** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.1. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type A P(a) = 25 x H ± 72 psf (2 ft Surcharge)

Depth of trench (feet)	Size (S4S) and Spacing of Membe								
	Cross Braces							Wales	
	Horiz. spacing (feet)	Width of Trench (Feet) Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)	Ve spa (fe
5	Up to 6	4 x 4	4 x 4	4 x 4	4 x 4	4 x 6	4	Not Req'd	No Re
To	Up to 8	4 x 4	4 x 4	4 x 4	4 x 6	4 x 6	4	Not Req'd	No Re
10	Up to 10	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	8 x 8	4
	Up to 12	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	8 x 8	4
10	Up to 6	4 x 4	4 x 4	4 x 4	6 x 6	6 x 6	4	Not Req'd	No Re
To	Up to 8	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	4	6 x 8	4
15	Up to 10	6 x 6	6 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4
	Up to 12	6 x 6	6 x 6	6 x 6	6 x 6	6 x 6	4	8 x 10	4
15	Up to 6	6 x 6	6 x 6	6 x 6	6 x 6	6 x 6	4	6 x 8	4
To	Up to 8	6 x 6	6 x 6	6 x 6	6 x 6	6 x 6	4	8 x 8	4
20	Up to 10	6 x 6	6 x 6	6 x 6	6 x 6	6 x 8	4	8 x 10	4
	Up to 12	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	4	8 x 12	4
Over 20	See Note 1								

----
* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.2. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type B P(a) = 45 x H + 72 psf (2 ft Surcharge)

Depth of trench (feet)	Size (S4S) and Spacing of Membe: Cross Braces: Horiz. spacing (feet)	Cross Braces: Width of Trench (Feet): Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Wales: Size (in)
5 To 10	Up to 6	4 x 6	4 x 6	4 x 6	6 x 6	6 x 6	5	6 x 8
	Up to 8	4 x 6	4 x 6	6 x 6	6 x 6	6 x 6	5	8 x 8
	Up to 10	4 x 6	4 x 6	6 x 6	6 x 6	6 x 8	5	8 x 10
	See Note 1							
10 To 15	Up to 6	6 x 6	6 x 6	6 x 6	6 x 8	6 x 8	5	8 x 8
	Up to 8	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 10
	Up to 10	6 x 8	6 x 8	8 x 8	8 x 8	8 x 8	5	10 x 12
	See Note 1							
15 To 20	Up to 6	6 x 8	6 x 8	6 x 8	6 x 8	8 x 8	5	8 x 10
	Up to 8	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 12
	Up to 10	8 x 8	8 x 8	8 x 8	8 x 8	8 x 8	5	12 x 12
	See Note 1							
Over 20	See Note 1							

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* Douglas fir or equivalent with a bending strength not less than 1500 psi.
** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.3. -- Timber Trench Shoring -- Minimum Timber Requirements*

Soil Type C P(a) = 80 x H + 72 psf (2 ft Surcharge)

	Size (S4S) and Spacing of Membe							
	Cross Braces							Wales
		Width of Trench (Feet)						
Depth of trench (feet)	Horiz. spacing (feet)	Up to 4	Up to 6	Up to 9	Up to 12	Up to 15	Vert. spacing (feet)	Size (in)
5	Up to 6	6 x 6	6 x 6	6 x 6	6 x 6	8 x 8	5	8 x 8
To	Up to 8	6 x 6	6 x 6	6 x 6	8 x 8	8 x 8	5	10 x 10
10	Up to 10	6 x 6	6 x 6	8 x 8	8 x 8	8 x 8	5	10 x 12
	See Note 1							
10	Up to 6	6 x 8	6 x 8	6 x 8	8 x 8	8 x 8	5	10 x 10
To	Up to 8	8 x 8	8 x 8	8 x 8	8 x 8	8 x 8	5	12 x 12
15	See Note 1							
	See Note 1							
15	Up to 6	8 x 8	8 x 8	8 x 8	8 x 10	8 x 10	5	10 x 12
To	See Note 1							
20	See Note 1							
	See Note 1							
Over 20	See Note 1							

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* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

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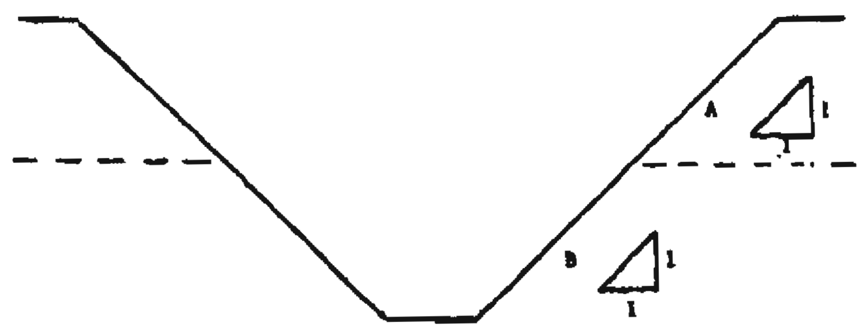

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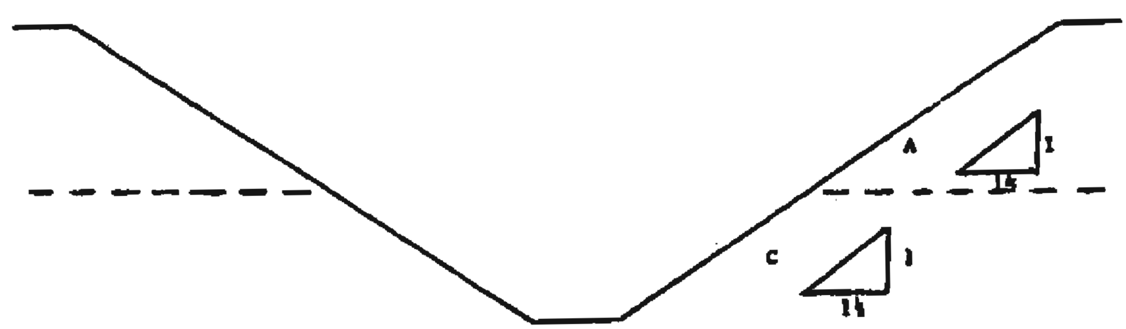
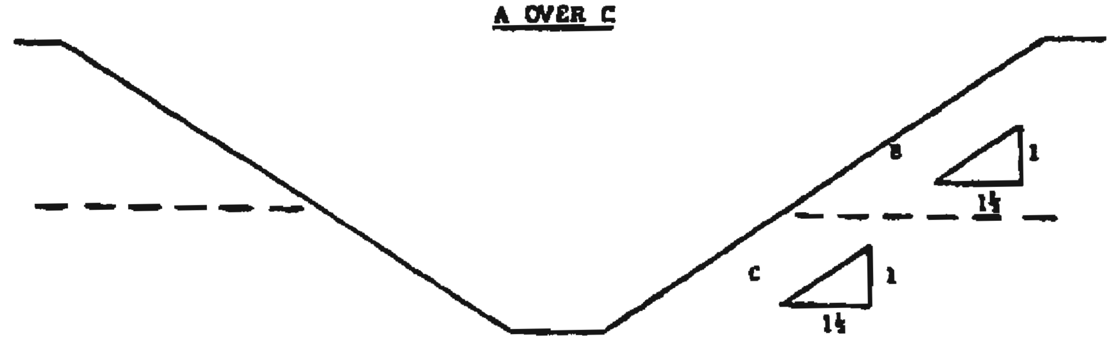


A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

Appendix C to Subpart P—Timber Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with §1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in §1926.652(b) and §1926.652(c).

(b) *Soil Classification.* In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C-1.1, C-1.2, and C-1.3, and Tables C-2.1, C-2.2 and C-2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shoring system, and each table contains data only for the particular soil type in which the excavation or portion of

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Subject Terms: health & safety, employee, maintenance, design, safety, construction, operating, compliance
Source: Integrated Document

Appendix D to Subpart P -- Aluminum Hydraulic Shoring for Trenches

(a) Scope. This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with § 1926.652(c)(2).
(b) Soil Classification. In order to use data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of Subpart P of part 1926.
(c) Presentation of Information. Information is presented in several forms as follows:
(1) Information is presented in tabular form in Tables D-1.1, D-1.2, D-1.3 and D-1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D-1.1 and D-1.2 are for vertical shores in Types A and B soil. Tables D-1.3 and D-1.4 are for horizontal water systems in Types B and C soil.
(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix.
(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.
(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.
(5) Miscellaneous notations (footnotes) regarding Table D-1.1 through D-1.4 are presented in paragraph (g) of this appendix.
(6) Figures, illustrating typical installations of hydraulic shoring, are included just prior to the Tables. The illustration page is entitled "Aluminum Hydraulic Shoring; Typical Installations."
(d) Basis and limitations of the data.
(1) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D-1 Tables. Aluminum material is 6061-T6 or material of equivalent strength and properties.
(2) Hydraulic cylinders specifications.
(i) 2-inch cylinders shall be a minimum 2-inch inside diameter with a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include

full range of cylinder extensions as recommended by product manufacturer.
(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe working capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.
(3) Limitation of application.
(i) It is not intended that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in § 1926.652(c).
(ii) When any of the following conditions are present, the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with § 1926.652.
(A) When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.
(B) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.
(C) When only the lower portion or a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.
(e) Use of Tables D-1.1, D-1.2, D-1.3 and D-1.4. The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D-1.1 and D-1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting are found in the horizontal wale Tables D-1.3 and D-1.4. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables the vertical spacing is held constant at four feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.
(f) Example to Illustrate the Use of the Tables:
(1) Example 1:
A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D-1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)
(2) Example 2:
A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)
(3) A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D-1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote #2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically, plywood (per footnote (g)(7) to the D-1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)
(4) Example 4: A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide, 8 foot horizontal spacing between cylinders is desired for working space. From Table D-1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3 x 12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) Example 5: A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D-1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizonal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically. 3 x 12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)
(g) Footnotes, and general notes, for Tables D-1.1, D-1.2, D-1.3, and D-1.4.
(1) For applications other than those listed in the tables, refer to § 1926.652(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to § 1926.652(c)(2) and § 1926.652(c)(3).
(2) 2 inch diameter cylinders, at this width, shall have structural steel tube (3.5 x 3.5 x 0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.
(3) Hydraulic cylinders capacities.
(i) 2 inch cylinders shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.
(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.
(4) All spacing indicated is measured center to center.
(5) Vertical shoring rails shall have a minimum section modulus of 0.40 inch.
(6) When vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.
(7) Plywood shall be 1.125 in. thick softwood or 0.75 inch, thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural member, but only for prevention of local raveling (sloughing of the trench face) between shores.
(8) See appendix C for timber specifications.
(9) Wales are calculated for simple span conditions.
(10) See appendix D, item (d), for basis and limitations of the data.

ENFLEX Note: For a copy of the following figures, please call the ENFLEX Hotline at (800)544-3118:
ALUMINUM HYDRAULIC SHORING -- TYPICAL INSTALLATIONS
Figure 1: VERTICAL ALUMINUM HYDRAULIC SHORING (SPOT BRACING);
Figure 2: VERTICAL ALUMINUM HYDRAULIC SHORING (WITH PLYWOOD);
Figure 3: VERTICAL ALUMINUM HYDRAULIC SHORING (STACKED);
Figure 4: ALUMINUM HYDRAULIC SHORING -- WATER SYSTEM (TYPICAL).

```
Table D-1.1. -- Aluminum Hydraulic Shoring Vertical Shores
                for Soil Type A

-----------------------------------------------------------------
                      Hydraulic Cylinders
-----------------------------------------------------------------
                                     Width of Trench (feet)
```

Depth of trench (feet)	Maximum horizontal spacing (feet)	Maximum vertical spacing (feet)	Up to 8	Over 8 up to 12	Over 12 up to 25
Over 5 Up to 10	8				
Over 10 Up to 15	8	4	2 Inch diameter	2 Inch diameter Note (2)	3 Inch diamater
Over 15 Up to 20	7				
Over 20			Note (1)		

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)

Table D-1.2. -- Aluminum Hydraulic Shoring Vertical Shores for Soil Type B

Hydraulic Cylinders					
			Width of Trench (feet)		
Depth of trench (feet)	Maximum horizontal spacing (feet)	Maximum vertical spacing (feet)	Up to 8	Over 8 up to 12	Over 12 up to 25
Over 5 Up to 10	8				
Over 10 Up to 15	6.5	4	2 Inch diameter	2 Inch diameter Note (2)	3 Inch diamater
Over 15 Up to 20	5.5				
Over 20			Note (1)		

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)

ENFLEX Note: The following table is wider than your screen. Please scroll right to see the entire table.

Table D-1.3. -- Aluminum Hydraulic Shoring Waler Systems for Soil Type B

	Wales		Hydraulic Cylinders				
			Width of Trench (feet)				
			Up to 8		Over 8 up to 12		Over 12 up
Depth of Trench (feet)	Vertical spacing (feet)	Section modulus * (in[3])	horiz. spacing	Cylinder diameter	Horiz. spacing	Cylinder diameter	Horiz. spacing
Over 5 Up to 10	4	3.5	8.0	2 IN	8.0	2 IN Note (2)	8.0
		7.0	9.0	2 IN	9.0	Note (2)	2 IN 9.0
		14.0	12.0	3 IN	12.0	3 IN	12.0
Over 10 Up to 15	4	3.5	6.0	2 IN	6.0	2 IN Note (2)	6.0
		7.0	8.0	3 IN	8.0	3 IN	8.0
		14.0	10.0	3 IN	10.0	3 IN	10.0
Over 15 UP TO 20	4	3.5	5.5	2 IN	5.5	2 IN Note (2)	5.5
		7.0	6.0	3 IN	6.0	3 IN	6.0
		14.0	9.0	3 IN	9.0	3 IN	9.0
Over 20			Note (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g)(1)
Notes (2): See Appendix D, Item (g)(2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

Table D-1.4. -- Aluminum Hydraulic Shoring Waler Systems for Soil Type C

			Width of Trench (feet)				
			Up to 8		Over 8 up to 12		Over 12 up
Depth of Trench (feet)	Vertical spacing (feet)	Section modulus * (in[3])	horiz. spacing	Cylinder diameter	Horiz. spacing	Cylinder diameter	Horiz. spacing

Over 5	4	3.5	6.0	2 IN	6.0	2 IN Note (2)	6.0
Up to 10		7.0	6.5	2 IN	6.5	2 IN Note (2)	6.5
		14.0	10.0	3 IN	10.0	3 IN	10.0
Over 10	4	3.5	4.0	2 IN	4.0	2 IN Note (2)	4.0
		7.0	5.5	3 IN	5.5	3 IN	5.5
Up to 15		14.0	8.0	3 IN	8.0	3 IN	8.0
Over 15	4	3.5	3.5	2 IN	3.5	2 IN Note (2)	3.5
		7.0	5.0	3 IN	5.0	3 IN	5.0
Up to 20		14.0	6.0	3 IN	6.0	3 IN	6.0
Over 20		Note (1)					

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g)(1)
Notes (2): See Appendix D, item (g)(2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

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ALUMINUM HYDRAULIC SHORING TYPICAL INSTALLATIONS

FIGURE NO. 1
VERTICAL ALUMINUM HYDRAULIC SHORING (SPOT BRACING)

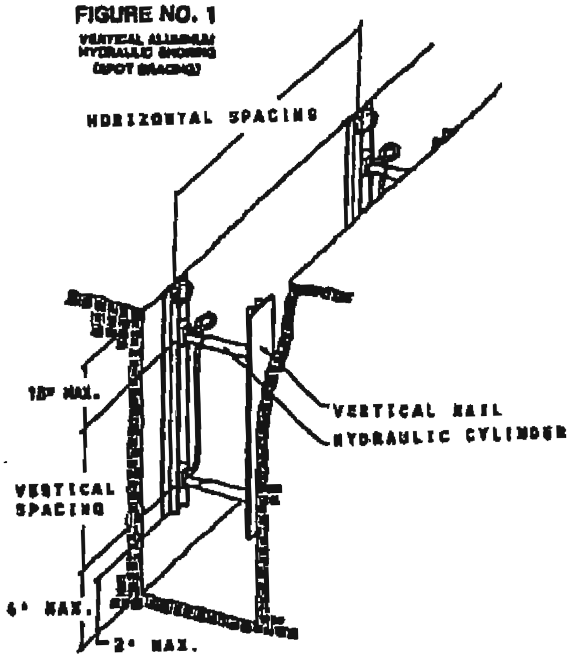

FIGURE NO. 2
VERTICAL ALUMINUM HYDRAULIC SHORING (WITH PLYWOOD)

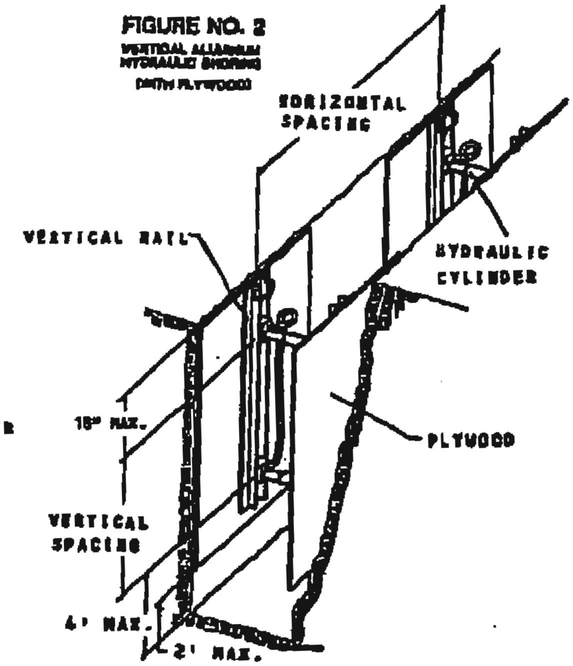

FIGURE NO. 3
VERTICAL ALUMINUM HYDRAULIC SHORING (STACKED)

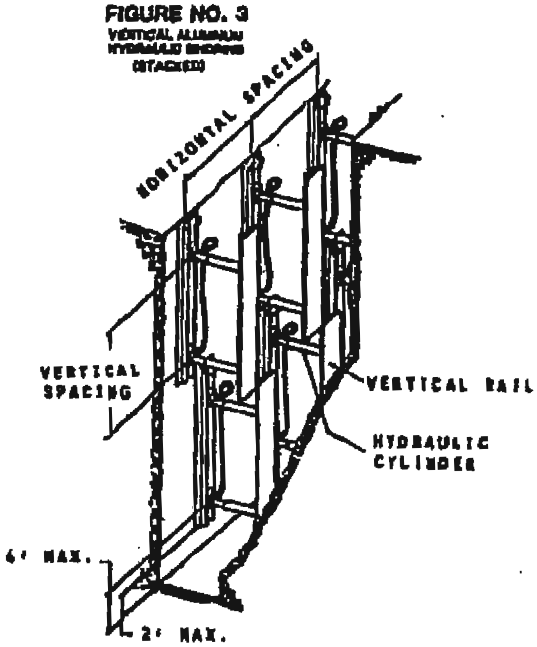

FIGURE NO. 4
ALUMINUM HYDRAULIC SHORING WALER SYSTEM (TYPICAL)

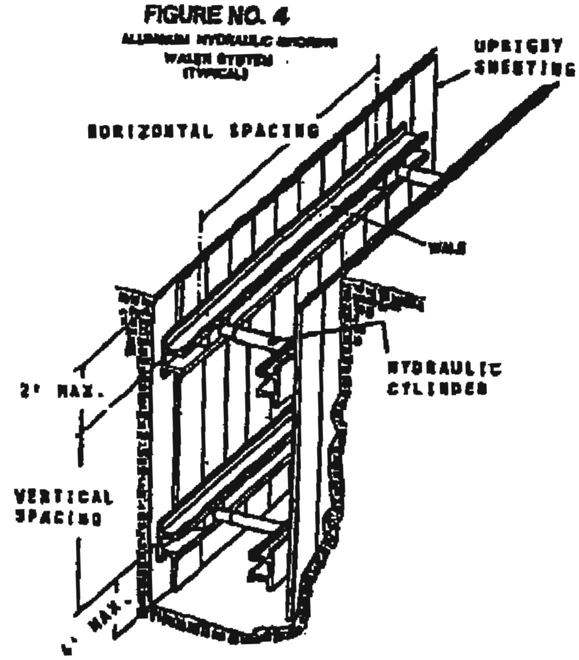

TABLE D - 1.1
ALUMINUM HYDRAULIC SHORING
VERTICAL SHORES

Citation: Title 29, Part 1926
Jurisdiction: Federal **Document Date:** October 31, 1989 **Page Count:** 1
Section Title: Appendix E to Subpart P Alternatives to Simber Shoring (Integrated)
Subject Terms: health & safety, employee, maintenance, design, safety, construction, operating, compliance
Source: Integrated Document

Appendix E to Subpart P -- Alternatives to Timber Shoring

ENFLEX Note: For a copy of the following figures, please call the ENFLEX Hotline at (800)544-3118:
Figure 1: ALUMINUM HYDRAULIC SHORING;
Figure 2: PNEUMATIC/HYDRAULIC SHORING;
Figure 3: TRENCH JACKS [SCREW JACKS];
Figure 4: TRENCH SHIELDS.

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Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, Item (g) (1)
Notes (2): See Appendix D, Item (g) (2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

Figure 1. Aluminum Hydraulic Shoring

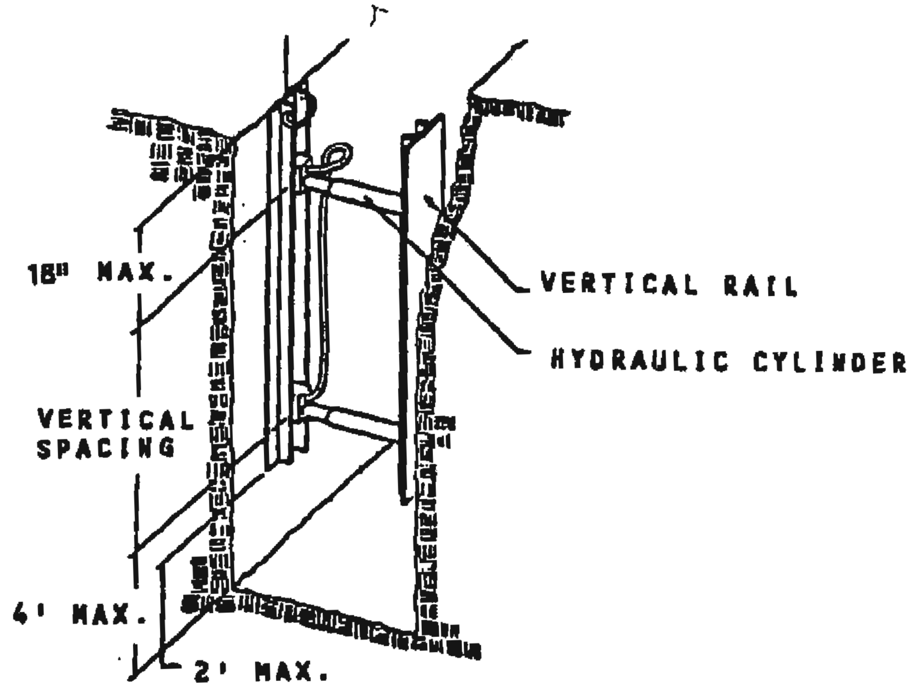
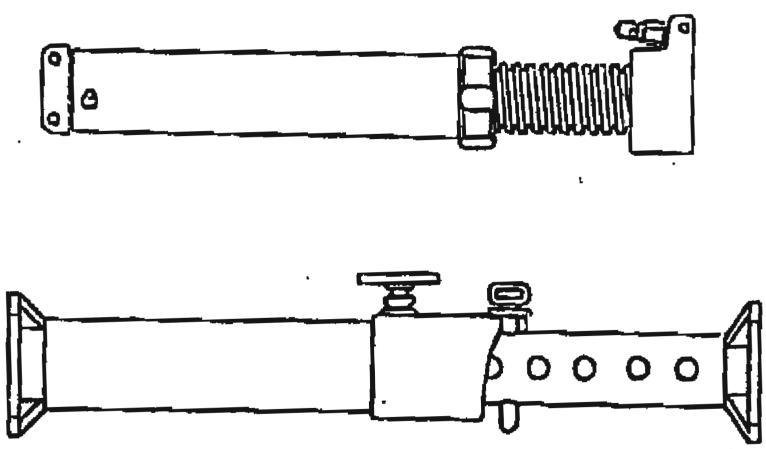


Figure 2. Pneumatic/hydraulic Shoring



ENFLEX Federal and State Regulations, April 2000

Citation: Title 29, Part 1926
Jurisdiction: Federal **Document Date:** October 31, 1989 **Page Count:** 1
Section Title: Appendix F to Subpart P Selection of Protective Systems (Integrated)
Subject Terms: health & safety, employee, maintenance, design, safety, construction, operating, compliance
Source: Integrated Document

Appendix F to Subpart P -- Selection of Protective Systems

The following figures are a graphic summary of the requirements contained in Subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with § 1926.652(b) and (c).

ENFLEX Note: For a copy of the following figures please call the ENFLEX Hotline at (800)544-3118:
Figure 1: PRELIMINARY DECISIONS;
Figure 2: SLOPING OPTIONS;
Figure 3: SHORING AND SHIELDING OPTIONS.

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Figure 3. Trench Jacks (Screw Jacks)

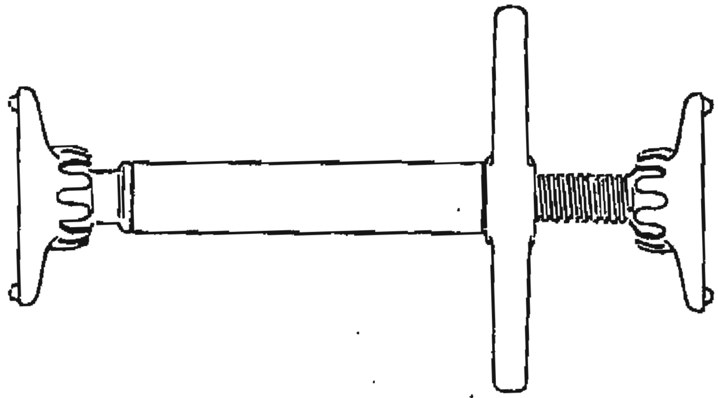
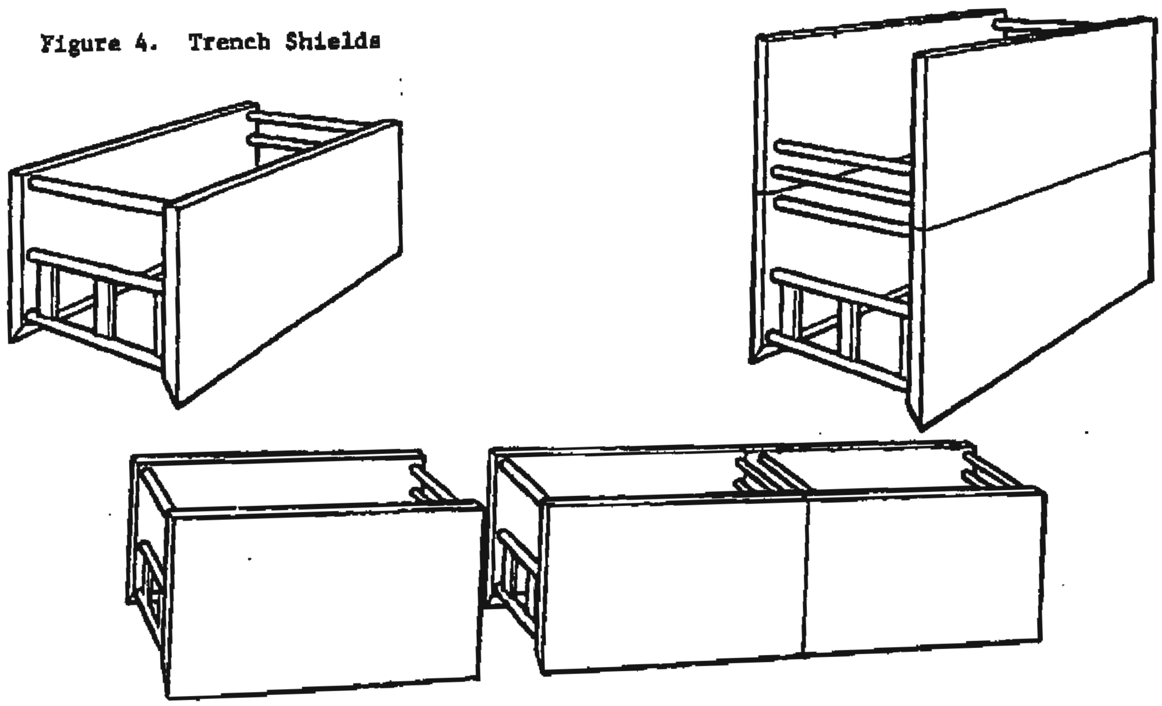


Figure 4. Trench Shields



APPENDIX F TO SUBPART P—SELECTION OF PROTECTIVE SYSTEMS

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with §1926.652 (b) and (c).

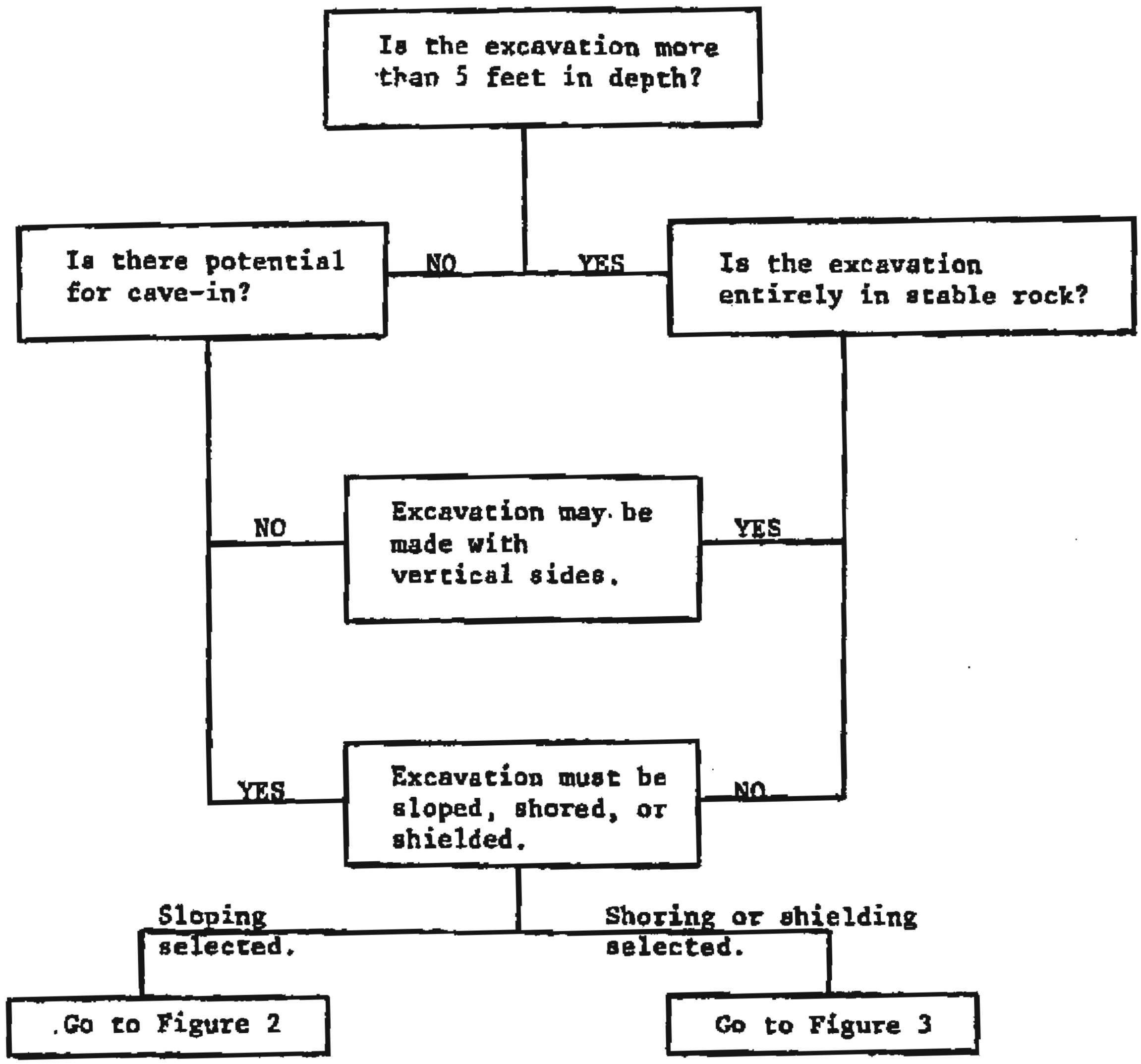


FIGURE 1 - PRELIMINARY DECISIONS

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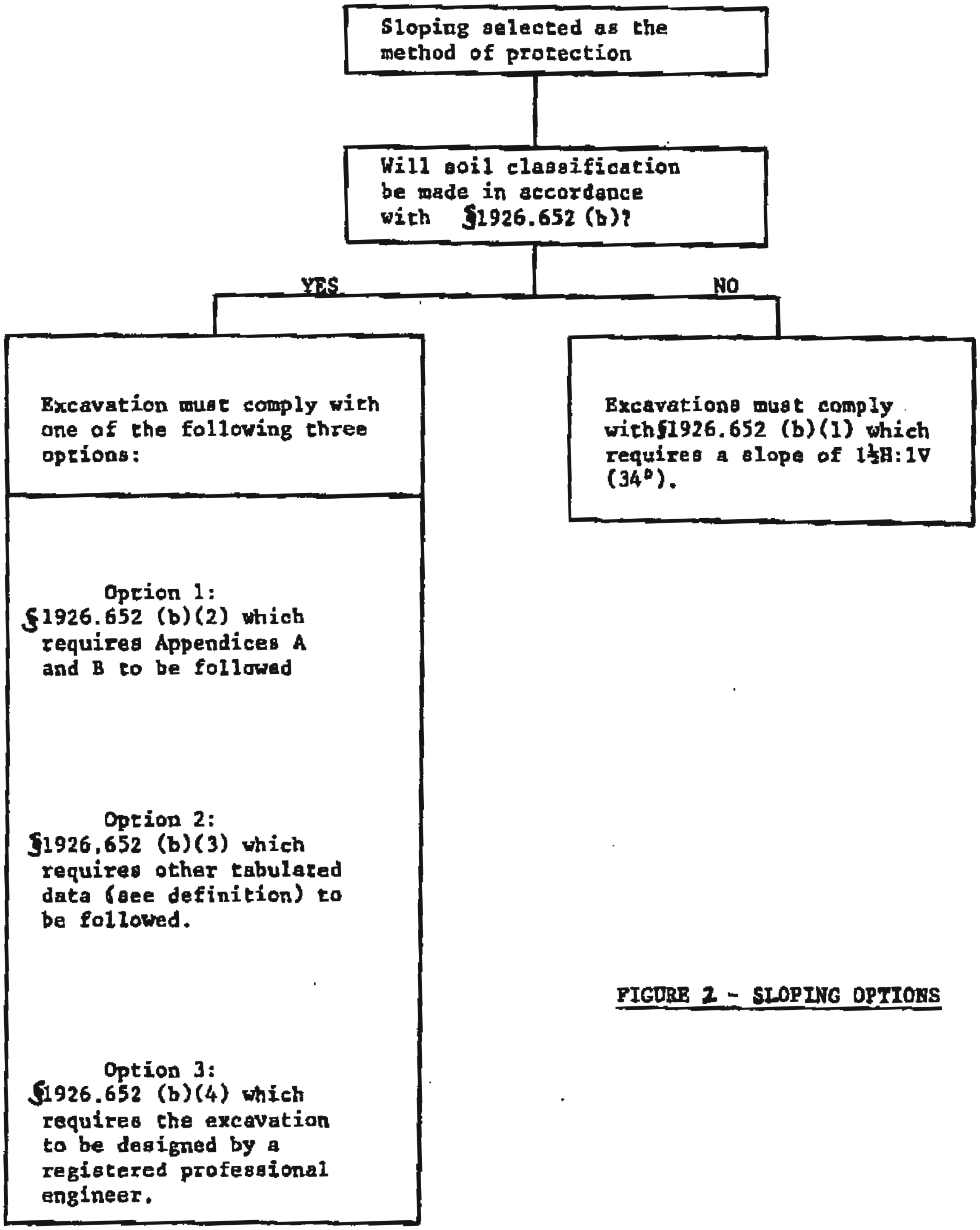

FIGURE 2 - SLOPING OPTIONS

Shoring or shielding selected as the method of protection.

Soil classification is required when shoring or shielding is used. The excavation must comply with one of the following four options:

Option 1
§1926.652 (c)(1) which requires Appendices A and C to be followed (e.g. timber shoring).

Option 2
§1926.652 (c)(2) which requires manufacturers data to be followed (e.g. hydraulic shoring, trench jacks, air shores, shields).

Option 3
§1926.652 (c)(3) which requires tabulated data (see definition) to be followed (e.g. any system as per the tabulated data).

Option 4
§1926.652 (c)(4) which requires the excavation to be designed by a registered professional engineer (e.g. any designed system).

FIGURE 3 - SHORING AND SHIELDING OPTIONS

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APPENDIX G

DRILLING SAFETY GUIDELINES

Drilling Safety Guide

INTERNATIONAL DRILLING FEDERATION

DCDMA
The Drilling Equipment Manufacturers Association

NDCA
National Drilling Contractors Association

CDDA
Canadian Diamond

DRILLING SAFETY GUIDE

The *Drilling Safety Guide* has been prepared through the combined efforts of member delegations of the Diamond Core Drill Manufacturers Association (DCDMA), the National Drilling Contractors Association (NDCA) and the National Water Well Association-Drill Rig/Heavy Equipment Products Group (NWWA) and is published by the International Drilling Federation for the benefit of the drilling industries.

This guide contains suggested safety procedures. It is not intended to set forth any standard industry procedures or requirements. This manual is to be used as a guideline for the safe operation of drilling equipment. IDF, DCDMA, NDCA, NWWA, their officers, and members deny any liability for any injury to people or property that may occur even if these procedures are properly followed. Further, the IDF, DCDMA, NDCA, NWWA, their officers, and members do not accept responsibility for the completeness of the guide or the applicability of the statements or procedures to the use of all drilling machines and tools in all environments. Many aspects of drilling safety cannot be expressed in detail and cannot be met by mechanical means; drilling safety can only be accomplished with the exercise of intelligence, care, and common sense.

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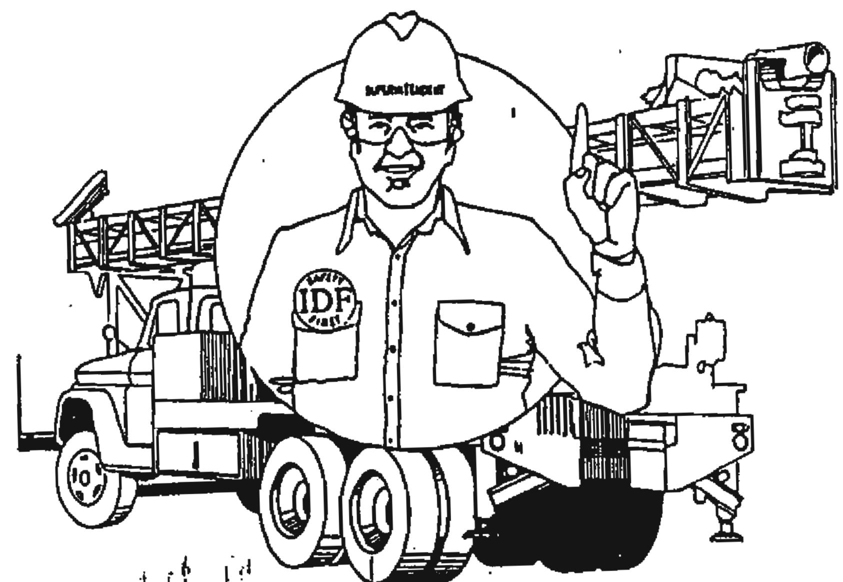
DRILLING SAFETY GUIDE

1. An Introduction To Drilling Safety

The organization for which you work is interested in your safety. Your employer cares about your safety not only when you are working on or around a drill rig, but also when you are traveling to and from a drilling site, moving the drill rig and tools from location to location on a site, or providing maintenance on a drill rig or drilling tools. This safety guide is for your benefit. Failure to heed the safety procedures contained in this manual could result in serious injury or death.



Every drill crew should have a designated safety supervisor who has the authority to enforce safety on the drilling site. A rig worker's first safety responsibility is to obey the directions of the safety supervisor.

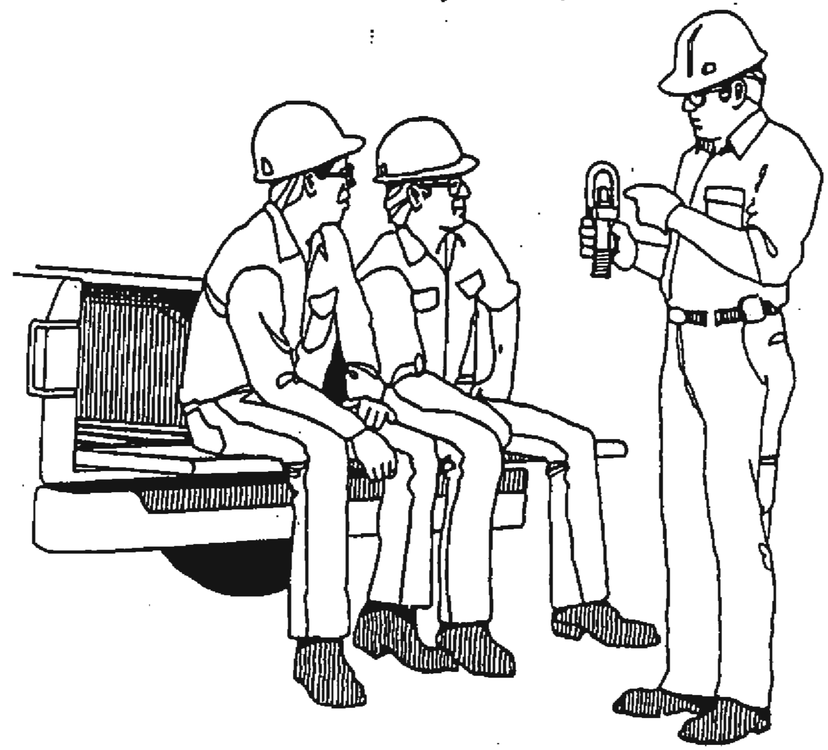
All local, state, and federal regulations or restrictions, currently in effect or effected in the future, take precedence over the recommendations and suggestions which follow. Government regulations will vary from country to country and from state to state.

3. The Safety Supervisor

The safety supervisor for the drill crew will, in most cases, be the drill rig operator. The safety supervisor must:

- Consider the "responsibility" for safety and the "authority" to enforce safety to be a matter of first importance.
- Be the leader in using proper personal safety gear and set an example in following the rules that are being enforced on others.
- Enforce the use of proper personal protective safety equipment and take appropriate corrective action when proper personal protective safety equipment is not being used.
- Understand that proper maintenance of tools and equipment and general "housekeeping" on the drill rig will provide an environment that will promote and enforce safety.
- Before drilling is started with a particular drill, ensure that anyone who operates the drill has had adequate training and is thoroughly familiar with the drill rig, its controls, and its capabilities.
- Inspect the drill rig at least daily for structural damage, loose bolts and nuts, proper tension in chain drives, loose or missing guards or protective covers, fluid leaks, damaged hoses, and/or damaged pressure gauges and pressure relief valves.
- Check and test all safety devices, such as emergency shutdown switches, at least daily and preferably at the start of a drilling shift. Drilling must not be permitted until all emergency shutdown and warning systems are working correctly. Do not allow any emergency device to be bypassed or removed.
- Check that all gauges, warning lights, and control levers are functioning properly and listen for unusual sounds each time an engine is started.
- Ensure that every drill rig worker is informed of safe operat-

manual, and when appropriate, the drill rig manufacturer's operations and maintenance manual. Ensure that every employee reads and understands the safety manual.



- Carefully instruct a new worker in drilling safety and observe the new worker's progress towards understanding safe operating practices.
- Assess the mental, emotional, and physical capability of each worker to perform the assigned work in a proper and safe manner. Remove any worker from the drill site whose mental and physical capabilities might cause injury to the worker or coworkers.
- Ensure that a first-aid kit and a fire extinguisher, which are properly maintained, are on each drill rig and each additional vehicle.
- Be well trained in and capable of using first-aid kits, fire extinguishers, and all other safety devices and equipment. Train crew members.

emergency assistance units (ambulance services, police, hospitals, etc.) and inform other members of the drill crew of the existence and location of the list.

4. Individual Protective Equipment

For most geotechnical, mineral, and/or groundwater drilling projects, individual protective equipment must include a safety hat, safety shoes, safety glasses, and close-fitting gloves and clothing. The clothing of the individual drill rig worker is not generally considered protective equipment; however, the worker's clothing should be comfortable but must be close fitting, without loose ends, straps, draw strings, belts or otherwise unfastened parts that might catch on some rotating or translating component of the drill rig. Rings and jewelry must not be worn during a work shift.

- *Safety Head Gear.* Safety hats (hard hats) must be worn by everyone working or visiting at or near a drilling site. All safety hats must meet the requirements of ANSI Z89.1. All safety hats must be kept clean and in good repair with the headband and crown straps properly adjusted for the individual drill rig worker or visitor.
- *Safety Shoes or Boots.* Safety shoes or boots must be worn by all drilling personnel and all visitors to the drill site that observe drilling operations within close proximity of the drill rig. All safety shoes or boots must meet the requirements of ANSI Z41.1.
- *Gloves.* All drilling personnel must wear gloves for protection against cuts and abrasions that could occur while handling wire rope or cable and from contact with sharp edges and burrs on drill rods and other drilling or sampling tools. All gloves must be close fitting and not have large cuffs or loose ties that can catch on rotating or translating components of the drill rig.
- *Safety Glasses.* All drilling personnel must wear safety glasses. All safety glasses must meet the requirements of ANSI Z87.1.
- *Other Protective Equipment.* For some drilling operations, the environment or regulations may dictate that other protective equipment be used. The requirement for such equipment must

face or ear protection or reflective clothing. Each drill rig worker must wear noise-reducing ear protectors when appropriate.

When drilling is performed in chemically or radiologically contaminated ground, special protective equipment and clothing may, and probably will, be required. The design and composition of the protective equipment and clothing must be determined jointly by the management and the client who requests the drilling services, and under some circumstances, with the concurrence of a health and safety professional.

The first requirement for safe field operations is that the safety supervisor understand and fulfill the responsibility for maintenance and "housekeeping" on and around the drill rig. The safety supervisor must:

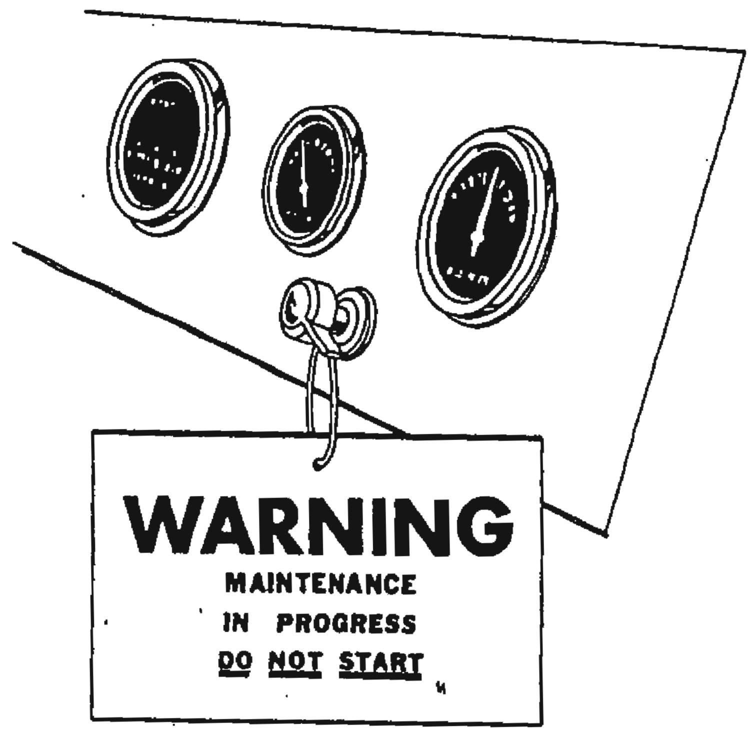
- Provide suitable storage locations for all tools, materials, and supplies so that these items can be conveniently and safely handled without hitting or falling on a member of the drill crew or a visitor.
- Avoid storing or transporting tools, materials, or supplies within or on the mast (derrick) of the drill rig, unless designed for this purpose.
- Stack pipe, drill rods, casing, augers, and similar drilling tools in orderly fashion on racks or sills to prevent spreading, rolling, or sliding.
- Place penetration or other driving hammers at a safe location on the ground or secure them to prevent movement when not in use.
- Keep work areas, platforms, walkways, scaffolding, and other accessways free of materials, debris, obstructions, and substances such as ice, grease or oil that could cause a surface to become slick or otherwise hazardous.
- Keep all controls, control linkages, warning and operation lights and lenses free of oil, grease, and/or ice.
- Store gasoline only in a non-sparking, red container with a flame arrester in the fill spout and having the word "gasoline" easily visible.

6. Maintenance

Good maintenance will make drilling operations safer. Also, maintenance must be performed safely. The following points are essential to safety:

- Wear safety glasses when performing maintenance on a drill rig or on drilling tools.
- Shut down the drill rig engine to make repairs or adjustments to a drill rig or to lubricate fittings (except repairs or adjustments that can only be made with the engine running). Take precautions to prevent accidental starting of an engine during maintenance by removing or tagging the ignition key.

- Release all pressure on the hydraulic systems, the drilling fluid system and the air pressure systems of the drill rig — when possible and appropriate — prior to performing maintenance. In other words, reduce the drill rig and operating systems to a "zero energy state" before performing maintenance. Use extreme caution when opening drain plugs and radiator caps and other pressurized plugs and caps.
- Do not touch an engine or the exhaust system of an engine following its operation until the engine and exhaust system have had adequate time to cool.



- Never climb the mast (derrick) to do maintenance or make repairs. Lower mast, stop engine and deenergize rig before starting maintenance or repair on mast.
- Never weld or cut on or near a fuel tank.
- Do not use gasoline or other volatile or flammable liquids as a cleaning agent on or around a drill rig.

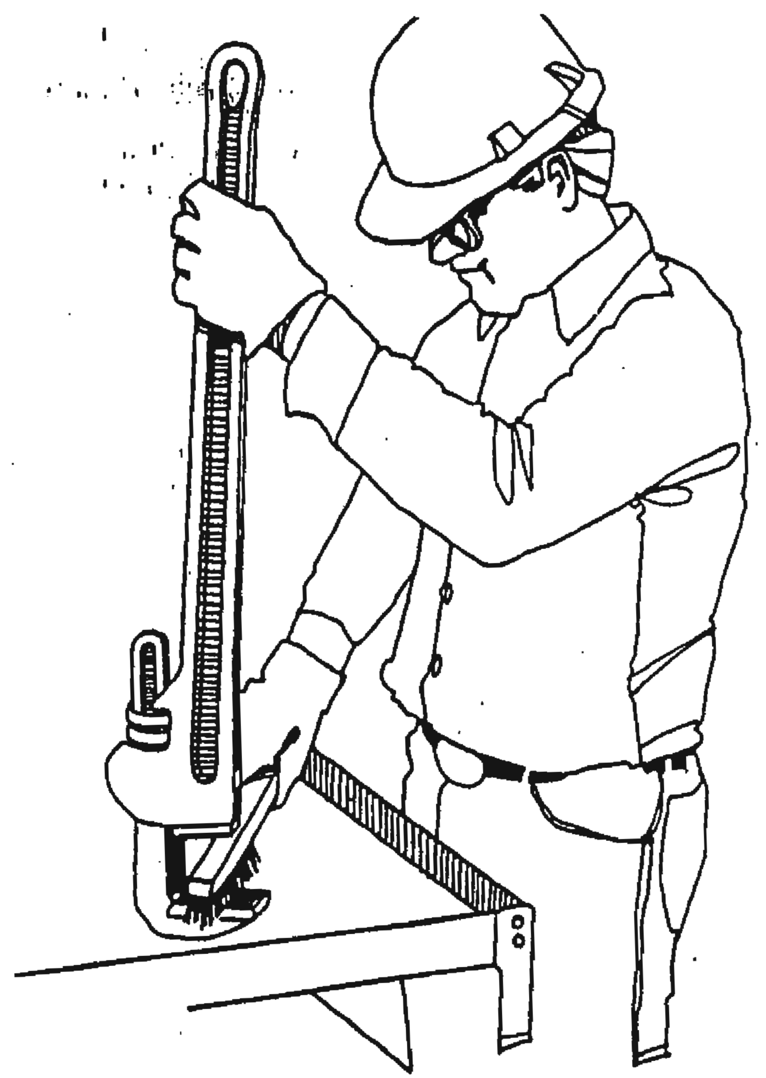
• Follow the manufacturer's recommendations for applying the proper quantity and quality of lubricants, hydraulic oils and/or coolants.

• Replace all caps, filler plugs, protective guards or panels, and high pressure hose clamps and chains or cables that have been removed for maintenance before returning the drill rig to service.

7. Hand Tools

Since there are almost an infinite number of hand tools that can be used on or around a drill rig and in repair shops, there are an equal number of instructions for proper use. "Use the tool for its intended purpose" is the most important rule. The following suggestions apply to safe use of several hand tools that frequently are used on and around drill rigs:

• When a tool becomes damaged, either repair it before using it again or get rid of it.
• When using a hammer, any kind of hammer for any purpose, wear safety glasses and require all others around you to wear safety glasses.
• When using any kind of chisel or punch, for any purpose, wear safety glasses and require all others around you to wear safety glasses.
• Keep all tools cleaned and stored appropriately when not in use.
• Use wrenches — not pliers — on nuts.
• Use screwdrivers with blades that fit the screw.
• When using a wrench on a tight nut, first use some penetrating oil and then use the largest wrench available that fits the nut. When possible pull on the wrench handle rather than push on it; apply force to the wrench with both hands when possible and with both feet firmly placed. Always assume that you may lose your footing; check the place that you may fall for sharp objects.
• Keep all pipe wrenches clean and in good repair. Use a wire brush frequently to clean the jaws of pipe wrenches. An accumulation of dirt and grease can cause wrenches to slip.
• Never use pipe wrenches in place of a rod-holding device.
• Replace hook and heel jaws when they become visibly worn.



• When breaking tool joints on the ground or on a drilling platform, position your hands so that your fingers will not be smashed between the wrench handle and the ground or the platform if the wrench should slip or the tool joint suddenly let go.

8. Clearing the Work Area

Prior to drilling, adequately clear and level the site to accommodate the drill rig and supplies and provide a safe working area.

Do not begin drilling if tree limbs, unstable ground, or site obstructions cause unsafe tool handling conditions.

9. Start-Up

Instruct all drill rig personnel and visitors to "stand clear" of the drill rig immediately prior to starting the engine.

- Make sure all brakes are set, all gear boxes are in neutral, all hoist levers are disengaged, all hydraulic levers or air controls are in the correct positions, and the cathead rope is not on the cathead before starting a drill rig engine.
- Start all engines according to the manufacturer's manual.

10. Drilling Operations

Safety requires the attention and cooperation of every worker and site visitor.

- Do not drive the drill rig from hole to hole with the mast (derrick) in the raised position.
- Before raising the mast (derrick), look up to check for overhead obstructions. (Refer to Section 11 on Overhead and Buried Utilities.)
- Before raising the mast (derrick), clear all drill rig personnel (with exception of the operator) and visitors from the areas immediately to the rear and the sides of the mast. Inform all drill rig personnel and visitors that the mast is being raised prior to raising it.
- Before the mast (derrick) of a drill rig is raised and drilling is begun, the drill rig must first be leveled and stabilized with leveling jacks and/or solid cribbing. Relevel the drill rig if it settles after initial set up. Lower the mast (derrick) only when the leveling jacks are down and do not raise the leveling jack pads until the mast (derrick) is lowered completely.
- Before starting drilling operations, secure, and/or lock the mast (derrick) if required, according to the drill manufacturer's recommendations.
- Do not stand on the elevated deck of a truck-mounted or all-terrain-mounted drill rig while the drill rig is in operation unless necessary for special tasks and the operator has been notified.
- Only operate a drill rig from the position of the controls. Before leaving the area of the controls, shift the transmission

in neutral. Before leaving the vicinity of the drill, shut down the drill engine.

- Throwing or dropping tools must not be permitted. Carefully pass tools by hand between personnel or use a hoist line.
- Do not consume alcoholic beverages, other depressants, or chemical stimulants prior to starting work on a drill rig or while on the job.
- If it is necessary to drill within an enclosed area, make certain that exhaust fumes are conducted out of the area. Exhaust fumes are toxic and some cannot be detected by smell.
- Clean mud and grease from boots before stepping on a drill platform and use hand holds and railings. Watch for slippery ground when stepping down from the platform.
- During freezing weather, do not touch any metal parts of the drill rig with exposed flesh. Freezing of moist skin to metal can occur almost instantaneously.
- Drain all air and water lines and pumps when not in use if freezing weather is expected.
- Adequately cover or protect all unattended boreholes to prevent drill rig personnel, site visitors, or animals from stepping or falling into the hole. Cover, protect or backfill all open boreholes according to local or state regulations on completion of the drilling project.
- Never allow "horsing around" within the vicinity of the drill rig and tool and supply storage areas — even when the drill rig is shut down.
- When using a ladder on a drill rig, face the ladder and grasp either the side rails or the rungs with both hands while ascending or descending. Do not attempt to use one or both hands to carry a tool while on a ladder. Use a hoist line and a tool "bucket" or a safety hook to raise or lower hand tools.
- Terminate drilling operations during an electrical storm and move the complete crew away from the drill rig.

An elevated derrick platform should be used with the following precautions:

- When working on a derrick platform, use a safety belt and a lifeline. The safety belt must be at least 4 in. (100 mm) wide and should fit snugly but comfortably. The lifeline, when attached and lifeline must be strong enough to withstand the dynamic force of a 250 lb. (115 kg) weight (contained within the belt) falling 6 ft. (2 m).

- Use a safety device when climbing to a derrick platform that is higher than 20 ft. (6 m).
- When on a derrick platform, fasten the lifeline to the derrick just above the derrick platform and to a structural member that is not attached to the platform or to other lines or cables supporting the platform.
- When first arriving at a derrick platform, immediately inspect for broken members, loose connections, loose tools, or other loose materials.
- Securely attach tools to the platform with safety lines. Do not attach a tool to a line attached to one's wrist or any other part of the body.
- When working on a derrick platform, do not guide drill rods or pipe into racks or other supports by taking hold of a moving hoist line or a traveling block.
- Do not leave loose tools and similar items on the derrick platform or on structural members of the derrick.
- A derrick platform over 4 ft. (1.2 m) above ground surface must have toe boards and safety railing that are in good condition.
- Avoid being under rig workers on elevated platforms whenever possible.

If heavy objects must be manually lifted, exercise care to avoid injury.

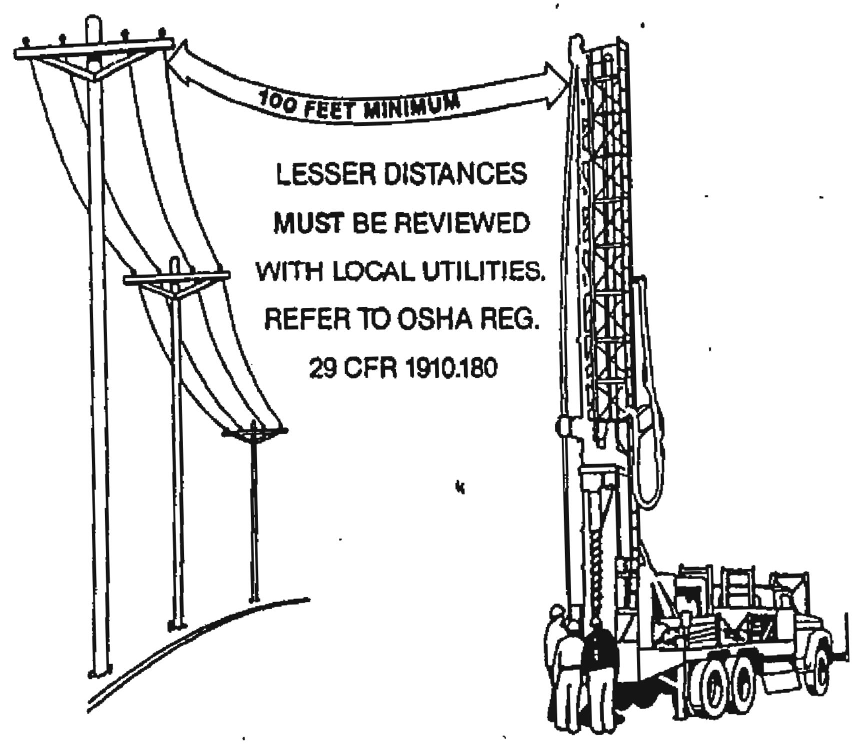
- Before lifting an object without using a hoist, make sure that the load is within your personal lifting capacity. If it is too heavy, ask for assistance.
- Before lifting a relatively heavy object, approach the object by bending at the knees, keeping the back vertical and unarched while obtaining a firm footing. Grasp the object firmly with both hands and stand slowly and squarely while keeping the back vertical and unarched. In other words, perform the lifting with the muscles in the legs, not with the muscles in the lower back.
- If a heavy object must be moved some distance without the aid of machinery, keep the back straight and unarched. Change directions by moving the feet, not by twisting the body.

possible.

11. Overhead and Buried Utilities

Both supervisors and members of the exploration crew must take special precautions when a drill rig will be used on a site or project within the vicinity of electrical power lines and other utilities. Electricity can shock, it can burn, and it can cause death.

- Locate, note, and emphasize overhead and buried utilities on all boring location plans and boring assignment sheets.
- When overhead electrical power lines exist at or near a drilling site or project, consider all wires to be alive and dangerous.



- Watch for sagging power lines before entering a site. Do not lift power lines to gain entrance. Call the utility and ask them to lift or raise the lines or deenergize (turn off) the power.
- Before raising the drill rig mast (derrick) on a site in the vicinity of power lines, walk completely around the drill rig. Determine the minimum horizontal distance from any point on the drill rig

raised. If this horizontal distance is less than 100 ft. (30 m), first consult the local utility company and refer to OSHA REG 29 CFM 1910.180 before commencing operations.

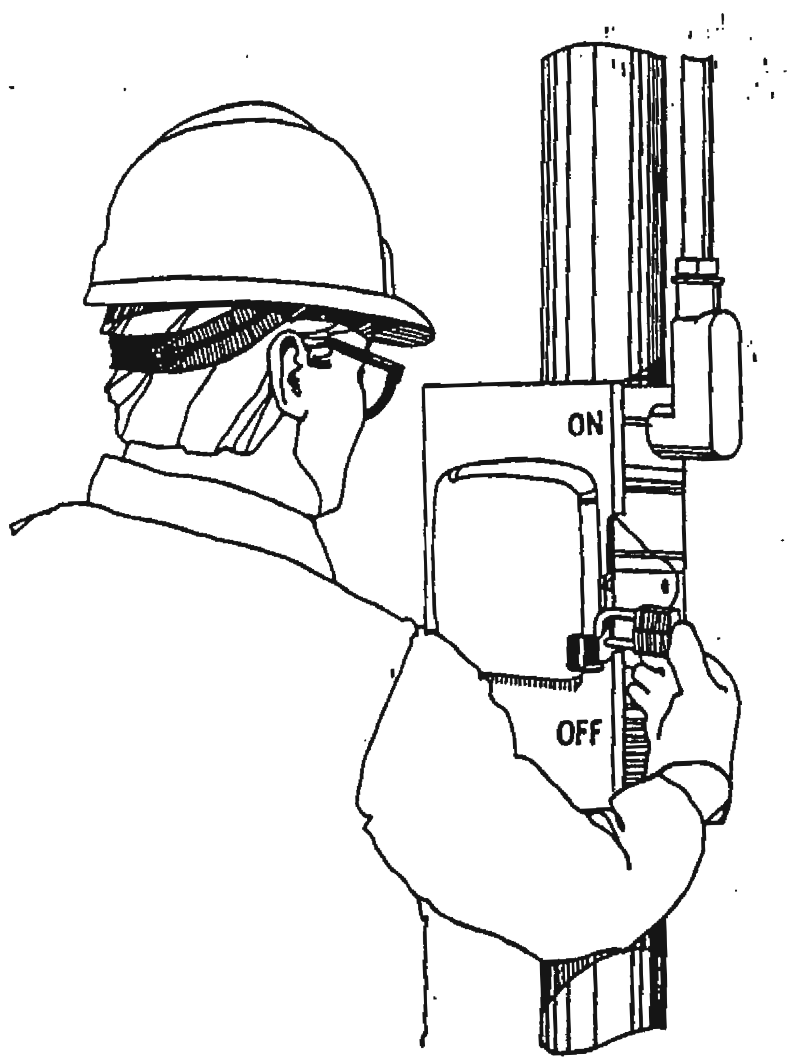
- Keep in mind that both hoist lines and overhead power lines can be moved toward each other by the wind.
- In order to avoid contact with power lines, only move the drill rig with the mast (derrick) down.
- If there are any questions concerning the safety of drilling on sites in the vicinity of overhead power lines, call the power company. The power company will provide expert advice at the drilling site as a public service and at no cost.

Electricity is as dangerous underground as overhead. Be aware of and always suspect the existence of underground utilities such as electrical power, gas, petroleum, telephone, sewer and water:

- If a sign warning of underground utilities is located on a site boundary, do not assume that underground utilities are located on or near the boundary or property line under the sign. Call the utility and check it out. The underground utilities may be a considerable distance away from the warning sign.
- Always contact the owners of utility lines or the nearest underground utility location service before drilling. Determine jointly with utility personnel the precise location of underground utility lines, mark and flag the locations, and determine jointly with utility personnel what specific precautions must be taken to ensure safety.

12. Supplying Power to the Job Site

Drilling projects sometimes require around-the-clock operations and, therefore, require temporary electrical lighting. In general, all wiring and fixtures used to provide electricity for drilling operations should be installed by qualified personnel in accordance with the National Electrical Code (NFPA70-1984) with consideration of the American Petroleum Institute's recommended practices for electrical installations for production facilities (API-RP-500B). Lights should be installed and positioned so that the work area and operating positions are well



- Before working on an electrical power or lighting system, lock-out the main panel box with your own lock and keep the key on your person at all times.
- Install all wiring using high quality connections, fixtures and wire. Be sure that the wiring is insulated and protected with consideration for the drilling environment. Do not use makeshift

- Place all lights positioned directly above working areas in cages or similar enclosures to prevent loose or detached lamps or vaportight enclosures from falling on workers.
- Install lights so as to eliminate glare or "blind spots" on tools, ladders, walkways, platforms, and the complete working area.
- Locate and guard electrical cables to prevent damage by drilling operations or by the movement of personnel, tools, or supplies.
- Use only three-prong, U-blade, grounded type plug receptacles and have adequate current carrying capacity for the electrical tools that may be used.
- Use only electrical tools that have three-prong, U-blade, ground wire plugs and cords.
- Do not use electrical tools with lock-on devices.
- Provide adequate grounding for all electrical welders, generators, control panels, and similar devices.
- Provide secure protective enclosures on control panels, fuse boxes, transformers, and similar equipment.
- Avoid attaching electrical lighting cables to the derrick or other components of the drill rig. If this must be done, use only approved fasteners. Do not "string" wire through the derrick.
- Do not use poles used to hold wiring and lights for any other purpose.
- Turn power off before changing fuses or light bulbs.
- Require all workers in a drilling area illuminated with electrical lighting to wear safety head gear that protects the worker's head, not only against falling or flying objects, but also against limited electrical shock and burns according to ANSI Z89.1 and Z89.2.
- Allow only trained, designated personnel to operate electrical equipment.
- Do not permit unqualified field personnel to work on or near electric lines or devices.

13. Contact with Electricity

If a drill rig makes contact with electrical wires, it may or may not be insulated from the ground by the tires of the carrier. Under either circumstance, if the human body simultaneously rig carrier makes contact with overhead or underground electrical lines:

- Under most circumstances the operator and other personnel on the seat of the vehicle should remain seated and not leave the vehicle. They should not move or touch any part, particularly a metallic part, of the vehicle or the drill rig.
- If it is determined that the drill rig should be vacated, all personnel must jump clear and as far as possible from the drill. Personnel must not step off — but must jump off. Do not hang on to the vehicle or any part of the drill when jumping clear.
- If you are on the ground, stay away from the vehicle and the drill rig; do not allow others to get near the vehicle and the drill rig. Seek assistance immediately from local emergency personnel such as the police or a fire department.
- When an individual is injured and in contact with the drill rig or with power lines, attempt rescue with extreme caution. If a rescue is attempted, use a long, dry, unpainted piece of wood or a long, dry, clean rope. Keep as far away from the victim as possible and do not touch the victim until the victim is completely clear of the drill rig or electrical lines.
- Do not attempt to administer first aid unless the victim is completely clear of the electrical source. Begin cardiopulmonary resuscitation (CPR) immediately if a heart beat (pulse) cannot be detected.

14. Wire Line Hoists, Wire Rope, and Hoisting Hardware

Use wire line hoists, wire rope, and hoisting hardware only as stipulated by the American Iron and Steel Institute *Wire Rope Users Manual.*

- Visually inspect all wire ropes and fittings during use and thoroughly inspect them at least once a week for abrasion, broken wires, wear, reduction in rope diameter, reduction in wire diameter, fatigue, corrosion, damage from heat, improper reeving, jamming, crushing, bird caging, kinking, core protrusion, and/or damage to lifting hardware. Replace wire ropes when inspection indicates excessive damage, as described in the *Wire Rope Users Manual.*

for a period of a month or more.

- Install all connections and end fittings, which consist of spliced eyes and various manufactured devices, according to the manufacturer's specifications. Do not exceed ratings specified by manufacturer.
- If a ball-bearing type hoisting swivel is used to hoist drill rods, inspect and lubricate swivel bearing daily to assure that the swivel freely rotates under load.
- If a rod slipping device is used to hoist drill rods, do not drill through or rotate drill rods through the slipping device; do not hoist more than 1 ft. (0.3 m) of the drill rod column above the top of the mast (derrick); do not hoist a rod column with loose tool joints; and do not make, tighten, or loosen tool joints while the rod column is being supported by a rod slipping device. If drill rods should slip back into the borehole, do not attempt to break the fall of the rods by hand or by tensioning the slipping device.
- Most sheaves on exploration drill rigs are stationary with a single part line. Never increase the number of parts of line without first consulting with the manufacturer of the drill rig.
- Wire ropes must be properly matched with each sheave. If the rope is too large, the sheave will pinch the wire rope. If the rope is too small, it will groove the sheave. Once the sheave is grooved, it will severely pinch and damage larger-sized wire ropes.

The following procedures and precautions must be understood and implemented for use of wire ropes and rigging hardware:

- Use tool handling hoists only for vertical lifting of tools (except when angle hole drilling). Do not use tool handling hoists to pull on objects away from the drill rig; however, drills may be moved using the main hoist of the drill if the wire rope is spooled through proper sheaves according to the manufacturer's recommendations.
- When stuck tools or similar loads cannot be raised with a hoist, disconnect the hoist line and connect the stuck tools directly to the feed mechanism of the drill. Do not use hydraulic leveling jacks for added pull to the hoist line or to the feed mechanism of the drill.

carrier, only use a winch on the front or rear of the vehicle and stay as far as possible away from the wire rope. Do not attempt to use tool hoists to pull out a mired down vehicle or drill rig carrier.

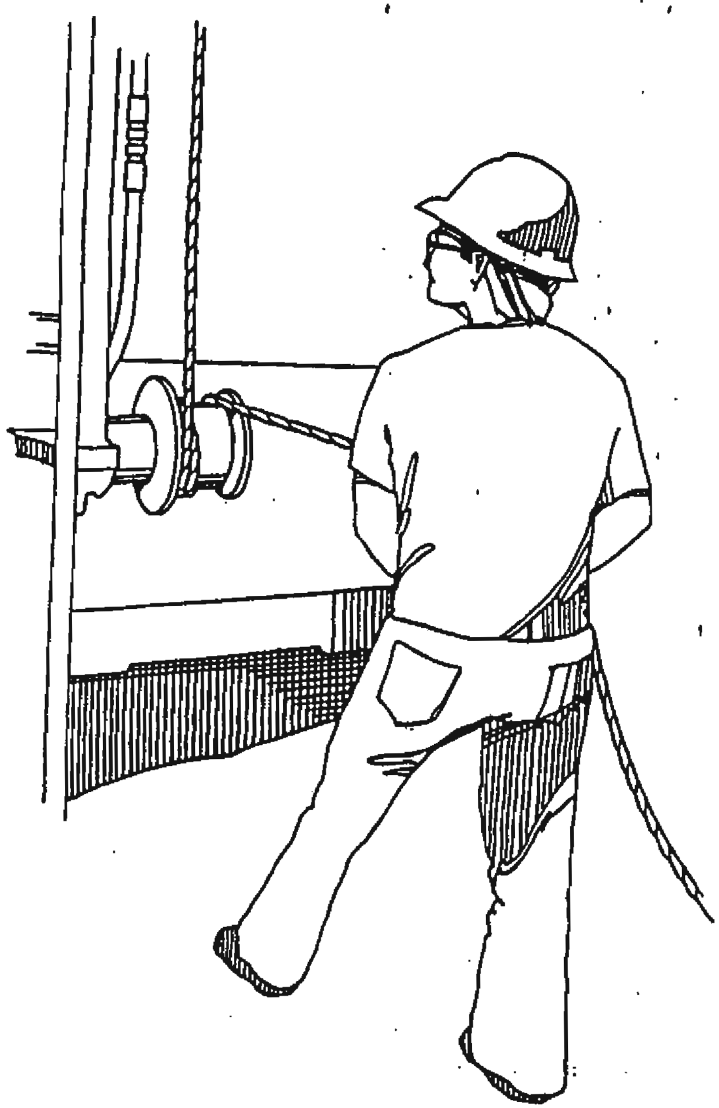
- Apply loads smoothly and steadily to minimize shock loading of a wire rope.
- Avoid sudden loading in cold weather.
- Never use frozen ropes.
- Protect wire rope from sharp corners or edges.
- Replace faulty guides and rollers.
- Replace worn sheaves or worn sheave bearings.
- Replace damaged latches on hooks before using.
- Know the working load of the equipment and tackle being used. Never exceed this limit.
- Periodically inspect and test hoist clutches and brakes.
- Know and do not exceed the rated capacity of mast hooks, rings, links, swivels, shackles, and other lifting aids.
- Always wear gloves when handling wire ropes.
- Do not use hands to guide wire rope on hoist drums.
- Following the installation of a new wire rope, first lift a light load to allow the wire rope to adjust.
- Never conduct any hoisting operations when the weather conditions are such that hazards to personnel, the public, or property are created.
- Never leave a load suspended in the air when the hoist is unattended.
- Keep hands away from hoists, wire rope, hoisting hooks, sheaves, and pinch points while slack is being taken up or when the load is being hoisted.
- Never hoist the load over the head, body, or feet of any personnel.
- Never use a hoist line to "ride" up the mast (derrick) of a drill rig.
- Use replacement wire ropes that conform to the drill rig manufacturer's specifications.

15. Cathead and Rope Holsts

Follow these procedures when using a cathead hoist:

- Keep the cathead clean and free ... should be removed from the cathead with a wire brush having a handle.
- Check the cathead periodically, when the engine is not running, for rope wear grooves. If a rope groove forms to a depth greater than 1/8 in. (3 mm), replace the cathead.
- Always use a clean, dry, sound rope. A wet or oily rope may "grab" the cathead and cause drill tools or other items to be rapidly hoisted to the top of the mast.
- Should the rope "grab" the cathead or otherwise become tangled in the drum, release the rope and sound an appropriate alarm for all personnel, including the operator, to rapidly back away and stay clear. If the rope "grabs" the cathead, and tools are hoisted to the sheaves at the top of the mast, the rope will often break, releasing the tools. If the rope does not break, stay clear of the drill rig until the operator cautiously returns to turn off the drill rig engine and appropriate action is taken to release the tools. Keep careful watch on the suspended tools and quickly back away after turning off the engine.
- Always protect the rope from contact with chemicals. Chemicals can cause deterioration of the rope that may not be detected visibly.
- Never wrap the rope from the cathead (or any other rope, wire rope, or cable on the drill rig) around a hand, wrist, arm, foot, ankle, legs, or any other part of the body.
- Always maintain a minimum of 18 inches of clearance between the operating hand and the cathead drum when driving samplers, casing, or other tools with the cathead and rope method. Be aware that the rope advances toward the cathead with each hammer blow as the sampler or other drilling tool advances into the ground.
- Never operate a cathead (or perform any other task around a drill rig) with loose, unbuttoned, or otherwise unfastened clothing or when wearing gloves with large cuffs or loose straps or lacings.
- Do not use a rope that is any longer than necessary. A rope that is too long can form a ground loop or otherwise become entangled with the operator's legs.
- Do not use more rope wraps than are required to hoist a load.

- Position all other hoist lines to prevent contact with the operating cathead rope.



- When using the cathead and rope for driving or back-driving, make sure that all threaded connections are tight and stay as far away as possible from the hammer impact point.

good, firm footing conditions without distraction or disturbance.

16. Augers

Follow these general procedures when starting a boring with continuous flight or hollow-stem augers:

- Start an auger boring with the drill rig level, the clutch or hydraulic rotation control disengaged, the transmission in low gear, and the engine running at low RPM.
- Apply an adequate amount of down pressure prior to rotation to seat the auger head below the ground surface.
- Look at the auger head while slowly engaging the clutch or rotation control and starting rotation. Stay clear of the auger.
- Slowly rotate the auger and auger head while continuing to apply down pressure. Keep one hand on the clutch or on the rotation control at all times until the auger has penetrated about one foot or more below ground surface.
- If the auger head slides out of alignment, disengage the clutch or hydraulic rotation control and repeat the hole starting process.
- An auger guide can facilitate the starting of a straight hole through hard ground or a pavement.

Establish a system of responsibility for the operator and tool handler to follow during the series of various activities required for auger drilling, such as connecting and disconnecting auger sections, and inserting and removing the auger fork. The operator must ensure that the tool handler is well away from the auger column and that the auger fork is removed before starting rotation. In addition:

- When rotating augers, stay clear of the rotating auger and other rotating components of the drill rig. Never reach behind or around a rotating auger for any reason whatever.
- Only use the manufacturer's recommended method of securing the auger to the power coupling. Do not use an over-length pin or bolt. Do not touch the coupling or the auger with hands, a wrench, or any other tools during rotation.
- Whenever possible, use tool hoists to handle auger sections.
- Never place hands or fingers under the bottom of an auger

form.

- Never allow feet to get under the auger section that is being hoisted.
- Use a long-handed shovel to move auger cuttings away from the auger. Never use hands or feet to move cuttings away from the auger.
- Do not attempt to remove earth from rotating augers. Clean augers only when the drill rig is in neutral and the augers are stopped from rotating.

17. Rotary and Core Drilling

Check rotary drilling tools prior to drilling:

- Lubricate and check for frozen bearings before using water/air swivels and hoisting plugs. Water/air swivel bearings must be free before using, and stay clear of water/air swivel hose when rotating.
- Check drill rod chuck jaws periodically and replace when necessary.
- Check the capacities of hoists and sheaves against the anticipated weight to the drill rod string plus other expected hoisting loads.

During rotary or core drilling, follow these special precautions that involve chucking, joint break, hoisting, and lowering of drill rods:

- Only the operator of the drill rig should be allowed to brake or set a manual chuck so that rotation of the chuck will not occur prior to removing the wrench from the chuck.
- Drill rods should not be braked during lowering into the hole with drill rod chuck jaws.
- Do not lower drill rods into the hole with pipe wrenches.
- If a string of drill rods is accidentally or inadvertently released into the hole, do not attempt to grab the falling rods by hand or with a wrench.
- In the event of a plugged bit or other circulation blockage, relieve the high pressure in the piping and hose between the pump and the obstruction before breaking the first tool joint.

with a wiper made of rubber or other suitable material. Do not use hands to clean drilling fluid from drill rods.

- If work must progress above a portable drilling fluid (mud) pit, do not attempt to stand on narrow sides or cross members. Equip the mud pit with rough surfaced, fitted cover panels of adequate strength to hold drill rig personnel.
- Do not lift or lean unsecured drill rods against the mast. Either provide some method of securing the upper ends of the drill rod sections for safe vertical storage or lay the rods down.

18. Transporting a Drill Rig

When transporting a drill rig on and off a drilling site:

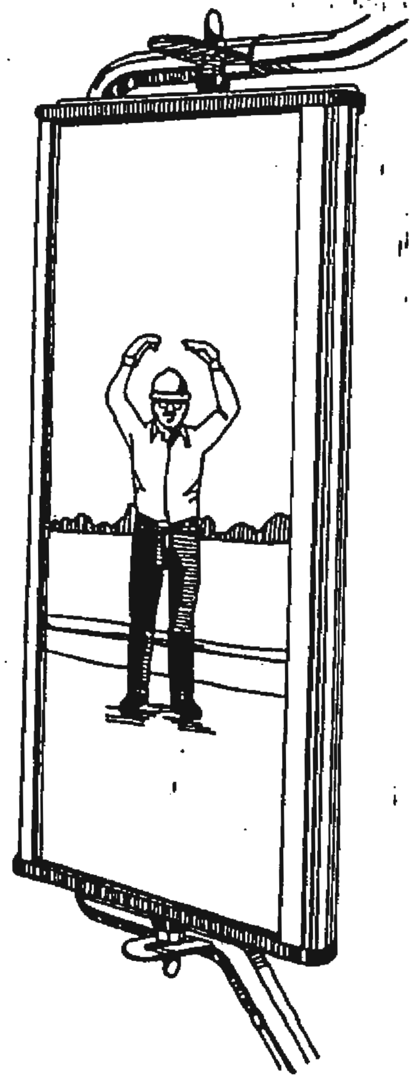
- Allow only licensed individuals to operate the vehicle. Comply with all federal, state, and local regulations.
- Know the traveling height (overhead clearance), width, length, and weight of the drill rig with carrier and know the highway and bridge load, width, and overhead limits. Allow adequate margins and make sure that they are not exceeded.
- Never move a drill rig unless the vehicle brakes are in sound working order.
- Allow for mast overhang when cornering or approaching other vehicles or structures.
- Be aware that the canopies of service stations and motels are often too low for a drill rig mast to clear with the mast in the travel position.
- Watch for low hanging electrical lines, particularly at the entrances to drilling sites, restaurants, motels, or other commercial sites.
- Never travel on a street, road, or highway with the mast (derrick) of the drill rig in the raised or partially raised position.
- Remove all ignition keys when a drill rig is left unattended.

19. Loading and Unloading

When loading or unloading a drill rig on a trailer or a truck:

- Use ramps of adequate design that are solid and substantial enough to bear the weight of the drill rig with carrier —

• Load and unload on level ground.
• Use the assistance of someone on the ground as a guide.
• Check the brakes on the drill rig carrier before approaching loading ramps.



• Distribute the weight on the drill rig, carrier, and tools on the trailer so that the center of weight is approximately on the center-line of the trailer and so that some of the trailer load is transferred to the hitch of the pulling vehicle. Refer to the trailer manufacturer's weight distribution recommendations.
• Secure the drill rig and tools to the hauling vehicle with ties, chains, and/or load binders of adequate capacity.

20. Off-Road Movement

Follow these procedures during off-road movement:
• Before moving a drill rig, first walk the route of travel, inspecting for depressions, stumps, gulleys, ruts, and similar obstacles.
• Always check the brakes of a drill rig carrier before traveling, particularly on rough, uneven, or hilly ground.
• Check the complete drive train of a carrier at least weekly for loose or damaged bolts, nuts, studs, shafts, and mountings.
• Discharge all passengers before moving a drill rig on rough or hilly terrain.
• Engage the front axle (for 4 x 4, 6 x 6, etc. vehicles or carriers) when traveling off highway on hilly terrain.
• Use caution when traveling side-hill. Conservatively evaluate side-hill capability of drill rigs because the arbitrary addition of drilling tools may raise the center of mass. When possible, travel directly uphill or downhill. Increase tire pressures before traveling in hilly terrain (do not exceed rated tire pressure).
• Attempt to cross obstacles such as small logs and small erosion channels or ditches squarely rather than at an angle.
• Use the assistance of someone on the ground as a guide when lateral or overhead clearance is close.
• Set all brakes and/or locks after the drill has been moved to a new drilling site. When grades are present, block the wheels.
• Never travel off-road with the mast (derrick) of the drill rig in the raised or partially raised position.

21. Tires, Batteries, and Fuel

Check tires on the drill daily for safety and, during extended travel, for loss of air. Maintain air pressures for travel on streets, roads, and highways according to the manufacturer's recommendations. Only repair truck and off-highway tires with the required special tools and follow the recommendations of a tire manufacturer's repair manual.

pressure for movement on soft ground, reinflate the tires to normal pressures before movement on firm or hilly ground or on streets, roads, and highways. Underinflated tires are not stable on firm ground.

During air pressure checks, inspect for:

- Missing or loose wheel lugs.
- Objects wedged between duals or embedded in the tire casing.
- Damaged or poorly fitting rims or rim flanges.
- Abnormal or uneven wear and cuts, breaks, or tears in the casing.

Batteries contain strong acid. Use extreme caution when servicing batteries.

- Service batteries only in a ventilated area and while wearing safety glasses.
- When a battery is removed from a vehicle or service unit, disconnect the battery ground clamp first.
- When installing a battery, connect the battery ground clamp last.
- When charging a battery with a battery charger, turn off the power source to the battery before either connecting or disconnecting charger leads to the battery posts. Loosen cell caps before charging to permit the escape of gas.
- Spilled battery acid can burn skin and should be immediately flushed with lots of water. If battery acid gets into someone's eyes, flush immediately with large amounts of water and see a medical physician at once.
- To avoid battery explosions, keep the cells filled with electrolyte, use a flashlight (not an open flame) to check electrolyte levels and avoid creating sparks around the battery by shorting across a battery terminal. Keep lighted or smoking materials and flames away from batteries.

Take special precautions for handling fuel and refueling the drill rig or carrier.

- Only use the type and quality of fuel recommended by the engine manufacturer.
- Refuel in a well-ventilated area.

electrical switches.

- Do not spill fuel on hot surfaces. Clean any spills before starting an engine.
- Wipe up spilled fuel with cotton rags or cloths; do not use wool or metallic cloth.
- Keep open lights, lighted smoking materials, flames, or sparking equipment well away from the fueling area.
- Turn off heaters in carrier cabs when refueling the carrier or the drill rig.
- Do not fill portable fuel containers completely full to allow expansion of the fuel during temperature changes.
- Keep the fuel nozzle in contact with the tank being filled to prevent static sparks from igniting the fuel.
- Do not transport portable fuel containers in the vehicle or carrier cab with personnel.
- During travel store fuel containers and hoses so they are in contact with a metal surface. This should prevent the buildup of static charge.

22. First Aid

Train at least one member of the drill crew, and if only one, preferably the drilling and safety supervisor, to perform first aid. First aid must be taught on a person-to-person basis, not by providing or reading a manual. Manuals should only provide continuing reminders and be used for reference. Courses provided or sponsored by the American Red Cross or a similar organization best satisfy the requirements of first aid training for drill crews.

For drilling operations it is particularly important that those responsible for first aid should be able to recognize the symptoms of and be able to provide first aid for electrical shock, heart attack, stroke, broken bones, eye injury, snake bite, and cuts or abrasions to the skin. Again, first aid for these situations is best taught to drill crew members by instructors qualified by an agency such as the American Red Cross.

23. Drill Rig Utilization

Do not attempt to exceed manufacturers' ratings of speed, force, torque, pressure, flow, etc. Only use the drill rig and tools for the purposes for which they are intended and designed.

24. Drill Rig Alterations

Alterations to a drill rig or drilling tools must only be made by qualified personnel and only after consultation with the manufacturer.

APPENDIX H

MSDs FOR CHEMICALS BROUGHT ON-SITE

J. T. Baker Chemical Co.
222 Red School Lane Phillipsburg N J 08865
24 Hour Emergency Telephone (201) 859-2151
Chemtrec # (800) 424-9300
National Response Center # (800) 424-8802

MATERIAL SAFETY DATA SHEET

SECTION I - PRODUCT IDENTIFICATION

Product Name:	Methanol
Formula:	CH_3OH
Formula Wt:	32.04
CAS No.:	00067-56-1
NIOSH/RTECS No.:	PC1400000
Common Synonyms:	Methyl Alcohol; Wood Alcohol; Carbinol; Methylol; Wood Spirit
Product Codes:	9049,9072,9075,9076,9071,5217,5370,9074,P704,9093,5536,9068 9073,9091,9263,9069,9070

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA™ System

Laboratory Protective Equipment

Precautionary Label Statements

POISON! DANGER!
FLAMMABLE
HARMFUL IF INHALED
CANNOT BE MADE NON-POISONOUS
MAY BE FATAL OR CAUSE BLINDNESS IF SWALLOWED

Keep away from heat, sparks, flame. Do not get in eyes, on skin, on clothing. Avoid breathing vapor. Keep in tightly closed container. Use with adequate ventilation. Wash thoroughly after handling. In case of fire, use alcohol foam, dry chemical, carbon dioxide - water may be ineffective. Flush spill area with water spray.

SECTION II - HAZARDOUS COMPONENTS

Component	%	CAS No.

Continued on Page: 2

0001

SECTION II - HAZARDOUS COMPONENTS (Continued)

Methanol	90-100	67-56-1

SECTION III - PHYSICAL DATA

Boiling Point: 65°C (149°F) Vapor Pressure(mmHg): 96

Melting Point: -98°C (-144°F) Vapor Density(air=1): 1.11

Specific Gravity: 0.79 (H_2O=1) Evaporation Rate: 4.6 (Butyl Acetate=1)

Solubility(H_2O): Complete (in all proportions) % Volatiles by Volume: 100

Appearance & Odor: Clear, colorless liquid with characteristic pungent odor.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point (Closed Cup): 12°C (54°F) NFPA 704M Rating: 1-3-0

Flammable Limits: Upper - 36.0 % Lower - 6.0 %

Fire Extinguishing Media
Use alcohol foam, dry chemical or carbon dioxide.
(Water may be ineffective.)

Special Fire-Fighting Procedures
Firefighters should wear proper protective equipment and self-contained breathing apparatus with full facepiece operated in positive pressure mode. Move containers from fire area if it can be done without risk. Use water to keep fire-exposed containers cool.

Unusual Fire & Explosion Hazards
Vapors may flow along surfaces to distant ignition sources and flash back. Closed containers exposed to heat may explode. Contact with strong oxidizers may cause fire.
Burns with a clear, almost invisible flame.

Toxic Gases Produced
carbon monoxide, carbon dioxide, formaldehyde

SECTION V - HEALTH HAZARD DATA

TLV listed denotes (TLV-skin).

Threshold Limit Value (TLV/TWA): 260 mg/m^3 (200 ppm)

Short-Term Exposure Limit (STEL): 310 mg/m^3 (250 ppm)

Continued on Page: 3

SECTION V - HEALTH HAZARD DATA (Continued)

Permissible Exposure Limit (PEL): 260 mg/m^3 (200 ppm)

Toxicity:	LD_{50} (oral-rat)(mg/kg)	-	5628
	LD_{50} (ipr-rat)(mg/kg)	-	9540
	LD_{50} (scu-mouse)(mg/kg)	-	9800
	LD_{50} (skn-rabbit) (g/kg)	-	20

Carcinogenicity: NTP: No IARC: No Z List: No OSHA reg: No

Effects of Overexposure

Inhalation and ingestion are harmful and may be fatal.
Inhalation may cause headache, nausea, vomiting, dizziness, narcosis, suffocation, lower blood pressure, central nervous system depression.
Liquid may be irritating to skin and eyes. Prolonged skin contact may result in dermatitis. Eye contact may result in temporary corneal damage.
Ingestion may cause blindness.
Ingestion may cause nausea, vomiting, headaches, dizziness, gastrointestinal irritation.
Chronic effects of overexposure may include kidney and/or liver damage.

Medical Conditions Generally Aggravated By Exposure

None Identified

Routes Of Entry

inhalation, ingestion, eye contact, skin contact

Emergency and First Aid Procedures

CALL A PHYSICIAN.
If swallowed, if conscious, immediately induce vomiting.
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Wash clothing before re-use.

SECTION VI - REACTIVITY DATA

Stability: Stable Hazardous Polymerization: Will not occur

Conditions to Avoid: heat, flame, other sources of ignition

Incompatibles: strong oxidizing agents, strong acids, aluminum

Decomposition Products: carbon monoxide, carbon dioxide, formaldehyde

Continued on Page: 4

SECTION VII - SPILL AND DISPOSAL PROCEDURES

Steps to be taken in the event of a spill or discharge

Wear self-contained breathing apparatus and full protective clothing. Shut off ignition sources; no flares, smoking or flames in area. Stop leak if you can do so without risk. Use water spray to reduce vapors. Take up with sand or other non-combustible absorbent material and place into container for later disposal. Flush area with water.

J. T. Baker Solusorb® solvent adsorbent is recommended for spills of this product.

Disposal Procedure

Dispose in accordance with all applicable federal, state, and local environmental regulations.

EPA Hazardous Waste Number: U154 (Toxic Waste)

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

Ventilation:	Use general or local exhaust ventilation to meet TLV requirements.
Respiratory Protection:	Respiratory protection required if airborne concentration exceeds TLV. At concentrations above 200 ppm, a self-contained breathing apparatus is advised.
Eye/Skin Protection:	Safety goggles and face shield, uniform, protective suit, rubber gloves are recommended.

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA™ Storage Color Code: Red

Special Precautions

Bond and ground containers when transferring liquid. Keep container tightly closed. Store in a cool, dry, well-ventilated, flammable liquid storage area.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

Proper Shipping Name	Methanol
Hazard Class	Flammable liquid
UN/NA	UN1230
Labels	FLAMMABLE LIQUID
Reportable Quantity	5000 LBS.

Continued on Page: 5

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION (Continued)

INTERNATIONAL (I.M.O.)

Proper Shipping Name	Methanol
Hazard Class	3.2, 6.1
UN/NA	UN1230
Labels	FLAMMABLE LIQUID, POISON

N/A = Not Applicable or Not Available

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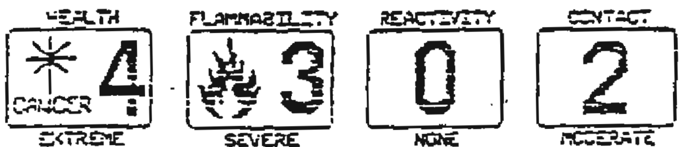
H2379 -04 Hexanes Page: 1
Effective: 09/26/86 Issued: 12/17/86

SECTION I - PRODUCT IDENTIFICATION

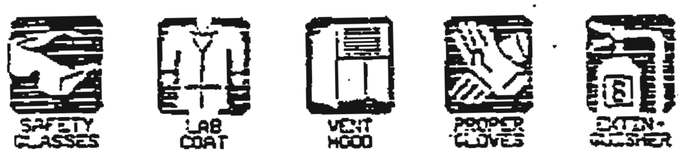
Product Name:	Hexanes
Formula:	C_6H_{14}
Formula Wt:	86.18
CAS No.:	00110-54-3
NIOSH/RTECS No.:	MN9275000
Common Synonyms:	Normal Hexane; Hexyl Hydride
Product Codes:	9262,9306,N169,9309,9308

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA™ System



Laboratory Protective Equipment



Precautionary Label Statements

DANGER!
CAUSES IRRITATION
EXTREMELY FLAMMABLE
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN
CAUTION: CONTAINS BENZENE, CANCER HAZARD

Keep away from heat, sparks, flame.
Do not breathe vapor. Keep in tightly closed container. Use with adequate ventilation. Wash thoroughly after handling. In case of fire, use alcohol foam, dry chemical, carbon dioxide - water may be ineffective.
Flush spill area with water spray.

SECTION II - HAZARDOUS COMPONENTS

Component	%	CAS No.
n - Hexane	>70	110-54-3
Methylpentanes	>17	

Continued on Page: 2

SECTION II - HAZARDOUS COMPONENTS (Continued)

Methylcyclopentane	>12	96-37-7
Diethylbutanes	>1	
Benzene	65ppm	71-43-2

SECTION III - PHYSICAL DATA

Boiling Point: 69°C (156°F) Vapor Pressure(mmHg): 124

Melting Point: -95°C (-139°F) Vapor Density(air=1): 3.0

Specific Gravity: 0.66 (H_2O=1) Evaporation Rate: 9 (Butyl Acetate=1)

Solubility(H_2O): Negligible (less than 0.1 %) % Volatiles by Volume: 100

Appearance & Odor: Colorless liquid with mild odor.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point (Closed Cup): -22°C (-7°F) NFPA 704M Rating: 1-3-0

Flammable Limits: Upper - 7.5 % Lower - 1.1 %

Fire Extinguishing Media

Use alcohol foam, dry chemical or carbon dioxide. (Water may be ineffective.)

Special Fire-Fighting Procedures

Firefighters should wear proper protective equipment and self-contained (positive pressure if available) breathing apparatus with full facepiece. Move exposed containers from fire area if it can be done without risk. Use water to keep fire-exposed containers cool.

Unusual Fire & Explosion Hazards

Vapors may flow along surfaces to distant ignition sources and flash back. Closed containers exposed to heat may explode. Contact with strong oxidizers may cause fire.

Toxic Gases Produced

carbon monoxide, carbon dioxide

SECTION V - HEALTH HAZARD DATA

Blood changes have been reported in laboratory animals. Fetal death has been reported in laboratory animals but not found in two additional studies.

Threshold Limit Value (TLV/TWA): 180 mg/m^3 (50 ppm)

Continued on Page: 3

SECTION V - HEALTH HAZARD DATA (Continued)

Permissible Exposure Limit (PEL): 1800 mg/m^3 (500 ppm)

Toxicity: LD_{50} (oral-rat)(g/kg) - 28.7

Carcinogenicity: NTP: No IARC: No Z List: No OSHA reg: No

Effects of Overexposure

Inhalation of vapors may cause headache, nausea, vomiting, dizziness, drowsiness, irritation of respiratory tract, and loss of consciousness.
Inhalation of vapors may cause narcosis.
Contact with skin or eyes may cause irritation.
Contact with skin has a defatting effect, causing drying and irritation.
Ingestion may cause nausea, vomiting, headaches, dizziness, gastrointestinal irritation.
Chronic effects of overexposure may include central nervous system depression.

Medical Conditions Generally Aggravated By Exposure

None Identified

Routes Of Entry

inhalation, ingestion, eye contact, skin contact

Emergency and First Aid Procedures

CALL A PHYSICIAN.
If swallowed, do NOT induce vomiting.
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes.

This product contains up to 65 ppm of Benzene.

SECTION VI - REACTIVITY DATA

Stability: Stable Hazardous Polymerization: Will not occur

Conditions to Avoid: heat, flame, other sources of ignition

Incompatibles: strong oxidizing agents, chlorine, fluorine, magnesium perchlorate

Decomposition Products: carbon monoxide, carbon dioxide

SECTION VII - SPILL AND DISPOSAL PROCEDURES

Continued on Page: 4

SECTION VII - SPILL AND DISPOSAL PROCEDURES (Continued)

Steps to be taken in the event of a spill or discharge

Wear suitable protective clothing. Shut off ignition sources; no flares, smoking, or flames in area. Stop leak if you can do so without risk. Use water spray to reduce vapors. Take up with sand or other non-combustible absorbent material and place into container for later disposal. Flush area with water.

J. T. Baker Solusorb[R] solvent adsorbent is recommended for spills of this product.

Disposal Procedure

Dispose in accordance with all applicable federal, state, and local environmental regulations.

EPA Hazardous Waste Number: D001 (Ignitable Waste)

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

Ventilation:	Use general or local exhaust ventilation to meet TLV requirements.
Respiratory Protection:	Respiratory protection required if airborne concentration exceeds TLV. At concentrations up to 1000 ppm, a chemical cartridge respirator with organic vapor cartridge is recommended. Above this level, a self-contained breathing apparatus is recommended.
Eye/Skin Protection:	Safety goggles, uniform, apron, neoprene gloves are recommended.

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA[TM] Storage Color Code: Red

Special Precautions

Bond and ground containers when transferring liquid. Keep container tightly closed. Store in a cool, dry, well-ventilated, flammable liquid storage area.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

Proper Shipping Name	Hexane
Hazard Class	Flammable liquid
UN/NA	UN1208
Labels	FLAMMABLE LIQUID

Continued on Page: 5

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION (Continued)

INTERNATIONAL (I.M.O.)

Proper Shipping Name	Hexanes
Hazard Class	3.1
UN/NA	UN1208
Labels	FLAMMABLE LIQUID

N/A = Not Applicable or Not Available

The information published in this Material Safety Data Sheet has been compiled from our experience and data presented in various technical publications. It is the user's responsibility to determine the suitability of this information for the adoption of necessary safety precautions. We reserve the right to revise Material Safety Data Sheets periodically as new information becomes available.

-- LAST PAGE --

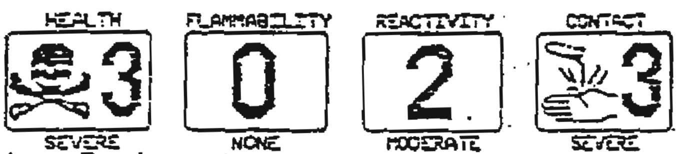
H3880 -02 Hydrochloric Acid Page: 1
Effective: 08/07/86 Issued: 12/17/86

SECTION I - PRODUCT IDENTIFICATION

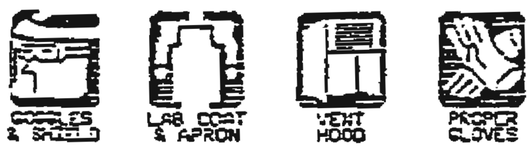
Product Name: Hydrochloric Acid
Formula: HCl
Formula Wt: 36.46
CAS No.: 7647-01-0
NIOSH/RTECS No.: MW4025000
Common Synonyms: Muriatic Acid; Chlorohydric Acid; Hydrochloride
Product Codes: 9543,9539,9535,5367,9534,9544,9529,9542,4800,9549,9530,9548 9540,9547,9546,9537

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA™ System



Laboratory Protective Equipment



Precautionary Label Statements

POISON! DANGER!
CAUSES SEVERE BURNS
MAY BE FATAL IF SWALLOWED OR INHALED

Do not get in eyes, on skin, on clothing.
Do not breathe vapor. Causes damage to Respiratory system (lungs), eyes and skin. Keep in tightly closed container. Loosen closure cautiously. Use with adequate ventilation. Wash thoroughly after handling. In case of spill neutralize with soda ash or lime and place in dry container.

SECTION II - HAZARDOUS COMPONENTS

Component	%	CAS No.
Hydrochloric Acid (23° Baume)	35-40	7647-01-0

SECTION III - PHYSICAL DATA

Boiling Point: 110°C (230°F) Vapor Pressure(mmHg): N/A

Continued on Page: 2

SECTION III - PHYSICAL DATA (Continued)

Melting Point: -25°C (-13°F) Vapor Density(air=1): 1.3

Specific Gravity: 1.19 (H_2O=1) Evaporation Rate: N/A (Butyl Acetate=1)

Solubility(H_2O): Complete (in all proportions) % Volatiles by Volume: 100

Appearance & Odor: Clear, colorless or slightly yellow, pungent, fuming liquid.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A NFPA 704M Rating: 3-0-0

Flammable Limits: Upper - N/A % Lower - N/A %

Fire Extinguishing Media
Use extinguishing media appropriate for surrounding fire.

Special Fire-Fighting Procedures
Firefighters should wear proper protective equipment and self-contained breathing apparatus with full facepiece operated in positive pressure mode. Move containers from fire area if it can be done without risk. Use water to keep fire-exposed containers cool.
Do not get water inside containers.

Unusual Fire & Explosion Hazards
May emit hydrogen gas upon contact with metal.

Toxic Gases Produced
hydrogen chloride, hydrogen gas

SECTION V - HEALTH HAZARD DATA

PEL and TLV listed denote ceiling limit.

Threshold Limit Value (TLV/TWA): 7 mg/m^3 (5 ppm)

Permissible Exposure Limit (PEL): 7 mg/m^3 (5 ppm)

Toxicity:	LD_{50} (oral-rabbit)(mg/kg)	- 900
	LD_{50} (ipr-mouse)(mg/kg)	- 40
	LC_{50} (inhl-rat-1H) (ppm)	- 3124

Continued on Page: 3

SECTION III - PHYSICAL DATA (Continued)

Melting Point: -25°C (-13°F)

Vapor Density(air=1): 1.3

Specific Gravity: 1.19 (H_2O=1)

Evaporation Rate: N/A (Butyl Acetate=1)

Solubility(H_2O): Complete (in all proportions)

% Volatiles by Volume: 100

Appearance & Odor: Clear, colorless or slightly yellow, pungent, fuming liquid.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A

NFPA 704M Rating: 3-0-0

Flammable Limits: Upper - N/A % Lower - N/A %

Fire Extinguishing Media

Use extinguishing media appropriate for surrounding fire.

Special Fire-Fighting Procedures

Firefighters should wear proper protective equipment and self-contained breathing apparatus with full facepiece operated in positive pressure mode. Move containers from fire area if it can be done without risk. Use water to keep fire-exposed containers cool.
Do not get water inside containers.

Unusual Fire & Explosion Hazards

May emit hydrogen gas upon contact with metal.

Toxic Gases Produced

hydrogen chloride, hydrogen gas

SECTION V - HEALTH HAZARD DATA

PEL and TLV listed denote ceiling limit.

Threshold Limit Value (TLV/TWA): 7 mg/m^3 (5 ppm)

Permissible Exposure Limit (PEL): 7 mg/m^3 (5 ppm)

Toxicity: LD_{50} (oral-rabbit)(mg/kg) - 900
LD_{50} (ipr-mouse)(mg/kg) - 40
LC_{50} (inhl-rat-1H) (ppm) - 3124

Continued on Page: 3

SECTION V - HEALTH HAZARD DATA (Continued)

Carcinogenicity: NTP: No IARC: No Z List: No OSHA reg: No

Effects of Overexposure

Inhalation of vapors may cause pulmonary edema, circulatory system collapse, damage to upper respiratory system, collapse.
Inhalation of vapors may cause coughing and difficult breathing.
Liquid may cause severe burns to skin and eyes.
Ingestion is harmful and may be fatal.
Ingestion may cause severe burning of mouth and stomach.
Ingestion may cause nausea and vomiting.

Medical Conditions Generally Aggravated By Exposure

None Identified

Routes Of Entry

ingestion, inhalation, skin contact, eye contact

Emergency and First Aid Procedures

CALL A PHYSICIAN.
If swallowed, do NOT induce vomiting; if conscious, give water, milk, or milk of magnesia.
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Wash clothing before re-use.

SECTION VI - REACTIVITY DATA

Stability: Stable Hazardous Polymerization: Will not occur

Conditions to Avoid: heat, moisture

Incompatibles: most common metals, water, amines, metal oxides, acetic anhydride, propiolactone, vinyl acetate, mercuric sulfate, calcium phosphide, formaldehyde, alkalies, carbonates, strong bases, sulfuric acid, chlorosulfonic acid

Decomposition Products: hydrogen chloride, hydrogen, chlorine

SECTION VII - SPILL AND DISPOSAL PROCEDURES

Steps to be taken in the event of a spill or discharge

Wear self-contained breathing apparatus and full protective clothing. Stop leak if you can do so without risk. Ventilate area. Neutralize spill with soda ash or lime. With clean shovel, carefully place material into clean, dry container and cover; remove from area. Flush spill area with water.

Continued on Page: 4

SECTION VII - SPILL AND DISPOSAL PROCEDURES (Continued)

J. T. Baker Neutrasorb[R] or Neutrasol[R] "Low Na+" acid neutralizers are recommended for spills of this product.

Disposal Procedure

Dispose in accordance with all applicable federal, state, and local environmental regulations.

EPA Hazardous Waste Number: D002 (Corrosive Waste)

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

Ventilation:	Use general or local exhaust ventilation to meet TLV requirements.
Respiratory Protection:	Respiratory protection required if airborne concentration exceeds TLV. At concentrations up to 100 ppm, a chemical cartridge respirator with acid cartridge is recommended. Above this level, a self-contained breathing apparatus is advised.
Eye/Skin Protection:	Safety goggles and face shield, uniform, protective suit, acid-resistant gloves are recommended.

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA[TM] Storage Color Code: White

Special Precautions

Keep container tightly closed. Store in corrosion-proof area.
Isolate from incompatible materials.
Do not store near oxidizing materials.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

Proper Shipping Name	Hydrochloric acid
Hazard Class	Corrosive material (liquid)
UN/NA	UN1789
Labels	CORROSIVE
Reportable Quantity	5000 LBS.

INTERNATIONAL (I.M.O.)

Proper Shipping Name	Hydrochloric acid, solution
Hazard Class	8

Continued on Page: 5

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION (Continued)

UN/NA	UN1789
Labels	CORROSIVE

N/A = Not Applicable or Not Available

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J.T.BAKER(R) J.T. BAKER CHEMICAL CO. MATERIA
222 RED SCHOOL LANE PHILLIPSBURG, N.J. 08865 SAFETY DAT
Rc'd 25 Jan 89 24-HOUR EMERGENCY TELEPHONE #(201)859-2151 SHEET

CHEMTREC #(800) 424-9300
NATIONAL RESPONSE CENTER #(800) 424-8802

S4040 -02 SODIUM HYDROXIDE, SOLUTIONS PAGE:
EFFECTIVE: 08/28/86 ISSUED: 09/24/87

SECTION I - PRODUCT IDENTIFICATION

PRODUCT NAME:	SODIUM HYDROXIDE, SOLUTIONS
FORMULA:	NAOH IN H2O
FORMULA WT:	40.00
CAS NO.:	--
NIOSH/RTECS NO.:	WB4900000
COMMON SYNONYMS:	CAUSTIC SODA SOLUTION
PRODUCT CODES:	5635, 5636, 5633, 5634

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA(TM) SYSTEM

HEALTH----------2------MODERATE
FLAMMABILITY-----0------NONE
REACTIVITY-------1------SLIGHT
CONTACT---------3------SEVERE

LABORATORY PROTECTIVE EQUIPMENT
GOGGLES & SHIELD, LAB COAT & APRON, VENT HOOD, PROPER GLOVE

PRECAUTIONARY LABEL STATEMENTS
SODIUM HYDROXIDE 0.1-4 1310-73-2

SECTION III - PHYSICAL DATA

BOILING POINT:	N/A	VAPOR PRESSURE(MMHG):	N/A
MELTING POINT:	N/A	VAPOR DENSITY(AIR=1):	N/A

CONTINUED ON PAGE: 2

SECTION III - PHYSICAL DATA (CONTINUED)

SPECIFIC GRAVITY: N/A EVAPORATION RATE: N/A
(H2O=1) (BUTYL ACETATE=1)
SOLUBILITY(H2O): COMPLETE (IN ALL PROPORTIONS) % VOLATILES BY VOLUME: >95
APPEARANCE & ODOR: COLORLESS, ODORLESS LIQUID.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: N/A NFPA 704M RATING: 3-0-1
FLAMMABLE LIMITS: UPPER - N/A % LOWER - N/A %

FIRE EXTINGUISHING MEDIA
USE EXTINGUISHING MEDIA APPROPRIATE FOR SURROUNDING FIRE.

SPECIAL FIRE-FIGHTING PROCEDURES
FLOOD WITH WATER, DO NOT SPLATTER OR SPLASH THIS MATERIAL.

UNUSUAL FIRE & EXPLOSION HAZARDS
REACTS WITH MOST METALS TO PRODUCE HYDROGEN GAS, WHICH CAN FORM AN

EXPLOSIVE MIXTURE WITH AIR.

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SECTION V - HEALTH HAZARD DATA

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TOXICITY TEST RESULTS AND SAFETY AND HEALTH EFFECTS ARE BASED ON THE SOLUTE.
THRESHOLD LIMIT VALUE <9TLV/TWA): 2 MG/M3 (PPM)
PERMISSIBLE EXPOSURE LIMIT (PEL): 2 MG/M3 (PPM)
TOXICITY: LD50 (IPR-MOUSE) (MG/KG) - 40
CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO
EFFECTS OF OVEREXPOSURE
INHALATION OF VAPORS MAY CAUSE SEVERE IRRITATION OR BURNS OF THE RESPIRATORY SYSTEM, PULMONARY EDEMA, OR LUNG INFLAMMATION.
LIQUID MAY CAUSE BURNS TO SKIN AND EYES.
LIQUID MAY CAUSE PERMANENT EYE DAMAGE.
INGESTION MAY CAUSE SEVERE BURNING OF MOUTH AND STOMACH
INGESTION MAY CAUSE NAUSEA AND VOMITING.
TARGET ORGANS
EYES, SKIN, RESPIRATORY SYSTEM

CONTINUED ON PAGE: 3

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SECTION V - HEALTH HAZARD DATA (CONTINUED)

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE
NONE IDENTIFIED.
ROUTES OF ENTRY
INHALATION, INGESTION, EYE CONTACT, SKIN CONTACT
EMERGENCY AND FIRST AID PROCEDURES
CALL A PHYSICIAN.
IF SWALLOWED, DO NOT INDUCE VOMITING; IF CONSCIOUS, GIVE LARGE AMOUNTS OF WATER. FOLLOW WITH DILUTED VINEGAR, FRUIT JUICE OR WHITES OF EGGS, BEATEN WITH WATER. IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN. IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES. FLUSH SKIN WITH WATER.
TLV LISTED DENOTES CEILING LIMIT.

==

SECTION VI - REACTIVITY DATA

==

STABILITY: STABLE HAZARDOUS POLYMERIZATION: WILL NOT OCCUR
INCOMPATIBLES: STRONG ACIDS, ORGANIC MATERIALS, MOST COMMON METALS, ZINC, ALUMINUM, MAGNESIUM, HALOGENATED HYDROCARBONS

==

SECTION VII - SPILL AND DISPOSAL PROCEDURES

==

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE
WEAR SELF-CONTAINED BREATHING APPARATUS AND FULL PROTECTIVE CLOTHING.
STOP LEAK IF YOU CAN DO SO WITHOUT RISK. VENTILATE AREA. CAREFULLY NEUTRALIZE SPILL WITH DILUTE HCL. FLUSH AREA WITH FLOODING AMOUNTS OF WATER. (USE CAUTION.)
J.T. BAKER NEUTRACIT-2(R) CAUSTIC NEUTRALIZER IS RECOMMENDED FOR SPILLS OF THIS PRODUCT.
DISPOSAL PROCEDURE
DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.
EPA HAZARDOUS WASTE NUMBER: D002 (CORROSIVE WASTE)

CONTINUED ON PAGE: 4

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

VENTILATION	USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET TLV REQUIREMENTS
RESPIRATORY PROTECTION:	RESPIRATORY PROTECTION REQUIRED IF AIRBORNE CONCENTRATION EXCEEDS TLV. AT CONCENTRATIONS UP TO 60 PPM, A HIGH-EFFICIENCY PARTICULATE RESPIRATOR IS RECOMMENDED. ABOVE THIS LEVEL, A SELF-CONTAINED BREATHING APPARATUS IS ADVISED.
EYE/SKIN PROTECTION:	SAFETY GOGGLES AND FACE SHIELD, UNIFORM, PROTECTIVE SUIT, RUBBER GLOVES ARE RECOMMENDED.

ABOVE 1 PPM, A SELF-CONTAINED BREATHING APPARATUS IS ADVISED.

EYE/SKIN PROTECTION: SAFETY GOGGLES AND FACE SHIELD, UNIFORM, PROTECTIVE SUIT, PROPER GLOVES ARE RECOMMENDED.

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA(TM) STORAGE COLOR CODE: WHITE STRIPE

SPECIAL PRECAUTIONS
KEEP CONTAINER TIGHTLY CLOSED. STORE IN CORROSION-PROOF AREA. ISOLATE FROM INCOMPATIBLE MATERIALS.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME	SODIUM HYDROXIDE, SOLUTION
HAZARD CLASS	CORROSIVE MATERIAL (LIQUID)
UN/NA	UN1824
LABELS	CORROSIVE
REPORTABLE QUANTITY	1000 LBS.

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME	SODIUM HYDROXIDE, SOLUTION
HAZARD CLASS	8
UN/NA	UN1824
LABELS	CORROSIVE

N/A = NOT APPLICABLE OR NOT AVAILABLE

THE INFORMATION PUBLISHED IN THIS MATERIAL SAFETY DATA SHEET HAS BEEN COMPILED FROM OUR EXPERIENCE AND DATA PRESENTED IN VARIOUS TECHNICAL PUBLICATIONS. IT IS THE USER'S RESPONSIBILITY TO DETERMINE THE SUITABILITY OF THIS INFORMATION FOR THE ADOPTION OF NECESSARY SAFETY PRECAUTIONS. WE RESERVE THE RIGHT TO REVISE MATERIAL SAFETY DATA SHEETS PERIODICALLY AS NEW INFORMATION BECOMES AVAILABLE. J. T. BAKER MAKES NO WARRANTY OR REPRESENTATION ABOUT THE ACCURACY OR COMPLETENESS NOR FITNESS FOR PURPOSE OF THE INFORMATION CONTAINED HEREIN. COPYRIGHT 1987 J.T. BAKER INC.

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222 Red School Lane Phillipsburg, N.J. 08865
24-Hour Emergency Telephone – (201) 859-2151
Chemtrec # (800) 424-9300
National Response Center # (800) 424-8802

SAFETY DATA SHEET

S8234 -02 Sulfuric Acid
Effective: 09/08/86 Issued: 12/17/86

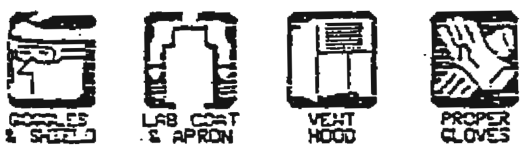
SECTION I - PRODUCT IDENTIFICATION

Product Name: Sulfuric Acid
Formula: H_2SO_4
Formula Wt: 98.08
CAS No.: 07664-93-9
NIOSH/RTECS No.: WS5600000
Common Synonyms: Oil of Vitriol
Product Codes: 5030,9691,9675,5340,9679,9687,9674,9686,9694,9681,9688,9673
5432,5137,9685,4802,9684,9623,5643,9680,5374

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA[TM] System

Laboratory Protective Equipment



Precautionary Label Statements

POISON! DANGER!
HARMFUL IF INHALED
CAUSES SEVERE BURNS
MAY BE FATAL IF SWALLOWED
REACTS VIOLENTLY WITH WATER.

Do not get in eyes, on skin, on clothing.
Do not breathe vapor. Keep in tightly closed container. Loosen closure cautiously. Use with adequate ventilation. Wash thoroughly after handling. In case of spill neutralize with soda ash or lime and place in dry container.

SECTION II - HAZARDOUS COMPONENTS

Component	%	CAS No.
Sulfuric Acid	90-100	7664-93-9

Continued on Page: 2

SECTION III - PHYSICAL DATA

Boiling Point: 327°C (621°F) Vapor Pressure(mmHg): <0.3

Melting Point: -2°C (28°F) Vapor Density(air=1): 3.4

Specific Gravity: 1.84 (H_2O=1) Evaporation Rate: <1 (Butyl Acetate=1)

Solubility(H_2O): Complete (in all proportions) % Volatiles by Volume: N/A

Appearance & Odor: Clear, colorless to light yellow, oily odorless liquid.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A NFPA 704M Rating: 3-0-2 W

Flammable Limits: Upper - N/A % Lower - N/A %

Fire Extinguishing Media
Use dry chemical or carbon dioxide. Do not use water.

Special Fire-Fighting Procedures
Firefighters should wear proper protective equipment and self-contained breathing apparatus with full facepiece operated in positive pressure mode. Do not get water inside containers.

Unusual Fire & Explosion Hazards
Reacts with most metals to produce hydrogen gas, which can form an explosive mixture with air.
A violent exothermic reaction occurs with water. Sufficient heat may be produced to ignite combustible materials.

Toxic Gases Produced
sulfur dioxide

SECTION V - HEALTH HAZARD DATA

Threshold Limit Value (TLV/TWA): 1 mg/m^3 (ppm)

Permissible Exposure Limit (PEL): 1 mg/m^3 (ppm)

Toxicity: LD_{50} (oral-rat)(mg/kg) -- 2140

Carcinogenicity: NTP: No IARC: No Z List: No OSHA reg: No

Continued on Page: 3

SECTION V - HEALTH HAZARD DATA (Continued)

Effects of Overexposure

Inhalation of vapors may cause severe irritation of the respiratory system.
Liquid may cause severe burns to skin and eyes.
Ingestion is harmful and may be fatal.
Ingestion may cause nausea and vomiting.
Ingestion may cause severe burns to mouth, throat, and stomach. May have adverse effect on kidney function and may be fatal.
Chronic overexposure may result in lung damage.

Medical Conditions Generally Aggravated By Exposure

None Identified

Routes Of Entry

inhalation, ingestion, eye contact, skin contact

Emergency and First Aid Procedures

CALL A PHYSICIAN.
If swallowed, do NOT induce vomiting; if conscious, give water, milk, or milk of magnesia.
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Wash clothing before re-use.

SECTION VI - REACTIVITY DATA

Stability: Stable — Hazardous Polymerization: Will not occur

Conditions to Avoid: moisture, heat

Incompatibles: water, most common metals, organic materials, strong reducing agents, combustible materials, strong bases, strong oxidizing agents

Decomposition Products: oxides of sulfur

SECTION VII - SPILL AND DISPOSAL PROCEDURES

Steps to be taken in the event of a spill or discharge

Wear self-contained breathing apparatus and full protective clothing.
Stop leak if you can do so without risk. DO NOT use water.
Neutralize spill and/or washings with soda ash or lime.
With clean shovel, place material into clean, dry container and cover.
Move container(s) from spill area.

J. T. Baker Neutrasorb[R] or Neutrasol[R] "Low Na+" acid neutralizers

Continued on Page: 4

SECTION VII - SPILL AND DISPOSAL PROCEDURES (Continued)

are recommended for spills of this product.

Disposal Procedure
Dispose in accordance with all applicable federal, state, and local environmental regulations.

EPA Hazardous Waste Number: D002, D003 (Corrosive, Reactive Waste)

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

Ventilation:	Use general or local exhaust ventilation to meet TLV requirements.
Respiratory Protection:	None required where appropriate ventilation conditions exist. If the TLV is exceeded, a self-contained breathing apparatus is advised.
Eye/Skin Protection:	Safety goggles and face shield, uniform, protective suit, rubber gloves are recommended.

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA™ Storage Color Code: White

Special Precautions
Keep container tightly closed. Store in corrosion-proof area.
Keep containers out of sun and away from heat.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

Proper Shipping Name	Sulfuric acid
Hazard Class	Corrosive material (liquid)
UN/NA	UN1830
Labels	CORROSIVE
Reportable Quantity	1000 LBS.

INTERNATIONAL (I.M.O.)

Proper Shipping Name	Sulphuric acid
Hazard Class	8
UN/NA	UN1830
Labels	CORROSIVE

N/A = Not Applicable or Not Available

The information published in this Material Safety Data Sheet has been compiled

Continued on Page: 5

from our experience and data presented in various technical publications. It is the user's responsibility to determine the suitability of this information for the adoption of necessary safety precautions. We reserve the right to revise Material Safety Data Sheets periodically as new information becomes available.

J.T.Baker

[illegible]
24-Hour Emergency Telephone - [illegible]
Chemtrec # (800) 424-9300
National Response Center # (800) 424-8802

SAFETY DATA SHEET

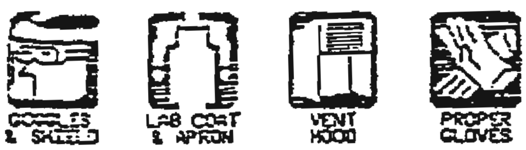
SECTION I - PRODUCT IDENTIFICATION

Product Name: Nitric Acid
Formula: HNO_3
Formula Wt: 63.01
CAS No.: 7697-37-2
NIOSH/RTECS No.: QU5775000
Common Synonyms: Hydrogen Nitrate; Azotic Acid
Product Codes: 4801,9605,9602,9598,9606,9601,9597,9600,5113,9616,5371

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA[TM] System

Laboratory Protective Equipment



Precautionary Label Statements

POISON! DANGER!
STRONG OXIDIZER - CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE
LIQUID AND VAPOR CAUSE SEVERE BURNS - MAY BE FATAL IF SWALLOWED
HARMFUL IF INHALED AND MAY CAUSE DELAYED LUNG INJURY
SPILLAGE MAY CAUSE FIRE OR LIBERATE DANGEROUS GAS

Keep from contact with clothing and other combustible materials. Do not store near combustible materials. Do not get in eyes, on skin, on clothing. Do not breathe vapor. Keep in tightly closed container. Use with adequate ventilation. In case of fire, use water spray, alcohol foam, dry chemical, or carbon dioxide. Flush spill area with waterspray.

SECTION II - HAZARDOUS COMPONENTS

Component	%	CAS No.
Nitric Acid	65-75	7697-37-2

Continued on Page: 2

SECTION III - PHYSICAL DATA

Boiling Point:	121°C (250°F)	Vapor Pressure(mmHg):	
Melting Point:	-42°C (-44°F)	Vapor Density(air=1):	
Specific Gravity: (H_2O=1)	1.41	Evaporation Rate: (Butyl Acetate=1)	N/A
Solubility(H_2O):	Complete (in all proportions)	% Volatiles by Volume:	100

Appearance & Odor: Colorless liquid, with choking odor.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A NFPA 704M Rating: 3-0-0 OXY

Flammable Limits: Upper - N/A % Lower - N/A %

<u>Fire Extinguishing Media</u>
Use water spray.

<u>Special Fire-Fighting Procedures</u>
Firefighters should wear proper protective equipment and self-contained breathing apparatus with full facepiece operated in positive pressure mode. Move exposed containers from fire area if it can be done without risk. Use water to keep fire-exposed containers cool; do not get water inside containers.

<u>Unusual Fire & Explosion Hazards</u>
Strong oxidizer. Contact with other material may cause fire.

<u>Toxic Gases Produced</u>
nitrogen oxides, hydrogen gas

SECTION V - HEALTH HAZARD DATA

Threshold Limit Value (TLV/TWA): 5 mg/m^3 (2 ppm)

Short-Term Exposure Limit (STEL): 10 mg/m^3 (4 ppm)

Permissible Exposure Limit (PEL): 5 mg/m^3 (2 ppm)

Carcinogenicity: NTP: No IARC: No Z List: No OSHA reg: No

<u>Effects of Overexposure</u>
Inhalation of vapors may cause nausea, vomiting, lightheadedness or

Continued on Page: 3

J. T. Baker Chemical Co.
222 Red School Lane Phillipsburg, N.J. 08865
24-Hour Emergency Telephone 201-859-2151
Chemtrec # (800) 424-9300
National Response Center # (800) 424-8802

MATERIAL SAFETY DATA SHEET

SECTION V - HEALTH HAZARD DATA (Continued)

headache.
Inhalation of vapors may cause severe irritation of the respiratory system.
Inhalation of vapors may cause coughing, chest pains, difficulty breathing, or unconsciousness.
Contact with liquid or vapor may cause severe irritation or burns of the skin, eyes, and mucous membranes.
Ingestion may cause severe burns to mouth, throat, and stomach. May have adverse effect on kidney function and may be fatal.
Ingestion is harmful and may be fatal.

Medical Conditions Generally Aggravated By Exposure
None Identified

Routes Of Entry
inhalation, ingestion, eye contact, skin contact

Emergency and First Aid Procedures
CALL A PHYSICIAN.
If swallowed, do NOT induce vomiting; if conscious, give water, milk, or milk of magnesia.
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Wash clothing before re-use.

SECTION VI - REACTIVITY DATA

Stability: Stable Hazardous Polymerization: Will not occur

Conditions to Avoid: heat, light, moisture

Incompatibles: strong bases, combustible materials, strong reducing agents, alkalies, most common metals, organic materials, alcohols, carbides

Decomposition Products: oxides of nitrogen, hydrogen

SECTION VII - SPILL AND DISPOSAL PROCEDURES

Steps to be taken in the event of a spill or discharge
Wear self-contained breathing apparatus and full protective clothing. Stop leak if you can do so without risk. Ventilate area. Neutralize spill with soda ash or lime. With clean shovel, carefully place material into clean, dry container and cover; remove from area. Flush spill area with water. Keep combustibles (wood, paper, oil, etc.) away from spilled material.

J. T. Baker Neutrasorb[R] or Neutrasol[R] "Low Na+" acid neutralizers

Continued on Page: 4

SECTION VII - SPILL AND DISPOSAL PROCEDURES (Continued)

are recommended for spills of this product.

Disposal Procedure

Dispose in accordance with all applicable federal, state, and local environmental regulations.

EPA Hazardous Waste Number: D002 (Corrosive Waste)

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

Ventilation:	Use general or local exhaust ventilation to meet TLV requirements.
Respiratory Protection:	Respiratory protection required if airborne concentration exceeds TLV. At concentrations up to 100 ppm, a chemical cartridge respirator with acid cartridge is recommended. Above this level, a self-contained breathing apparatus is advised.
Eye/Skin Protection:	Safety goggles and face shield, uniform, protective suit, acid-resistant gloves are recommended.

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA[TM] Storage Color Code: Yellow

Special Precautions

Keep container tightly closed. Store separately and away from flammable and combustible materials.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

Proper Shipping Name	Nitric acid (over 40%) Poison - Inhalation Hazard
Hazard Class	Oxidizer
UN/NA	UN2031
Labels	OXIDIZER, CORROSIVE
Reportable Quantity	1000 LBS.

INTERNATIONAL (I.M.O.)

Proper Shipping Name	Nitric acid
Hazard Class	8
UN/NA	UN2031
Labels	CORROSIVE

Continued on Page: 5

N/A = Not Applicable or Not Available

The information published in this Material Safety Data Sheet has been compiled from our experience and data presented in various technical publications. It is the user's responsibility to determine the suitability of this information for the adoption of necessary safety precautions. We reserve the right to revise Material Safety Data Sheets periodically as new information becomes available.

PRECAUTIONARY LABELING (CONTINUED)

INTERNATIONAL LABELING

GHLY FLAMMABLE.
EP CONTAINER TIGHTLY CLOSED. KEEP AWAY FROM SOURCES OF IGNITION - NO
OKING.

F-T-DATA® STORAGE COLOR CODE: RED (FLAMMABLE)

SECTION II - COMPONENTS

MPONENT	CAS NO.	WEIGHT %	OSHA/PEL	ACGIH/TLV
PROPANOL	67-63-0	99-100	400 PPM	400 PPM

SECTION III - PHYSICAL DATA

ILING POINT: 82 C (179 F)
(AT 760 MM HG)

VAPOR PRESSURE (MMHG): 33
(20 C)

LTING POINT: -89 C (-128 F)
(AT 760 MM HG)

VAPOR DENSITY (AIR=1): 2.1

ECIFIC GRAVITY: 0.79
(H2O=1)

EVAPORATION RATE: 2.5
(BUTYL ACETATE = 1)

LUBILITY(H2O): COMPLETE (100%)

% VOLATILES BY VOLUME: 100
(21 C)

I: N/A

OR THRESHOLD (P.P.M.): 28.2

PHYSICAL STATE: LIQUID

EFFICIENT WATER/OIL DISTRIBUTION: N/A

PEARANCE & ODOR: CLEAR, COLORLESS LIQUID. ALCOHOL ODOR.

CONTINUED ON PAGE: 3

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

ASH POINT (CLOSED CUP): 11 C (53 F) NFPA 704M RATING: 1-3-0

TOIGNITION TEMPERATURE: 399 C (750 F)

AMMABLE LIMITS: UPPER - 12.0 % LOWER - 2.0 %

RE EXTINGUISHING MEDIA
USE ALCOHOL FOAM, DRY CHEMICAL OR CARBON DIOXIDE. (WATER MAY BE INEFFECTIVE.)

ECIAL FIRE-FIGHTING PROCEDURES
FIREFIGHTERS SHOULD WEAR PROPER PROTECTIVE EQUIPMENT AND SELF-CONTAINED BREATHING APPARATUS WITH FULL FACEPIECE OPERATED IN POSITIVE PRESSURE MODE. MOVE CONTAINERS FROM FIRE AREA IF IT CAN BE DONE WITHOUT RISK. USE WATER TO KEEP FIRE-EXPOSED CONTAINERS COOL.

USUAL FIRE & EXPLOSION HAZARDS
VAPORS MAY FLOW ALONG SURFACES TO DISTANT IGNITION SOURCES AND FLASH BACK. CLOSED CONTAINERS EXPOSED TO HEAT MAY EXPLODE. CONTACT WITH STRONG OXIDIZERS MAY CAUSE FIRE.

)XIC GASES PRODUCED
CARBON MONOXIDE, CARBON DIOXIDE

XPLOSION DATA-SENSITIVITY TO MECHANICAL IMPACT
NONE IDENTIFIED.

XPLOSION DATA-SENSITIVITY TO STATIC DISCHARGE
NONE IDENTIFIED.

SECTION V - HEALTH HAZARD DATA

HRESHOLD LIMIT VALUE (TLV/TWA): 980 MG/M3 (400 PPM)

HORT-TERM EXPOSURE LIMIT (STEL): 1225 MG/M3 (500 PPM)

ERMISSIBLE EXPOSURE LIMIT (PEL): 980 MG/M3 (400 PPM)

TOXICITY OF COMPONENTS

CONTINUED ON PAGE: 4

SECTION V - HEALTH HAZARD DATA (CONTINUED)

ORAL RAT LD50 FOR 2-PROPANOL	5840 MG/KG
INTRAPERITONEAL MOUSE LD50 FOR 2-PROPANOL	933 MG/KG
ORAL DOG LD50 FOR 2-PROPANOL	6150 MG/KG
SKIN RABBIT LD50 FOR 2-PROPANOL	13 G/KG

CARCINOGENICITY: NTP: NO IARC: NO Z LIST: NO OSHA REG: NO

CARCINOGENICITY
NONE IDENTIFIED.

REPRODUCTIVE EFFECTS
NONE IDENTIFIED.

EFFECTS OF OVEREXPOSURE

INHALATION: IRRITATION OF NOSE AND THROAT, HEADACHE, NAUSEA, DIZZINESS, DROWSINESS, IRRITATION OF UPPER RESPIRATORY TRACT, NARCOSIS, CENTRAL NERVOUS SYSTEM DEPRESSION, DIFFICULT BREATHING, PULMONARY EDEMA, UNCONSCIOUSNESS

SKIN CONTACT: IRRITATION, PROLONGED CONTACT MAY CAUSE DERMATITIS

EYE CONTACT: IRRITATION, MAY CAUSE CORNEAL DAMAGE

SKIN ABSORPTION: RAPID ABSORPTION

INGESTION: HEADACHE, NAUSEA, VOMITING, DIZZINESS, GASTROINTESTINAL IRRITATION, NARCOSIS, CENTRAL NERVOUS SYSTEM DEPRESSION, UNCONSCIOUSNESS

CHRONIC EFFECTS: NONE IDENTIFIED

TARGET ORGANS
EYES, SKIN, RESPIRATORY SYSTEM, LUNGS, CENTRAL NERVOUS SYSTEM

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE
SKIN DISORDERS, EYE DISORDERS, RESPIRATORY SYSTEM DISEASE

PRIMARY ROUTES OF ENTRY
INHALATION, INGESTION, SKIN CONTACT, EYE CONTACT, ABSORPTION

CONTINUED ON PAGE: 5

SECTION V - HEALTH HAZARD DATA (CONTINUED)

EMERGENCY AND FIRST AID PROCEDURES

INGESTION: CALL A PHYSICIAN. IF SWALLOWED, IF CONSCIOUS, GIVE LARGE AMOUNTS OF WATER. INDUCE VOMITING.

INHALATION: IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.

SKIN CONTACT: IN CASE OF CONTACT, IMMEDIATELY FLUSH SKIN WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES. WASH CLOTHING BEFORE RE-USE.

EYE CONTACT: IN CASE OF EYE CONTACT, IMMEDIATELY FLUSH WITH PLENTY OF WATER FOR AT LEAST 15 MINUTES.

MEDICAL SURVEILLANCE
PROVIDE PREPLACEMENT AND PERIODIC MEDICAL EXAMS WITH EMPHASIS ON SKIN, SINUSES, AND RESPIRATORY SYSTEM.

SARA/TITLE III HAZARD CATEGORIES AND LISTS

ACUTE: YES CHRONIC: YES FLAMMABILITY: YES PRESSURE: NO REACTIVITY: NO

EXTREMELY HAZARDOUS SUBSTANCE:	NO	
CERCLA HAZARDOUS SUBSTANCE:	NO	
SARA 313 TOXIC CHEMICALS:	YES	CONTAINS ISOPROPYL ALCOHOL
GENERIC CLASS:		C05
TSCA INVENTORY:	YES	

SECTION VI - REACTIVITY DATA

STABILITY: STABLE HAZARDOUS POLYMERIZATION: WILL NOT OCCUR

CONDITIONS TO AVOID: HEAT, FLAME, OTHER SOURCES OF IGNITION

INCOMPATIBLES: STRONG OXIDIZING AGENTS, ALUMINUM, STRONG ACIDS, NITRIC ACID, SULFURIC ACID, HALOGENS, ACTIVE HALOGEN COMPOUNDS, AMINES AND AMMONIA, ALDEHYDES

CONTINUED ON PAGE: 6

SECTION VI - REACTIVITY DATA (CONTINUED)

DECOMPOSITION PRODUCTS: CARBON MONOXIDE, CARBON DIOXIDE

SECTION VII - SPILL & DISPOSAL PROCEDURES

STEPS TO BE TAKEN IN THE EVENT OF A SPILL OR DISCHARGE
WEAR SUITABLE PROTECTIVE CLOTHING. SHUT OFF IGNITION SOURCES; NO FLARES, SMOKING, OR FLAMES IN AREA. STOP LEAK IF YOU CAN DO SO WITHOUT RISK. USE WATER SPRAY TO REDUCE VAPORS. TAKE UP WITH SAND OR OTHER NON-COMBUSTIBLE ABSORBENT MATERIAL AND PLACE INTO CONTAINER FOR LATER DISPOSAL. FLUSH AREA WITH WATER.
DO NOT ALLOW TO ENTER DRAINS OR SEWER SYSTEM.

J. T. BAKER SOLUSORB(R) SOLVENT ADSORBENT IS RECOMMENDED FOR SPILLS OF THIS PRODUCT.

DISPOSAL PROCEDURE
DISPOSE IN ACCORDANCE WITH ALL APPLICABLE FEDERAL, STATE, AND LOCAL ENVIRONMENTAL REGULATIONS.

EPA HAZARDOUS WASTE NUMBER: D001 (IGNITABLE WASTE)

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

VENTILATION: USE GENERAL OR LOCAL EXHAUST VENTILATION TO MEET TLV REQUIREMENTS.

RESPIRATORY PROTECTION: RESPIRATORY PROTECTION REQUIRED IF AIRBORNE CONCENTRATION EXCEEDS TLV. AT CONCENTRATIONS UP TO 1000 PPM, A CHEMICAL CARTRIDGE RESPIRATOR WITH ORGANIC VAPOR CARTRIDGE IS RECOMMENDED. ABOVE THIS LEVEL, A SELF-CONTAINED BREATHING APPARATUS IS RECOMMENDED.

EYE/SKIN PROTECTION: SAFETY GOGGLES, UNIFORM, APRON, NEOPRENE GLOVES ARE RECOMMENDED.

CONTINUED ON PAGE: 7

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA# STORAGE COLOR CODE: RED (FLAMMABLE)

STORAGE REQUIREMENTS
KEEP CONTAINER TIGHTLY CLOSED. STORE IN A COOL, DRY, WELL-VENTILATED, FLAMMABLE LIQUID STORAGE AREA. DO NOT STORE NEAR OXIDIZING MATERIALS.

SPECIAL PRECAUTIONS
BOND AND GROUND CONTAINERS WHEN TRANSFERRING LIQUID.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

DOMESTIC (D.O.T.)

PROPER SHIPPING NAME: ISOPROPANOL
HAZARD CLASS: FLAMMABLE LIQUID
UN/NA: UN1219
LABELS: FLAMMABLE LIQUID
REGULATORY REFERENCES: 49CFR 172.101; 173.125

INTERNATIONAL (I.M.O.)

PROPER SHIPPING NAME: ISOPROPANOL
HAZARD CLASS: 3.2 I.M.O. PAGE: 3100
UN: UN1219 MARINE POLLUTANTS: NO PACKAGING GROUP: II
LABELS: FLAMMABLE LIQUID
REGULATORY REFERENCES: 49CFR 172.102; PART 176; IMO

AIR (I.C.A.O.)

PROPER SHIPPING NAME: ISOPROPANOL
HAZARD CLASS: 3.2
UN: UN1219 PACKAGING GROUP: II
LABELS: FLAMMABLE LIQUID
REGULATORY REFERENCES: 49CFR 172.101; 173.6; PART 175; ICAO/IATA

U.S. CUSTOMS HARMONIZATION NUMBER: 2905120507

CONTINUED ON PAGE: 8

/A = NOT APPLICABLE OR NOT AVAILABLE
/E = NOT ESTABLISHED

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HE INFORMATION IN THIS MATERIAL SAFETY DATA SHEET MEETS THE
EQUIREMENTS OF THE UNITED STATES OCCUPATIONAL SAFETY AND HEALTH ACT AND
EGULATIONS PROMULGATED THEREUNDER (29 CFR 1910.1200 ET. SEQ.) AND THE
ANADIAN WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM. THIS DOCUMENT
S INTENDED ONLY AS A GUIDE TO THE APPROPRIATE PRECAUTIONARY HANDLING OF
HE MATERIAL BY A PERSON TRAINED IN, OR SUPERVISED BY A PERSON TRAINED
N, CHEMICAL HANDLING. THE USER IS RESPONSIBLE FOR DETERMINING THE
RECAUTIONS AND DANGERS OF THIS CHEMICAL FOR HIS OR HER PARTICULAR
PPLICATION. DEPENDING ON USAGE, PROTECTIVE CLOTHING INCLUDING EYE AND
ACE GUARDS AND RESPIRATORS MUST BE USED TO AVOID CONTACT WITH MATERIAL
R BREATHING CHEMICAL VAPORS/FUMES.
XPOSURE TO THIS PRODUCT MAY HAVE SERIOUS ADVERSE HEALTH EFFECTS. THIS
HEMICAL MAY INTERACT WITH OTHER SUBSTANCES. SINCE THE POTENTIAL USES
RE SO VARIED, BAKER CANNOT WARN OF ALL OF THE POTENTIAL DANGERS OF USE
R INTERACTION WITH OTHER CHEMICALS OR MATERIALS. BAKER WARRANTS THAT
HE CHEMICAL MEETS THE SPECIFICATIONS SET FORTH ON THE LABEL.
AKER DISCLAIMS ANY OTHER WARRANTIES, EXPRESSED OR IMPLIED WITH REGARD
O THE PRODUCT SUPPLIED HEREUNDER, ITS MERCHANTABILITY OR ITS FITNESS
OR A PARTICULAR PURPOSE.
HE USER SHOULD RECOGNIZE THAT THIS PRODUCT CAN CAUSE SEVERE INJURY AND
VEN DEATH, ESPECIALLY IF IMPROPERLY HANDLED OR THE KNOWN DANGERS OF USE
RE NOT HEEDED. READ ALL PRECAUTIONARY INFORMATION. AS NEW DOCUMENTED
ENERAL SAFETY INFORMATION BECOMES AVAILABLE, BAKER WILL PERIODICALLY
EVISE THIS MATERIAL SAFETY DATA SHEET. IF YOU HAVE ANY QUESTIONS,
LEASE CALL CUSTOMER SERVICE (1-800-JTBAKER) FOR ASSISTANCE.

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PPROVED BY QUALITY ASSURANCE DEPARTMENT.

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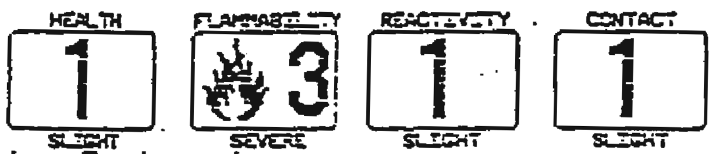
SECTION I - PRODUCT IDENTIFICATION

Product Name: 2-Propanol
Formula: $CH_3CHOHCH_3$
Formula Wt: 60.10
CAS No.: 00067-63-0
NIOSH/RTECS No.: NT8050000
Common Synonyms: Isopropanol; Isopropyl Alcohol; IPA; sec-Propanol; Dimethylcarbinol
Product Codes: 5610,9083,9088,9334,9095,9079,9089,9084,5373,9081,9082

PRECAUTIONARY LABELLING

BAKER SAF-T-DATA™ System



Laboratory Protective Equipment

Precautionary Label Statements

WARNING!
FLAMMABLE.
CAUSES IRRITATION
HARMFUL IF SWALLOWED OR INHALED

Keep away from heat, sparks, flame. Avoid contact with eyes, skin, clothing. Avoid breathing vapor. Keep in tightly closed container. Use with adequate ventilation. Wash thoroughly after handling. In case of fire, use alcohol foam, dry chemical, carbon dioxide - water may be ineffective. Flush spill area with water spray.

SECTION II - HAZARDOUS COMPONENTS

Component	%	CAS No
2-Propanol	90-100	67-63-
2-Propanol	90-100	67-63-

Continued on Page: 2

SECTION II - HAZARDOUS COMPONENTS (Continued)

2-Propanol	90-100	67-63-0

SECTION III - PHYSICAL DATA

Boiling Point: 82°C (180°F)

Vapor Pressure(mmHg): 33

Melting Point: -89°C (-128°F)

Vapor Density(air=1): 2.1

Specific Gravity: 0.79
(H_2O=1)

Evaporation Rate: 2.88
(Butyl Acetate=1)

Solubility(H_2O): Complete (in all proportions)

% Volatiles by Volume: 100

Appearance & Odor: Liquid with slight odor of rubbing alcohol.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point (Closed Cup): 12°C (53°F)

NFPA 704M Rating: 1-3-0

Flammable Limits: Upper - 12 % Lower - 2.0 %

Fire Extinguishing Media

Use alcohol foam, dry chemical or carbon dioxide. (Water may be ineffective.)

Special Fire-Fighting Procedures

Firefighters should wear proper protective equipment and self-contained breathing apparatus with full facepiece operated in positive pressure mode. Move containers from fire area if it can be done without risk. Use water to keep fire-exposed containers cool.

Unusual Fire & Explosion Hazards

Vapors may flow along surfaces to distant ignition sources and flash back. Closed containers exposed to heat may explode. Contact with strong oxidizers may cause fire.

Toxic Gases Produced

carbon monoxide, carbon dioxide

SECTION V - HEALTH HAZARD DATA

Threshold Limit Value (TLV/TWA): 980 mg/m^3 (400 ppm)

Short-Term Exposure Limit (STEL): 1225 mg/m^3 (500 ppm)

Permissible Exposure Limit (PEL): 980 mg/m^3 (400 ppm)

Continued on Page: 3

SECTION V - HEALTH HAZARD DATA (Continued)

Toxicity:	LD_{50} (oral-rat)(mg/kg)	-	5840
	LD_{50} (ipr-mouse)(mg/kg)	-	933
	LD_{50} (oral-dog)(mg/kg)	-	6150
	LD_{50} (skn-rabbit) (g/kg)	-	13

Carcinogenicity: NTP: No IARC: No Z List: No OSHA reg: No

Effects of Overexposure

Vapors may be irritating to eyes, nose and throat.
Inhalation of vapors may cause headache, nausea, vomiting, dizziness, drowsiness, irritation of respiratory tract, and loss of consciousness.
Liquid may be irritating to skin and eyes. Prolonged skin contact may result in dermatitis. Eye contact may result in temporary corneal damage
Substance is readily absorbed through the skin.
Ingestion may cause nausea, vomiting, headaches, dizziness, gastrointestinal irritation.

Medical Conditions Generally Aggravated By Exposure

None Identified

Routes Of Entry

inhalation, ingestion, skin contact, eye contact

Emergency and First Aid Procedures

CALL A PHYSICIAN.
If swallowed, if conscious, give large amounts of water. Induce vomiting.
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Flush skin with water.

SECTION VI - REACTIVITY DATA

Stability: Stable Hazardous Polymerization: Will not occur

Conditions to Avoid: heat, flame, other sources of ignition

Incompatibles: strong oxidizing agents, aluminum, strong acids, nitric acid, sulfuric acid, halogens, active halogen compounds

Decomposition Products: carbon monoxide, carbon dioxide

SECTION VII - SPILL AND DISPOSAL PROCEDURES

Steps to be taken in the event of a spill or discharge

Wear suitable protective clothing. Shut off ignition sources; no flares,

Continued on Page: 4

SECTION VII - SPILL AND DISPOSAL PROCEDURES (Continued)

smoking, or flames in area. Stop leak if you can do so without risk. Use water spray to reduce vapors. Take up with sand or other non-combustible absorbent material and place into container for later disposal. Flush area with water.

J. T. Baker Solusorb® solvent adsorbent is recommended for spills of this product.

__Disposal Procedure__

Dispose in accordance with all applicable federal, state, and local environmental regulations.

EPA Hazardous Waste Number: D001 (Ignitable Waste)

SECTION VIII - INDUSTRIAL PROTECTIVE EQUIPMENT

Ventilation:	Use general or local exhaust ventilation to meet TLV requirements.
Respiratory Protection:	Respiratory protection required if airborne concentration exceeds TLV. At concentrations up to 1000 ppm, a chemical cartridge respirator with organic vapor cartridge is recommended. Above this level, a self-contained breathing apparatus is recommended.
Eye/Skin Protection:	Safety goggles, uniform, apron, butyl rubber gloves are recommended.

SECTION IX - STORAGE AND HANDLING PRECAUTIONS

SAF-T-DATA™ Storage Color Code: Red

__Special Precautions__

Bond and ground containers when transferring liquid. Keep container tightly closed. Store in a cool, dry, well-ventilated, flammable liquid storage area.

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION

__DOMESTIC (D.O.T.)__

Proper Shipping Name	Isopropanol
Hazard Class	Flammable liquid
UN/NA	UN1219
Labels	FLAMMABLE LIQUID

Continued on Page: 5

SECTION X - TRANSPORTATION DATA AND ADDITIONAL INFORMATION (Continued)

INTERNATIONAL (I.M.O.)

Proper Shipping Name	Isopropanol
Hazard Class	3.2
UN/NA	UN1219
Labels	FLAMMABLE LIQUID

N/A = Not Applicable or Not Available

The information published in this Material Safety Data Sheet has been compile
from our experience and data presented in various technical publications. It
the user's responsibility to determine the suitability of this information fo
the adoption of necessary safety precautions. We reserve the right to revise
Material Safety Data Sheets periodically as new information becomes available

APPENDIX I

PUBLIC HEALTH FACT SHEET ON LYME DISEASE

PUBLIC HEALTH FACT SHEET

Lyme Disease

Massachusetts Department of Public Health, 150 Tremont Street, Boston, MA 02111

What is Lyme Disease?

Lyme Disease is an infectious disease caused by bacteria that are spread by tiny infected ticks. Both people and animals can be infected by Lyme tick bites. Lyme Disease can be serious if it is not treated, but it is not fatal.

Where is Lyme Disease found?

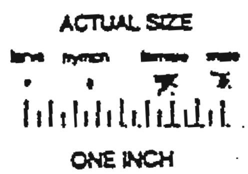
Lyme Disease can be found all over the United States, but it is most common along the east coast, the Great Lakes, and the Pacific Northwest.

In Massachusetts, Lyme ticks are most often found in the coastal areas, islands, and the Connecticut River Valley in the western part of the state. The disease is most likely to be spread between late May and early autumn, when ticks are most active.

How is Lyme Disease spread?

Lyme ticks cling to plants near the ground in brushy, wooded, or grassy places. The ticks, which cannot jump or fly, climb onto animals and people who brush against the plants. Very young ticks (called larvae) pick up the bacteria that cause Lyme Disease by biting infected animals, such as field mice. The bite of older ticks (called nymphs) can pass the infection along to the next host.

Lyme ticks are so tiny that the larvae are no bigger than the period at the end of this sentence. The ticks live for two years, during which they can infect wild and domestic animals as well as people.



Not all ticks carry Lyme Disease, and even being bitten by a Lyme tick does not necessarily mean that you will get the disease. The tick must be attached for at least 24 hours to pass on the bacteria, so removing the tick promptly will cut down your chances of becoming infected.

What are the symptoms of Lyme Disease?

Early stage: The first symptom of Lyme Disease is usually — but not always — an unusual rash where the tick bit. (Often the tick isn't even noticed, and it drops off before the rash appears.) The rash first appears anywhere from three days to a month after the bite. It starts as a small red area then spreads out, often clearing up in the center so it looks like a donut. Other skin signs include burning or itching, hives, redness of the cheeks and under the eyes, and swollen eyelids with bloodshot eyes. Flu-like symptoms such as fever, headache, stiff neck, sore and aching muscles and joints, fatigue, sore throat, and swollen glands are also common in the early stage of Lyme Disease.

These symptoms often go away by themselves after a few weeks, but the person remains infected. Without medical treatment, about half the infected people will get the rash again in other places on their bodies, and many will develop more serious problems later. Treatment with antibiotics clears up the rash within days and often prevents later problems.

Later stages: Three major organ systems — the joints, nerves, and heart — can be affected months after the tick bite, although symptoms usually show up within four to six weeks. People with Lyme Disease can develop late-stage symptoms even if they never got the donut-shaped rash.

About 60% of people with untreated Lyme Disease get arthritis in their large joints, usually knees, elbows, and wrist The arthritis can move from joint to joint and become chronic.

About 10% to 20% of people who don't get treatment develop nerve problems. The most common symptoms are sever headache and stiff neck, facial paralysis or other cranial nerve palsies, and weakness or pain (or both) in their hands arms, feet and/or legs. These symptoms can last for weeks, often shifting from mild to severe and back again.

About 6% to 10% of people who don't get treatment develop heart problems, such as inflamed heart muscles or erratic heart beats.

How is Lyme Disease diagnosed?

Lyme Disease is easy to diagnose when someone gets the donut-shaped rash. It is much harder to diagnose without the rash because other symptoms mimic other diseases, like flu. To help diagnose these cases, doctors can ask the Massachusetts Department of Public Health or other labs to test their patient's blood for antibodies to the Lyme Disease bacteria.

How is Lyme Disease treated?

Lyme Disease can be treated with antibiotic pills if it is diagnosed early. Tetracycline seems to work best. Children under seven are given penicillin instead because tetracycline can stain their permanent teeth. Other antibiotics can be prescribed for people who cannot take tetracycline or penicillin. **Prompt treatment of early symptoms can prevent later and more serious problems.**

How can you prevent Lyme Disease?

The only known way to get Lyme Disease is from the bite of an infected tick. The best ways to prevent Lyme Disease are to know where these ticks are found, avoid these places, and promptly remove the tick if you do get bitten. If you live in or visit a high-risk area, follow these tips:

- Don't walk barelegged in tall grass, woods, or dunes where ticks may live.
- If you do walk in these places, wear a long-sleeved shirt, long pants, high socks (with pants tucked tightly into the socks), and sneakers. Light colors will help you spot ticks on your clothes before they reach your skin.
- Use insect repellants made with DEET (check the label) on your skin, and the ones made with permethrin on your clothes.
- Check for ticks every day. Their favorite places are on the legs, thighs and groin, in the armpits, along the hairline, and in or behind the ears. The ticks are tiny, so look for new "freckles."
- To remove a tick, use tweezers to grip the body firmly and pull it straight out. If you must use your fingers, protect your fingertips with a plastic bag or a tissue and wash your hands afterward. Put antiseptic on the bite.
- Drown the tick in alcohol or kerosene. (Never leave these liquids where children can reach them.)
- Know the symptoms of Lyme Disease. If you have been someplace likely to have ticks between May and early autumn and you develop Lyme Disease symptoms — especially if you get a donut-shaped rash — see a doctor right away. Early treatment can prevent later problems.

Where can you get more information?

Your local board of health
Listed in the telephone book under local government

Massachusetts Department of Public Health
Division of Epidemiology (617) 522-3700, x420 or 425

May 1990