Utah
Underground Storage Tank (UST) Groundwater & Soil Sampling Reference Material

August 2011

www.undergroundtanks.utah.gov

INDEX

UST Branch: Program Overview.

Section 1: Sampling Procedures

- Sampling Procedures and Requirements For Underground Stogage Tank (UST) Sites
- Subsurface Investigations, Sampling & Analytical Requirements (Chapter 6 - Consultant Certification Manual 2009)
- EPA-RCRA Ground-Water Technical Enforcement Guidance Document – Chapter 4 (September 1986)
- Compendium of ERT Surface Water and Sediment Sampling Procedures (January 1991)
- Closure Plan Requirements
- UST Closure Plan
- UST Closure Notice
- Other DEQ Division Requirements
- Site Assessment and Mitigation Manual – Section 5(III) http://www.co.san-diego.ca.us/deh/water/sam_manual.html

Section 2: Cleanup Standards

- Initial Screening Levels (ISLs)
- Analytical Methods for Environmental Sampling at Underground Storage Tank Sites in Utah
- Screening /Cleanup Levels for LUST Sites (Chapter 7 - Consultant Certification Manual 2009)
- Leaking Underground Storage Tanks (LUST) Subsurface Investigation Report (SIR) Guide
- Guidelines for Disposition and Treatment of Petroleum Contaminated Soils For Underground Storage Tank Sites

Section 3: Health & Safety

- General Site Health and Safety (Chapter 5 - Consultant Certification Manual 2009)
- Health and Safety Training for Underground Storage Tank Inspector (Partial - June 1992)

Rules and Regulation: see UST Certification Requirements and Rules
http://www.undergroundtanks.utah.gov/study_guides.htm

UST Branch: Program Overview

The Utah State Underground Storage Tank program is a regulatory branch of the Department of Environmental Quality. Its primary goal is to protect human health and the environment from leaking underground storage tanks (USTs). The UST staff oversees: UST notification, installation, inspection, removal, and compliance with State and Federal UST regulations concerning release prevention and remediation.

What are Underground Storage Tanks?

An UST is a tank system, including piping connected to the tank, that has at least 10 percent of its volume underground. Federal and state regulations apply only to those USTs containing petroleum products or certain hazardous chemicals. USTs not regulated include:

- Farm or residential tanks 1,100 gallons or less, used non-commercially.
- Tanks storing heating oil, used on the premises.
- Flow-through process tanks.
- Emergency spill and overflow tanks.
- Tanks holding 110 gallons or less.
- Others as described in the federal register.

Why Worry About An UST Release?

Utah obtains more than 50% of the population's drinking water from groundwater. Currently, there are more than 3000 leaking UST sites in Utah. These sites have resulted in contaminated ground water and in some cases, explosive situations. Many more USTs in Utah could leak or have yet to be discovered in the future adding to the existing problems.

What Do the UST Regulations Accomplish?

The Environmental Protection Agency (EPA), with the help of the regulated industry, developed regulations concerning UST owners and operators. The goals of these regulations include:

- To prevent leaks and spills.
- To find leaks and spills.
- To correct the problems created by leaks and spills.
- To ensure the owners and operators can pay for clean-up associated with leaking USTs.
- To ensure that Utah has a regulatory program that complies with the Federal regulations.

The EPA phased-in many of the requirements over a ten year period beginning December 22, 1988. By December 22, 1998, all operating facilities were required to be upgraded with corrosion protection, spill and overfill equipment, and regularly monitored for a release. Non-operational facilities must be properly closed..

The Utah UST Program

As a result of the federal mandate, the State of Utah amended the Solid and Hazardous Waste Act in 1986 which established the Utah UST Program. UST owners and operators were required to register all USTs. In 1989, the Underground Storage Tank Act was enacted; it details the duties and responsibilities of the Executive Secretary (UST), the Solid and Hazardous Waste Control Board, and the Utah UST Program Authority. The act established the Petroleum Storage Tank (PST) Fund and provides certain requirements for UST owners and operators.

Executive Secretary (UST)

The Executive Secretary (UST) is an individual who has the authority to administer the UST Program as established by the Utah Legislature. The Executive Secretary answers to the Utah Solid and Hazardous Waste Control Board which consists of approximately ten individuals appointed by the Governor.

The UST Section

The UST section of the Division of Environmental Response and Remediation (DERR), is a group of environmental scientists whose task is to oversee the regulated public in issues that concern the operational life of USTs up to proper closing of UST systems. The UST staff has tracked about 15,000 USTs and currently regulates approximately 4,300 USTs at more than 1,500 different facilities. UST staff members perform compliance inspections, issue compliance notices, and serve as expert witnesses at administrative hearings. Outreach classes and seminars are taught throughout the state.

The LUST Section

The Leaking Underground Storage Tank (LUST) section of DERR oversees remediation of contamination from USTs. LUST scientists and engineers review and reestablish clean-up guidelines. When responsible parties are not available or are unable to pay for the remediation of a LUST site, the LUST staff is required to define the degree of hazard, possibly take action with LUST-TRUST money to abate the hazard and remediate the site, and recover costs incurred from responsible parties. Often, responsible parties seek the guidance of the LUST staff to insure clean-up in a timely and economical fashion.

Administrative Support Section

The administrative support section oversees collection of UST fees and monitors expenditures. Accountants and technicians answer questions concerning billings and distribute funds where appropriate.

What are the Requirements for Owner/Operators of Underground Storage Tank Systems?

- Notify the DERR of all regulated USTs with EPA Notification Form 7530-1.
- Pay any applicable fees.
- Obtain a Certificate of Compliance.
- Maintain compliance with regulations.
- Upgrade USTs when required.
- Report any UST release to the DERR.
- Remediate contamination.
- Remove UST appropriately.

Comments and Questions

You can obtain more information and forms from the DERR, 195 North 1950 West, Salt Lake City, Utah 84116; phone 801-536-4100.

Sampling Procedures

Sampling Procedures and Requirements for Underground Storage Tank (UST) Sites

The below-listed items assist to ensure that all types of samples collected are of good integrity, representative of environmental conditions, and provide legally defensible data.

1. Describe and document any necessary property access requirements.

2. All soil, groundwater, and surface water samples must be collected by a Utah certified sampler. The name and certification number of the sampler must be clearly identified.

3. All soil, groundwater, and surface water samples must be analyzed by a Utah certified laboratory. The name of the analytical laboratory must be clearly identified.

4. Native soil type must be evaluated using Unified Soil Classification methods. Other detailed lithologic descriptions may also be necessary.

5. Describe subsurface stratigraphy and continuity of strata beneath the site. Describe features such as discontinuous clay, silt, or sand lenses, interbedded strata, and other features.

6. Chain of Custody documentation must be maintained and provided for all samples collected.

7. Identify sampled media (soil, groundwater, surface water, drinking water, air, other) and ensure that the identification for each sampled media is consistent.

8. All sample identifications, names and numbers must be consistent throughout the Chain of Custody documentation, laboratory analytical results, site map, data tables, and the report text.

9. Describe the rationale for selecting sample locations and sampled intervals in excavations, test pits, soil/well borings, soil land farms, soil stockpiles, or other sample locations. Describe whether the sample location determination was based on field instrument measurements, random selection, judgmental or other reasons.

10. Describe and/or illustrate depths at which samples are collected.

11. Show sample locations on a properly scaled and oriented site map.

12. Specify the following sampled features and the applicable media sampled, including but not limited to:
    a. Excavations
    b. Test pits
    c. Soil borings
    d. Soil borings for wells
    e. Soil land farms

    f. Soil stockpiles
    g. Wells, including vadose injection and extraction, groundwater monitor, groundwater injection and extraction or other.
    h. Piezometer
    i. Surface water

13. Identify the sample type(s) including, but not limited to, the following:
    a. Grab
    b. Composite
    c. Headspace
    d. Time-flow averaged
    e. Closure sample
    f. Confirmation sample (verification)
    g. Quality control (QC) samples (duplicates, splits, blanks, etc).

14. Provide detailed descriptions of field screening methods and devices used, including but not limited to organic vapor meters, or other methods for detecting the presence of vapor contamination.

15. Describe sampling methodology, equipment and devices used.

16. Describe devices used to measure the depth to groundwater.

17. Describe the proper QA/QC sample collection methods and equipment used.
    a. Describe sample containers for each sample type and media, and identify the source or supplier of the sample containers.
    b. Describe decontamination procedures for all sampling equipment, containers, water and product level measuring devices, drilling equipment, or other devices that contact and affect the sample.
    c. **Sampling procedures must be conducted in a manner that minimizes the loss of volatile organic compounds.** Describe the methods used to minimize the loss of volatiles and maintain sample integrity, including but not limited to the following: Zero headspace in sample container, methods used to preserve the sample at 4° Celsius (approximately 39.2° Fahrenheit).
    d. Describe methods used to transport environmental samples to the laboratory.
    e. If samples are not immediately delivered to the laboratory, describe the methods used to preserve samples and maintain sample integrity.
    f. Describe how groundwater wells were purged and the calculations that support the reported number of casing or borehole volumes removed. Purging is complete when the pH, electrical conductivity, and temperature stabilize. If following this procedure is not possible, remove a minimum of three volumes.

18. If a health and safety plan was prepared for the site, please submit a copy.

19. Analytical Methods and Contamination Concentration Determination: The following chart shows the constituents in each product type that must be analyzed using suggested analytical methods. The analyses of additional constituents may be required, as determined by the Executive Secretary.

Substance or Product Type	**Contaminant Compounds to be Analyzed** (Table of Analytical Methods for Sampling March 31, 1999)	**ANALYTICAL METHODS[1]** **Soil, Groundwater or Surface Water**
Gasoline	Total Petroleum Hydrocarbons (TPH); and Benzene, Toluene, Ethyl benzene, Xylenes, Naphthalene, (BTEXN) and MTBE	EPA 8015B[1] and EPA 8021B[1] or 8260B
Diesel	Total Petroleum Hydrocarbons (TPH); and Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene (BTEXN)	EPA 8015B and EPA 8021B or 8260B
Used Oil	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH); and Benzene, Toluene, Ethyl benzene, Xylenes, Naphthalene (BTEXN) and MTBE; and Halogenated Volatile Organic Compounds (VOC's)	EPA 1664 or 5520[2] and EPA 8021B or 8260B
New Oil	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664 or 5520
Other or Unknown	Total Petroleum Hydrocarbons (TPH); and Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene (BTEXN); and Halogenated Volatile Organic Compounds (VOC's)	EPA 8015B and EPA 8021B or 8260B

[1] The following modifications to thesse certified methods are considered acceptable by the Executive Secretary (UST):

A. Dual column confirmation may not be required for TPH & BTEXN/MTBE analysis.

B. A micro-extraction or scale-down technique may be used for aqueous samples.

C. Hexane may be used as an extraction solvent.

Note: The sample preparation method and any modification(s) to a certified method must be reported by the laboratory on the final analytical report.

[2] Methods or test procedures allowed for Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH) are 5520(b) or 5520(f) respectively.

* When sampling a known substance, analyze for that substance, i.e anti-freeze tank analyze for ethylene glycol.

20. Laboratory analytical detection limits must be sufficiently low in order to detect contaminant concentrations at or below their applicable maximum contaminant levels or state-established cleanup levels.

21. Submit copies of original laboratory report forms; must include detection levels.

22. If soil samples are corrected for moisture content, please provide the moisture content of the sample and any other relevant information.

23. Ensure that dates of sample collection, date submitted to the laboratory, and date analyzed are clearly identified in all submitted reports and information.

24. Groundwater well installation and abandonment must be conducted in accordance with the Utah Division of Water Rights specifications.

25. If soil borings and wells are emplaced, the following information at a minimum is required:
    1. Type of drilling apparatus and equipment.
    2. Drilling fluids used, if applicable.
    3. Appropriate vertical scale must be shown on the boring logs.
    4. Detailed geologic boring logs describing the lithology, grain sizes, grain angularity, sorting, color, moisture, firmness, plasticity, strata characteristics such as bed thickness, lenses, interbedding, or other pertinent features.
    5. Sample collection locations, including soil, groundwater, and organic vapor meter measurements, headspace, or other.
    6. Blow counts per foot, if applicable.
    7. Presence or absence of hydrocarbon staining.
    8. Depth to groundwater, if encountered, and groundwater elevations.
    9. Total depth of well or boring.
    10. Number of wells and/or borings.
    11. As-built drawings.
    12. Well construction materials, including casing screen type, filter pack material and particle size.
    13. Screen length and slot size.
    14. Type and placement of pumps, if applicable.

26. Describe in detail the procedures used to dispose of drill cuttings, purged water, or any other materials generated during any phase of work.

Environmental Sampling

INTRODUCTION

Investigations at UST sites usually require chemical and physical analyses of soil and groundwater samples that were collected at the sites. The data obtained serve as the basis for decisions regarding impacts to soil and potential drinking water supplies, and assessing actual and potential impacts to human health and the environment. Data obtained on soil and groundwater quality at UST sites must, to the greatest extent possible, be accurate and representative of site conditions. This chapter reviews environmental sampling with emphasis on those techniques and pertinent items discussed in the Certified Samplers Training and is customized to DERR rules and regulations.

REGULATIONS

Field operations involving environmental sampling at underground storage tank sites in the state of Utah shall conform to all rules and regulations set forth in 40 CFR Part 280 Subparts: A,B,C,D,E,F and G; and in State of Utah Administrative Code (UAC): R311, Parts 200-208. Additionally, a State of Utah Closure Plan conforming to UAC R311-204 must be submitted outlining details of the UST system closure. Soil and groundwater samples must be collected by a State of Utah Certified Soil and Groundwater Sampler during closure operations and during subsequent field investigations.

Following the UST closure, the Owner/Operator (O/O) must submit a completed "Closure Notice" to the DERR UST section to document that the closure was performed as outlined in the Closure Plan.

SAMPLING EQUIPMENT AND TECHNIQUES

Sampling equipment and techniques must conform to the State's Site Assessment Protocol. A brief summary of protocol guidelines follows.

Sample Types

In addition to the environmental and USC samples required at UST sites, as discussed above, state regulations stipulate that grab samples be collected rather than composite samples. If groundwater is encountered at a site, water samples are to be collected in the same sampling locations as soil samples, but 6-inches below the top of the water level.

State of Utah regulations require that two types of samples be collected during closure at all UST sites in the State:

- Environmental samples, which are soil and/or groundwater samples, which are analyzed for petroleum constituents. Environmental samples must be analyzed by a State of Utah certified laboratory.
- Uniform soil classification (UST) samples which are analyzed for soil type.

Environmental samples must be collected during subsurface investigations and after corrective actions at LUST sites. USC samples are not required during these phases, if USC samples were collected during UST closure.

UST Closure Sampling Locations

Sampling locations depend upon the number of tanks at the site and whether or not groundwater is encountered during excavation. Generally, at a one tank site, and if no groundwater is encountered, two environmental soil samples must be collected one at each end of the tank, 0-2 feet below native soil-tank backfill interface. If groundwater is encountered, a minimum of one groundwater sample and one soil sampled must be collected at each end of the excavation. One USC soil sample must be collected at the same depth as the environmental sample. If two or more tanks are in the same excavation, and if no groundwater is encountered, four environmental soil samples must be collected, one from each corner of the excavation, 0-2 feet below native soil-tank backfill interface. If groundwater is encountered, a minimum of one groundwater sample and one soil sample must be collected at each end of the excavation. One USC soil sample must be collected at the same depth as the environmental sample. Please Read R311-205

Subsurface Investigation Sampling Locations

Soil borings and monitoring wells are installed as part of the subsurface investigation at a LUST site to delineate the lateral and vertical extent of contamination. A decision on the locations and number of soil borings and monitoring wells should be made in consultation with the DERR project manager, and should be determined based on site-specific information. At some sites three or four soil borings may be enough to delineate the extent of contamination, while at other sites a dozen or more soil borings may be needed. Soil or rock samples should be collected for potential laboratory analysis. A minimum of one soil sample should be analyzed from each soil boring, regardless of depth of the boring. Several soil samples should be analyzed from deep soil borings. A sufficient number of soil samples from each soil boring should be analyzed to determine the vertical extent of contamination in the boring.

Groundwater monitoring wells are required at sites where groundwater is impacted. A minimum of three groundwater monitoring wells are necessary to define the groundwater flow direction. In practice, more than three wells are typically necessary so that at least one monitoring well is directly down gradient from the source of the contamination. A down gradient monitoring well is helpful to demonstrate if contamination remains onsite or has migrated offsite. Conversely, an upgrading well is helpful to demonstrate if contamination is moving onto the site from an offsite source.

Corrective Action Confirmation Sampling Locations

Corrective action confirmation samples are environmental samples that are collected to demonstrate that cleanup goals have been achieved after corrective action at site is complete. The number and locations of samples should be determined in consultation with the DERR project manager, and are based on site-specific information. By way of example:

- at least one soil sample should be collected and analyzed from each sidewall and bottom of an excavation pit after over excavation is complete

- groundwater samples should be collected from each monitoring well at a site after groundwater remediation is complete

PID/FID Monitoring

Photoionization detector (PID) and Flame ionization detector (FID) instruments are the most common hydrocarbon vapor analyzers in use. Their use serves two purposes: protection of worker health; and screening of environmental samples to determine which samples to analyze and the relative concentrations of hydrocarbons that the sample may contain.

Soil Sampling

Clean and decontaminated stainless steel spoons, trowels, hand augers, or split-spoon sampler should be used to collect soil samples. Excavate, or hand auger, the natural soil until the correct location and depth are reached as required in the State Site Assessment Protocol. The sample container should be full with no air or head space between the soil and the cap. All samples should be shipped to the laboratory as soon as possible to ensure quality. The maximum time between sample collection and analysis is 14 days.

Groundwater Sampling

Groundwater samples are typically collected with a bailer. The bailer should be lowered into the water slowly allowing only the top portion of the water, near the surface, to be sampled. The sample should be sufficient to fill the sampling container. No air should be allowed between the liquid surface and the lid of the container. It is important not to shake or agitate the sample in the bailer as this might cause the loss of volatiles (BTEX).

Prior to water being sampled from a monitoring well, the depth to groundwater must be measured and the total water volume calculated. A minimum of 3 well-~~[illegible]~~ casing volumes of water should be removed to ensure that all stagnant water has been replaced by fresh formation water. If free product is suspected or verified during water level measurements, an interface probe, or hydrocarbon sensitive paste should be used to measure the apparent thickness of the free product.

Analytical Methods

Soil and groundwater environmental samples are analyzed for petroleum constituents as follows:

- Total petroleum hydrocarbons (TPH) as gasoline and/or diesel (based on contents of the USTs) using 8015B. If the USTs contained oil or used oil, total recoverable hydrocarbons (TRH) using U.S. EPA Method 5520 or oil and grease (O&G) using U.S. EPA Method 1664 are substituted for the TPH analyses.

- Benzene, toluene, ethylbenzene, total xylenes and naphthalene (BTEXN) and MTBE using U.S. EPA Method 8021B or 8260B.

- Closure soil samples are also analyzed for USC using ASTM Method D2488-90.

Quality Assurance and Control

The object of quality assurance and control (QA/QC) in groundwater sampling is to produce data which are appropriately accurate and representative, and which are credible and defensible. As part of the QA/QC program, a trip blank should be submitted with all environmental samples. In addition, a blind duplicate should be submitted every 20 to 25 samples.

DECONTAMINATION PROCEDURES

Small sampling equipment should be washed with a non-phosphatic detergent in hot water, followed by a rinse in distilled water. Repeat if necessary until the equipment is completely decontaminated. If possible, disposable bailers should be used for sampling purposes. Larger equipment such as bits, augers, core barrels, etc. should be steam cleaned on-site if possible, but away from the sampling area.

SAMPLE PRESERVATION AND DOCUMENTATION

Proper sample preservation, and complete, accurate documentation of a sample during all phases of sampling, handling, shipping, and analyzing at a state certified lab are critical to ensure that results are credible and defensible in regulatory or other legal proceedings.

Documentation

Proper and complete documentation materials will include appropriate chain of custody forms, proper sampling labels, sample and container seals, and sample analysis request sheets. Each sample must have a chain of custody record. The chain of custody form is used to track the possession of a sample from the time the sample is collected until the time the sample is analyzed. A sample must remain in sight of the individual in custody at all times or in a secured location until the sample is release to the next chain of custody recipient or to the analytical lab. The chain of custody must include the sample collection number; date and time of collection; place of collection; type of material, sample container, and preservation; signature of the collector; signatures and dates of persons involved in the transportation and handling of the sample.

The chain of custody form may also combine a sample analysis request. Many labs have chain of custody/analytical request forms available for use.

Each sample container should be labeled with a permanent label that includes the sample collection number; date and time of collection; place of collection; and name of person collecting the sample. The sample number on the sample container should be the same as the sample number on the chain of custody form. Waterproof or indelible ink should be used to write on the sample labels.

Coordination with a Certified Laboratory

The sampler should contact a state Certified Lab in advance of sampling to determine that the lab is capable of conducting the sample analysis within the specified holding time, usually 14 calendar days. For oil and grease samples, the time is 28 calendar days. The State Certified Lab must use an approved detection method that will detect levels for BTEXN in water at 5 ug/L, or lower.

The USC sample may be described by a qualified geologist in the field, or analyzed by a certified lab or a geotechnical lab.

Preservation and Shipping Procedures

Soil and groundwater samples should be placed in a container acceptable by both the lab and carrier, if the samples are not going to be transported directly to the lab by the sampler or representative. Dry ice should not be used when shipping water samples as the samples may freeze and break the glass container. Additionally, when shipping samples of pure volatile like gasoline, never fill the container to the top, as expansion during transportation may rupture the glass container.

SAFETY

Personal safety is paramount at UST sites. Petroleum products are toxic and present fire and explosion hazards. Personal safety in the collection of soil and groundwater samples at UST facilities must meet the standards required by federal and state regulatory agencies.

Extreme care should be used when it becomes necessary to enter an excavation for sampling purposes. If this is the case, the excavation side walls should be sloped or shored to prevent slumping or cave-in.

CHAPTER 6
Subsurface Investigations, Sampling, and Analytical Requirements

Requirements and format guidelines for Subsurface Investigation Reports are presented in the *LUST Subsurface Investigation Report Guide* (Chapter 3). In accordance with Utah UST Rule R311-201-2 (Chapter 1), leaking underground storage tank (LUST)-related work must be overseen by a Utah-Certified UST Consultant in the event the owner/operator does not conduct and manage the investigative and cleanup work in house. Soil and groundwater sampling must be performed by a Utah-Certified Groundwater and Soil Sampler.

6.1 EXPEDITED SITE ASSESSMENT

An expedited site assessment (ESA) is a process of rapidly delineating the extent of soil and groundwater contamination, determining potential exposure pathways, and identifying potential receptors at LUST sites. An ESA utilizes rapid soil sampling methods (direct-push hydraulic borehole rigs), installation of small diameter groundwater monitoring wells (1 to 2 inch diameter), on-site surveying and determination of groundwater flow direction, field analytical methods (mobile laboratories), and on-site decision-making by experienced personnel. The goal of an ESA is to complete a subsurface investigation in one mobilization.

Conventional site assessment processes can involve several mobilizations because decisions regarding the placement of additional soil boreholes or monitor wells are usually made back in the office following data evaluation. The field work is usually conducted by less experienced field technicians who collect samples for off-site laboratory analysis.

For more detailed information on ESAs, the reader should review the U.S. EPA’s guidance document entitled *Expedited Site Assessment Tools For Underground Storage Tank Sites* (EPA, 1997).

6.2 BACKGROUND RESEARCH

Before conducting a subsurface investigation at a LUST site, background research on the current and historical uses of the site and surrounding area should be performed. The following examples illustrate the usefulness of this information.

- Review DERR Interactive Map to find information on other LUST sites within the vicinity of the subject LUST site. These files can provide information on soil types, depth to groundwater, and groundwater flow direction. This information can be used to determine the type of drilling rig to use and how deep monitor wells must be installed.

- Review Utah Division of Water Rights (DWR) records. These records can provide information on the presence of municipal, domestic, irrigation, and other types of water wells in the area. In some cases, geologic borehole logs and well construction information are available online as well.

- Review historical aerial photographs. This information can be used to determine past uses of the site and surrounding area. For example, aerial photographs can be used to determine if other USTs are/were located on the site.

6.3 SITE RECONNAISSANCE

Prior to performing a subsurface investigation, a reconnaissance of the site and surrounding area should be conducted. Information to be obtained includes:

- The locations of all USTs, product piping, and pump islands.
- The locations of all other potential sources of environmental contamination, such as septic tanks, leach fields, and floor drains.
- The locations of all wells on site or in the vicinity of the site. Verify the presence and use of all wells identified by the DWR records search.
- The locations of overhead and underground utilities for drilling safety purposes and potential contaminant transport. “Blue Stakes” can be called to mark out the site prior to your site visit (Chapter 9).
- The locations and addresses of businesses and property owners in the vicinity for access agreements and potential environmental concerns.
- Photographs of the site and vicinity.

Using the information collected during the site reconnaissance, prepare scaled site and vicinity maps.

6.4 SUBSURFACE INVESTIGATION

The following sections describe several types of techniques used for traditional and expedited subsurface investigations.

6.5 SOIL AND GROUNDWATER SAMPLING

The following section describes the various types and locations of soil and groundwater samples collected at UST sites in Utah.

6.5.1 Sample Types

Utah UST regulations require that the following types of samples be collected at UST closure:

- Environmental samples: Soil and groundwater samples collected for laboratory analysis for petroleum hydrocarbon compounds by a Utah-certified analytical laboratory. Soil and water samples must be discrete, not composites.

- Unified Soil Classification System (USCS) samples: Soil samples analyzed for soil type. USCS samples may be described by a qualified geologist in the field or analyzed by a Utah-certified analytical laboratory or a geotechnical laboratory. Information on field soil classification is included in the section below on Soil Classification.

- Environmental confirmation samples are collected during an UST closure if overexcavation has removed additional soil past the location of the closure samples. USCS samples are not required during this and later phases, if USCS samples were collected during UST closure. However, detailed descriptions of subsurface lithology are required during the subsurface investigation phase in order to determine contaminant migration potential and select a remediation methodology.

Requirements for sampling of soil and groundwater at UST closures are detailed in Utah Underground Storage Tank Rule R311-205-2(b). The UST Rules are referenced in Chapter 1.

6.5.2 Subsurface Investigation Sampling

Soil boreholes and monitoring wells are installed as part of a subsurface investigation at a LUST site to delineate the lateral and vertical extent of contamination. Decisions regarding the number and locations of soil boreholes and monitoring wells should be made in consultation with the DERR Project Manager. For example, at some sites three or four soil boreholes may be enough to delineate the extent of contamination. At other sites a dozen or more soil boreholes may be needed. A minimum of one soil sample should be analyzed from each soil borehole, regardless of the depth of the borehole.

Several soil samples should be analyzed from deep soil boreholes. A sufficient number of soil samples from each soil borehole should be analyzed to determine the vertical extent of contamination in the borehole and document the lithology. It may be necessary to collect soil samples below the water table to fully delineate the vertical extent of contamination.

Instruments with photoionization and flame-ionization detectors (PID/FID) are commonly used in the field to monitor ambient air for the protection of worker health and qualitatively determine relative volatile petroleum hydrocarbon vapor concentrations in soil samples. These instruments are used to screen soil samples to determine which samples to analyze in an off-site Utah-certified analytical laboratory.

Groundwater monitoring wells are required at sites where groundwater is encountered. A minimum of three groundwater monitoring wells are necessary to determine the groundwater flow direction and gradient. In practice, more than three wells are typically necessary so that at least one monitoring well is located directly downgradient of the source of the contamination. A downgradient monitoring well is required to determine if contamination has migrated off site. Conversely, an upgradient well is useful to determine if contamination is migrating onto the site from an off-site source.

6.5.3 Corrective Action Confirmation Samples

Corrective action confirmation samples are environmental samples that are collected to demonstrate that cleanup goals have been achieved after corrective action at site is complete. The number and locations of samples should be determined in consultation with the DERR Project Manager.

For example:

- Soil samples should be collected and analyzed from each sidewall and the bottom of an excavation pit after overexcavation of contaminated soil is complete.
- Groundwater samples should be collected from each monitoring well at a site after groundwater remediation is complete.
- Post remedial soil confirmation samples must indicate that contaminant concentrations in soil meet cleanup goals following in-situ remediation as well. These soil samples should be collected from each location where cleanup standards were exceeded during site investigation.

6.5.4 Soil Classification

In general, soil classification systems are used to describe soil particle-size distribution, or texture that affects hydrologic, engineering, and contaminant transport characteristics of the soil. The most common classification system utilized in classifying soils using their engineering properties is the USCS. Other classification systems not described in this manual may be better suited to interpret depositional environments and hydrologic and contaminant transport properties.

The American Society for Testing and Materials (ASTM) has developed a Standard Practice for Description and Identification of Soil (Visual-Manual Procedure) D2488-93, which describes the description of soils for engineering purposes using the USCS. Relative proportions of grain size are estimated either in the laboratory or field. The USCS also incorporates other soil properties such as plasticity, liquid limit, clod strength, dilatancy, toughness, and stickiness for classification.

6.38 GROUNDWATER SAMPLING AND HANDLING PROCEDURES

This section provides an overview of groundwater sampling and handling procedures, which generally are applicable to any groundwater monitoring program. This section is not intended to provide specific guidance on sampling for a specific situation, but provides information on the major activities that are required for sample collection and handling.

The starting point for any groundwater sampling program is the quality assurance/quality control (QA/QC) plan. Groundwater sampling protocols appropriate to the data quality objectives and the site conditions will define the specific procedures that will be followed for individual sampling events. Well purging typically has been an important element of sampling procedures, the specific procedures of which will vary with site conditions. Specific sample handling and preservation procedures are likely to vary somewhat, depending on the analyte of interest at a site, as will decontamination procedures.

6.39 LUST SITE GROUNDWATER MONITORING WELL PURGING

Prior to collecting groundwater samples from a monitoring well, stagnant water must be removed from the well. This is called “well purging.” A minimum of three well volumes of water should be removed to ensure that all stagnant water has been replaced by representative formation water.

If free product is detected during water level measurements, an interface probe or hydrocarbon-sensitive paste should be used to measure the apparent thickness of the LNAPL.

The following section excerpted from *Subsurface Characterization and Monitoring Techniques* (EPA, 1993b) describes well purging methods, considerations, and frequency of use.

6.40 LUST SITE GROUNDWATER SAMPLING

Following purging, groundwater samples are typically collected from monitoring wells with a bailer. The bailer should be lowered into the water slowly, allowing only the top portion of the water nearest the air-water interface to be sampled. For volatile petroleum hydrocarbon compounds, such as TPH, BTEX, and MTBE, the groundwater sample should be poured from the bailer into volatile organic analysis (VOA) vials. After filling, no air bubbles (no headspace) should be present in the VOA vials.

Groundwater may also be collected with a low-flow pump to minimize aeration of the sample.

6.41 WELL PURGING

6.41.1 Other Names Used to Describe Method Well flushing.

6.41.2 Uses at Contaminated Sites Removing stagnant water from a well before sample collection.

6.41.3 Method Description

Well purging involves the pumping of stagnant water from a well before sample collection. A monitoring well is pumped (generally at a rate from 1 to *5* gallons per minute) until a certain number of well volumes have been removed and until water quality indicators, such as pH, conductance and/or temperature, have stabilized, indicating that fresh formation water fills the well. Sampling takes place after purging is completed. Recent research (Kearl et al, 1992) has suggested that purging is not desirable because it can mobilize colloidal particles upon which contaminants are sorbed. The alternative to purging is to use a dedicated sampling device set at the level of the well screen capable of low pumping rates (around 100 mI./minute), which will not increase colloid density in the ground-water sample compared to natural colloidal flow through the well.

6.41.4 Method Selection Considerations

Recommended rules of thumb, such as purging three to five volumes (Fenn et al., 1977) should be treated only as a starting point. Accurate estimation of purge volume requires knowing: (1) Well yield, determined from a slug or pumping test, and (2) the stagnant volumes of both the well casing and the sand pack. Figure B.2a shows the volume of water stored per foot of well casing at different diameters. In slowly recovering wells, extra care is required when purging to ensure that water levels do not drop below the level of the well screen because aeration might allow loss of volatile or redox sensitive contaminants. After stagnant water has been removed or isolated, chemical indicators (pH, conductance, and temperature) should continue to be monitored until they reach a consistent end point (no upward or downward trend). Another important consideration in purging is that the pumping rate should not exceed levels that will cause turbulent flow. Turbulent flow in the well might cause pressure changes, which could result in loss of carbon dioxide and other volatile gases, subsequently changing pH and dissolved solids content (Meredith and Brine, 1992). The maximum discharge rate during pumping that avoids turbulent flow is a function of hydraulic conductivity, the length of the well screen, width of the screen openings, and the total open area of the screen. Figure B.2b shows the optimum screen entrance velocity related to the hydraulic conductivity of an aquifer. Table B2 provides guidelines for maximum purging rate based on screen type, diameter, slot size, open area, and entrance velocity (from Figure B.2b).

6.41.5 Frequency of Use

Has been a standard procedure for all ground-water sampling. Although, as noted above, the practice has been called into question.

6.41.6 Standard Methods/Guidelines Barcelona et al. (1985) provide a detailed procedure for estimating well purging volume.

6.41.7 Sources for Additional Information

All standard guides on ground-water sampling discuss purging (see general texts/reports and additional references listed under “purging” in Table B-I). Herzog et al. (1991) provide a good review of the literature on well purging.

6.42 QUALITY ASSURANCE/QUALITY CONTROL

The following section excerpted from *Subsurface Characterization and Monitoring Techniques* (EPA, 1993b) describes QA/QC protocols, considerations, and frequency of use.

The following section excerpted from *Subsurface Characterization and Monitoring Techniques* (EPA, 1993b) describes QAJQC protocols, considerations, and frequency of use.

6.42.1 Other Names Used to Describe Method QA/QC, sampling protocol.

6.42.2 Uses at Contaminated Sites

Minimizing the sources of error in ground-water (and soil) sampling results.

6.42.3 Method Description

A QA/QC plan involves the establishment of a sampling protocol, which is designed to minimize sources of error in each stage of the sampling process, from sample collection to analysis and reporting of analytical data. Key elements include: (1) Development of a statistically sound sampling plan for spatial and temporal characterization of ground water (U.S. EPA, 1989b); (2) installation of a vertical and horizontal sampling network, which allows collection of samples that are representative of the subsurface; (3) use of sampling devices that minimize disturbance of the chemistry of the formation water (4) use of decontamination procedures for all sampling equipment to minimize cross-contamination between sampling points (see Section B.4); (5) collection of QA/QC samples (see Table B.1 for types of samples); and (6) bottling, preservation, and transport of samples to maximize the integrity of the samples (Section B3). Additional QA/QC procedures must be followed in the laboratory. Figure B.1 shows a generalized flow diagram for ground-water soil sampling protocol.

6.42.4 Method Selection Considerations

As requirements for precision and accuracy increase, the type and number of QA/QC samples will increase. Field rinsate blanks should be collected any time there is a possibility of cross-contamination from sampling equipment.

6.42.5 Frequency of Use Required standard procedure for all ground-water sampling.

6.42.6 Standard Methods/Guidelines

6.42.7 Sources for Additional Information See Table B-L

6.43 LABORATORY ANALYTICAL REQUIREMENTS, SAMPLE HOLDING TIMES, AND DOCUMENTATION

6.43.1 Sample Containers and Preservation

The type and number of sample containers and the sample preservation method depends on the analysis required, the media sampled (soil or water), and the laboratory used. Check with the Utah-certified analytical laboratory that you will be using for specific information on sample containers and preservation.

6.43.2 Sample Holding Times

Check with the Utah-certified analytical laboratory in advance of sampling to determine if they can perform the analyses within the specified sample holding time. For example, the holding time for analysis of volatile petroleum hydrocarbon compounds (TPH, BTEX, and MTBE) is 14 calendar days (groundwater samples must be acidified with HCl for the 14-day holding time, otherwise the holding time is 7 days). For TRPH and Oil & Grease analyses, the holding times are 28 calendar days.

6.43.3 Sample Documentation

Sample documentation materials include chain-of-custody forms and sample labels. The chain-of-custody form is used to track the possession of a sample from the time the sample is collected until the time the sample is analyzed. Samples must remain in the control of the individual in custody of the samples at all times (or in a secured location) until the sample is released to the next chain-of-custody recipient or to the analytical laboratory. The chain-of-custody form must include the sample identification number, date/time of collection, place of collection (borehole/well number), type of material (soil or water), sample container type (VOA vial, 1-liter bottle, etc.), preservation method (acidified, cooled, etc.), signature/printed name and company of the sample collector, and signatures/printed names and dates/times of persons involved in the transportation and handling of the sample. An example chain-of-custody form is included at the end of this chapter.

Each sample container should be labeled with a permanent label that includes the sample identification number, date and time of collection, place of collection, and name of person/company collecting the sample. The sample number on the sample container should be the same as the sample number on the chain-of-custody form and the laboratory report.

6.43.4 Utah Certified Laboratories

The Utah Department of Health has a program that establishes and enforces standards for laboratories that provide test results for compliance purposes to the Utah Department of Environmental Quality. A laboratory requesting certification is required to complete an application, participate in a proficiency testing program, and meet state laboratory standards. The certification process requires an on-site survey of the laboratory by state certification officers to assess the laboratory's compliance with state standards. All analytical test results submitted to the DERR for an UST site in Utah must be performed by a Utah Certified laboratory. A list of Utah Certified laboratories is located at:
http://health.utah.gov/lab/labimp/labcert/LabsCertified_RCRA.xls.

6.43.5 Approved Analytical Methods

Specific analytical methods must be used when sampling for petroleum constituents at UST sites in Utah. Refer to the following table in this section for the correct analytical methods: *Analytical Methods for Environmental Sampling at Underground Storage Tank Sites in Utah (July 2004)***.**

6.54 SPECIAL SECTION ON MTBE

The following text comes from an MTBE Fact Sheet originally prepared in early 2000:

Methyl tertiary butyl ether (MTBE) is a fuel additive used as an octane-enhancing replacement for lead primarily in high-grade gasoline at concentrations as high as 8%. It is also used as a fuel oxygenate at higher concentrations, ranging from 11% to 15%, to reduce ozone and carbon monoxide levels, in response to either the Reformulated Gasoline Program or Oxygenated Fuel Program.

MTBE has been used widely throughout the country since the mid-1980s. According to the National LUST Programs Survey (1998), 251 to 422 public water supply wells in 19 states contained detectable concentrations of the MTBE. As a result, many of these wells have been shut down, required treatment, and/or required other water sources used at much greater expense than the original water source.

6.54.1 Use of MTBE in Utah

In Utah, there are three out of six refineries using MTBE: Phillips 66, Flying J and Inland Oil. The Phillips 66 refinery uses 8% to12% MTBE in gasoline in the summer as an octane enhancer (in the winter Phillips 66 uses 9.5% ethanol in Utah County). The Flying J and Inland Oil refineries use less than 1% by volume MTBE in the gasoline sold in Utah. The rest of the refineries, Chevron, BP Amoco, and Texaco use ethanol instead of MTBE. Ethanol is not a major environmental problem because it is much more biodegradable than MTBE. For comparison, California uses about 15% by volume MTBE in the gasoline sold throughout the state.

Retailers around the state may receive deliveries of gasoline containing MTBE due to their proximity to an area in which MTBE is used to achieve compliance with the Clean Air Act Amendments.

6.54.2 Risk, Fate, and Transport of MTBE

The EPA has classified MTBE as a possible human carcinogen. No MCL has been established for the compound, as its health effects are still being studied. However, MTBE is known to be a nuisance pollutant with respect to taste and odor. The EPA Drinking Water Advisory suggests that the range of 20 to 40 micrograms per liter (μg/L) would be below the unpleasant odor and taste thresholds for a large majority of people. UDEQ relies on the EPA Health Advisory concentration of 70 μg/L as a cleanup level.

MTBE is problematic as a pollutant due to its high water solubility and low biodegradability.

- MTBE migrates at about the same velocity as the groundwater;
- MTBE generates large plumes due to its affinity to water;

- MTBE has a lower volatility than benzene in the dissolved phase;
- MTBE travels through soil rapidly since it is not sorbed to soils or organic carbon; and
- MTBE is recalcitrant to biodegradation.

Active remediation of MTBE may be required at some LUST sites where MTBE has migrated much further than conventional gasoline components, *e.g.*, BTEXN. Due to the different physical and chemical characteristics of MTBE, the preferred techniques for cleanup may differ from a conventional gasoline plume.

According to the EPA (1998), MTBE's relatively high solubility allows it to dissolve into the groundwater in "pulses" that result in rapid orders of magnitude changes in groundwater concentrations. The pulses may result from changes in groundwater elevation or infiltration of rainwater. These pulses may warrant frequent groundwater sampling events to determine actual MTBE concentrations and levels of risk to down-gradient receptors. The velocity of the groundwater and density of the groundwater monitoring well network will dictate the frequency of sampling.

More information about MTBE can be found on the EPA's website at: **http://www.epa.gov/mtbe/.**

6.54.3 Salt Lake Valley Hydrogeology and MTBE

MTBE is a concern for aquifers in the Salt Lake Valley. Generally, the predominant groundwater production aquifer (principal aquifer) in the Salt Lake Valley is relatively deep and is confined/artesian. For the most part, it is separated from shallow groundwater by thick clay layers. These attributes reduce the likelihood that shallow groundwater contamination will impact the principal aquifer.

However, the clay layers are not continuous throughout the valley and continued pumping of the principal aquifer may, at some time in the future, pull contaminated shallow groundwater into the principal aquifer. In fact, a downward vertical hydraulic gradient between the shallow groundwater and the principal aquifer currently exists in the Midvale and Sandy area. In addition, old abandoned wells (there are many in the Salt Lake Valley) can act as conduits for shallow groundwater contamination to migrate to deeper aquifers and the eastern part of the Salt Lake Valley is considered an "unprotected recharge zone." Therefore, there is a potential for MTBE, and other contaminants in shallow groundwater, to migrate to the principal aquifer in the Salt Lake Valley.

6.54.4 Potential for MTBE to Impact Municipal Wells in Utah

Statewide, as of early 2000, about 209 sites out of a total of 730 open LUST sites (29%) have MTBE contamination in the shallow groundwater. In the Salt Lake Valley, about 80 sites out of about 300 open LUST sites (27%) have MTBE contamination in the shallow groundwater. Even though the MTBE content of gasoline in Utah is relatively low, the compound is prevalent at LUST sites.

Use of the shallow groundwater in the Salt Lake Valley is being planned because the principal aquifer has been fully appropriated. For example, the Jordan Valley Water Conservancy District (JVWCD) has recently received approval to install wells (screened from 10 to 100 feet below grade [bgs]) in the shallow unconfined groundwater aquifer to provide water for rapidly growing areas within its service area. The JVWCD plans to install about 60 wells east of the Jordan River from about 2100 South Street to 7800 South Street.

Fortunately, there has been only one municipal (irrigation) well in Utah impacted by MTBE to date. The well is in Milford, Utah and is located about 300 feet from a gasoline station LUST site. The shallow groundwater underlying the gas station is at about 30 feet bgs and the municipal (irrigation) well is screened from about 250 to 400 feet bgs in a deeper (reportedly confined) aquifer. Without other sources contributing to the plume, there must be some type of vertical hydraulic connection between the shallow groundwater and the deeper aquifer, possibly due to a discontinuous aquitard or a leaky grout seal on the municipal-irrigation well.

United States
Environmental Protection
Agency

Office of
Waste Programs Enforcement
Office of Solid Waste and
Emergency Response

September 1986

Solid Waste

RCRA Ground-Water Monitoring Technical Enforcement Guidance Document

EPA/530/SW-86/055

CHAPTER FOUR

SAMPLING AND ANALYSIS

Federal regulation 40 CFR Part 265, Subpart F, Section 265.92, requires the owner/operator to prepare and implement a written ground-water sampling and analysis (S&A) plan. This plan must include procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain-of-custody control. The plan is an important document. It allows the technical reviewer to thoroughly review how the owner/operator has structured the S&A program. Also, comparison of the written plan to field activities will allow the technical reviewer to ensure the owner/operator is, in fact, following his plan while collecting and analyzing ground-water samples. The purpose of this chapter is to describe important elements of written S&A plans and to discuss the level of detail that owner/operators should include in their plans.

EPA has observed a number of problems in the way in which owner/operators prepare their S&A plans or implement their S&A programs. Some of the more common problems are listed below.

- Owner/operators have not prepared S&A plans or do not keep plans on site.
- Plans contain very little information or do not adequately describe the S&A program that the owner/operator is employing at his facility.
- Field sampling personnel are not following the written plan or are not even aware that it exists.
- Improper well evacuation techniques are used.
- Sampling equipment is used that may alter chemical constituents in ground water.
- Sampling techniques are used that may alter chemical composition of samples, particularly in regard to stripping of volatile organic compounds in samples.

- Facility personnel are not using field blanks, chemical standards, and chemically spiked samples to identify changes in sample quality after collection.

- Field personnel do not properly clean nondedicated sampling equipment after use.

- Field personnel are placing sampling equipment (rope, bailer, tubing) on the ground where it can become contaminated prior to use.

- Field personnel do not document their field activities adequately (e.g., keep sampling logs).

- Field personnel are not following proper chain-of-custody procedures.

- Little attention is paid to data reporting errors or anomalies.

- QA/QC protocol is inadequate (field and/or laboratory).

This chapter describes important elements in S&A plans (Section 4.1), and then discusses the level of detail the owner/operator should include (Sections 4.2 through 4.6). Furthermore, this chapter describes important aspects of evaluating the field implementation of S&A plans (Sections 4.2 through 4.6). Section 4.7 describes how technical reviewers may examine ground-water data to identify problems in the way owner/operators acquire, process, and evaluate data.

4.1 Elements of Sampling and Analysis Plans

The owner/operator's S&A plan should, at a minimum, address a number of elements. Specifically, the S&A plan should include information on:

- Sample collection (Section 4.2);
- Sample preservation and handling (Section 4.3);
- Chain-of-custody control (Section 4.4);
- Analytical procedures (Section 4.5); and
- Field and laboratory quality assurance/quality control (Section 4.6).

4.2 Sample Collection

4.2.1 Measurement of Static Water Level Elevation

The sampling and analysis plan should include provisions for measurement of static water elevations in each well prior to each sampling event. Collection of water elevation on a continuing basis is important to determine if horizontal and vertical flow gradients have changed since initial site characterization. A change in hydrologic conditions may necessitate modification to the design of the owner/operator's ground-water monitoring system. The S&A plan should specify the device to be used for water level measurements, as well as the procedure for measuring water levels.

The owner/operator's field measurements should include depth to standing water and total depth of the well to the bottom of the intake screen structure. This information is required to calculate the volume of stagnant water in the well and provide a check on the integrity of the well (e.g., identify siltation problems). The measurements should be taken to 0.01 foot. Each well should have a permanent, easily identified reference point from which its water level measurement is taken. The reference points should be established by a licensed surveyor and typically located and marked at the top of the well casing with locking cap removed or on the apron, and, where applicable, the protective casing. The references points should be established in relation to an established National Geodetic Vertical Datum (NGVD). In remote areas, a temporary benchmark should be established to facilitate resurveying. The reference point should be established in relation to an established NGVD, and the survey should also note the well location coordinates and the coordinates of any temporary benchmarks. The device used to detect the water level surface must be sufficiently sensitive so that a measurement to ±0.01 foot can be obtained reliably. A steel tape will usually suffice; however, it is recommended that an electronic device (e.g., M-Scope) be used to measure depth to the surface of the ground water or light phase immiscibles. Whenever nondedicated equipment is used, procedures need to be instituted to ensure that the sample is not contaminated. Equipment should be constructed of inert materials and decontaminated prior to use at another well.

4.2.2 Detection of Immiscible Layers

The S&A plan should include provisions for detecting immiscible contaminants (i.e., "floaters" and "sinkers") where they would not be detected in an aqueous phase if the owner/operator manages wastes of this type at his facility. "Floaters" are those relatively insoluble organic liquids that are less dense than water and which spread across the potentiometric surface. "Sinkers" are those relatively insoluble organic liquids that are more dense than water and tend to migrate vertically through the sand and gravel aquifers to the underlying confining layer. The detection of these immiscible layers requires specialized equipment that must be used before the well is evacuated for conventional sampling. The S&A plan should specify the device to be used to detect light phases and dense phases, as well as the procedures to be used for detecting and sampling these contaminants.

Owner/operators should follow the procedures below for detecting the presence of light and/or dense phase immiscible organic layers. These procedures should be undertaken before the well is evacuated for conventional sampling:

1. Remove the locking and protective caps.
2. Sample the air in the well head for organic vapors using either a photoionization analyzer or an organic vapor analyzer, and record measurements.
3. Determine the static liquid level using a manometer and record the depth.
4. Lower an interface probe into the well to determine the existence of any immiscible layer(s), light and/or dense.

The air above the well head should be monitored in order to determine the potential for fire, explosion, and/or toxic effects on workers. This test also serves as a first indication of the presence of light phase immiscible organics. A manometer or acoustical sounder (for very shallow wells) will provide an accurate reading of the depth to the surface of the liquid in the well, but neither are capable of differentiating between the potentiometric surface and the surface of an immiscible layer. Nonetheless, it is very useful to determine that surface depth first to guide the lowering of the interface probe. The interface probe serves two related purposes. First, as it is lowered into the well, the probe registers when it is exposed to an organic liquid and thus identifies the presence of immiscible layers. Careful recording of the depths of the air/floater and floater/water interfaces establishes a measurement of the thickness of the light phase immiscible layer. Secondly, after passing through the light phase immiscible layer, the probe indicates the depth to the water level. The presence of floaters precludes the exclusive use of sounders to make a determination of static water level. Dense phase immiscible layers are detected by lowering the device to the bottom of the well where, again, the interface probe registers the presence of organic liquids.

The approach to collecting light phase immiscibles is dependent on the depth to the surface of the floating layer and the thickness of that layer. The immiscible phase must be collected prior to any purging activities. If the thickness of this phase is 2 feet or greater, a bottom valve bailer is the equipment of choice. The bailer should be lowered slowly until contact is made with the surface of the immiscible phase, and lowered to a depth less than that of the immiscible/water interface depth as determined by preliminary measure with the interface probe.

When the thickness of the floating layer is less than 2 feet, but the depth to the surface of the floating layer is less than 25 feet, a peristaltic pump can be used to "vacuum" a sample.

When the thickness of the floating layer is less than 2 feet and the depth to the surface of the floating layer is beyond the effective "reach" of a peristaltic pump (greater than 25 feet), a bailer must be modified to allow filling only from the top. Sampling personnel should disassemble the bottom check valve of the bailer and insert a piece of 2-inch diameter fluorocarbon resin sheet between the ball and ball seat. This will seal off the bottom valve. The ball from the top check valve should be removed to allow the sample to enter from the top. The buoyancy that occurs when the bailer is lowered into the floater can be overcome by placing a length of 1-inch stainless steel pipe (304, 316, 2205) on the retrieval line above the bailer (this pipe may have to be notched to allow sample entry if the pipe remains within the top of the bailer). The device should be lowered carefully, measuring the depth to the surface of the floating layer, until the top of the bailer is level with the top of the floating layer. The bailer should be lowered an additional one-half thickness of the floating layer and the sample collected. This technique is the most effective method of collection if the floating phase is only a few inches thick.

The best method for collecting dense phase immiscibles is to use a double check valve bailer. The key to sample collection is controlled, slow lowering (and raising) of the bailer to the bottom of the well. The dense phase must be collected prior to any purging activities.

4.2.3 Well Evacuation

The water standing in a well prior to sampling may not be representative of in-situ ground-water quality. Therefore, the owner/operator should remove the standing water in the well and filter pack so that formation water can replace the stagnant water. The owner/operator's S&A plan should include detailed, step-by-step procedures for evacuating wells. The equipment the owner/operator plans to use to evacuate wells should also be described.

The owner/operator's evacuation procedure should ensure that all stagnant water is replaced by fresh formation water upon completion of the process. The owner/operator's approach should allow drawing the water down from above the screen in the uppermost part of the water column in high yield formations to ensure that fresh water from the formation will move upward in the screen. In low-yield formations, water should be purged so that it is removed from the bottom of the screened interval.

The procedure the owner/operator should use for well evacuation depends on the hydraulic yield characteristics of the well. When evacuating low-yield wells (wells that are incapable of yielding three casing volumes), the owner/operator should evacuate wells to dryness once. As soon as the well recovers sufficiently, the first sample should be tested for pH, temperature, and specific conductance. Samples should then be collected and containerized in the order of the parameters' volatilization sensitivity. The well should be retested for pH, temperature, and specific conductance after sampling as a measure of purging efficiency and as a check on the stability of the water samples over time. Whenever full recovery exceeds two hours, the owner/operator should extract the sample as soon as sufficient volume is available for a sample for each parameter. At no time should an owner/operator pump a well to dryness if the recharge rate causes the formation water to vigorously cascade down the sides of the screen and cause an accelerated loss of volatiles. The owner/operator should anticipate this problem and purge three casing volumes from the well at a rate that does not cause recharge water to be excessively agitated. For higher yielding wells, the owner/operator should evacuate three casing volumes prior to sampling.

In order to minimize the introduction of contamination into the well positive-gas-displacement, fluorocarbon resin bladder pumps are recommended for purging wells. Fluorocarbon resin or stainless steel bailers are also recommended purging equipment. Where these devices cannot be used, peristaltic pumps, gas-lift pumps, centrifugal pumps, and venturi pumps may be used. Some of these pumps cause volatilization and produce high pressure differentials, which result in variability in the analysis of pH, specific conductance, metals, and volatile organic samples. They are, however, acceptable for purging the wells if sufficient time is allowed to let the water stabilize prior to sampling.

When purging equipment must be reused, it should be decontaminated, following the same procedures required for the sampling equipment. Clean gloves should be worn by the sampling personnel. Measures should be taken to prevent surface soils from coming in contact with the purging equipment and lines, which in turn could introduce contaminants to the well. Purged water should be collected and screened with photoionization or organic vapor analyzers, pH, temperature, and conductivity meters. If these parameters and facility background data suggest that the water is hazardous, it should be drummed and disposed of properly.

4.2.4 Sample Withdrawal

The technique used to withdraw a ground-water sample from a well should be selected based on a consideration of the parameters to be analyzed in the sample. To ensure the ground-water sample is representative of the formation, it is important to minimize physically altering or chemically contaminating the sample during the withdrawal process. In order to minimize the possibility of sample contamination, the owner/operator should:

- Use only fluorocarbon resin or stainless steel sampling devices, and
- Use dedicated samplers for each well. (If a dedicated sampler is not available for each well, the owner/operator should thoroughly clean the sampler between sampling events, and should take blanks and analyze them to ensure cross-contamination has not occurred.)

The S&A plan should specify the order in which samples are to be collected. Samples should be collected and containerized in the order of the volatilization sensitivity of the parameters. A preferred collection order for some common ground-water parameters follows:

- Volatile organics (VOA)
- Purgeable organic carbon (POC)
- Purgeable organic halogens (POX)
- Total organic halogens (TOX)
- Total organic carbon (TOC)
- Extractable organics
- Total metals
- Dissolved metals
- Phenols
- Cyanide
- Sulfate and chloride
- Turbidity
- Nitrate and ammonia
- Radionuclides

Temperature, pH, and specific conductance measurements should be made in the field before and after sample collection as a check on the stability of the water sampled over time. The S&A plan should also specify in detail the devices the owner/operator will use for sample withdrawal. The plan should state that devices are either dedicated to a specific well or are capable of being fully disassembled and cleaned between sampling events. Procedures for cleaning the sampling equipment should be included in the plan. Any special sampling procedures that the owner/operator must use to obtain samples for a particular constituent (e.g., TOX or TOC) should also be described in the plan.

Equipment and procedures that minimize sample agitation and reduce/eliminate contact with the atmosphere during sample transfer must be used. When used properly, the following are acceptable sampling devices for all parameters:

- Gas-operated, fluorocarbon resin or stainless steel squeeze pump (also referred to as a bladder pump with adjustable flow control);
- Bailer (fluorocarbon resin or stainless steel), provided it is equipped with double check valves and bottom emptying device;
- Syringe bailer (stainless steel or fluorocarbon resin); and
- Single check valve fluorocarbon resin or stainless steel bailer.

Sampling equipment should be constructed of inert material. Equipment with neoprene fittings, PVC bailers, tygon tubing, silicon rubber bladders, neoprene impellers, polyethylene, and viton is not acceptable. If the owner/operator is using bailers, an inert cable/chain (e.g., fluorocarbon resin-coated wire, single strand stainless steel wire) should be used to raise and lower the bailer.

While in the field, the technical reviewer should observe the owner/operator's sampling technique to ensure that the owner/operator satisfies the following:

- Positive gas displacement bladder pumps should be operated in a continuous manner so that they do not produce pulsating samples that are aerated in the return tube or upon discharge.
- Check valves should be designed and inspected to assure that fouling problems do not reduce delivery capabilities or result in aeration of the sample.
- Sampling equipment (e.g., especially bailers) should never be dropped into the well, because this will cause degassing of the water upon impact.
- The contents should be transferred to a sample container in a way that will minimize agitation and aeration.
- Clean sampling equipment should not be placed directly on the ground or other contaminated surfaces prior to insertion into the well.

When dedicated equipment is not used for sampling (or well evacuation), the owner/operator's sampling plan should include procedures for disassembly and cleaning of equipment before each use. If the constituents of interest are inorganic, the equipment should be cleaned with a nonphosphate detergent/soap mixture. The first rinse should be a dilute (0.1 N) hydrochloric acid or nitric acid, followed by a rinse of tap water and finally Type II reagent grade water. Dilute hydrochloric acid is generally preferred to nitric acid when cleaning stainless steel because nitric acid may oxidize stainless steel. When organics are the constituents of concern, the owner/operator should wash equipment with a nonphosphate detergent and rinse with tap water, distilled water, acetone, and pesticide-quality hexane, in that order. The sampling equipment should be thoroughly dried before use to ensure that the residual cleaning agents (e.g., HCl) are not carried over to the sample. The owner/operator should sample background wells first and then proceed to downgradient wells.

When collecting samples where volatile constituents or gases are of interest using a positive gas displacement bladder pump, pumping rates should not exceed 100 milliliters/minute. Higher rates can increase the loss of volatile constituents and can cause fluctuation in pH and pH-sensitive analytes. Once the portions of the sample reserved for the analysis of volatile components have been collected, the owner/operator may use higher pumping rate, particularly if a large sample volume must be collected. The sampling flow rate should not exceed the flow rate used while purging.

4.2.5 In-Situ or Field Analyses

Several constituents of the parameters being evaluated are physically or chemically unstable and must be tested either in the borehole using a probe (in-situ) or immediately after collection using a field test kit. Examples of unstable elements or properties include pH, redox potential, chlorine, dissolved oxygen, and temperature. Although specific conductivity (analogous to electrical resistance) of a substance is relatively stable, it is recommended that this characteristic be determined in the field. Most conductivity instruments require temperature compensation; therefore, the temperature of the samples should be measured at the time conductivity is determined. If the owner/operator uses probes (pH electrode, specific ion electrode, thermistor) to measure any of the above properties, it is important that this is done on water samples taken after well evacuation and after any samples for chemical analysis have been collected, so that the potential for probe(s) to contaminate a sample designated for laboratory analysis is minimized. Monitoring probes should not be placed in shipping containers containing ground-water samples for laboratory analysis.

The owner/operator should complete the calibration of any in-situ monitoring equipment or field-test probes and kits at the beginning of each use, according to the manufacturers' specifications and consistent with Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (SW-846), 2nd Edition, 1982.

4.3 Sample Preservation and Handling

Many of the chemical constituents and physiochemical parameters that are to be measured or evaluated in ground-water monitoring programs are not chemically stable, and therefore sample preservation is required. Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (SW-846) includes a discussion by analyte of the appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers that the owner/operator should use for each constituent or common set of parameters. The owner/operator should identify in the S&A plan what preservation methods and sample containers will be employed. Each sampling and analysis plan should also detail all procedures and techniques for transferring the samples to either a field or off-site laboratory.

Improper sample handling may alter the analytical results of the sample. Samples should be transferred in the field from the sampling equipment directly into the container that has been specifically prepared for that analysis or set of compatible parameters. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers. The S&A plan should specify how the samples for volatiles will be transferred from the sample collection device to the sample container in order to minimize loss through agitation/volatilization.

4.3.1 Sample Containers

The owner/operator's S&A plan should identify the type of sample containers to be used to collect samples, as well as the procedures the owner/operator will use to ensure that sample containers are free of contaminants prior to use.

When metals are the analytes of interest, fluorocarbon resin or polyethylene containers with polypropylene caps should be used. When organics are the analytes of interest, glass bottles with fluorocarbon resin-lined caps should be used. The plan should refer to the specific analytical method (in SW-846) that designates an acceptable container.

Containers should be cleaned based on the analyte of interest. When samples are to be analyzed for metals, the sample containers as well as the laboratory glassware should be thoroughly washed with nonphosphate detergent and tap water, and rinsed with (1:1) nitric acid, tap water, (1:1) hydrochloric acid, tap water, and finally Type II water, in that order.

Similarly, an EPA-approved procedure is available for cleaning containers used to store samples for organics analysis. The sampling container should be emptied of any residual materials, followed by washing with a nonphosphate detergent in hot water. It should then be rinsed with tap water, distilled water, acetone, and finally with pesticide-quality hexane. Dirty or contaminated glassware does not form a very thin sheet of water on its surface and may require treatment with chromic acid and/or baking in a muffle furnace at 400°C for 15 to 30 minutes to ensure that the glass is clean. Chromic acid may be useful to remove organic deposits from glassware; however, the analyst should be cautioned that the glassware must be thoroughly rinsed with water to remove the last traces of chromium. The use of chromic acid can cause a contamination problem and must be avoided if chromium is an analyte of interest.

Glassware should be sealed and stored in a clean environment immediately after drying or cooling to prevent any accumulation of dust or other contaminants. It should be stored capped with aluminum foil and inverted.

The cleanliness of a batch of precleaned bottles should be verified in the laboratory. The residue analysis should be available prior to sampling in the field.

4.3.2 Sample Preservation

The owner/operator's S&A plan should identify sample preservation methods that the owner/operator plans to use. Methods of sample preservation are relatively limited and are generally intended to (1) retard biological action, (2) retard hydrolysis, and (3) reduce sorption effects. Preservation methods are generally limited to pH, control, chemical addition, refrigeration, and protection from light. The owner/operator should refer to the specific preservation method in SW-846 that will be used for the constituent in the sample. A summary list of appropriate sample container types and sample preservation measures is presented in Table 4-1.

4.3.3 Special Handling Considerations

Samples requiring analysis for organics should not be filtered. Samples should not be transferred from one container to another, because

TABLE 4-1

SAMPLING AND PRESERVATION PROCEDURES FOR DETECTION MONITORING[a]

Parameter	Recommended Container[b]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis
		Indicators of Ground-Water Contamination[c]		
pH	T, P, G	Field determined	None	25 ml
Specific conductance	T, P, G	Field determined	None	100 ml
TOC	G, amber, T-lined cap[e]	Cool 4°C,[d] HCl to pH <2	28 days	4 x 15 ml
TOX	G, amber, T-lined septa or caps	Cool 4°C, add 1 ml of 1.1M sodium sulfite	7 days	4 x 15 ml
		Ground-Water Quality Characteristics		
Chloride	T, P, G	4°C	28 days	50 ml
Iron Manganese Sodium	T, P	Field acidified to pH <2 with HNO_3	6 months	200 ml
Phenols	G	4°C/H_2SO_4 to pH <2	28 days	500 ml
Sulfate	T, P, G	Cool, 4°C	28 days	50 ml
		EPA Interim Drinking Water Characteristics		
Arsenic Barium Cadmium Chromium Lead Mercury Selenium Silver	T, P Dark Bottle	Total Metals Field acidified to pH <2 with HNO_3 Dissolved Metals 1. Field filtration (0.45 micron) 2. Acidify to pH <2 with HNO_3	6 months 6 months	1,000 ml 1,000 ml
Fluoride	T, P	Cool, 4°C	28 days	300 ml
Nitrate/Nitrite	T, P, G	4°C/H_2SO_4 to pH <2	14 days	1,000 ml

(Continued)

TABLE 4-1 (Continued)

SAMPLING AND PRESERVATION PROCEDURES FOR DETECTION MONITORING

Parameter	Recommended Container[b]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis
Endrin Lindane Methoxychlor Toxaphene 2,4 D 2,4,5 TP Silvex	T, G	Cool, 4°C	7 days	2,000 ml
Radium Gross Alpha Gross Beta	P, G	Field acidified to pH <2 with HNO_3	6 months	1 gallon
Coliform bacteria	PP, G (sterilized)	Cool, 4°C	6 hours	200 ml
		Other Ground-Water Characteristics of Interest		
Cyanide	P, G	Cool, 4°C, NaOH to pH >12. 0.6 g ascorbic acid[f]	14 days[g]	500 ml
Oil and Grease	G only	Cool, 4°C H_2SO_4 to pH <2	28 days	100 ml
Semivolatile, nonvolatile organics	T, G	Cool, 4°C	14 days	60 ml
Volatiles	G, T-lined	Cool, 4°C	14 days	60 ml

[a] References: Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846 (2nd edition, 1982).
Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020.
Standard Methods for the Examination of Water and Wastewater, 16th edition (1985).

[b] Container Types:
P = Plastic (polyethylene)
G = Glass
T = Fluorocarbon resins (PTFE, Teflon®, FEP, PFA, etc.)
PP = Polypropylene

(Continued)

TABLE 4-1 (Continued)

SAMPLING AND PRESERVATION PROCEDURES FOR DETECTION MONITORING

[c] Based on the requirements for detection monitoring (§265.93), the owner/operator must collect a sufficient volume of ground water to allow for the analysis of four separate replicates.

[d] Shipping containers (cooling chest with ice or ice pack) should be certified as to the 4°C temperature at time of sample placement into these containers. Preservation of samples requires that the temperature of collected samples be adjusted to the 4°C immediately after collection. Shipping coolers must be at 4°C and maintained at 4°C upon placement of sample and during shipment. Maximum-minimum thermometers are to be placed into the shipping chest to record temperature history. Chain-of-custody forms will have Shipping/Receiving and In-transit (max/min) temperature boxes for recording data and verification.

[e] Do not allow any head space in the container.

[f] Use ascorbic acid only in the presence of oxidizing agents.

[g] Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before the pH adjustment in order to determine if sulfide is present. If sulfide is present, it can be removed by addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

losses of organic material onto the walls of the container or aeration may occur. Total organic halogens (TOX) and total organic carbon (TOC) samples should be handled and analyzed as materials containing volatile organics. No headspace should exist in the sample containers to minimize the possibility of volatilization of organics. Field logs and laboratory analysis reports should note the headspace in the sample container(s) at the time of receipt by the laboratory, as well as at the time the sample was first transferred to the sample container at the wellhead.

Metallic ions that migrate through the unsaturated (vadose) and saturated zones and arrive at a ground-water monitoring well may be present in the well. Particles (e.g., silt, clay), which may be present in the well even after well evacuation procedures, may absorb or adsorb various ionic species to effectively lower the dissolved metal content in the well water. Ground-water samples on which metals analysis will be conducted should be split into two portions. One portion should be filtered through a 0.45-micron membrane filter, transferred to a bottle, preserved with nitric acid to a pH less than 2 (Table 4-1), and analyzed for dissolved metals. The remaining portion should be transferred to a bottle, preserved with nitric acid, and analyzed for total metals. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and any sorption of ions to the particles.

4.4 Chain-of-Custody

The owner/operator must describe a chain-of-custody program in the S&A plan. An adequate chain-of-custody program will allow for the tracing of possession and handling of individual samples from the time of field collection through laboratory analysis. An owner/operator's chain-of-custody program should include:

- Sample labels, which prevent misidentification of samples;
- Sample seals to preserve the integrity of the sample from the time it is collected until it is opened in the laboratory;

- Field logbook to record information about each sample collection during the ground-water monitoring program;
- Chain-of-custody record to establish the documentation necessary to trace sample possession from the time of collection to analysis;
- Sample analysis request sheets, which serve as official communication to the laboratory of the particular analysis(es) required for each sample and provide further evidence that the chain of custody is complete; and
- Laboratory logbook and analysis notebooks, which are maintained at the laboratory and record all pertinent information about the sample.

4.4.1 Sample Labels

To prevent misidentification of samples, the owner/operator should affix legible labels to each sample container. The labels should be sufficiently durable to remain legible even when wet and should contain the following types of information:

- Sample identification number
- Name of collector
- Date and time of collection
- Place of collection
- Parameter(s) requested (if space permits)
- Internal temperature of shipping container at time sample was placed
- Internal temperature of shipping container upon opening at laboratory
- Maximum and minimum temperature range that occurred during shipment

4.4.2 Sample Seal

In cases where samples may leave the owner/operator's immediate control, such as shipment to a laboratory by a common carrier (e.g., air freight), a seal should be provided on the shipping container or individual sample bottles to ensure that the samples have not been disturbed during transportation.

4.4.3 Field Logbook

An owner/operator or the individual designated to perform ground-water monitoring operations should keep an up-to-date field logbook that documents the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield - high or low
- Purge volume and pumping rate
- Time well purged
- Collection method for immiscible layers and sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data and method(s)
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature
- Internal temperature of field and shipping (refrigerated) containers

4.4.4 Chain-of-Custody Record

To establish the documentation necessary to trace sample possession from time of collection, a chain-of-custody record should be filled out and should accompany every sample. The record should contain the following types of information:

- Sample number
- Signature of collector
- Date and time of collection
- Sample type (e.g., ground water, immiscible layer)
- Identification of well
- Number of containers
- Parameters requested for analysis
- Signature of person(s) involved in the chain of possession
- Inclusive dates of possession

- Internal temperature of shipping (refrigerated) container (chest) when samples were sealed into the shipping container
- Maximum temperature recorded during shipment
- Minimum temperature recorded during shipment
- Internal temperature of shipping (refrigerated) container upon opening in the laboratory

4.4.5 Sample Analysis Request Sheet

This document should accompany the sample(s) on delivery to the laboratory and clearly identify which sample containers have been designated (e.g., use of preservatives) for each requested parameter. The record should include the following types of information:

- Name of person receiving the sample
- Laboratory sample number (if different from field number)
- Date of sample receipt
- Analyses to be performed
- Internal temperature of shipping (refrigerated) container upon opening in the laboratory

4.4.6 Laboratory Logbook

Once the sample has been received in the laboratory, the sample custodian and/or laboratory personnel should clearly document the processing steps that are applied to the sample. All sample preparation techniques (e.g., extraction) and instrumental methods must be identified in the logbook. Experimental conditions, such as the use of specific reagents (e.g., solvents, acids), temperatures, reaction times, and instrument settings, should be noted. The results of the analysis of all quality control samples should be identified specific to each batch of ground-water samples analyzed. The laboratory logbook should include the time, date, and name of the person who performed each processing step.

4.5 Analytical Procedures

The S&A plan should describe in detail the analytical procedures that will be used to determine the concentrations of constituents or parameters of interest. These procedures should include suitable analytical methods as well as proper quality assurance and quality control protocols. The required precision, accuracy, detection limits, and percent recovery (if applicable) specifications should be clearly identified in the plan.

The S&A plan should identify one method that will be used for each specific parameter or constituent. The plan should specify a method in SW-846 or an EPA-approved method, and clearly indicate if there are going to be any deviations from the stated method and the reasons for these deviations.

Records of ground-water analyses should include the methods used, extraction date, and date of actual analysis. Data from samples that are not analyzed within recommended holding times should be considered suspect. Any deviation from an EPA-approved method (SW-846) should be adequately tested to ensure that the quality of the results meets the performance specifications (e.g., detection limit, sensitivity, precision, accuracy) of the reference method.

4.6 Field and Laboratory Quality Assurance/Quality Control

One of the fundamental responsibilities of the owner/operator is the establishment of continuing programs to ensure the reliability and validity of field and analytical laboratory data gathered as part of the overall ground-water monitoring program.

The owner/operator's S&A plan must explicitly describe the QA/QC program that will be used in the field and laboratory. Many owner/operators use commercial laboratories to conduct analyses of ground-water samples. In these cases, it is the owner/operator's responsibility to ensure that the laboratory of choice is exercising a proper QA/QC program. The QA/QC program described in the owner/operator's S&A plan must be used by the laboratory analyzing samples for the owner/operator.

4.6.1 Field QA/QC Program

The owner/operator's S&A plan should provide for the routine collection and analysis of two types of QC blanks: trip blanks and equipment blanks. Each time a group of bottles is prepared for use in the field, one bottle of each type (e.g., glass, fluorocarbon resin, polyethylene) should be selected from the batch and filled with deionized water. The bottles filled with the blank should be transported to the sampling location and returned to the laboratory in a manner identical to the handling procedure used for the samples. These trip blanks should be subjected to the same analysis as the ground water. Any contaminants found in the trip blanks could be attributed to (1) interaction between the sample and the container, (2) contaminated rinse water, or (3) a handling procedure that alters the sample analysis results. The concentration levels of any contaminants found in the trip blank should not be used to correct the ground-water data. The contaminant levels should be noted, and if the levels are within an order of magnitude when compared to the field sample results, the owner/operator should resample the ground water.

Various types of field blanks should be used to verify that the sample collection and handling process has not affected the quality of the samples. The owner/operator should prepare each of the following field blanks and analyze them for all of the required monitoring parameters:

> Trip Blank - Fill one of each type of sample bottle with Type II reagent grade water, transport to the site, handle like a sample, and return to the laboratory for analysis. One trip blank per sampling event is recommended.
>
> Equipment Blank - To ensure that the nondedicated sampling device has been effectively cleaned (in the laboratory or field), fill the device with Type II reagent grade water or pump Type II reagent grade water through the device, transfer to sample bottle(s), and return to the laboratory for analysis. A minimum of one equipment blank for each day that ground-water monitoring wells are sampled is recommended.

The results of the analysis of the blanks should not be used to correct the ground-water data. If contaminants are found in the blanks, the source of the contamination should be identified and corrective action, including resampling, should be initiated.

All field equipment that the owner/operator will use should be calibrated prior to field use and recalibrated in the field before measuring each sample. The owner/operator's S&A plan should describe a program for ensuring proper calibration of field equipment. Other QA/QC practices such as sampling equipment decontamination procedures and chain-of-custody procedures should also be described in the owner/operator's S&A plan.

4.6.2 Laboratory QA/QC Program

The owner/operator's S&A plan should provide for the use of standards, laboratory blanks, duplicates, and spiked samples for calibration and identification of potential matrix interferences. The owner/operator should use adequate statistical procedures (e.g., QC charts) to monitor and document performance and implement an effective program to resolve testing problems (e.g., instrument maintenance, operator training). Data from QC samples (e.g., blanks, spiked samples) should be used as a measure of performance or as an indicator of potential sources of cross-contamination, but should not be used to alter or correct analytical data. These data should be submitted to the Agency with the ground-water monitoring sample results.

4.7 Evaluation of the Quality of Ground-Water Data

A ground-water sampling and analysis program produces a variety of hydrogeological, geophysical, and ground-water chemical constituent (GWCC) data. This section pertains primarily to the evaluation of GWCC data because these data are specifically required by the regulations, are evaluated in the statistical tests, provide the fundamental evidence used to determine whether the facility is contaminating the ground water, and are used to determine the extent of plume migration during assessment monitoring. Also, details regarding how to obtain and identify quality hydrogeological and geophysical data have been discussed earlier. The GWCC data may be initially presented by the laboratory (by electronic transmittal or) on reporting sheets; these data then must be compiled and analyzed by the owner/operator prior to submission to the state or EPA in order to evaluate the degree of ground-water contamination.

It is essential for owner/operators to make sure that, during chemical analysis, laboratory reporting, computer automation, and report preparation, data are generated and processed to avoid mistakes, and that data are complete and fully documented. Data must be reported correctly to have accurate analyses and valid results. If data errors do occur, statistical analyses cannot discover, correct, or ameliorate these errors.

The following discussion considers aspects of data quality that may indicate to the technical reviewer that the data acquisition, processing, and evaluation were executed poorly or incorrectly.

The specific areas that are addressed include:

- Reporting of low and zero concentration values;
- Missing data values;
- Outliers; and
- Units of measure.

4.7.1 Reporting of Low and Zero Concentration Values

A critical concern is the interpretation, reporting, and analysis of GWCCs that are measured at less than (LT) a limit of detection. LT limit of detection values presently result from a variety of laboratory conventions and protocols. Technical reviewers, during the review of data submissions, may confront a variety of codes indicating that GWCC concentrations are below a value which the laboratory designates as the detection limit.

Values that are LT a limit of detection can result when:

- GWCCs are present at low concentrations;
- An insensitive analytical technique has been used; and
- The chemical matrix of the ground water interferes with the analytical technique.

The following guidelines should help the technical reviewer identify problems associated with the reporting of LT detection limit values, analyze the data sets that contain LT detection limit values, and prescribe remedies for future owner/operator submissions.

GWCC should be given close attention if the LT detection limit values appear to increase over time. Increasing detection limits may be used to conceal an increasing concentration trend. Similarly, if background data are reported without a LT designation at low concentrations and comparison downgradient data are presented at higher concentrations with a LT designation, then it is possible that LT detection limit values are being used to conceal larger downgradient concentrations. It is unacceptable to report only qualitative information for values that were measured below a limit of detection. The technical reviewer must ensure that numerical values accompany the LT designation, so that data are available for analysis. LT detection limit values that are high or that vary should be reduced in future work by laboratory procedures that remove or control interfering constituents.

The owner/operator must explain and follow a specific laboratory protocol for determining and reporting low concentration values. Technical reviewers should not allow the use of highly variable reporting formats. An appropriate protocol for determining and reporting GWCC data at low concentrations is described in Appendix B of 40 CFR §136, titled "Definition and Procedure for the Determination of the Method Detection Limit - Revision 1.11." Other methods are offered by the American Chemical Society and the International Union of Pure and Applied Chemistry.

LT values should not be deleted from the analysis. Instead, when data sets consist of a mixture of values that are LT a limit of detection and actual concentration measurements, LT values may be analyzed at half their reported value. This technique is simple to use and has been presented for use in the following references:

Gilbert, R.O. and Kinnison, R.R. 1981. Statistical Methods for Estimating the Mean and Variance from Radionuclide Data Sets Containing Negative, Unreported, or Less than Values. Health Physics 40:377-390.

Nehls, G.J. and Akland G.G. 1973. Procedures for Handling Aerometric Data. Journal of the Air Pollution Control Association 23:180-184.

LT values may also be analyzed using Cohen's Method. This method is also simple to use and has been described by:

Cohen C. 1961. Tables for Maximum Likelihood Estimates from Singly Truncated and Singly Censored Samples. Technometrics 3:535-541.

Finally, a variety of other techniques, which are slightly more complicated, are described in the following references:

Gilliom, R.J. and Helsel, D.R. 1986. Estimation of Distributional Parameters for Censored Trace Level Water Quality Data. 1. Estimation Techniques. Water Resources Research 22:135-146.

Helsel, D.R. and Gilliom, R.J. 1986. Estimation of Distributional Parameters for Censored Trace Level Water Quality Data. 2. Verification and Applications. Water Resources Research 22:147-155.

In some cases, the technical reviewer will be confronted with a situation where all the values for a chemical constituent in the background well system are LT a limit of detection. In this case, no data are available to estimate the background variance, and the background mean will be biased higher than its actual value, which is some value LT the limit of detection. In this case, the technical reviewer should ensure that laboratory protocols and data which are used to establish the detection limit values are provided. In addition, it is recommended that, especially in this case, the laboratory should ensure that any values, which are reported above a limit of detection, are quantifiable. The American Chemical Society's LOQ or the upper confidence limit of EPA's MDL may be used to establish a threshold criteria.

4.7.2 Missing Data Values

Owner/operators incur a substantial risk of missing an extreme environmental event and measurement of particularly large or small values if they fail to collect all of the data required for a monitoring program. This may result in an incomplete measure of environmental variability and an increased likelihood of falsely detecting contamination. Also, if assessment monitoring data are missing, there is a danger that the full extent of contamination may not be characterized. Owner/operators must take extreme care to ensure that concentration measurements result from all samples taken. Nevertheless, the technical reviewer is likely to confront situations where complete detection monitoring data have not been collected. The technical reviewer should have the owner/operator perform the t-test despite incomplete data collection, provided that the following criteria have been met:

- If there are data from one upgradient well and one downgradient well, statistical comparisons should still be made. If data exist for three quarters at a well, statistical comparisons should be made after applying the rule described in the next bullet.
- If only one quarter of data is missing, values should be assigned for the missing quarter by averaging the values obtained during the other three quarters.
- If there are missing replicate measurements from a sampling event, then average the replicate(s) that are available for that sampling event.

These guidelines have been described previously in the November 1983 EPA memorandum on statistical analyses of indicator parameter data. The intent of this methodology is to encourage use of the t-test, despite prior noncompliance with the data collection requirements in the regulations, so that a determination can be made as to whether assessment monitoring should begin. Regardless of whether there are sufficient data for performing the t-test, the technical reviewer should consider taking enforcement action to compel additional sampling on an accelerated schedule. The technical reviewer must minimize delays in the evaluation of a facility's ground water because of prior incomplete data collection.

4.7.3 Outliers

A GWCC value that is much different from most other values in a data set for the same GWCC can be referred to as an "outlier." The reasons for outliers can be:

- A catastrophic unnatural occurrence such as a spill;
- Inconsistent sampling or analytical chemistry methodology;
- Errors in the transcription of data values or decimal points; and
- True but extreme GWCC concentration measurements.

The technical reviewer should attempt to have owner/operators correct outlying values if the cause of the problem can be documented and corrected by the owner/operator without delay. The data should be corrected if outliers are caused by incorrect transcription and the correct values can be obtained and documented from valid owner/operator records. Also, if a catastrophic event or a problem in methodology occurred that can be documented, then data values should be from calculations with clear reference to this deletion at all relevant stages. Documentation and validation of the cause of outliers must accompany any attempt to correct or delete data values, because true but extreme values must not be altered. The technical reviewer should not accept the mere presence of an extreme value in data or the effect of an extreme value on the statistical analysis as a valid reason for the continuation of detection monitoring.

Ground-water contaminant concentrations when influenced by a hazardous waste management facility do not necessarily vary gradually. Instead, it is not uncommon for contamination (e.g., halogenated organic) to be reflected in a series of data collected over time with the following trend. Measurements remain below a limit of detection and then, in a single or several sampling event(s), concentrations rise to measurable levels and soon return to concentrations which are LT a limit of detection in subsequent sampling periods. In general, technical reviewers should not accept the contention that contaminant concentrations measured in wells immediately downgradient or in the vicinity of hazardous waste management areas increase only gradually. Rapidly increasing and decreasing concentrations can occur in ground waters subjected to contamination; the high concentrations in these cases would be true extreme values but not outliers.

4.7.4 Units of Measure

Associated with each GWCC value is a unit of measure that must be reported accurately. Mistakes in the reporting of the units of measure can result in gross errors in the apparent concentrations of GWCCs. For example, a lead value of 30.2 might have a unit of measure of parts per billion (ppb). Alternatively, the same lead value of 30.2 might have been incorrectly reported with a unit of measure in parts per million (ppm). The reported value would transform to a concentration with the units of measure in ppb as 30,200 ppb of lead or three orders of magnitude larger than it was measured.

The following guidelines should help the technical reviewers ensure that units of measure associated with data values are reported consistently and unambiguously:

- The units of measure should accompany each chemical parameter name. Laboratory data sheets that include a statement "values are reported in ppm unless otherwise noted" should generally be discouraged but at least reviewed in detail by the technical reviewer. It is common to find errors in reporting the units of measure on this type of data reporting sheet especially when these reporting sheets have been prepared manually.

- The units of measure for a given chemical parameter must be consistent throughout the report.

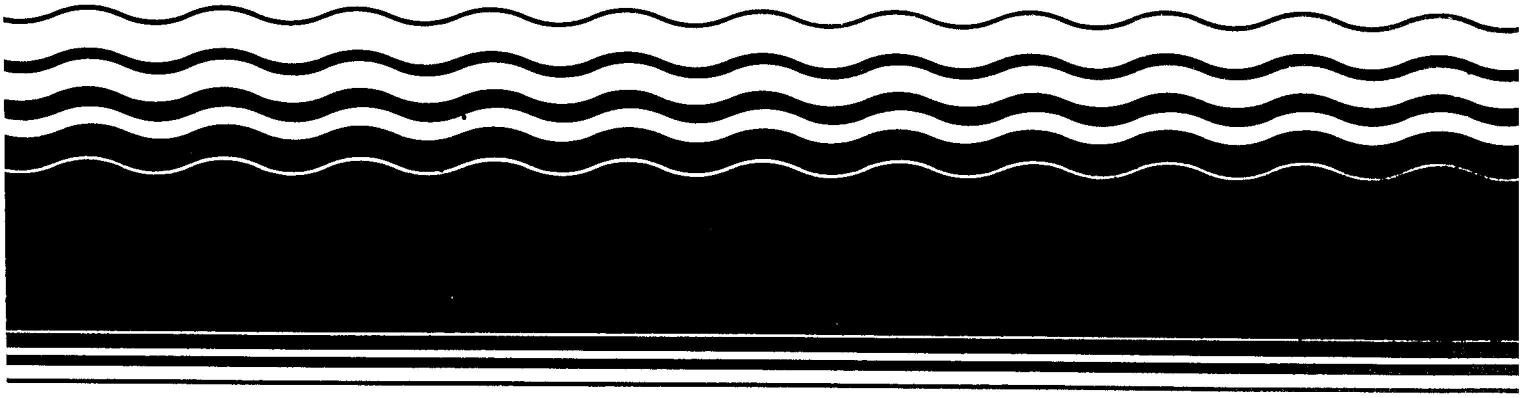
- Finally, reporting forms for detection monitoring, as specified in the EPA November 1983 memorandum, and the data presentation methods described in Chapter Five should help to reduce problems associated with the reporting of units of measure.

United States
Environmental Protection
Agency

Office of Solid Waste and
Emergency Response
Washington DC 20460

EPA/540/P-91/005
January 1991

Compendium of ERT Surface Water and Sediment Sampling Procedures



EPA/540/P-91/005
OSWER Directive 9360.4-03
January 1991

COMPENDIUM OF ERT SURFACE WATER AND SEDIMENT SAMPLING PROCEDURES

Sampling Equipment Decontamination

Surface Water Sampling

Sediment Sampling

Interim Final

Environmental Response Team
Emergency Response Division

Office of Emergency and Remedial Response
U.S. Environmental Protection Agency
Washington, DC 20460

Notice

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

The policies and procedures established in this document are intended solely for the guidance of government personnel, for use in the Superfund Removal Program. They are not intended, and cannot be relied upon, to create any rights, substantive or procedural, enforceable by any party in litigation with the United States. The Agency reserves the right to act at variance with these policies and procedures and to change them at any time without public notice.

Depending on circumstances and needs, it may not be possible or appropriate to follow these procedures exactly in all situations due to site conditions, equipment limitations, and limitations of the standard procedures. Whenever these procedures cannot be followed as written, they may be used as general guidance with any and all modifications fully documented in either QA Plans, Sampling Plans, or final reports of results.

Each Standard Operating Procedure in this compendium contains a discussion on quality assurance/quality control (QA/QC). For more information on QA/QC objectives and requirements, refer to the *Quality Assurance/Quality Control Guidance for Removal Activities*, OSWER directive 9360.4-01, EPA/540/G-90/004.

Questions, comments, and recommendations are welcomed regarding the Compendium of ERT Surface Water and Sediment Sampling Procedures. Send remarks to:

Mr. William A. Coakley
Removal Program QA Coordinator
U.S. EPA - ERT
Raritan Depot - Building 18, MS-101
2890 Woodbridge Avenue
Edison, NJ 08837-3679

For additional copies of the Compendium of ERT Surface Water and Sediment Sampling Procedures, please contact:

National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4600

Table of Contents

Section Page

1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

2.0 SURFACE WATER SAMPLING: SOP #2013

3.0 SEDIMENT SAMPLING: SOP #2016

List of Exhibits

Acknowledgments

Preparation of this document was directed by William A. Coakley, the Removal Program QA Coordinator of the Environmental Response Team, Emergency Response Division. Additional support was provided under U.S. EPA contract #68-03-3482 and U.S. EPA contract #68-WO-0036.

1.0 SAMPLING EQUIPMENT DECONTAMINATION: SOP #2006

1.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes methods used for preventing or reducing cross-contamination, and provides general guidelines for sampling equipment decontamination procedures at a hazardous waste site. Preventing or minimizing cross-contamination in sampled media and in samples is important for preventing the introduction of error into sampling results and for protecting the health and safety of site personnel.

Removing or neutralizing contaminants that have accumulated on sampling equipment ensures protection of personnel from permeating substances, reduces or eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample cross-contamination.

1.2 METHOD SUMMARY

Contaminants can be physically removed from equipment, or deactivated by sterilization or disinfection. Gross contamination of equipment requires physical decontamination, including abrasive and non-abrasive methods. These include the use of brushes, air and wet blasting, and high-pressure water cleaning, followed by a wash/rinse process using appropriate cleaning solutions. Use of a solvent rinse is required when organic contamination is present.

1.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

1.4 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free.

- An untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system for mixing of decontamination solutions.

- Acids and solvents utilized in the decontamination sequence pose the health and safety risks of inhalation or skin contact, and raise shipping concerns of permeation or degradation.

- The site work plan must address disposal of the spent decontamination solutions.

- Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

    - Stress work practices that minimize contact with hazardous substances.

    - Use remote sampling, handling, and container-opening techniques when appropriate.

    - Cover monitoring and sampling equipment with protective material to minimize contamination.

    - Use disposable outer garments and disposable sampling equipment when appropriate.

1.5 EQUIPMENT/APPARATUS

- appropriate personal protective clothing
- non-phosphate detergent
- selected solvents
- long-handled brushes
- drop cloths/plastic sheeting
- trash container
- paper towels
- galvanized tubs or buckets
- tap water

- distilled/deionized water
- metal/plastic containers for storage and disposal of contaminated wash solutions
- pressurized sprayers for tap and deionized/distilled water
- sprayers for solvents
- trash bags
- aluminum foil
- safety glasses or splash shield
- emergency eyewash bottle

1.6 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions and solvents. In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid(1)
- acetone (pesticide grade)(2)
- hexane (pesticide grade)(2)
- methanol

(1) Only if sample is to be analyzed for trace metals.
(2) Only if sample is to be analyzed for organics.

1.7 PROCEDURES

As part of the health and safety plan, develop and set up a decontamination plan before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- the number, location, and layout of decontamination stations

- which decontamination apparatus is needed

- the appropriate decontamination methods

- methods for disposal of contaminated clothing, apparatus, and solutions

1.7.1 Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated. Various decontamination methods will either physically remove contaminants, inactivate contaminants by disinfection or sterilization, or do both.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques appropriate for equipment decontamination can be grouped into two categories: abrasive methods and non-abrasive methods.

Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following abrasive methods are available:

- Mechanical: Mechanical cleaning methods use brushes of metal or nylon. The amount and type of contaminants removed will vary with the hardness of bristles, length of brushing time, and degree of brush contact.

- Air Blasting: Air blasting is used for cleaning large equipment, such as bulldozers, drilling rigs or auger bits. The equipment used in air blast cleaning employs compressed air to force abrasive material through a nozzle at high velocities. The distance between the nozzle and the surface cleaned, as well as the pressure of air, the time of application, and the angle at which the abrasive strikes the surface, determines cleaning efficiency. Air blasting has several disadvantages: it is unable to control the amount of material removed, it can aerate contaminants, and it generates large amounts of waste.

- Wet Blasting: Wet blast cleaning, also used to clean large equipment, involves use of a suspended fine abrasive delivered by compressed air to the contaminated area. The amount of materials removed can be carefully controlled by using very fine abrasives. This method generates a large amount of waste.

Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off of a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods. The following non-abrasive methods are available:

- High-Pressure Water: This method consists of a high-pressure pump, an operator-controlled directional nozzle, and a high pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) which relates to flow rates of 20 to 140 liters per minute.

- Ultra-High-Pressure Water: This system produces a pressurized water jet (from 1,000 to 4,000 atm). The ultra-high-pressure spray removes tightly-adhered surface film. The water velocity ranges from 500 m/sec (1,000 atm) to 900 m/sec (4,000 atm). Additives can enhance the method. This method is not applicable for hand-held sampling equipment.

Disinfection/Rinse Methods

- Disinfection: Disinfectants are a practical means of inactivating infectious agents.

- Sterilization: Standard sterilization methods involve heating the equipment. Sterilization is impractical for large equipment.

- Rinsing: Rinsing removes contaminants through dilution, physical attraction, and solubilization.

1.7.2 Field Sampling Equipment Cleaning Procedures

Solvent rinses are not necessarily required when organics are not a contaminant of concern and may be eliminated from the sequence specified below. Similarly, an acid rinse is not required if analysis does not include inorganics.

1. Where applicable, follow physical removal procedures specified in section 1.7.1.

2. Wash equipment with a non-phosphate detergent solution.

3. Rinse with tap water.

4. Rinse with distilled/deionized water.

5. Rinse with 10% nitric acid if the sample will be analyzed for trace organics.

6. Rinse with distilled/deionized water.

7. Use a solvent rinse (pesticide grade) if the sample will be analyzed for organics.

8. Air dry the equipment completely.

9. Rinse again with distilled/deionized water.

Selection of the solvent for use in the decontamination process is based on the contaminants present at the site. Use of a solvent is required when organic contamination is present on-site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. An acid rinse step is required if metals are present on-site. If a particular contaminant fraction is not present at the site, the nine-step decontamination procedure listed above may be modified for site specificity. The decontamination solvent used should not be among the contaminants of concern at the site.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air dried and rinsed with distilled/deionized water.

Sampling equipment that requires the use of plastic tubing should be disassembled and the tubing replaced with clean tubing, before commencement of sampling and between sampling locations.

1.8 CALCULATIONS

This section is not applicable to this SOP.

1.9 QUALITY ASSURANCE/ QUALITY CONTROL

One type of quality control sample specific to the field decontamination process is the rinsate blank. The rinsate blank provides information on the effectiveness of the decontamination process employed in the field. When used in conjunction with field blanks and trip blanks, a rinsate blank can detect contamination during sample handling, storage and sample transportation to the laboratory.

Table 1: Recommended Solvent Rinse for Soluble Contaminants

SOLVENT	SOLUBLE CONTAMINANTS
Water	• Low-chain hydrocarbons • Inorganic compounds • Salts • Some organic acids and other polar compounds
Dilute Acids	• Basic (caustic) compounds • Amines • Hydrazines
Dilute Bases -- for example, detergent and soap	• Metals • Acidic compounds • Phenol • Thiols • Some nitro and sulfonic compounds
Organic Solvents(1) - for example, alcohols, ethers, ketones, aromatics, straight-chain alkanes (e.g., hexane), and common petroleum products (e.g., fuel, oil, kerosene)	• Nonpolar compounds (e.g., some organic compounds)

(1) - WARNING: Some organic solvents can permeate and/or degrade protective clothing.

A rinsate blank consists of a sample of analyte-free (i.e, deionized) water which is passed over and through a field decontaminated sampling device and placed in a clean sample container.

Rinsate blanks should be run for all parameters of interest at a rate of 1 per 20 for each parameter, even if samples are not shipped that day. Rinsate blanks are not required if dedicated sampling equipment is used.

1.10 DATA VALIDATION

This section is not applicable to this SOP.

1.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods. For example, the decontamination solution or solvent may react with contaminants to produce heat, explosion, or toxic products. Decontamination methods may be incompatible with clothing or equipment; some solvents can permeate or degrade protective clothing. Also, decontamination solutions and solvents may pose a direct health hazard to workers through inhalation or skin contact, or if they combust.

The decontamination solutions and solvents must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods pose a direct health hazard, measures should be taken to protect personnel or the methods should be modified to eliminate the hazard.

2.0 SURFACE WATER SAMPLING: SOP #2013

2.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative liquid samples, both aqueous and nonaqueous from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface.

2.2 METHOD SUMMARY

Sampling situations vary widely and therefore no universal sampling procedure can be recommended.

However, sampling of both aqueous and non-aqueous liquids from the above mentioned sources is generally accomplished through the use of one of the following samplers or techniques:

- Kemmerer bottle
- bacon bomb sampler
- dip sampler
- direct method

These sampling techniques will allow for the collection of representative samples from the majority of surface waters and impoundments encountered.

2.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Once samples have been collected, follow these procedures:

1. Transfer the sample(s) into suitable labeled sample containers.

2. Preserve the sample if appropriate, or use pre-preserved sample bottles.

3. Cap the container, put it in a Ziploc plastic bag and place it on ice in a cooler.

4. Record all pertinent data in the site logbook and on a field data sheet.

5. Complete the chain of custody form.

6. Attach custody seals to the cooler prior to shipment.

7. Decontaminate all sampling equipment prior to the collection of additional samples.

2.4 INTERFERENCES AND POTENTIAL PROBLEMS

There are two primary interferences or potential problems with surface water sampling. These include cross-contamination of samples and improper sample collection.

- Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to ERT SOP #2006, Sampling Equipment Decontamination.

- Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems.

2.5 EQUIPMENT/APPARATUS

Equipment needed for collection of surface water samples includes:

- Kemmerer bottles
- bacon bomb sampler
- dip sampler
- line and messengers
- sample bottle preservatives
- Ziploc bags
- ice
- cooler(s)
- chain of custody forms, field data sheets

- decontamination equipment
- maps/plot plan
- safety equipment
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and film
- logbook/waterproof pen
- sample bottle labels

2.6 REAGENTS

Reagents will be utilized for preservation of samples and for decontamination of sampling equipment. The preservatives required are specified by the analysis to be performed. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

2.7 PROCEDURES

2.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are needed.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flags, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

2.7.2 Sampling Considerations

Representative Samples

In order to collect a representative sample, the hydrology and morphometrics (e.g., measurements of volume, depth, etc.) of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths.

Water quality data should be collected in impoundments to determine if stratification is present. Measurements of dissolved oxygen, pH, and temperature can indicate if strata exist which would effect analytical results. Measurements should be collected at 1-meter intervals from the substrate to the surface using an appropriate instrument, such as a Hydrolab (or equivalent).

Water quality measurements such as dissolved oxygen, pH, temperature, conductivity, and oxidation-reduction potential can assist in the interpretation of analytical data and the selection of sampling sites and depths anytime surface water samples are collected.

Generally, the deciding factors in the selection of a sampling device for sampling liquids in streams, rivers, lakes, ponds, lagoons, and surface impoundments are:

- Will the sample be collected from the shore or from a boat on the impoundment?

- What is the desired depth at which the sample is to be collected?

- What is the overall depth and flow direction of river or stream?

Sampler Composition

The appropriate sampling device must be of a proper composition. Samplers constructed of glass, stainless steel, PVC or PFTE (Teflon) should be used based upon the analyses to be performed.

2.7.3 Sample Collection

Kemmerer Bottle

Kemmerer bottle (Figure 1, Appendix A) may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Using a properly decontaminated Kemmerer bottle, set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing the substance to be sampled to pass through this tube.
2. Lower the pre-set sampling device to the predetermined depth. Avoid bottom disturbance.
3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.
4. Retrieve the sampler and discharge the first 10 to 20 mL to clear any potential contamination on the valve. Transfer the sample to the appropriate sample container.

Bacon Bomb Sampler

A bacon bomb sampler (Figure 2, Appendix A) may be used in similar situations to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut.
2. Release the trigger line and retrieve the sampler.
3. Transfer the sample to the appropriate sample container by pulling the trigger.

Dip Sampler

A dip sampler (Figure 3, Appendix A) is useful for situations where a sample is to be recovered from an outfall pipe or along a lagoon bank where direct access is limited. The long handle on such a device allows access from a discrete location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.
2. Extend the device to the sample location and collect the sample.
3. Retrieve the sampler and transfer the sample to the appropriate sample container.

Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the surface. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants are a concern.

Using adequate protective clothing, access the sampling station by appropriate means. For shallow stream stations, collect the sample under the water surface pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake.

When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation.

2.8 CALCULATIONS

This section is not applicable to this SOP.

2.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following general QA/QC procedures apply:

- All data must be documented on field data sheets or within site logbooks.
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and they must be documented.

2.10 DATA VALIDATION

This section is not applicable to this SOP.

2.11 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling lagoons or surface impoundments containing known or suspected hazardous substances, take adequate precautions. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him or her to lose their balance. The person performing the sampling should be on a lifeline and be wearing adequate protective equipment. When conducting sampling from a boat in an impoundment or flowing waters, follow appropriate boating safety procedures.

3.0 SEDIMENT SAMPLING: SOP #2016

3.1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) is applicable to the collection of representative sediment samples. Analysis of sediment may determine whether concentrations of specific contaminants exceed established threshold action levels, or if the concentrations present a risk to public health, welfare, or the environment.

The methodologies discussed in this procedure are applicable to the sampling of sediment in both flowing and standing water. They are generic in nature and may be modified in whole or part to meet the handling and analytical requirements of the contaminants of concern, as well as the constraints presented by the sampling area. However, if modifications occur, they should be documented in the site logbook or report summarizing field activities.

For the purposes of this procedure, sediments are those mineral and organic materials situated beneath an aqueous layer. The aqueous layer may be either static, as in lakes, ponds, or other impoundments or flowing, as in rivers and streams.

3.2 METHOD SUMMARY

Sediment samples may be recovered using a variety of methods and equipment, depending on the depth of the aqueous layer, the portion of the sediment profile required (surface versus subsurface), the type of sample required (disturbed versus undisturbed) and the sediment type.

Sediment is collected from beneath an aqueous layer either directly, using a hand-held device such as a shovel, trowel, or auger, or indirectly using a remotely activated device such as an Ekman or Ponar dredge. Following collection, the sediment is placed into a container constructed of inert material, homogenized, and transferred to the appropriate sample containers. The homogenization procedure should not be used if sample analysis includes volatile organics.

3.3 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

- Chemical preservation of solids is generally not recommended. Cooling is usually the best approach, supplemented by the appropriate holding time.

- Wide-mouth glass containers with Teflon-lined caps are utilized for sediment samples. The sample volume is a function of the analytical requirements and will be specified in the work plan.

- Transfer sediment from the sample collection device to an appropriate sample container using a stainless steel or plastic lab spoon or equivalent. If composite samples are collected, place the sediment sample in a stainless steel, plastic or other appropriate composition (e.g.: Teflon) bucket, and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Then place the sediment sample into labeled containers.

- Samples for volatile organic analysis must be collected directly from the bucket, before mixing the sample, to minimize loss due to volatilization of contaminants.

- All sampling devices should be decontaminated, then wrapped in aluminum foil. The sampler should remain in this wrapping until it is needed. Each sampler should be used for only one sample. Dedicated samplers for sediment samples may be impractical due to the large number of sediment samples which may be required and the cost of the sampler. In this case, samplers should be cleaned in the field using the decontamination procedure described in ERT SOP# 2006, Sampling Equipment Decontamination.

3.4 INTERFERENCES AND POTENTIAL PROBLEMS

Substrate particle size and organic content are directly related to water velocity and flow characteristics of a body of water. Contaminants are more likely to be concentrated in sediments typified by fine particle size and a high organic content. This type of sediment is most likely to be collected from depositional zones. In contrast, coarse sediments with low organic content do not typically concentrate pollutants and are found in erosional zones. The selection of a sampling location can, therefore, greatly influence the analytical results.

3.5 EQUIPMENT/APPARATUS

Equipment needed for collection of sediment samples includes:

- maps/plot plan
- safety equipment
- compass
- tape measure
- survey stakes, flags, or buoys and anchors
- camera and film
- stainless steel, plastic, or other appropriate composition bucket
- 4-oz., 8-oz., and one-quart, wide-mouth jars w/Teflon-lined lids
- Ziploc plastic bags
- logbook
- sample jar labels
- chain of custody forms, field data sheets
- cooler(s)
- ice
- decontamination supplies/equipment
- spade or shovel
- spatula
- scoop
- trowel
- bucket auger
- thin-walled auger
- extension rods
- T-handle
- sampling trier
- sediment coring device (tubes, points, drive head, drop hammer, "eggshell" check valve devices, acetate cores)
- Ponar dredge
- Ekman dredge
- nylon rope

3.6 REAGENTS

Reagents are not used for preservation of sediment samples. Decontamination solutions are specified in ERT SOP #2006, Sampling Equipment Decontamination.

3.7 PROCEDURES

3.7.1 Preparation

1. Determine the extent of the sampling effort, the sampling methods to be employed, and which equipment and supplies are required.

2. Obtain necessary sampling and monitoring equipment.

3. Decontaminate or preclean equipment, and ensure that it is in working order.

4. Prepare schedules, and coordinate with staff, client, and regulatory agencies, if appropriate.

5. Perform a general site survey prior to site entry in accordance with the site-specific health and safety plan.

6. Use stakes, flags, or buoys to identify and mark all sampling locations. Specific site characteristics, including flow regime, basin morphometry, sediment characteristics, depth of overlying aqueous layer, and extent and nature of contaminant should be considered when selecting sample location. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

3.7.2 Sample Collection

Selection of a sampling device is most often contingent upon: (1) the depth of water at the sampling location, and (2) the physical characteristics of the medium to be sampled.

Sampling Surface Sediments with a Trowel or Scoop From Beneath a Shallow Aqueous Layer

Collection of surface sediment from beneath a shallow aqueous layer can be accomplished with tools such as spades, shovels, and scoops. Surface material can be removed to the required depth; then a stainless steel or plastic scoop should be used to collect the sample.

This method can be used to collect consolidated sediments but is limited somewhat by the depth of the aqueous layer. Accurate, representative samples can be collected with this procedure depending on the care and precision demonstrated by the sample team member. A stainless steel or plastic scoop or lab spoon will suffice in most applications. Care should be exercised to avoid the use of devices plated with chrome or other materials. Plating is particularly common with garden trowels.

Follow these procedures to collect sediment samples with a scoop or trowel:

1. Using a precleaned stainless steel scoop or trowel, remove the desired thickness of sediment from the sampling area.
2. Transfer the sample into an appropriate sample or homogenization container.

Sampling Surface Sediments with a Thin-Wall Tube Auger From Beneath a Shallow Aqueous Layer

This system consists of an auger, a series of extension rods, and a "T" handle (see Figure 4, Appendix A). The auger is driven into the sediment and used to extract a core. A sample of the core is taken from the appropriate depth.

Use the following procedure to collect sediment samples with a thin-walled auger:

1. Insert the auger into the material to be sampled at a 0° to 45° angle from vertical. This orientation minimizes spillage of the sample from the sampler. Extraction of samples may require tilting of the sampler.
2. Rotate the auger once or twice to cut a core of material.
3. Slowly withdraw the auger, making sure that the slot is facing upward.
4. An acetate core may be inserted into the auger prior to sampling, if characteristics of the sediments or body of water warrant. By using this technique, an intact core can be extracted.
5. Transfer the sample into an appropriate sample or homogenization container.

Sampling Deep Sediments with Augers and Thin-Wall Tube Samplers From Beneath a Shallow Aqueous Layer

This system uses an auger, a series of extension rods, a "T" handle, and a thin-wall tube sampler (Figure 4, Appendix A). The auger bores a hole to a desired sampling depth and then is withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the sediment at the completion depth. The core is then withdrawn and the sample collected. This method can be used to collect consolidated sediments, but is somewhat limited by the depth of the aqueous layer.

Several augers are available which include bucket and posthole augers. Bucket augers are better for direct sample recovery, are fast, and provide a large volume of sample. Posthole augers have limited utility for sample collection as they are designed more for their ability to cut through fibrous, rooted, swampy areas.

Follow these procedures to collect sediment samples with a hand auger:

1. Attach the auger bit to a drill extension rod, then attach the "T" handle to the drill extension rod.
2. Clear the area to be sampled of any surface debris.
3. Begin augering, periodically removing any accumulated sediment from the auger bucket.
4. After reaching the desired depth, slowly and carefully remove the auger from boring. (When sampling directly from the auger, collect sample after the auger is removed from boring and proceed to Step 10.)
5. Remove auger tip from drill rods and replace with a precleaned thin-wall tube sampler. Install proper cutting tip.
6. Carefully lower tube sampler down borehole. Gradually force tube sampler into sediment.

Care should be taken to avoid scraping the borehole sides. Also, avoid hammering of the drill rods to facilitate coring, since the vibrations may cause the boring walls to collapse.

7. Remove tube sampler and unscrew drill rods.

8. Remove cutting tip and remove core from device.

9. Discard top of core (approximately 1 inch), as this represents material collected by the tube sampler before penetration of the layer of concern.

10. Transfer sample into an appropriate sample or homogenization container.

Sampling Surface Sediments From Beneath a Deep Aqueous Layer with an Ekman or Ponar Dredge

This technique consists of lowering a sampling device to the sediment by use of a rope, cable, or extended handle. The mechanism is triggered, and the device entraps sediment in spring-loaded jaws, or within lever-operated jaws.

Follow these procedures for collecting sediment with an Ekman dredge (Figure 5, Appendix A):

1. Thread a sturdy nylon or stainless steel cable through the bracket, or secure the extended handle to the bracket with machine bolts.

2. Attach springs to both sides. Arrange the Ekman dredge sampler so that the jaws are in the open position and trip cables are positioned over the release studs.

3. Lower the sampler to a point just above the sediment surface.

4. Drop the sampler sharply onto the sediment.

5. Trigger the jaw release mechanism by lowering a messenger down the line, or by depressing the button on the upper end of the extended handle.

6. Raise the sampler and slowly decant any free liquid through the top of the sampler. Be careful to retain fine sediments.

7. Open the dredge and transfer the sediment into a stainless steel or plastic bucket. Continue to collect additional sediment until sufficient material has been secured. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample container.

8. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

Follow these procedures for collecting sediment with a Ponar dredge (Figure 6, Appendix A):

1. Attach a sturdy nylon or steel cable to the hook provided on top of the dredge.

2. Arrange the Ponar dredge sampler in the open position, setting the trip bar so the sampler remains open when lifted from the top.

3. Slowly lower the sampler to a point just above the sediment.

4. Drop the sampler sharply into the sediment, then pull sharply up on the line, thus releasing the trip bar and closing the dredge.

5. Raise the sampler to the surface and slowly decant any free liquid through the screens on top of the dredge. Be careful to retain fine sediments.

6. Open the dredge and transfer the sediment to a stainless steel or plastic bucket. Continue to collect additional sediment until sufficient material has been gained. Thoroughly mix sediment to obtain a homogeneous sample, and then transfer to the appropriate sample container.

7. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

Sampling Subsurface Sediments From Beneath a Deep Aqueous Layer with a Sample Coring Device

Follow these procedures when using a sample coring device (Figure 7, Appendix A) to collect subsurface sediments. It consists of a coring device, handle, and acetate core utilized in the following procedure:

1. Assemble the coring device by inserting the acetate core into the sampling tube.
2. Insert the "eggshell" check valve mechanisms into the tip of the sampling tube with the convex surface positioned inside the acetate core.
3. Screw the coring point onto the tip of the sampling tube.
4. Screw the handle onto the upper end of the sampling tube and add extension rods as needed.
5. Place the sampler in a perpendicular position on the material to be sampled.
6. This sampler may be used with either a drive hammer for firm consolidated sediments, or a "T" handle for soft sediments. If the "T" handle is used, place downward pressure on the device until the desired depth is reached. Rotate the sampler to shear off the core of the bottom, retrieve the device and proceed to Step 15.
7. If the drive hammer is selected, insert the tapered handle (drive head) of the drive hammer through the drive head.
8. With left hand holding the tube, drive the sampler into the material to the desired depth. Do not drive the tube further than the tip of the hammer's guide.
9. Record the length of the tube that penetrated the sample material, and the number of blows required to obtain this depth.
10. Remove the drive hammer and fit the keyhole-like opening on the flat side of the hammer onto the drive head. In this position, the hammer serves as a handle for the sampler.
11. Rotate the sampler at least two revolutions to shear off the sample at the bottom.
12. Lower the sampler handle (hammer) until it just clears the two ear-like protrusions on the drive head, and rotate about 90°.
13. Withdraw the sampler by pulling the handle (hammer) upwards and dislodging the hammer from the sampler.
14. Unscrew the coring point and remove the "eggshell" check valve.
15. Slide the acetate core out of the sampler tube. The acetate core may be capped at both ends. The sample may be used in this fashion, or the contents transferred to a stainless steel or plastic bucket and mixed thoroughly to obtain a homogeneous sample representative of the entire sampling interval.
16. Samples for volatile organic analysis must be collected directly from the bucket before mixing the sample to minimize volatilization of contaminants.

3.8 CALCULATIONS

This section is not applicable to this SOP.

3.9 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities which apply to the implementation of these procedures. However, the following QA/QC procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

3.10 DATA VALIDATION

This section is not applicable to this SOP.

3.11 HEALTH AND SAFETY

When working with potentially hazardous materials follow U.S. EPA, OSHA and specific health and safety procedures.

More specifically, when sampling sediment from bodies of water containing known or suspected hazardous substances, adequate precautions must be taken to ensure the sampler's safety. The team member collecting the sample should not get too close to the edge of the water, where bank failure may cause him or her to lose their balance. To prevent this, the person performing the sampling should be on a lifeline, and be wearing adequate protective equipment. If sampling from a vessel is necessary, implement appropriate protective measures.

APPENDIX A

Figures

Figure 1: Kemmerer Bottle

SOP #2013

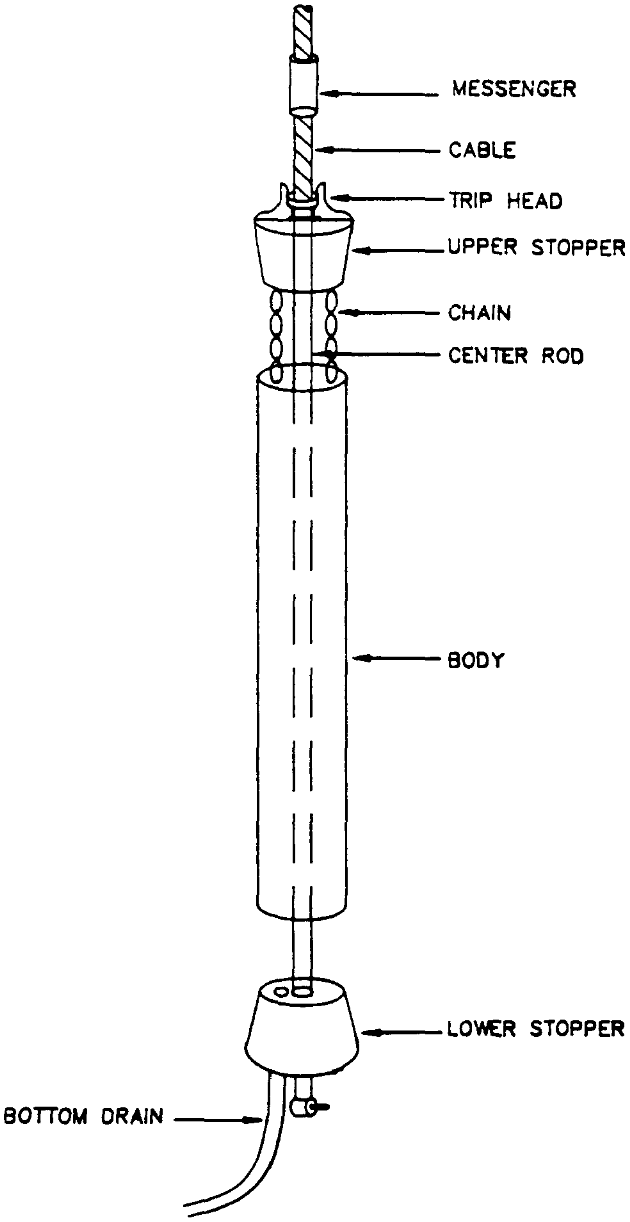


Figure 2: Bacon Bomb Sampler

SOP #2013

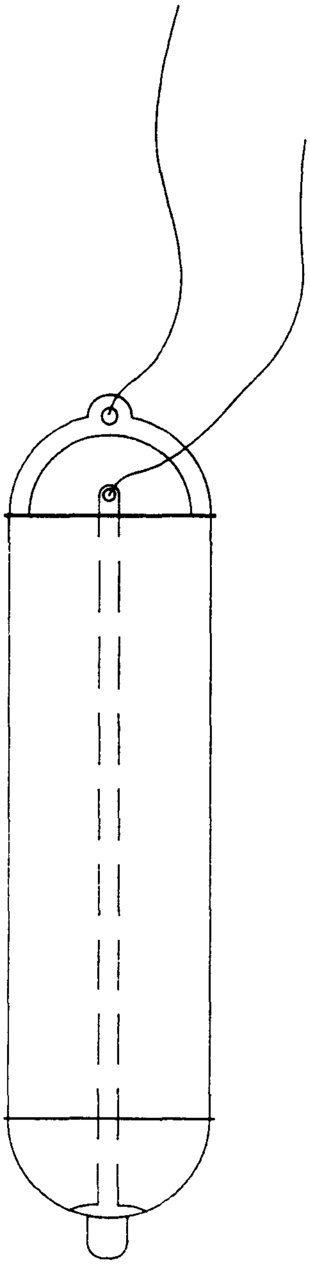


Figure 3: Dip Sampler

SOP #2013

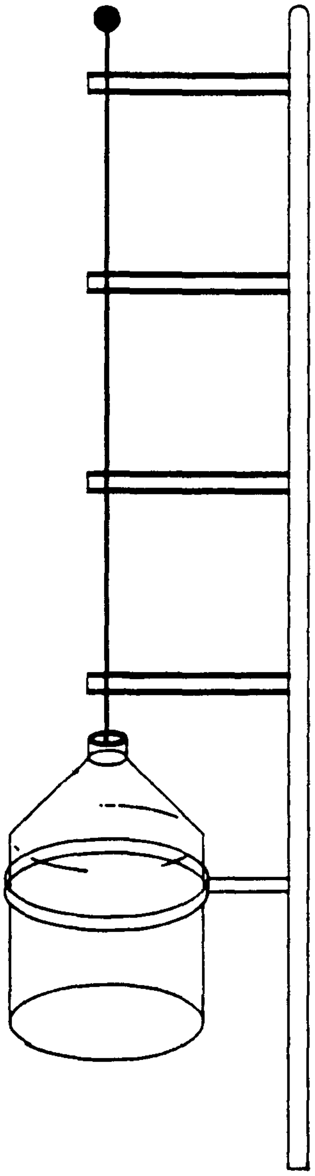
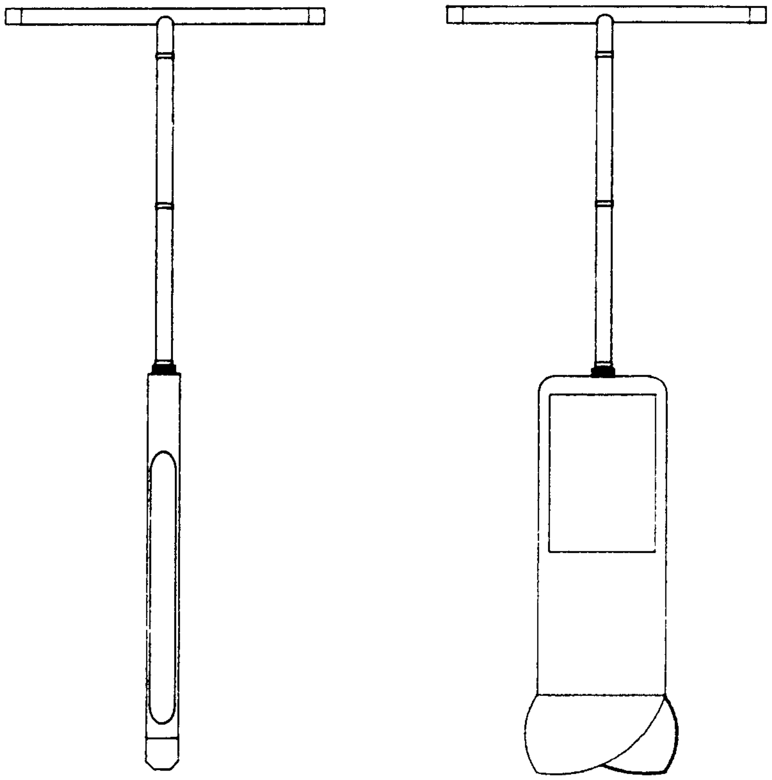


Figure 4: Sampling Auger

SOP #2016



TUBE AUGER

BUCKET AUGER

Figure 5: Ekman Dredge

SOP #2016

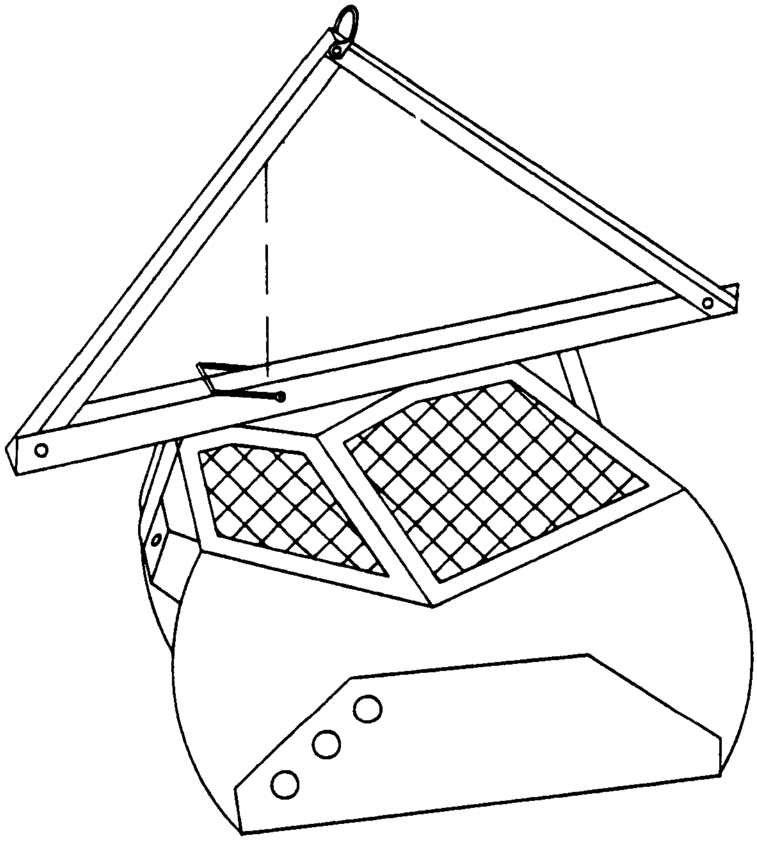


Figure 6: Ponar Dredge

SOP #2016

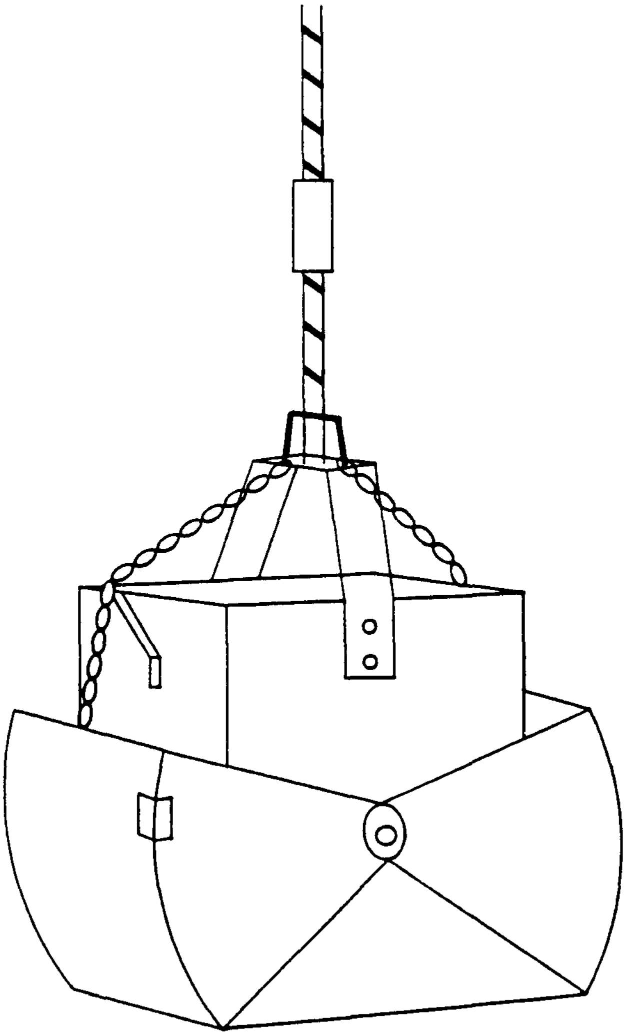
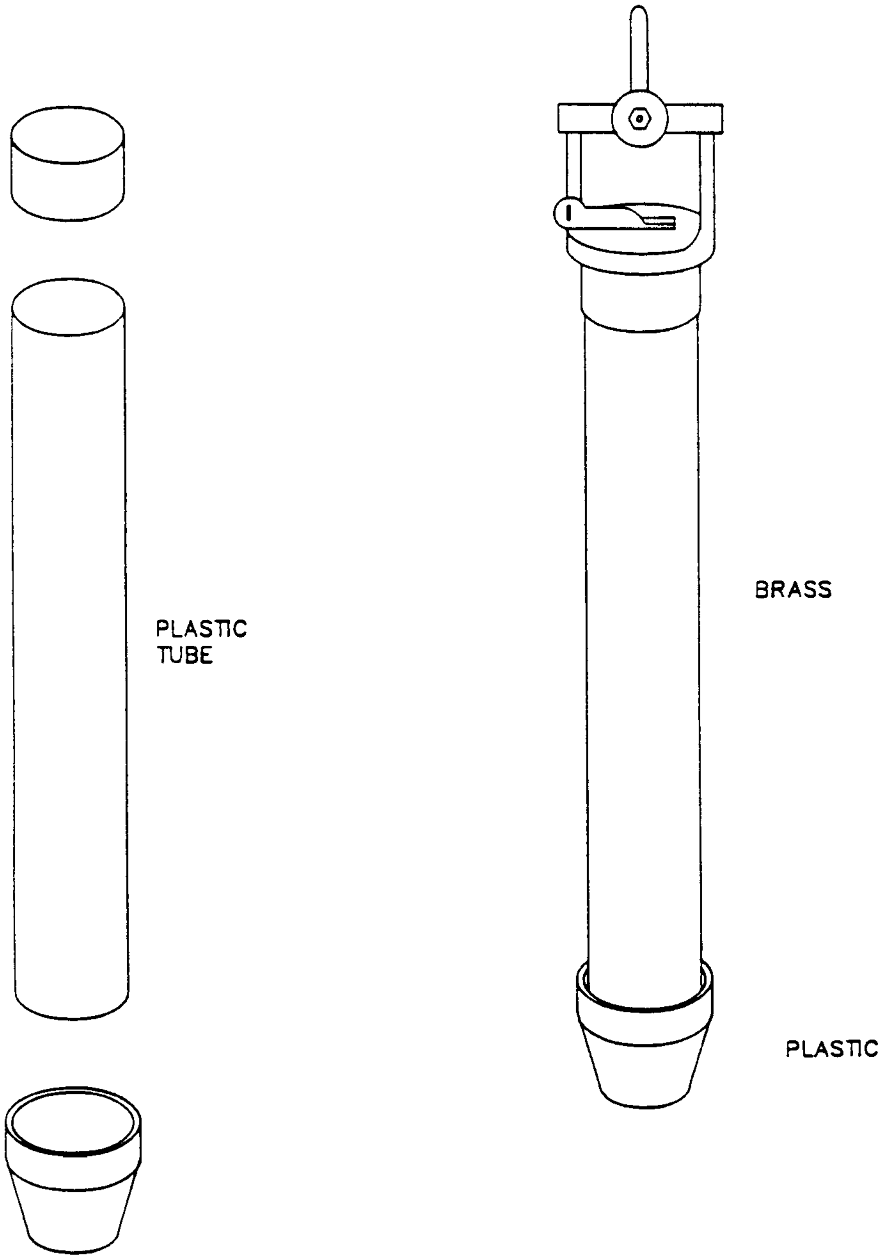


Figure 7: Sample Coring Device

SOP #2016



References

Barth, D.S. and B.J. Mason. 1984. Soil Sampling Quality Assurance User's Guide. EPA-600/4-84/043.

de Vera, E.R., B.P. Simmons, R.D. Stephen, and D.L. Storm. 1980. Samplers and Sampling Procedures for Hazardous Waste Streams. EPA/600/2-80/018.

Mason, B.J. 1983. Preparation of Soil Sampling Protocol: Technique and Strategies. EPA-600/4-83/020.

National Institute for Safety and Health. October, 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. [Alternate title: Guidance Manual for Hazardous Waste Sites]

New Jersey Department of Environmental Protection, Division of Hazardous Site Mitigation. 1988. Field Sampling Procedures Manual.

U.S. EPA. 1984. Characterization of Hazardous Waste Sites - A Methods Manual: Volume II. Available Sampling Methods, Second Edition. EPA/600/4-84/076.

U.S. EPA Region IV, Environmental Services Division. April 1, 1986. Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual. Athens, Georgia.

U.S. EPA, OSWER/Remedial Planning and Response Branch. December 1, 1987. Compendium of Superfund Field Operation Methods. EPA/540/P-87/001.

U.S. Geological Survey. 1977. National Handbook of Recommended Methods for Water Data Acquisition. Office of Water Data Coordination. Reston, Virginia. (Chapter updates available).

*U.S. Government Printing Office: 1991 — 548-187/40580

UST Branch: Closure Plan Requirements

R311-204, Utah Administrative Code (U.A.C.), requires Underground Storage Tank (UST) owners/operators to submit a Closure Plan outlining the details of the UST closure to the Executive Secretary (UST), Utah Solid and Hazardous Waste Control Board.

1. The Owner(s)/Operator(s) (O/O) must submit to the Division of Environmental Response and Remediation (DERR) a completed "CLOSURE PLAN" which must be approved before commencing closure of the UST. A contractor may complete the closure plan, however the O/O is responsible for compliance with the UST rules and regulations.
2. For **closure in-place or change in service**, the Closure Plan must now be submitted and approved prior to completing the site assessment.
3. The approved Closure Plan is valid for one year from the approval date. If closure does not take place within one year the O/O must submit a new Closure Plan for approval.
4. The O/O must notify the Local Health and Fire Departments **and the DERR/UST** at least 72 hours prior to starting closure activities.
5. The certified UST remover and sampler performing the closure must have a current Utah certification and follow the approved Closure Plan. **Changes to an approved plan must be submitted in writing to the Executive Secretary and approved before closure**.
6. The O/O must have a copy of the approved Closure Plan on-site during closure activities.
7. The O/O must ensure the completion of a site assessment in accordance with 40CFR 280.72 and R311-205, U.A.C. Indicate the proposed sample locations on the Facility Site Plat of the Closure Plan and complete the Sample Information Table. If contamination is encountered or suspected at locations other than the approved sample locations, additional samples must be collected at the location(s) where contamination is most likely to be present. If groundwater is encountered a soil sample must be collected, in the unsaturated zone, in addition to each groundwater sample.
8. The O/O must report suspected or confirmed contamination (any amount) to the Executive Secretary by reporting to the DERR/Leaking Underground Storage Tanks (LUST) section at (801)536-4100 within 24 hours of discovery.
9. The O/O must submit to the DERR a Closure Notice within 90 days after the tank closure. The Closure Notice should include:

    a. A properly completed Closure Notice form signed by the owner and certified groundwater and soil sampler.

    b. An updated Site Plat and a Sample Information Table with actual depths and locations of all samples, including depth of ground water.

    c. Analytical results of samples

    d. A Chain of Custody Form

10. The O/O must pay Registration and PST Fund fees for the assessment period in which the tank is closed and all other unpaid fees.
11. If contamination is suspected or confirmed during UST closure activities, or is based on analytical results, the O/O may receive a reporting and remediation schedule from the DERR/LUST section, outlining their obligation to characterize and possibly remediate the release. Any person providing remedial assistance for a fee, including over-excavation (of more than 50 yd^3) and aeration, must be a Certified UST Consultant (a list is available from the DERR). Expenses to be applied toward the Petroleum Storage Tank (PST) Fund deductible must meet the same test of reasonable, customary and legitimate as expenses submitted for reimbursement. For expenses above the $10,000 deductible to be eligible for reimbursement from the PST Fund, all work plans and budgets must be approved the State Project Manager before any work begins

Refer questions concerning the Closure Plan approval process to the DERR/UST section at 801-536-4100.

Send the completed Closure Plan to:

State of Utah Department of Environmental Quality
Division of Environmental Response and Remediation UST Section
P.O. Box 144840
195 North 1950 West
Salt Lake City, Utah 84114-4840

UNDERGROUND STORAGE TANK CLOSURE PLAN (rev. 1/05) **FACILITY ID# __________________**

LHD USE ONLY
Date Received
Reviewer
Date LHD Approved
Date mailed to State

STATE USE ONLY
Date Received
Date Mailed to LHD
Date Received From LHD
Reviewer/Date Approved
Mgr. Review/Date

Closure Plan prepared at the request of the owner/operator (identified below) by			
of (company name)		Phone #	
Address	City	State	Zip

A Contractor may prepare this Closure Plan as the owner/operator's agent. In preparing the Closure Plan, the Contractor must act with the owner/operator's knowledge and approval. The owner/operator must sign the Closure Plan.

This Closure Plan is submitted in compliance with the requirements contained in 40 CFR 280 Subpart G and R311-204 (U.A.C.)

FACILITY INFORMATION

Tank Owner			Phone #
☐ sole proprietorship	☐ partnership	☐ corporation	
Address	City	State	Zip
Facility Name			
Address	City	State	Zip
Contact person			Phone #
Total number of regulated underground tanks at this site			
Total number of regulated underground tanks at this site to be closed			

Tank #						
Type (Steel,FRP,etc.)						
Date Installed						
Capacity						
Substance stored*						
Date last operated						
Removed/In Place/ Change in Service (CIS)?						

*Indicate the specific substance stored in each tank to be closed (regular, unleaded, diesel, waste oil, etc.)

For waste oil tanks: Have degreasing or other types of solvents been stored or mixed with the waste oil?

Yes (identify if known) ____ No ☐ Not Known ☐

Analysis for lead or other contaminants may be required prior to disposal of contaminated soil or other material. (Check with your disposal facility.)

TANK REMOVER Name	Cert. # TR	Exp. Date

Company	Phone #

Address	City	State	Zip

SOIL/GROUNDWATER SAMPLER Name	Cert. # GS	Exp. Date

Company	Phone #

Address	City	State	Zip

Before the closure plan is submitted for approval, the local health and fire departments where the facility is located must be contacted. *If the facility is in Beaver, Carbon, Davis, Emery, Garfield, Grand, Iron, Kane, Salt Lake, San Juan, Wasatch, or Washington county contact DERR (UST) at (801)536-4100 instead of the local health district. <u>You still must contact the local fire department in these counties</u>.*

CONTACT LOCAL HEALTH DISTRICT: Name of Dist. | Date

Contact | Title | Phone#

CONTACT LOCAL FIRE DEPT. Name of Dept. | Date

Contact | Title | Phone#

DISPOSAL INFORMATION

Tank(s) will be disposed at: Facility

Address | City | State | Zip

Contact person | Phone#

Product lines will either be: ☐ removed or ☐ cleaned, secured in place, and capped.

Vent lines will either be: ☐ removed or ☐ cleaned and secured open.

Piping will be disposed at: Facility

Address | City | State | Zip

Contact person | Phone#

Tank(s) will be **emptied** by: company | Phone#

Tank(s) will be **cleaned** by: company | Phone#

Contaminated water in the tank/rinsate will be disposed at: Facility

Contact person | Phone#

Tank(s) will be: ☐ purged or ☐ rendered inert by the following method:

Residual sludges will be disposed at the following facility:

Address | City | State | Zip

Contact person | Phone#

FOR CLOSURE IN PLACE ONLY

☐ Approval for in-place closure has been granted by the Local Fire Department.

Fire Dept. | Phone# | Contact person | Date

☐ Approval for in-place closure has been granted by the Local Health Department.

Health Dept. | Phone# | Contact person | Date

Substance to be used to fill tanks:

SITE ASSESSMENT

A site assessment must be performed for all UST closures and change-in-service. Site assessments must be performed as outlined in 40 CFR 280.72 and R311-205 (U.A.C.). If contamination is suspected, additional samples must be collected at the location where contamination is most likely to be present. If groundwater is encountered, a soil sample must be collected, in the unsaturated zone, in addition to each groundwater sample. Soil and groundwater samples must be analyzed for the compounds shown in the following table, using appropriate lab methods.

Substance or Product Type	**Contaminant Compounds to be Analyzed for Each Substance or Product Type**	**ANALYTICAL METHODS[1]**
		Soil, Groundwater or Surface Water
Gasoline	Total Petroleum Hydrocarbons (purgeable TPH as gasoline range organics C_6 - C_{10})	EPA 8015B or EPA 8260B
	Benzene, Toluene, Ethyl benzene, Xylenes, Naphthalene, (BTEXN) and MTBE	EPA 8021B or EPA 8260B
Diesel	Total Petroleum Hydrocarbons (extractable TPH as diesel range organics C_{10} – C_{28})	EPA 8015B
	Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene (BTEXN)	EPA 8021B or EPA 8260B
Used Oil	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A (SGT*)
	Benzene, Toluene, Ethyl benzene, Xylenes, Naphthalene (BTEXN) & MTBE; and Halogenated Volatile Organic Compounds (VOX)	EPA 8021B or EPA 8260B
New Oil	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A (SGT*)
Other	Type of analyses will be based upon the substance or product stored, and as approved by the Executive Secretary (UST)	Method will be based upon the substance or product type
Unknown	Total Petroleum Hydrocarbons (purgeable TPH as gasoline range organics C_6 - C_{10})	EPA 8015B or EPA 8260B
	Total Petroleum Hydrocarbons (extractable TPH as diesel range organics C_{10} – C_{28})	EPA 8015B
	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A (SGT*)
	Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene (BTEXN) and MTBE; and Halogenated Volatile Organic Compounds (VOX)	EPA 8021B or EPA 8260B

[1] The following modifications to these certified methods are considered acceptable by the Executive Secretary (UST):

- Dual column confirmation may not be required for TPH and BTEXN/MTBE analysis.
- A micro-extraction or scale-down technique may be used for aqueous samples, but only for the determination of extractable TPH as diesel range organics (C_{10} – C_{28}).
- Hexane may be used as an extraction solvent.
- *Silica Gel Treatment (SGT) may be used in the determination of Total Recoverable Petroleum Hydrocarbons.

NOTE: The sample preparation method and any modification(s) to a certified method must be reported by the laboratory.

CONTAMINATED MATERIALS MUST BE DISPOSED AT AN ACCEPTABLE FACILITY:

All materials generated from UST closures must be managed and disposed in a manner that does not place those materials in direct contact with the environment. On-site stockpiling of contaminated soils may be required prior to any soil management activities. *Any person providing remedial assistance for a fee, including aeration and over-excavation (of more than 50 yd^3), must be a Certified UST Consultant.*

Contaminated soils generated as part of tank removal are to be disposed at the following facility:
Address City State Zip
Contact person Phone

Complete the Facility Site Plat and Sample Information Table on pages 4 and 5 to provide site assessment information.

CONTAMINATION INFORMATION

If contamination at the facility is suspected or confirmed, the information must be reported to the Executive Secretary (UST) at (801) 536-4100 within 24 hours. The Division of Water Quality must be notified at (801) 538-6146 if Free Product is encountered or if surface water has been impacted. If contamination is confirmed, any person assisting in the remediation process for a fee must be a Certified UST Consultant.

SAMPLE INFORMATION TABLE

Complete table for all samples to be taken for closure.

Sample #	Substance stored in tank	Sample type[1]	Depth[2]	Compounds[3]	Analysis method(s)[4]

1 Soil (SS), Groundwater (GW), or Unified Soil Classification (USC).
2 Approx. depth in feet below grade. The required minimum site assessment samples must be taken at 0-2 feet below the backfill/native soil interface.
3 Contaminant compounds to be analyzed for each sample (from table on p. 3).
4 Appropriate analysis methods for contaminant compound(s) in each sample (from table on p. 3).

Facility Site Plat (Closure Plan)

The site plat must be drawn to an appropriate identified scale. It must show planned sampling locations, substances stored in tanks, and other relevant information. Tank and sample identification numbers must be consistent with the information given on p. 1 and 4 of the Closure Plan.

North

⇧

Scale: 1”= ___ Feet

Facility ID:	Drawn By:	Date:

X = Sample locations (SS-#, WS-#, USC-#)
θ = Monitoring Wells (MW-#,)
▨ = Soil boring (SB-#), or Geoprobe Boring (GP-#)
■ = Water Wells (domestic, livestock, etc.)
Slope of Surface Topography: (N,NW,W,SW,S,SE,E,NE)
Land Use At Site: _Residential _Commercial _Industrial
Surrounding Land: _Residential _Commercial _Industrial

Site Plat Must Indicate Approximate Locations Of:

Y Current & former tanks, piping & dispensers
Y Location of all samples to be taken
Y Buildings, fences, & property boundaries
Y Utility conduits (sewers, gas, water, storm drains, electrical, etc.)

Approximate depth to groundwater in the vicinity of the tanks: feet.			
Regional groundwater flow direction:			
State Certified Laboratory to be used:			
Address	City	State	Zip
Contact Person		Phone	

Please explain any unusual or extenuating circumstances expected regarding the site assessment or closure:

I certify under penalty of law that I am the owner/operator of the tank(s) referenced above and that I am familiar with the information on this form and that it is true, accurate and complete, and further, that the procedures described herein will be followed during tank closure.

Signature of tank owner	
Full Name of tank owner	Date

UNDERGROUND STORAGE TANK PERMANENT CLOSURE NOTICE (rev. 3/4/03) **FACILITY ID# ___________**

State Use Only	
Date Processed	by
Date Mailed to LHD	
LUST ID#	
Date to LUST Review	

Closure Notice prepared at the request of the owner/operator (identified below) by			
of (company name)		Phone #	
Address	City	State	Zip

FACILITY INFORMATION

Tank Owner			Phone #
☐ sole proprietorship	☐ partnership	☐ corporation	
Address	City	State	Zip
Facility Name			
Address	City	State	Zip
Contact person			Phone #
Total number of regulated underground tanks at this site before closure			
Total number of regulated underground tanks at this site after closure			

TANKS CLOSED

Tank #						
Type (Steel,FRP,etc.)						
Date Installed						
Capacity (Gallons)						
Substance stored*						
Date last operated						
Date Closed						
Removed/In Place/ Change in Service (CIS)?						

*Indicate the specific substance stored in each tank to be closed (regular, unleaded, diesel, waste oil, etc.)

TANK REMOVER Name	Cert. # TR	Exp. Date	
Company		Phone #	
Address	City	State	Zip
SOIL/GROUNDWATER SAMPLER Name	Cert. # GS	Exp. Date	
Company		Phone #	
Address	City	State	Zip

CLOSURE INFORMATION

Fuel was emptied ☐	Sludge was removed ☐	Tank was cleaned ☐
Tank was: Purged ☐ Inerted ☐	Method Used:	
Location of Closure Records:		
For In-Place Closure: tanks filled with:		
For Change-In-Service: Substance to be stored:		

DISPOSAL SITES USED

	Location Name	Contact Name	Phone #	Date	Amount
Tank(s)					Tank #
Product From Tank(s)					
Contaminated Water From Tank Cleaning					
Sludge					
Contaminated Water From Excavation					
Contaminated Soil					

SITE ASSESSMENT

Complete the Facility Site Plat (Closure Notice) and Sample Information Table (Closure Notice) on pages 3 and 4 to show the locations, depths, and other information on all soil/groundwater samples taken for closure. The samples must be consistently identified by sample ID # on the site plat, table, and lab analysis report.

☐ Completed Facility Site Plat (Closure Notice) is attached.

The following **must** be included (enter the distance, and direction (N,S,E,W) from the area of contamination or, where applicable, use OH for overhead, NP for not present):

_____Water Line _____Sewer Line _____Natural Gas _____Storm Drain _____Telephone _____Electrical _____Property Line _____ Buildings

☐ Completed Sample Information Table (Closure Notice) is attached.
☐ Certified lab analytical environmental sample results are attached.
☐ Unified Soil Classification (USC) sample results are attached.
☐ Chain of Custody form is attached.
Samples were properly: ☐ Collected ☐ Labeled ☐ Packaged ☐ Transported
☐ Samples were in sight of the person in custody at all times or in a secured locked place.

I certify under penalty of law that the closure site assessment at this facility was conducted in accordance with R311-202 (parts 280.52 and 280.72) and R311-205 U.A.C., and that any additional samples required by R311-202 parts 280.52 and 280.72 and R311-205-2(a)(1) were properly collected.

Signature of Certified Groundwater/Soil Sampler	
Full name of Certified Sampler	Date

If contamination at the facility is confirmed, any person providing remedial assistance for a fee must be a Certified UST Consultant. The Certified UST Consultant providing assistance is:

CERTIFIED UST CONSULTANT

Name		Cert. #CC	Exp. Date
Company	Address		
City	State	Zip	Phone #

Please explain any unusual or extenuating circumstances expected regarding the site assessment or closure:

Facility Site Plat (Closure Notice)

The site plat must be drawn to an appropriate identified scale. It must show planned sampling locations, substances stored in tanks, and other relevant information. Tank and sample identification numbers must be consistent with the information given on p. 1 and 4 of the Closure Notice.

⇧

North

Scale: 1”= ___ Feet

Facility ID:	Drawn By:	Date:

X = Sample locations (SS-#, WS-#, USC-#)
ρ = Monitoring Wells (MW-#,)
□ = Soil boring (SB-#), or Geoprobe Boring (GP-#)
● = Water Wells (domestic, livestock, etc.)
Slope of Surface Topography: (N,NW,W,SW,S,SE,E,NE)
Land Use At Site: _Residential _Commercial _Industrial
Surrounding Land: _Residential _Commercial _Industrial

Site Plat Must Indicate Actual Locations Of:

√ Current & former tanks, piping & dispensers
√ Location of all samples to be taken
√ Buildings, fences, & property boundaries
√ Utility conduits (sewers, gas, water, storm drains, electrical, etc.)
√ Depth to groundwater (if encountered)
√ Excavations, GW monitoring wells & soil stockpiles

SAMPLE INFORMATION TABLE (Closure Notice)

Complete table for all samples that were taken for closure. Sample ID numbers on the table must be consistent with the sample ID numbers given on the site plat and in the lab analysis report.

Sample #	**Substance stored in tank**	**Sample type[1]**	**Depth[2]**	**Compounds[3]**	**Analysis method(s)[4]**

1 Soil (SS), Groundwater (GW), or Unified Soil Classification (USC).
2 Final depth (in feet) below grade at which samples were taken.
3 Contaminant compound(s) analyzed for each sample (TPH, BTEXN, O&G, etc).
4 Appropriate analysis methods for contaminant compound(s) in each sample

State Certified Laboratory used

Address

City

State

Zip

Contact Person

Phone #

I certify under penalty of law that I am the Owner of the tank(s) described above and that I am familiar with the information on this form and that it is true, accurate and complete and further, that the procedures described herein were followed during tank closure.

Signature of UST owner

Full Name of owner

Date

Return completed Closure Notice form, Facility Site Plat and Sample Information Table, Soil/Groundwater sample lab analysis results, USC sample results, and Chain of Custody form within 90 days of UST Closure to:

State of Utah Dept. of Environmental Quality
Division of Environmental Response and Remediation / UST Section
P.O. Box 144840
195 North 1950 West
Salt Lake City, Utah 84114-4840

Other DEQ Division Requirements

INTRODUCTION

Other Divisions of the DEQ have requirements that are applicable to UST sites. These requirements are briefly discussed below.

GROUNDWATER MONITORING WELL PERMITTING REQUIREMENTS

The Utah Division of Water Rights (DWR) requires that all groundwater monitoring wells in the state of Utah constructed to a depth of 30-feet or greater below natural ground surface shall be properly permitted, and properly installed by a well driller currently licensed in the State of Utah. The DWR must be contacted for well installation procedures and any other permit requirements contained in the Division's Administrative Rules for Water Well Drillers. Any documentation of the notification and any permits or approvals obtained must be submitted to DERR. Applicable sections in Administrative Rules for Water Well Drillers include: R655-4-4 General Procedural Requirements; and R655-4-7 Minimum Construction Requirements.

GROUNDWATER MONITORING WELL ABANDONMENT PROCEDURES

The Utah Division of Water Rights must be notified at (801) 538-7240 for well installation, abandonment procedures, and any other permit requirements contained in Administrative Rules for Water Well Drillers. Documentation of the notification and any permits or approvals obtained must be submitted to the DERR. Well abandonment requirements are contained in State Regulation R655-4-12, Administrative Rules for Water Well Drillers.

BLUE STAKES REQUIREMENTS

Section 54-8a-1 thru 11 of the Utah Code Annotated 1953, as Amended in 1993, Damage to Underground facilities requires that Blue Stakes (1-800-662-4111) must be notified by telephone at least 2 working days before excavating or drilling at an UST site, and that the work must begin within 7 days of the request. Excavation or any digging at the site without first calling Blue Stakes is "prima facie" evidence of negligence.

AIR EMISSIONS

The Utah Division of Air Quality (DAQ) must be notified at (801) 536-4000 prior to any release of petroleum vapors from free product removal, soil or groundwater treatment, so a determination can be made whether or not an Air Permit is required. Documentation of the notification and any permits or approvals obtained must be submitted to the DERR. DAQ requirements are contained in State Regulation R307-6 "De minimis Emissions from Air Strippers and Soil Venting Projects."

HAZARDOUS WASTE

Improper disposition and aeration of petroleum-contaminated soils and other hazardous wastes from leaking underground storage tank sites could potentially cause public health and environmental problems. The owner/operator (O/O) is responsible for notifying and obtaining approval from the DERR, the DAQ, local health departments, and local fire agencies prior to any soil management activity at an underground storage tank site. As outlined in State Regulation R311-204-2, the Executive Secretary of the Utah Solid and Hazardous Waste Control Board approves closure plans which includes information concerning contaminated soils management.

POTW REQUIREMENTS

Publically Operated Treatment Works (POTW) requirements concerning pretreatment regulations and discharge concentrations of groundwater impacted by petroleum free-phase or dissolved product are site and Sewer District specific. If an owner/operator (O/O) is planning to dispose of water from a water treatment system, a permit from the Utah Division of Water Quality (DWQ) at (801) 538-6146 must be obtained. Additionally, the specific local sanitary sewer district must be contacted before any treated or untreated waters are discharged to the sanitary sewer. Documentation of the notification and any permits or approvals obtained must be submitted to the DERR.

LOCAL HEALTH DEPARTMENT AUTHORITY/RESPONSIBILITY

Local health and fire departments must be notified of installation or closure of underground storage tanks, treatment of petroleum contaminated soils on-site or the storage of free product on-site, if any. Some local health and fire departments require prior approval of the installation or closure of underground storage tanks and must be notified at least 72 hours prior to any such activity.

STORM DRAIN AND RECEIVING STREAM DISCHARGE REGULATIONS

If an owner/operator of an UST site is aware that groundwater has been impacted by petroleum free-phase or dissolved product, or that surface waters have been contaminated, the DWQ must immediately be notified (801) 538-6146. Any required permits such as the Utah Pollution Discharge Elimination System (UPDES) permit must be obtained prior to initiating corrective action of abatement measures. The UPDES permit is required if treated water will be disposed to surface waters including streams, ditches, storm drains, or lakes.

REINJECTION OF CONTAMINATED MEDIA REGULATIONS

An Underground Injection Control (UIC) Permit is required when placing or re-injecting treated water back into the ground. The permit must be secured from the DWQ at (801) 538-6146 prior to implementing any corrective action or abatement measures. Documentation of the notification and any permits or approvals obtained must be submitted to the DERR. UIC rules and regulations are found in Utah Administrative Code R317-7.

Utah Administrative Code R655-4 Water Well Drillers

R655-4-11. Drilling of Monitor Wells.

11.0 General.

All monitor wells in the state constructed to a depth of 30 feet or greater below natural ground surface shall be installed by a currently licensed well driller.

11.1 Approval.

Approval to drill monitor wells is issued by the state engineer following review of written requests from the owner or applicant, federal or state agency or engineering representative. The requests for approval shall be made on forms provided by the state engineer and shall include the following information:

1) General location or common description of the monitoring project.

2) Specific course and distance locations from established government surveyed outside section corners or quarter corners or location by 1/4, 1/4 section.

3) Total anticipated number of wells to be installed.

4) Diameters, approximate depths and materials used in the wells.

5) Projected start and completion dates.

6) Name and license number of the driller contracted to install the wells.

11.2 Start Card/Official Well Drillers Report.

Upon written approval by the state engineer the project will be assigned an approved authorization number which will be referenced by the licensed driller on all intention to drill (start) cards and official well drillers reports as required in Section R655-4.1.1 and Section R655-4.3.

11.3 Installation and Construction.

11.3.1 All material used in the installation of monitor wells shall be sterile and contaminant free when placed in the ground. During construction contaminated water should not be allowed to enter contaminant-free geologic formations or water bearing zones. 11.3.2 Some minor cross-contamination may occur during the drilling process, but the integrity of the borehole and individual formations must then be safeguarded.

11.3.3 The well casing should be perforated or screened and filter packed with sand or gravel where necessary to provide adequate sample collection at depths where appropriate aquifer flow zones exist. The annular space between the borehole and casing should be adequately sealed using bentonite-slurry, pellets, granules or chips, cement grout or neat cement.

11.3.4 The gravel or filter pack should generally extend two feet to ten feet above screened or perforated areas to prevent the migration of the sealing material from entering the zones being sampled. Drill cutting should not be placed into the open borehole annulus. Figure 6, dated December 15, 1994 refers to typical groundwater monitor well construction standards and is incorporated by reference to these rules.

11.4 Abandonment.

Abandonment of monitor wells shall be completed in compliance with the provisions of Sections R655-4-12.1 through R655-4-12.12. The provisions of subsection R655-4-12.4(4) are not required for the permanent abandonment of monitor wells or wells completed less than 30 feet below natural ground surface.

11.5 Summary.

Most monitor well projects are the result of compliance with the Environmental Protection Agency (EPA), Federal Regulations such as the Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or "Superfund"), or specific State Solid and Hazardous Waste requirements. The contracts governing their installation are tightly written containing specific requirements as to site location, materials used, sampling procedures and overall objectives.
Therefore specific construction requirements for monitor well installation shall be governed by applicable contracts and regulations providing they meet or exceed state requirements and specifications. Guidelines and recommended practices dealing with the installation of monitor wells may be obtained from the state engineer upon request. Additional recommended information may be obtained from the Environmental Protection Agency (EPA), Resource Conservation and Recovery Act (RCRA), Groundwater Monitoring Enforcement and Compliance Document available from EPA's regional office in Denver, Colorado and from the Handbook of Suggested Practices for the Design and Installation of Groundwater Monitoring Wells, available from the National Groundwater Association in Dublin, Ohio.

R655-4-12. Abandonment of Wells.

12.1 Temporary Abandonment.

When any well is temporarily removed from service, the top of the well shall be sealed with a tamper resistant, water-tight cap or seal. If the well is temporarily abandoned during construction, it shall be assumed that the well is permanently abandoned after 90 days and an official report of well driller (well log) must be submitted in compliance with Section R655-4.4.3.

12.2 Permanent Abandonment.

Any well that is to be permanently abandoned shall be completely filled in a manner to prevent vertical movement of water within the borehole as well as preventing the annular space surrounding the well casing from becoming a conduit for possible contamination of the groundwater supply.

12.3 License Required.

Well abandonment shall be accomplished under the direct supervision of a currently licensed water well driller who shall be responsible for verification of the procedures and materials used.

12.4 Materials Used.

The following materials may be used in the permanent abandonment of wells:

1) Neat Cement conforming to ASTM standard C150-94 (standard specification for Portland Cement) of sufficient weight of not less than 15 lbs/gallon to prevent the flow of any water into the borehole from any aquifer penetrated.

2) Cement grout consisting of equal parts of cement conforming to ASTM standard C150 and sand or aggregate with no more than 6 gallons of water per 94 pound sack of cement.

3) Bentonite-based, commercially produced products specifically designed for permanent well abandonment, which are mixed and placed according to manufacturer's recommended procedures (i.e. Plug-Gel, Shur-Gel, Benseal, etc.).

4) The uppermost ten feet of the abandoned well casing or borehole shall consist of neat cement as required in Subsection R655-4-12.4(1) or cement grout as required in Subsection R655-4-12.4(2).

5) The liquid phase of the abandonment fluid shall be non-saline water containing no chemicals or toxic materials or other substances which may decompose or possibly contaminate the groundwater supply.

6) Abandonment materials placed opposite any nonwater bearing intervals or zones shall be at least as impervious as the formation or strata prior to penetration during the drilling process.

12.5 Placement of Materials.

1) Neat cement and cement grout shall be introduced at the bottom of the well or required sealing interval and placed progressively upward to the top of the well. The sealing material shall be placed by the use of a grout pipe, tremie line or dump bailer in order to avoid segregation or dilution of the materials.

2) Bentonite-based abandonment products shall be mixed and placed according to manufacturer's recommended procedures.

12.6 Termination of Casing.

The casings of wells to be abandoned shall be severed a minimum of two feet below either the natural ground surface adjacent to the well or at the collar of the hole, whichever is the lower elevation. A minimum of two feet of compacted native material shall be placed above the abandoned well upon completion.

12.7 Report of Abandonment.

Within 30 days of the completion of well abandonment procedures, a report must be submitted to the state engineer by the responsible licensed driller giving data relating to the abandonment of the well. The report shall be made on an official report of well driller (well log) forms furnished by the state engineer and shall contain information he may require, including the following:

1) Name of licensed driller or other person(s) performing the abandonment procedures.

2) Name of the well owner at time of abandonment.

3) Local address or location of well by section, township and range.

4) Abandonment materials, equipment and procedures used.

5) Water right or authorization number covering the well.

6) Final disposition of the well.

7) Date of completion.

12.8 Abandonment of Artesian Wells.

A neat cement, cement grout or concrete plug shall be placed in the confining stratum overlying the artesian zone so as to prevent subsurface leakage from the artesian zone. The remainder of the well shall be filled with cement grout, neat cement, bentonite abandonment products, concrete, or clay slurry. The uppermost ten feet of the well shall be abandoned as required in Subsection R655-4-12.4(1) and Subsection R655-4-12.4(2).

12.9 Abandonment of Drilled and Jetted Wells.

A cement grout, neat cement or concrete plug shall be placed opposite all perforations, screens or openings in the well casing. The remainder of the well shall be filled with cement grout, neat cement, bentonite abandonment products, concrete, or clay slurry. The uppermost ten feet of the well shall be abandoned as required in Subsection R655-4-12.4(1) and Subsection R655-4-12.4(2).

12.10 Abandonment of Gravel Packed Wells.

All gravel packed wells shall be pressure grouted throughout the perforated or screened section of the well. The remainder of the well shall be filled with cement grout, neat cement, bentonite abandonment products, concrete, or clay slurry. The uppermost ten feet of the well shall be abandoned as required in Subsection R655-4-12.4(1) and Subsection R655-4-12.4(2).

12.11 Removal of Casing.

It is desirable to remove the well casing during well abandonment, and when doing so the abandonment materials shall be placed from the bottom of the well or borehole progressively upward as the casing is removed. The well shall be sealed with cement grout, neat cement, bentonite abandonment products, concrete, or clay slurry. In the case of gravel packed wells, the entire gravel section shall be pressure grouted. The uppermost ten feet of the well shall be abandoned as required in Subsection R655-4-12.4(1) and Subsection R655-4-12.4(2).

12.12 Replacement Wells.

Wells which are to be removed from operation and replaced by the drilling of a new well, under an approved replacement application, shall be abandoned in a manner consistent with the provisions of Subsections R655-4-12.1 through R655-4-12.12 before the rig is removed from the site of the newly constructed replacement well. Also refer to the requirements provided in Subsection R655-4-7.12.

Please refer to Appendix B.II for local standards on well construction, well reconstruction, and well and boring destruction. Additionally, San Diego County requires all work to comply with the Department of Water Resources Bulletins 74-81 and 74-90.

III. SOIL AND ROCK SAMPLING

A. Geologic Observations and Interpretations

Understanding the geology at a site is critical in designing and implementing site assessment and remediation programs. Observations of soil and rock types encountered during site investigations should be integrated with all site findings and correlated with the local geologic environment.

Consider the following items to improve your understanding of the site.

- Review of existing geologic information from all available sources such as:

  - ➢ Published geologic maps and reports,
  - ➢ Personal or company experience in the site vicinity,
  - ➢ Reference material at local university libraries,
  - ➢ Site investigation and assessment reports prepared by environmental consultants on file with governmental agencies such as DEH, RWQCB, building departments, GeoTracker or others.

- Review of aerial photographs
- Review of topographic maps
- Observation of road cuts, excavations, and other exposures in the site vicinity
- Drilling one or more soil boring(s) using continuous coring methods

It is important to understand the local geologic environment to interpret the significance of changes in soil and rock types encountered in excavations and boreholes at the site.

Field observations, chemical analytical data, presence of groundwater, and presence of free product should be detailed in boring logs and trench logs. The depth and thickness of perched water or zones with non-aqueous phase liquid (NAPL) above the water table should be logged, sampled, and reported on the boring logs. Drilling generates cuttings that can be logged and interpreted to describe the underlying rock type and geologic structure. An interpretation should be made between fill and native soil, and should include an identification of the fill and native soil contact. Furthermore, all soil and fill materials should be described by using a soil classification system. Rocks and geologic formations should be described by using an appropriate rock classification system, such as ASTM.

A list of the observations that should be made and noted on field logs is presented in Table 5-1. Note that additional field descriptions for soils may be made depending on grain size. A key must be submitted with all boring logs. A list of field description guides is available in Appendix I.II, under *Technical References.*

An PG, CEG, RCE, or CHG who is registered with, or certified by, the State of California must log all soil and rock materials. A trained and experienced technician working under the direct supervision and review of one of these registered professionals shall be deemed qualified, provided this professional assumes responsibility for the accuracy and completeness of the logs. In addition, all work and reports that require geologic or engineering evaluations and/or judgments must be performed under the direction of an appropriately registered or certified professional. The registered professional must sign all reports containing such information.

TABLE 5-1: FIELD DESCRIPTIONS FOR SOIL AND ROCK

DESCRIPTIONS	(1) SOIL	(2) SEDIMENTARY
Classification System	USCS	List system used
Classification	ML, SW, CL, etc. Specify fill or native soil.	Sandstone, siltstone, conglomerate
Distribution/Abundance of Grain Size	Relative (include maximum Particle size)	Relative (include maximum particle size)
Minerals	Optional	List most abundant to least abundant
Color	Munsell Color Chart	Munsell Color Chart
Moisture Content/Saturation	Relative	Relative
Odor	Optional	Optional
OVA Readings	Optional	Optional
Contaminant Discoloration	As present	As present
Natural Organics	As present	As present
Plasticity	Degree of	Degree of
Visible Porosity	As applicable	As applicable
Blow Counts	As applicable	As applicable
Density (field)	Relative	Relative
Induration	Optional	Relative
Cementation	As present (type and degree)	As present (type and degree)
Weathering	Not applicable	Degree of
Fossil Assemblages or Trace Fossils	As present	As present
Texture/Structure	Grain shape(s) layers/laminations	Bed thickness, laminations, sorting, packing, grain shape(s), fracturing or folding, etc.
Other Observations	As present	As present

TABLE 5-1 (cont.): FIELD DESCRIPTIONS FOR SOIL AND ROCK

DESCRIPTIONS	(3) IGNEOUS	(4) METAMORPHIC
Classification System	List system used	List system used
Classification	Diorite, monzonite, gabbro, dacite, basalt, etc.	Schist, gneiss, quartzite, mylonite, etc.
Minerals	List most abundant to least abundant	List most abundant to least abundant
Particle/Grain Size Distribution	Relative (include maximum particle size)	Relative (include maximum particle size)
Color	Munsell Color Chart	Munsell Color Chart
Moisture Content/Saturation	Relative	Relative
Odor	Optional	Optional
OVA Readings	Optional	Optional
Contaminant Discoloration	As present	As present
Natural Organics	Not applicable, unless in fractures	Not applicable, unless in fractures
Visible Porosity	As applicable	As applicable
Blow Counts	As applicable	As applicable
Density (field)	Relative	Relative
Induration	Relative	Relative
Weathering	Degree of	Degree of
Fossil Assemblages or Trace Fossils	Not applicable	As present (remnant)
Texture	Euhedral to anhedral, equigranular to porphyritic, vesicular to scoriaceous, crystalline or glassy, etc.	Lineations, foliation, cleavage, cataclastic to mylonitic, etc.
Structure	Size and density of fractures, faulting, folding, cleavage, etc.	Size and density of fractures, faulting, folding, cleavage, etc.
Other Observations	As present	As present

Site geology controls the migration of contaminants. An understanding of soil and rock types within their geologic framework allows for better determination of the location of additional soil borings and monitoring wells, should further assessment or monitoring of subsurface contamination be necessary. Graphical presentations such as geologic cross sections are essential to illustrate interpreted changes in soil and rock types (refer to Appendix F.I for examples of site maps and geologic cross sections). Site-specific geologic information is necessary to evaluate and design remediation programs and to perform fate and transport studies.

B. Sample Collection

The goal of the site assessment is to determine the nature and extent of contamination. The quality and integrity of samples, sample locations, and other field observations will strongly influence interpretation of site conditions. Sample collection, management, and analysis must be done in accordance with the procedures specified in:

- CCR Title 22, Division 4.5, Chapter 11, Article 3, Section 66261.20(c), and
- U.S. Environmental Protection Agency document, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, Sixth Edition (2007).

Many container types are available for contaminant sampling and/or storage. The contaminant class determines the type of container that is selected. Follow the protocols outlined in EPA SW-846 for selecting the appropriate containers and for determining proper handling and storage requirements. Sleeves or liners are generally used when volatile compounds are present or suspected. Their use, however, may be limited by certain geologic conditions in San Diego County. Non-clear sleeves and liners also limit observations of lithology and the presence or absence of contamination. For these reasons, glass jars with Teflon-lined lids are commonly used. When glass jars are used they should be filled completely to minimize headspace.

C. Sampling to Delineate Contamination

Subsurface sample locations should be guided by the underlying geology, contaminant characteristics, and field conditions to determine the extent and magnitude of contamination. Discrete samples are required to demonstrate delineation of contamination; composite samples will not be accepted. Delineation is generally complete when successive nondetectable levels of contaminants are observed.

Samples have historically been collected at intervals of 5 feet. However, since thin distinct layers of contaminated soil may exist, or changes in lithology that affect contaminant distribution may occur within a 5-foot interval, soil and rock samples should be collected at significant changes in lithology and other locations as necessary, based on field observations of contamination.

Within the capillary fringe and the saturated zone, samples should generally be collected at 1- to 2-foot intervals in order to delineate the "smear zone." For the purpose of this manual, the "smear zone" is defined as soil or rock in the vicinity of the capillary fringe, and below the water table, which contains contaminants in a sorbed or free product phase (light non-aqueous phase liquid or LNAPL). The smear zone develops when the water table fluctuates or is depressed by NAPL. The smear zone will provide a continuing source of groundwater contamination and must be delineated for an effective remediation program to be designed.

Site-specific sampling protocol and sampling strategy must be presented in a workplan (Section 4.III), and should be discussed with DEH staff. Sampling plans often need to be modified during field operations; therefore, details of the sampling and analyses actually performed must be described in the site assessment report.

D. Drilling Techniques for Sample Collection

A number of sample collection techniques are used in subsurface investigations. Determining a suitable approach to sampling will depend upon the site accessibility, underlying lithology, and contaminant type. Driven sampling methods that utilize split-spoon samplers, probe/push-sampling techniques, and continuous coring techniques are preferred because these methods allow collection of samples at precise depths. Samples should be collected at least 6 to 18 inches in advance of the drill bit or auger to ensure that undisturbed native material is obtained.

Because the original borehole depth of grab samples collected from auger flights is uncertain, this sampling technique should only be used when driven-sampler and continuous-coring methods are not feasible. When grab samples are being collected, they should be obtained from the lowest flight of the auger and close to the auger stem. Caving or sloughing of the sides of the borehole in softer sediments may further complicate identification of grab sample depths and should be noted on field logs.

Drilling methods that add water, drilling fluids, or other substances into the boring during drilling may contaminate samples, spread contamination, and interfere with analysis for target compounds. A Material Safety Data Sheet (MSDS) must be obtained from the manufacturer for each drilling fluid or additive used at the site. For percussion drilling and other down-hole devices that require lubrication, a pure vegetable oil or other petroleum-free hydrocarbon lubricant must be used. Any substance introduced into the boring or drilling environment should be sampled for comparison analysis of target compounds if cross-contamination is suspected.

The most common drilling and auguring methods are presented in Table 5-2. Actual site conditions may affect the suitability of these methods. Alternative approaches must be discussed with DEH staff.

Cleanup Standards

Initial Screening Levels
November 1, 2005

Contaminants*	**Groundwater** *(mg/L)*	**Soil** *(mg/kg)*
Benzene	0.005	0.2
Toluene	1.0	9
Ethylbenzene	0.7	5
Xylenes	10.0	142
Naphthalene	0.7	51
Methyl t-butyl ether (MTBE)	0.2	0.3
Total Petroleum Hydrocarbons (TPH) as gasoline	1	150
Total Petroleum Hydrocarbons (TPH) as diesel	1	500
Oil and Grease or Total Recoverable Petroleum Hydrocarbons (TRPH)	10	1000

Tier 1 Screening Criteria
November 1, 2005

Tier 1 Screening Levels are applicable only when the following site conditions are met:

1.) No buildings, property boundaries or utility lines within 30 feet of the highest measured concentration of any contaminant that is greater than the initial screening levels but less than or equal to the Tier 1 screening levels AND,

2.) No water wells or surface water within 500 feet of highest measured concentration of any contaminant that is greater than the initial screening levels but less than or equal to the Tier 1 screening levels.

Contaminants *	**Groundwater** *(mg/L)*	**Soil** *(mg/kg)*
Benzene	0.3	0.9
Toluene	3	25
Ethylbenzene	4	23
Xylenes	10	142
Naphthalene	0.7	51
Methyl t-butyl ether (MTBE)	0.2	0.3
Total Petroleum Hydrocarbons (TPH) as gasoline	10	1500
Total Petroleum Hydrocarbons (TPH) as diesel	10	5000
Oil and Grease or Total Recoverable Petroleum Hydrocarbons (TRPH)	10	10000

Analytical Methods for Environmental Sampling at Underground Storage Tank Sites in Utah

Substance or Product Type	Contaminant Compounds to be Analyzed for Each Substance or Product Type	ANALYTICAL METHODS[1]
		Soil, Groundwater or Surface Water
Gasoline	Total Petroleum Hydrocarbons (purgeable TPH as gasoline range organics C_6 - C_{10})	EPA 8015B or EPA 8260B
	Benzene, Toluene, Ethyl benzene, Xylenes, Naphthalene, (BTEXN) and MTBE	EPA 8021B or EPA 8260B
Diesel	Total Petroleum Hydrocarbons (extractable TPH as diesel range organics C_{10} – C_{28})	EPA 8015B
	Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene (BTEXN)	EPA 8021B or EPA 8260B
Used Oil	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A (SGT*)
	Benzene, Toluene, Ethyl benzene, Xylenes, Naphthalene (BTEXN) & MTBE; and Halogenated Volatile Organic Compounds (VOX)	EPA 8021B or EPA 8260B
New Oil	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A (SGT*)
Other	Type of analyses will be based upon the substance or product stored, and as approved by the Executive Secretary (UST)	Method will be based upon the substance or product type
Unknown	Total Petroleum Hydrocarbons (purgeable TPH as gasoline range organics C_6 - C_{10})	EPA 8015B or EPA 8260B
	Total Petroleum Hydrocarbons (extractable TPH as diesel range organics C_{10} – C_{28})	EPA 8015B
	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A (SGT*)
	Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene (BTEXN) and MTBE; and Halogenated Volatile Organic Compounds (VOX)	EPA 8021B or EPA 8260B

[1] The following modifications to these certified methods are considered acceptable by the Executive Secretary (UST):

- Dual column confirmation may not be required for TPH and BTEXN/MTBE analysis.
- A micro-extraction or scale-down technique may be used for aqueous samples, but only for the determination of extractable TPH as diesel range organics (C_{10} – C_{28}).
- Hexane may be used as an extraction solvent.
- *Silica Gel Treatment (SGT) may be used in the determination of Total Recoverable Petroleum Hydrocarbons.

NOTE: The sample preparation method and any modification(s) to a certified method must be reported by the laboratory

CHAPTER 7
Screening/Cleanup Levels for LUST Sites

7. INTRODUCTION

The question: “How clean is clean?” is not easily answered. In a perfect world, the answer would be “non-detectable” or “pristine” or “the way it was before you spilled chemicals on it.” In the real world, however, the answer is complex and depends on several factors:

- Contaminant type,
- Contaminant location,
- Contaminant migration potential (fate and transport),
- Threat or risk to human health and the environment,
- Current and future use of property, and
- Economics.

Utah's Department of Environmental Quality, Division of Environmental Response and Remediation (DERR), Leaking Underground Storage Tank (LUST) Section has developed an assessment process to evaluate risks to human health and the environment resulting from petroleum contamination from LUSTs. This process is intended to address cleanup when Maximum Contaminant Levels (MCLs), Initial Screening Levels (ISLs), or other applicable cleanup standards cannot reasonably be achieved and is based on Utah Administrative Code R311-211, *Corrective Action Cleanup Standards Policy-UST and CERCLA Sites*, referred to as *Cleanup Standards Policy* (2006). A copy of the *Cleanup Standards Policy* is provided in this Chapter. A table summarizing MCLs, ISLs, and other applicable standards is included in this Chapter.

A summary of Utah’s cleanup levels for petroleum contaminated soil and groundwater can be found on the DERR’s website at **www.undergroundtanks.utah.gov/docs/cleanuplevels.pdf**.

Utah’s risk assessment process is derived from, and is consistent with, the United States Environmental Protection Agency’s (EPA) Office of Solid Waste and Emergency Response (OSWER) Directive 9610.17 (February 24, 1994) (“EPA Directive” entitled *Use of Risk-Based Decision-Making in UST Corrective Action Programs*). The EPA Directive references the American Society for Testing Materials (ASTM) *Standard Guide for Risk-Based Corrective Action (RBCA) Applied at Petroleum Release Sites* (ASTM, 1995) which identifies and describes one method of evaluating the risk to human health and the environment posed by multiple constituents in petroleum-contaminated soil, groundwater and air.

The ASTM (1995) document provides guidance for evaluating risks at petroleum release sites using a three-tiered approach. The first tier (Tier 1) is a screening process that uses only general hydrogeologic information and conservative assumptions to ensure protection of potential receptors. The second and third tiers require increasingly more accurate site-specific data, as well as increasingly sophisticated contaminant fate and transport modeling, to achieve greater accuracy and certainty in evaluating risks to receptors. The 1995 ASTM document contains the mathematical exposure equations for calculating risk-based screening levels (RBSLs) for a specified target excess risk (TER) limit.

CHAPTER 7
Screening/Cleanup Levels for LUST Sites

Utah has generally adopted the 1995 ASTM method but has modified it into a two-tiered approach for performing risk assessments. Utah's method is designed to provide systematic and consistent determinations of risk to potential receptors in accordance with the *Cleanup Standards Policy*. Like the ASTM (1995) approach, Utah's two-tiered approach requires increasingly more accurate site-specific data and increasingly complex transient contaminant fate and transport modeling with each option upgrade in order to achieve greater accuracy and certainty in evaluating risks to receptors.

Utah's Tier 1 Screening Levels (SLs) are contaminant concentrations in soil and groundwater that are considered "safe to leave in the subsurface" at any site if all of the Tier 1 distance criteria are met. Tier 1 SLs were developed by the DERR using conservative formulas and general Utah-specific (not site-specific) input parameters. Tier 1 distance criteria are distances from contaminated subsurface soil or groundwater to "receptors".

Receptors include wells (municipal, domestic, and irrigation), surface water bodies (lakes, rivers, streams, and canals), utilities (water supply lines, storm drain pipes, and sewer lines), and property lines. In order to use Tier 1 SLs, the contaminated soil and groundwater at the site must be located over 30 feet from utilities and property lines, and over 500 feet from wells and surface water bodies. In most cases, if subsurface contamination is below Tier 1 Screening Levels and the site meets all Tier 1 criteria, then no additional cleanup work is required at the site and the case is closed.

A summary of the Tier 1 Screening Process can be found in the DERR's *Guidelines for Utah's Corrective Action Process for Leaking Underground Storage Tank Sites*, October 30, 2005. This guide is available on the DERR's website at: http://www.undergroundtanks.utah.gov/rbca.htm.

Utah's Tier 2 SLs are developed using site specific input parameters from the site and more realistic (less conservative) formulas than those used to develop the Tier 1 SLs. Details on determining Tier 2 site-specific screening levels (SSCLs) can be found in DERR's *Guidelines for Utah's Corrective Action Process for Leaking Underground Storage Tank Sites*, October 30, 2005. This guide is available on the DERR's website at: http://www.undergroundtanks.utah.gov/rbca.htm.

CHAPTER 7
Screening/Cleanup Levels for LUST Sites

7.1 FATE AND TRANSPORT OF PETROLEUM HYDROCARBONS IN THE SUBSURFACE

An understanding of contaminant fate and transport processes in the subsurface is fundamental to making informed decisions at leaking underground storage tank (LUST) sites. The behavior of petroleum hydrocarbons in the subsurface is governed by the physical and chemical properties of the contaminants, as well as the site-specific characteristics of the media (soil, groundwater, soil gas) through which the contaminants migrate. Fate and transport mechanisms are complex and the discipline is rapidly evolving.

Numerous computer software packages are available to assist in simulating fate and transport processes. In most cases, the objective of computer simulations is to generate numerical models that predict concentrations of petroleum contaminants in soil or groundwater over time. Their success in predicting actual site conditions depends on the availability and reliability of site-specific data including (but not limited to) input parameters which represent soil sorption, dispersion, and biodegradation processes.

Computer models are only as reliable as the input parameters on which they are based. Whenever possible, site-specific parameters should be utilized, and a discussion of model assumptions and limitations should always accompany the computer simulations. When valid assumptions are made, computer fate and transport modeling can be a valuable tool for planning subsurface investigations, screening remedial options, or designing corrective action systems.

7.2 DETERMINATION OF RBSL AND SSCL VALUES FOR TOTAL PETROLEUM HYDROCARBONS (TPH)

TPH fractionation is only required when a LUST site has been approved to conduct a risk assessment following RBCA protocols as outlined in *Guidelines for Utah's Corrective Action Process for Leaking Underground Storage Tank Sites.* Utah's *Guidelines for TPH Fractionation at Leaking Underground Storage Tank Sites* document can be found on the DERR's website at **http://www.undergroundtanks.utah.gov/docs/fractionation.pdf**.

7.3 SAMPLE COLLECTION

Collect a minimum of one environmental sample which is representative of each contaminated medium (*e.g.*, soil and groundwater) and the maximum concentration and composition of the petroleum contamination at the site. For sites where TPH contamination is highly variable in concentration or composition, the user should collect multiple TPH samples at representative locations to ensure a representative analysis by the laboratory.

7.4 LABORATORY ANALYSIS

Analyze the sample(s) using EPA Methods 8260B and 8270B. Specify “Utah TPH Fractionation” on the chain-of-custody forms to ensure that the laboratory uses the reporting format specific for TPH fractionation, which differs from a typical 8260B and/or 8270B chemical parameter listing. The laboratory should report concentrations for each of the 10 different TPH fractions shown on the following flowchart. In addition, on the 8260B report, the laboratory should list values for any detectable BTEXN and MTBE. For fractions where the measured concentration is below the method reporting limit, a value of half of the method reporting limit should be used as the representative source area concentration in deriving SSCLs.

7.5 DETERMINATION OF TIER 2 RBSLS FOR EACH TPH FRACTION

Fraction-specific RBSL values must be derived for each complete exposure pathway at the site. For each TPH fraction, RBSL values can be calculated for each relevant exposure pathway using the equations provided on Table C-1 of the Tier 2 Guidance Document (Equations C.1 through C.8). Fraction-specific chemical property values and toxicological parameters to be used in the RBSL calculations are provided in Table C-2 of the Tier 2 Guidance Document.

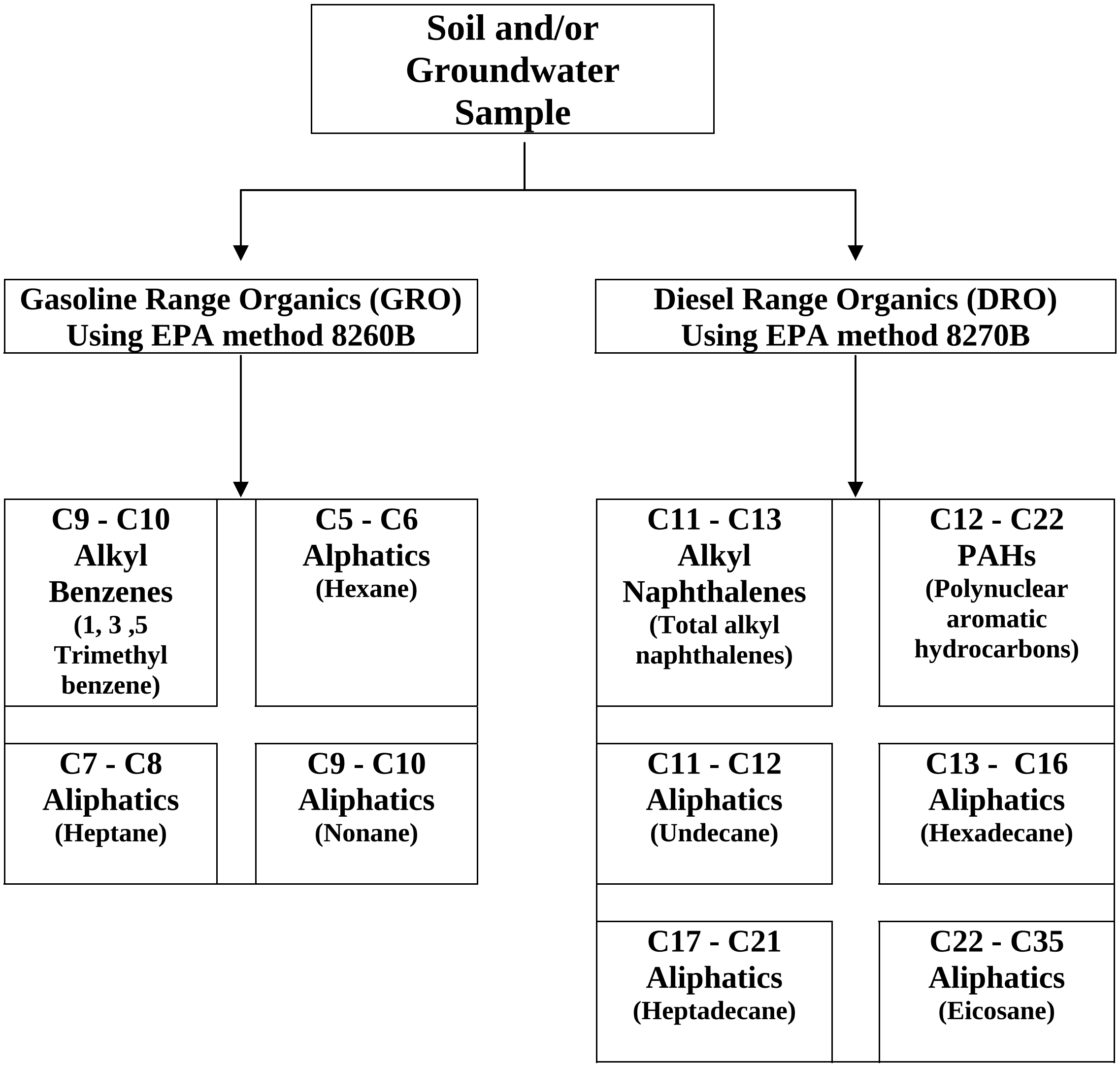
7.6 DETERMINATION OF SSLC VALUES FOR TPH FRACTIONS

Under Tier 2 Options 2 through 4, SSCL values for the individual TPH fractions are developed in the same manner as for any other COCs (*e.g.*, BTEXN and MTBE). Using the chemical property values and toxicological parameter values, a NAF value may be derived for each TPH fraction using the Option 2 through 4 calculation methods. The NAF is then multiplied by the appropriate RBSL value to obtain an SSCL for each complete exposure pathway. The fraction that exceeds its applicable SSCL the most will ultimately drive the cleanup for all the other fractions contained within TPH at the site.

7.7 CONFIRMATION SAMPLING FOR TPH FRACTIONS FOLLOWING TPH-DRIVEN CLEANUP ACTIVITIES

After completing cleanup activities that are driven by the exceedence of the SSCLs for the TPH fraction(s), the user should obtain an appropriate number of environmental samples at representative locations and depths in order to verify the effectiveness of the cleanup at the release site. The same procedures described herein would again be employed for comparison with representative source area TPH fractionation values obtained. During cleanup, the user may elect to obtain samples for TPH fractionation, and BTEXN and MTBE (EPA Method 8020) if applicable, to measure the relative progress of the cleanup activities and to estimate the cleanup duration.

Figure 7-1 Utah's Total Petroleum Hydrocarbon Fractionation & Analytical Method Relationship



* = Surrogate Chemical used for Toxicity values (RfD) in the RBCA Document.

State Of Utah
Department of Environmental Quality
Division of Environmental Response and Remediation

Leaking Underground Storage Tank (LUST) Subsurface Investigation Report Guide

A Customer Guide to assist Utah owners and operators of underground
storage tanks in their investigation of the extent and degree
of petroleum contamination from LUST sites.

December 2009

A petroleum release has been confirmed at your facility, and screening levels have been exceeded. You are therefore required to investigate and remediate the release.

The former reporting formats have been replaced and they should not be used any more.

This publication will guide you through the process of preparing the **Subsurface Investigation Report** as required under the state-established compliance schedule(s) for releases of petroleum products from underground storage tank (UST) systems. A subsurface investigation, to define the extent and degree of contamination, is required in order to establish site-specific clean-up levels prior to consideration of closing the release site.

This Subsurface Investigation Report replaces the former versions known as the "Abatement and Initial Site Characterization Report" and the "Subsurface Investigation Report," formally required under the "Phase I" and "Phase II Reporting and Remediation Schedules." The "Corrective Action Plan Report" has been replaced by the "Corrective Action Plan Guide." The former reporting formats should be discontinued immediately.

TABLE OF CONTENTS

REPORT COMPONENTS

ADDITIONAL INFORMATION

State of Utah
Department of Environmental Quality
Division of Environmental Response and Remediation
Leaking Underground Storage Tank (LUST) Section
168 North 1950 West, First Floor
Salt Lake City, Utah 84116
Telephone: (801) 536-4100
Fax: (801) 359-8853
TDD: (801) 536-4414

Subsurface Investigation and Clean-up Checklist

The following checklist will provide you with a summary of the steps between discovery of a petroleum release, investigation and remediation (clean-up) of your release and final site closure. It is designed to help you understand the steps involved, to graphically track your progress, and show how near to completion of the process you are.

X	Important Steps to Remember
	Report the release within 24 hours of discovery to the Division of Environmental Response and Remediation (DERR). Stop the source of the release and prevent the spread of further contamination.
	If the leak or release occurred from a tank that is covered by the Utah Petroleum Storage Tank Trust Fund (FUND)*, submit an Eligibility Application for reimbursement of investigation and clean-up costs. Refer to the DERR's publication "Petroleum Storage Tank Fund Claims Packet" for complete eligibility and reimbursement information.
	Prepare and submit a "Subsurface Investigation Report" within **90** days of notification from the DERR. Use this guide for preparing the report.**
	If free product is found, prepare a "Free Product Removal Report" and include it with your Subsurface Investigation report. Use this guide for preparing your Free Product Removal Report (page 10).
	Refer to the “Permitting Requirements List” contained in this guide (page 11) for any applicable reporting or permitting requirements by other regulatory agencies for the release at your facility.
	Submit a "Corrective Action Plan", as requested by the DERR, to clean up contamination to established or recommended clean-up levels, or conduct a risk assessment to establish site-specific clean-up levels.
	Once work or clean-up at the site is completed as determined by the DERR, request site closure in the form of a "no further action" letter from the DERR.

Frequently Asked Questions

Why should I submit a Subsurface Investigation Report?

The answers to these questions can help get you started.

There are two reasons why you must submit this report to the Utah Division of Environmental Response and Remediation (DERR). First, you are required by Utah law to report, control, abate and characterize the release by defining the extent and degree of contamination, and conduct remediation (clean-up) if necessary. And second, it will enable the DERR to help guide you through the investigation and clean-up process to make it as timely, site-specific and cost effective as possible. If information regarding your release site indicates relatively high levels of petroleum contamination, further investigation will help determine if there are risks of contaminating drinking water, indoor air, surface water, sensitive wildlife habitats or other sensitive receptors. This report provides information to help determine these potential risks.

---

*Even if the tank is not currently on the Fund, the release may be covered by the Fund if the release occurred while the tank was on the Fund and if the tank was on the Fund within the last six (6) months (or one year in some circumstances). If there is any possibility that the release is covered, the eligibility application should be submitted immediately because the claim will be ineligible if it is not submitted on time. See Utah Code §19-6-524.

**Depending on the results of your subsurface investigation, more work may be needed at the release site. This additional work may consist of conducting groundwater monitoring, abatement or cleanup activities, additional investigations or other related work.

Should I hire a consultant?

Depending on the scope of work to be done at your release site, you may need to use a state-certified environmental consultant.

Utah law requires that starting on January 1, 1996, contractors or environmental consultants must be certified as a “Certified UST Consultant” to perform work at any UST release site.

You will need to hire the services of a trained and experienced environmental consultant or contractor to assist you with necessary abatement, investigation and clean-up work and associated reports. Environmental professionals with experience in leaking underground storage tank (LUST) site investigations and clean-ups are available to help you with this work in a timely and cost effective manner. It is in your best interest to get several competitive bids before beginning the work. The DERR has a list of contractors and certified consultants available upon request. The State of Utah does not endorse any consultant or company, but maintains this list of contractors who have indicated an ability to perform the required work for your benefit.

When do I submit the report?

A Subsurface Investigation Report is due **90** days after receiving this guide from the DERR. Please contact your project manager with any questions regarding your release site or the required report.

How do I file the report?

Submit your Subsurface Investigation Report to your DERR project manager at:

Utah Department of Environmental Quality
Division of Environmental Response and Remediation
Leaking Underground Storage Tank (LUST) Section
168 North 1950 West, First Floor
Salt Lake City, Utah 84116
(801) 536-4100

You can deliver or submit the report in person to this address or you may send it by mail.

What information should the report contain?

The remainder of this guide contains the information necessary for putting together the Subsurface Investigation Report. If you use this guide and include the specific information detailed in it, your report will be complete and will minimize the DERR's review and response time. Also, a complete report will help minimize any additional expense or time on your part for the collection of additional data and information.

COMPONENTS OF THE SUBSURFACE INVESTIGATION REPORT

Executive Summary

Create an at-a-glance summary of your report.

The Executive Summary is a brief summary of this report. It may be as brief as one or two paragraphs and should provide a summary of the information contained in this report and your (or your consultant's) conclusions and recommendations for achieving clean-up and site closure.

Table of Contents

A table of contents can work as a checklist assuring the report is complete.

Your Subsurface Investigation Report's table of contents should contain the following:

1. *Introduction*
2. *Site Description and Maps*
3. *Tier 1 Criteria*
4. *Nature of the Release and Abatement Measures*
5. *Methodology*
6. *Results*
7. *Conclusions and Recommendations*
8. *References and Appendices*
9. *Free Product Removal Report (If applicable)*

1 Introduction

Your introduction should include general information about the site.

The Introduction should include the following information:

- Your facility identification number, release site number and location or address of the release site.
- A brief history of land use at the site including a description of how the release was determined.
- A brief description of the work completed at the site, and a brief summary of the conclusions and recommendations for further work (if any) at the site.

2 Site Description and Maps

A picture is worth a thousand words. Prepare a good site map!

A good site description will help determine potential exposure pathways for petroleum contamination to reach or impact people or the environment. This section should consist of a vicinity and site map providing a complete graphical description of the facility and the land surrounding the facility. Each map should be drawn to scale with proper orientation (showing a North arrow) and should be no larger than 11" x 17". This way the maps can be bound into the report. The maps should provide the following information:

- The facility address or location, with an appropriate scale (e.g., bar scale with 1 inch = 20 feet, etc.) and North arrow.
- Existing and removed UST systems including piping, dispensers and fill ports.
- Underground utilities including; culinary water supply, sewer or septic systems, natural gas lines, storm drains, power and telephone lines.

- Property boundaries, on-site buildings and any adjacent buildings.
- Any excavations showing width, length and depth.
- Any known contaminated areas (square footage or volume if known)
- Location and depths of ALL soil and groundwater samples collected during any phase of the investigation of this release. Include closure sample locations, confirmation sample locations, soil boring locations, groundwater monitoring well location and other relevant information. Be sure to include depth (feet below grade) of sample collection.
- Location of soil stockpiles, aeration piles, etc.
- Land features surrounding the site including; lakes, rivers, streams, irrigation canals, wetlands, slope of local land surface, etc.

Identify all sample locations shown on your site map. Make sure your sample numbers and locations are consistent with the identification labels used on the chain-of-custody forms and the laboratory analytical reports.

If the site map becomes cluttered or confusing due to a large number of sample identification labels, you may wish to use more than one sampling map, or use other techniques to identify the sample locations. You may also include additional site maps showing contaminant iso-concentration contours, geologic cross sections and groundwater elevation contours. You should also present the sampling results in a table format so sample data can be easily referenced to sample locations marked on the site map.

3 Tier 1 Criteria

This section, "Tier 1 Criteria," describes the environmental features and possible risks to human health or the environment at the release site. These features help to determine risks presented by your release site and its classification status. Site classification is a dynamic process for prioritizing release sites according to the seriousness of the release. The corresponding response action needed is based on the current and potential degree and severity of hazards to human health or the environment. This process is evaluated on a case-by-case basis and ensures that when maximum contaminant limits are exceeded, appropriate response actions are taken to protect human health and the environment. Site classification is based on the most recent data and reflects current site conditions. Since the risks posed by contamination at any given release site are expected to change as more information is learned about a site, a site may be re-classified. Please provide the following information:

Tier 1 Criteria affects the clean-up level and subsequent closure of your site. Be as accurate as possible.

- Describe the current land use at, and surrounding the release site. It is considered residential if a residence is located on, or adjacent to your site in any direction.
- Describe the naturally occurring soil type and the depth and location where the samples were obtained. Unified soil classification (USC) is preferred; however, a geologic field description is acceptable (e.g., gravel, sand, silt, clay, etc.), if done by a qualified person.
- Indicate if you encountered groundwater at your site during UST closure, investigation activities, or obtained groundwater information from other sources. If so, indicate the groundwater depth (in feet) below the ground surface at or near your site.
- Groundwater flow direction can be determined if you have at least three (3) groundwater monitoring wells properly installed at your site. You may also be able to determine groundwater flow direction from other wells installed at a nearby LUST release site. Describe which method you used to determine groundwater flow direction.

Your site classification will help determine if immediate response actions are needed.

Site classification is a dynamic process and can change as more information is obtained.

- Indicate the distance and estimated depth (in feet) below grade from the source area of petroleum contamination to the following buried utilities; water line, sanitary sewer, natural gas, storm drain, telephone, electrical, other (specify).
- Indicate the distance (in feet) from the source area of petroleum contamination to property lines and buildings (indicate type of building; residential, commercial, industrial, etc.).
- If available, document the water well survey (e.g., Points of Diversion Information) conducted at the release site.

4 Nature of the Release & Abatement Measures

Identify the product released and describe where the leak occurred.

In this section, you provide details about the release, including age, condition and contents of the UST. You are also required to perform and report abatement measures to stop the source of contamination and to prevent further releases of contamination. Describe the following:

- Age and condition of the UST system, including piping and tanks, corrosion holes, soil staining or odor, sheen on surface of groundwater or surface water.
- Types and amount of product(s) stored in the USTs, and the type and estimated amount of product released into the environment.
- Cause and location of the release such as the tank, dispenser island, piping, overfills and spills, etc.
- The method(s) used for detecting contamination.
- The location of where the contaminated soil or groundwater was either properly disposed of, or is currently being stockpiled or stored.

Have you stopped the release to minimize future problems?

All stockpiled or aerated soils should be managed in accordance with the DERR'S "Guidelines for Disposition and Treatment of Petroleum- Contaminated Soils." Prior to aeration, approval must be obtained from the local health department, the Utah Division of Air Quality and the DERR. Contact your DERR project manager for assistance with these aeration requirements.

On- or off-site soil treatment such as aeration or land farming needs approval from more than one regulatory agency.

- If contaminated soils are over-excavated, or if groundwater is removed from the release site, confirmation soil or groundwater samples must be taken to confirm that the levels of contamination remaining in-place are at or below established clean-up levels.
- Determine the total volume, contaminant type(s) and concentration(s) of the removed groundwater or soil, and any soil or groundwater contamination remaining in-place.
- Determine the volume, concentration and disposal method or location used for well development or purge water, groundwater, excavation water or other waste water, etc.
- Collect representative environmental samples (soil, groundwater, etc.) to define the nature, extent and degree of the contamination at the site. Information regarding the results of the investigation and plans for future work, if any, should be included in the "Conclusions and Recommendations" section of the report.
- Consult with your DERR project manager or your environmental consultant prior to any confirmation sampling. There may be site-specific requirements necessary for site close-out. See "Sampling Procedures and Requirements" (page 12) for general descriptions of analytical testing requirements for various types of petroleum contamination.

Don't forget to take confirmation samples!

IMPORTANT: ***You must IMMEDIATELY begin removal of any free petroleum product in excess of ⅛ inch thick. Refer to enclosed Free Product Removal Report (pg 10) for info.***

5 Methodology

This section describes the methods and procedures used to conduct the investigation and should include the following:

- Document that all the proper agencies have been contacted and that all necessary permits or approvals have been obtained. Refer to the list of agencies in the "Permitting Requirements List" (page 11) to determine if you need their involvement or approval.
- Describe all methods of investigation used to define the extent and degree of soil and groundwater contamination. This may include on- or off-site soil borings by drilling or direct-push methods, groundwater monitoring wells, soil vapor surveys, over-excavation, test pits, etc.
- Describe each of the following for all groundwater monitoring well installations:
    - Method of drilling or other types of placement of wells (such as digging, backfilling or direct-push techniques).
    - As-built drawings to document well construction.
    - How drill cuttings were disposed.
    - Explain the method used to survey all groundwater wells for elevation and their relative location.
- Include the following information to document soil conditions and sampling procedures:
    - Describe the visual appearance of the soil, including odor, staining, depth to static water level, thickness of capillary fringe and other field observations made during the investigation and soil sampling.
    - Describe native soil type (color, grain size, consistency, hardness, moisture content, etc.) and stratigraphy. This information is collected from soil boring logs, test pits and other methods.
    - Describe your field screening methods, analytical sampling results and other relevant sampling procedures.
- Include the following information to document groundwater conditions and sampling procedures:
    - Describe the visual appearance of the groundwater, odor, sheen or thickness of free product, depth to groundwater (in feet) below grade, general site conditions and other field observations made while measuring static water level (SWL), purging and sampling the wells.
    - Describe method used for purging wells, and how many well casing volumes (total number of gallons) were purged from the well(s).
    - Describe how the SWL measurement was determined.
    - Explain how purge, development or rinsate water generated from wells was disposed.

These descriptions, methods and rationale are generally referred to as your "standard operating procedures" (SOPs). If your SOPs don't substantially change between different sampling events and reports to the DERR, you don't need to describe them again. Simply refer to the previous report.

Do you need to notify any other regulatory agencies? Refer to the Permitting Requirements List to see if you do.

You may need to obtain off-site access agreements to determine the full extent and degree of soil and groundwater contamination.

Describe how the subsurface investigation was conducted.

You may need to conduct quarterly monitoring for a year or so to determine trends in flow direction, contamination levels and depth to groundwater.

6 Results

Describe the results obtained from your subsurface investigation which should define the extent and degree of soil and groundwater contamination.

In this section, describe the extent and degree of the contamination from the information you gathered in the field.

- Soil sampling results should include:
    - A description and documentation of the subsurface geology of the site, both soil type and stratigraphy. As part of the documentation, you should include boring logs, excavation or cross-section drawings, test pit information, and any other data you collected.
    - Include any field screening results. Be sure dates, locations, depths and method(s) for soil screening or sampling are clearly identified.
    - A summary of the analytical results developed from laboratory analysis reports should be provided in tabular format. The table should include sample location or other identification number, methods of analyses, depth of sample collection (feet below grade) and results. Copies of the original laboratory analysis reports and chain-of-custody forms must be included in the appendices of the report.
- Groundwater sampling results should include:
    - A groundwater gradient map showing groundwater elevations and flow direction.
    - A summary of the analytical results developed from laboratory analysis reports should be provided in tabular format. The table should include sample location or other identification number, methods of analyses, depth to water (feet below grade) and results. Copies of the original laboratory analysis reports and chain-of-custody forms must be included in the appendices of the report.
    - Dissolved oxygen and any other field parameters (e.g., pH, temperature, redox potential, nitrate, sulfate, etc.) or readings collected in the field, if applicable.
    - Site maps showing current chemical concentration results (e.g., iso-concentration maps) for benzene, naphthalene, etc. Show sampling locations and depths using the same sample ID from the laboratory analytical results table.

Refer to "Sampling Procedures and Requirements" in the Additional Information and Resources section at the end of this guide.

7 Conclusions and Recommendations

Include your recommendations for clean-up if additional work is needed, or if site closure is warranted with no further action needed at the site.

This section allows you the opportunity to summarize the release site conditions obtained during your investigation, the potential risks they present, and to add your perceptions and recommendations on:

- The extent and degree of the contamination, and the volume and highest contaminant concentrations remaining at the release site.
- Whether or not additional work is necessary, underway or planned in the future in order to achieve clean-up goals.
- Further action required on your part for filing claims against the Petroleum Storage Tank Fund for reimbursement of your investigation and clean-up costs.
- Recommendations for DERR action at your site including extensions of deadlines, assistance with resources such as reimbursement of investigation and clean-up costs from the PST Fund, or site closure with no further action required.

8 References and Appendices

Refer to any outside publications or sources you used for information in preparing this report, or references to documents or reports previously submitted.

Additional documents to be added as appendices, include:

- Soil boring logs and stratigraphic cross sections
- Groundwater monitor well construction logs
- Photographs and other supporting information
- Water well surveys (e.g., Points of Diversion Plots)
- Other agency permits or approval letters if applicable

Include any other additional documentation you feel would be helpful in this investigation, clean-up efforts, or to support the conclusions presented.

9 Free Product Removal Report

Free product can be a severe safety hazard as well as a high risk to human health and the environment. If free phase product is observed at any time (e.g., a ⅛" or more of gasoline, diesel or other petroleum products outside the intended storage system), you must immediately begin source removal. Your free product removal procedures should minimize the spread and migration of contamination into uncontaminated areas and must be removed as completely as possible. This Free Product Removal Report section should include:

- Documentation that you notified the Utah Division of Air Quality at (801) 536-4000 for obtaining approvals or permits related to air emissions from your free product recovery system.
- Documentation that you notified the Utah Division of Water Quality at (801) 538-6146 of free product in contact with groundwater or surface water, and that you obtained the necessary permits or approvals for free product disposal or effluent water discharge related to your free product recovery system.
- Site map and tables showing any information pertinent to free product quantity, thickness, type, extent and other relevant details.
- Construction details and other relevant aspects of the free product removal system such as how much was removed, the disposal location or disposal method used and the current site status.
- If water was extracted in conjunction with free product, sample collection may be necessary in order to characterize the effluent (water) quality and dissolved contamination levels. If so, please include all sampling results in the report. Proper procedures, as detailed in the "Sampling Procedures and Requirements" (page 12), should be followed and documented.

It may be necessary to file a Free Product Removal Report with your Subsurface Investigation Report.

Groundwater shall not be disposed of in a manner placing it in direct contact with the environment or which causes contamination to previously uncontaminated areas.

ADDITIONAL INFORMATION

Permitting Requirements List

You may need the approval of the following agencies during the course of investigating and remediating petroleum releases. If you have any questions about obtaining approval from other agencies, please contact your DERR project manager at (801) 536-4100.

Contact other agencies for necessary approvals or permits.

Utah Division of Air Quality (801) 536-4000

If you anticipate emitting hydrocarbon or petroleum vapors into the atmosphere during any phase of the investigation or clean-up, notify Air Quality so they may determine whether an air discharge permit or approval letter is required. Submit documentation of notification and any permits or approvals to the DERR.

Utah Division of Water Quality (801) 538-6146

If you know that groundwater has been impacted by a free-phase petroleum product, or that surface waters have been contaminated, notify Water Quality. Any required permits or approvals, including groundwater or surface water discharge, pretreatment or injection, must be obtained prior to implementing corrective action or abatement measures. Documentation of the notification and any permits or approvals obtained should be submitted to the DERR.

Utah Division of Solid and Hazardous Waste (801) 538-6170

If you suspect or know the release at your site is a hazardous waste (such as cleaning solvents) or a mixed hazardous/petroleum waste, notify Solid and Hazardous Waste to ensure compliance with permitting, disposal, sampling and other related activities.

Utah Division of Water Rights (801) 538-7240

Contact Water Rights for well installation and abandonment procedures for wells greater than 30 feet below grade, and any other permits required by their Administrative Rules for water well drillers. Submit documentation of the notification and any permits or approvals obtained to the DERR.

Utah Department of Transportation (UDOT) (801) 965-4000

If you need to work in the public right of way for investigation, sampling or any construction activities, call UDOT, city, county or other appropriate agency for the necessary approvals.

Sanitary Sewer District

To discharge petroleum contaminated water or waste water to the local sanitary sewer, check your local listing in the Blue Pages for specific numbers listed under "Public Works" or "Sewer," or call the DERR for more information.

Local Health Department

Contact your local health department or other appropriate agencies (Fire Department, etc.) for any applicable permits, applications or fees they may require for activities related to investigation, construction, corrective action, system operation, disposal or emissions at your release site. These approvals or requirements may vary greatly between different cities or counties.

Blue Stakes (800) 662-4111 or (801) 532-5000

Contact Blue Stakes or other appropriate agency for marking underground public utilities prior to any digging or construction activities.

Sampling Procedures and Requirements

Follow the guidelines and items in this section to ensure that all types of samples collected are of good integrity, are representative of environmental conditions and contaminant levels. Remember that all samples must be collected by an UST Certified Soil and Groundwater Sampler.

Following these sampling guidelines will help minimize the need to re-sample. It's important to do it right the first time, so call the DERR with any sampling questions.

- Describe or document any necessary property access and other permitting requirements.
- All soil, groundwater, surface water, or other types of environmental samples must be collected by a Utah certified sampler and analyzed by a Utah certified laboratory. The name and certification number of the sampler and laboratory must be clearly identified.
- Native soil type can be evaluated using Unified Soil Classification methods. Other detailed lithological descriptions may also be necessary.
- Describe subsurface stratigraphy and continuity of strata beneath the site, such as clay, silt or sand lenses, interbedded strata and other features.
- Chain-of-custody protocols and documentation must be maintained and provided for all environmental samples collected.
- All sample identifications, names and numbers should be consistent throughout the chain-of-custody protocol and documentation, laboratory analytical results, site map, data tables and report text.
- Describe sampling methodology, equipment and decontamination procedures.
- Describe the rationale for selecting sample locations and sampled intervals in excavations, test pits, soil/well borings, soil land farms, soil stockpiles or other sample locations. Describe whether sample location determination was based on field instrument measurements, pre-selected intervals or other rationale.
- Describe and/or illustrate depths at which all soil & groundwater samples were collected, show sample locations on a properly scaled and oriented map.
- Identify the sample type(s) collected such as confirmation, grab, composite, headspace, blanks, duplicates, etc., and rationale for their selection.
- Specify the following sampled features and the applicable media sampled, including but not limited to; excavations, test pits, soil borings, soil stockpiles, soil land farms or aeration piles, groundwater monitoring wells, groundwater injection or extraction wells or other types of water wells.
- Provide descriptions of field screening methods and devices used including organic vapor meters or other test methods for detecting the presence of contamination.
- **Sampling procedures must be conducted in a manner which minimizes the loss of volatile organic compounds.** Describe the methods used to minimize the loss of volatiles and maintain sample integrity, such as zero headspace in sample containers and preserving the sample at 4^{o} Celsius.
- Samples should be immediately delivered to the laboratory. If not, describe the methods use preserve samples and maintain sample integrity within the applicable holding times.

- Laboratory analytical detection limits must be sufficiently low in order to detect contaminant concentrations at or below their applicable minimum detection levels or state-established clean-up levels.
- Describe the volume removed (gallons), the method used for purging groundwater wells, and location or method used for the disposal of purge water.
- Groundwater well installation and abandonment must be conducted in accordance with the Utah Division of Water Rights specifications if the wells are deeper than 30 feet below grade.
- If soil borings or wells are emplaced, the following information if required:
  - Type of drilling equipment used, and detailed geologic boring logs with an appropriate vertical scale shown.
  - As-built drawings showing: number of wells and/or borings; total depth of well or boring; well construction materials including casing screen type, length, slot size, filter pack material and particle size;
  - Sample locations for soil or groundwater; and, any organic vapor meter measurements.
  - Type and placement of extraction pumps, if applicable.
  - Identify the depth of groundwater (feet below grade) encountered at the site during sampling or investigations.
  - Describe the volume generated and the procedures used to dispose of drill cuttings, purge water or other waste materials generated during any phase of the work at the release site.
- Confirmation environmental samples (soil, groundwater, etc.) are required any time contaminant is treated in-place or removed from the subsurface or release site area.
- Analytical Methods and Contamination Determination: The following table shows the constituents for each product type which must be analyzed using approved analytical methods. Other appropriate analytical methods may be used as approved by the Executive Secretary (UST) for any of the methods outlined below. The analysis of additional constituents may be required as determined by the Executive Secretary (UST).

Don't forget to take confirmation samples.

Consult this table to determine the right testing methods to use during your investigation and other sampling events. Other fuel types such as kerosene, aviation fuel, etc., may be able to be determined by some of these analytical methods.

Analytical Methods for Environmental Sampling at Underground Storage Tank Sites in Utah (July 2004)

Substance or Product Type	**Contaminant Compounds to be Analyzed for Each Substance or Product Type**	**ANALYTICAL METHODS[1]**
		Soil, Groundwater or Surface Water
Gasoline	Total Petroleum Hydrocarbons (purgeable TPH as gasoline range organics C_6 - C_{10})	EPA 8015B or EPA 8260B
	Benzene, Toluene, Ethyl benzene, Xylenes, Naphthalene, (BTEXN) and MTBE	EPA 8021B or EPA 8260B
Diesel	Total Petroleum Hydrocarbons (extractable TPH as diesel range organics C_{10} – C_{28})	EPA 8015B
	Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene (BTEXN)	EPA 8021B or EPA 8260B
Used Oil	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A (SGT*)
	Benzene, Toluene, Ethyl benzene, Xylenes, Naphthalene (BTEXN) & MTBE; and Halogenated Volatile Organic Compounds (VOX)	EPA 8021B or EPA 8260B
New Oil	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A (SGT*)
Other	Type of analyses will be based upon the substance or product stored, and as approved by the Executive Secretary (UST)	Method will be based upon the substance or product type
Unknown	Total Petroleum Hydrocarbons (purgeable TPH as gasoline range organics C_6 – C_{10})	EPA 8015B or EPA 8260B
	Total Petroleum Hydrocarbons (extractable TPH as diesel range organics C_{10} – C_{28})	EPA 8015B
	Oil and Grease (O&G) or Total Recoverable Petroleum Hydrocarbons (TRPH)	EPA 1664A or EPA 1664A **(SGT*)**
	Benzene, Toluene, Ethyl benzene, Xylenes, and Naphthalene (BTEXN) and MTBE; and Halogenated Volatile Organic Compounds (VOX)	EPA 8021B or EPA 8260B

. [1] The following modifications to these certified methods are considered acceptable by the Executive Secretary (UST):

- Dual column confirmation may not be required for TPH and BTEXN/MTBE analysis.
- A micro-extraction or scale-down technique may be used for aqueous samples, but only for the determination of extractable TPH as diesel range organics (C_{10} – C_{28}).
- Hexane may be used as an extraction solvent.
- *Silica Gel Treatment (SGT) may be used in the determination of Total Recoverable Petroleum Hydrocarbons.

NOTE: The sample preparation method and any modification(s) to a certified method must be reported by the laboratory.

Final Advice

Be sure to check with your DERR project manager or your environmental consultant if you have any questions regarding your sampling program or corrective action plan requirements. Some suggestions or ideas to consider when developing your sampling, operation or maintenance plan may include:

- Take both types of samples (e.g., soil and groundwater) if groundwater was encountered during the course of soil sampling.
- Take two or more soil samples in selected locations to better define the vertical extent of contamination. This data will aid in clean-up or closure evaluations.
- Conduct continuous sampling of soil boring(s) or collect multiple samples per location to better define the native soil type, contaminated interval or vertical profile, geological features and related items.
- Upgrade your analytical method(s) to get more complete information during the initial sampling events and minimize re-sampling events.
- Have enough budget set aside to be flexible in the number of actual samples submitted for laboratory analyses, or the number of soil borings or groundwater monitoring wells drilled, etc.
- Check with other regulatory agencies to ensure sampling meets with their requirements for waste disposal or other related items.
- Obtain any necessary off-site access agreements or highway easements for potential work outside your property boundaries in determining the extent and degree of subsurface soil and groundwater contamination.
- For vapor, air, or any other type of environmental sampling, determine the appropriate analytical method and sampling procedures <u>prior</u> to field collection.

Some suggestions to make your sampling more cost effective and to provide more information during the initial sampling event(s).

GUIDELINES FOR DISPOSITION AND TREATMENT OF PETROLEUM CONTAMINATED SOILS FROM UNDERGROUND STORAGE TANK SITES

Improper disposition and aeration of petroleum-contaminated soils from leaking underground storage tank (LUST) sites in close proximity to residential and environmentally sensitive areas could present a direct or potential threat to human health and the environment. This document represents advisory guidelines set by the Executive Secretary (UST) of the Utah Solid and Hazardous Wastes Control Board when soil management activities are proposed at any facility.

As outlined in Utah Admin. Code Section R311-204-2, the Executive Secretary reviews and approves closure plans, which include information concerning management of petroleum contaminated soils. If a closure plan (or corrective action plan for LUST sites) indicates that a specific form of soil management or disposal will be performed at a facility, the Executive Secretary will require additional information concerning this activity. Because of the potential for improper management of petroleum contaminated soils, the following information should be provided to the Executive Secretary (UST) for review*.

GENERAL SOIL MANAGEMENT GUIDELINES AND CONDITIONS FOR CONSIDERATION:

All underground storage tank owners/operators who are planning to close their tank systems should plan for the possibility that they will be generating contaminated soils during the removal process. Proper disposal of the soil should be arranged before beginning any removal activities to minimize the concerns discussed above. If aeration is not proposed as part of the closure plan, but later proposed following any activity which will probably generate contaminated soil, then the responsible party must immediately take the following actions upon the overexcavation or generation of the impacted soils:

- the contaminated soils should be placed on an impermeable liner (to minimize leaching of the contamination into the ground);
- the contaminated soils should be covered by an impermeable liner (to minimize both emissions of volatile hydrocarbons to the atmosphere, and to limit potential human contact); and,
- the site should be secured from the general public to minimize any potential exposure.

* *A staff member from the UST compliance section will assist you in meeting the UST closure requirements. If petroleum contaminated soils are reported or confirmed at the site, a project manager from the LUST section will be assigned to assist you. Contacting the appropriate person will save time and avoid confusion. If you have questions about what to do, call either section at (801) 536-4100.*

The proposed soil aeration plan is discussed in more detail below. The following items provide general considerations which must be satisfied or completed prior to submitting the proposal. If the following conditions at a site cannot be met, it is doubtful that approval for the actual aeration would be granted by the Executive Secretary (UST). If that is the case, and you cannot satisfy the following conditions, then you should start making arrangements for the proper disposal of the soil at an acceptable facility.

If you can meet the following conditions, and plan on submitting a proposal as discussed below, and if you have already generated any contaminated soil, it is important that any stockpiled soil should be properly managed pending either the aeration approval, or other final disposition of the soil.

- The owner/operator or responsible party of the underground storage tank system is responsible for notifying and obtaining approval from the Local Health Department, the Utah Division of Air Quality, and Local Fire Agency prior to any soil management or treatment activity. The Executive Secretary (UST) will require the documentation of these approvals from other agencies prior to considering granting final authorization of any soil treatment activity. In the event that the other agencies do not approve of the aeration plan, or, even if they have approved the plan, but the Executive Secretary (UST) does not approve of the proposed plan, then the owner will be required to dispose of the soil properly at an acceptable disposal facility. It should be noted that these guidelines <u>do not</u> preempt or supersede any other federal, state or local law, ordinance or jurisdiction.
- If the aeration plan is not approved by any of the agencies involved, including the Executive Secretary (UST), then proper disposal of the contaminated soil at an approved facility will need to occur within **30** days of the disapproval.
- Contaminated soils should not be placed in direct contact with groundwater/surface water or in an area which may impact groundwater/surface water. Soils should not be placed near structures, utility conduits, or other conduits (such as irrigation ditches, water wells, or surface/subsurface drainage systems) that may serve as pathways for migration of contamination.
- Contaminated soils should be placed on level ground, on an impermeable liner, cordoned off, and bermed to reduce the potential health risks and prevent runoff from leaving the site. Contaminated soils should be placed such that the environment cannot be affected or degraded.
- Contaminated soils should not be placed in close proximity to the general public. The placement of the soils must provide sufficient distance from nearby residences and buildings to prevent potential health risks or nuisance to surrounding populations. The area used for the treatment of the soils should be secured to prevent access by the general public. In addition, the contaminated soils should be covered by an impermeable liner (to minimize both emissions of volatile hydrocarbons to the atmosphere, and to limit potential human contact).

PROPOSAL FOR SOIL MANAGEMENT OR AERATION:

- The notification to the DERR must be in the form of a written underground storage tank closure plan, or leaking underground storage tank corrective action plan which is to be submitted for the Executive Secretary's review and approval, disapproval, or conditional approval. The proposal should give specific information about the following:

  - Verification of the approval from the other referenced regulatory agencies.
  - Documentation that the conditions discussed above have been satisfied.
  - The methodology or treatment technology to be used for the soil management activity.
  - The sampling plan to be used to monitor the progress of the soil treatment activities (e.g., frequency of sample collection, type of samples collected, analytical methods to be used, and certified samplers and laboratories to be used).
  - The proposed final disposition (or the final disposal location to be used) of the soil.
  - A vicinity map and site map providing a complete graphical description of the facility and the land surrounding the facility. The maps should be drawn to scale with proper orientation (showing a North arrow) and should be no larger than 11" x 17". The maps should provide the following information:
    - The facility address or location, with an appropriate scale (e.g., bar scale with 1 inch = 20 feet, etc.) and North arrow.
    - Underground utilities (e.g., water supply, sewer or septic systems, natural gas lines, storm drains, power lines, and telephone lines).
    - Property boundaries, on-site buildings, on- and off-site land use, and any adjacent buildings surrounding the property where the soil treatment will occur.
    - Location of soil stockpile(s) and proposed treatment area(s).
    - Land features surrounding the site including; lakes, rivers, streams, irrigation canals, wetlands, slope of land surface, irrigation, agricultural or other types of water wells, etc.

- The maximum volume and concentration of the contaminated soils to be treated should be indicated in the proposed plan. If the approved levels of volatile emissions are exceeded during the soil management activity, a revised plan must be submitted to the DERR for approval prior to treatment of the exceeded amounts.

IMPLEMENTATION OF THE APPROVED TREATMENT PLAN:

- Any deviation from the plan, which was approved by the Executive Secretary, should be submitted in written form and approved prior to implementation.
- Progress reports (in regards to their content and frequency of submittals) for the implemented soil treatment technology or plan are to be submitted to the DERR in accordance with the approval letter issued by the Executive Secretary.
- Once the soil treatment activities are completed, submit a proposal to conduct final confirmation sampling to verify meeting established cleanup levels. Upon meeting cleanup levels, document the same to the DERR by providing the required information as outlined in the approval letter (e.g., sampling, reporting, disposal and other related issues), and request a closure letter for the soil management area. If cleanup levels have not yet been met, additional treatment or work may be required prior to site closure.

¶490 Summary of API Publication 1628: A Guide to the Assessment and Remediation of Underground Petroleum Releases

by Peg Chandler, API Marketing Department*

Introduction

For many years, the American Petroleum Institute (API) has developed approaches to safeguarding against leaks and spills from underground storage tanks and has published a number of documents that summarize these recommendations, including API Recommended Practices (RPs) 1604, 1615, 1621, 1631, and 1632. The U.S. Environmental Protection Agency (EPA) cited these five RPs as appropriate standards and guidance documents in its UST regulations.

Recently, API revised another document, RP 1628, *A Guide to the Assessment and Remediation of Underground Petroleum Releases* (formerly the *Spill Cleanup Manual*). The revised RP 1628 provides an overview of proven methods to assess and remediate petroleum-contaminated soil and/or ground water. The following is a summary of the updated RP 1628.

RP 1628 is organized around the phases in which petroleum is commonly found in releases— that is, vapor phase; liquid phase, including residual hydrocarbon; and dissolved phase in ground water. The document discusses:

- Fundamental technical concepts, including earth material characteristics, subsurface water characteristics, properties of petroleum, and subsurface migration principles;
- Emergency response and initial abatement;
- Site assessments, including collecting background information, contaminant characterization, and exposure assessment;
- Site remediation, including liquid recovery, vapor treatment, and groundwater treatment; and
- Cleanup objectives.

Fundamental Technical Concepts

A basic knowledge of the subsurface environment is necessary to assess properly underground releases of petroleum. A quick discussion of the most basic concepts and definitions follows.

Earth Material Characteristics. In general, earth materials that may be contaminated by petroleum releases include unconsolidated sediments (loose earth materials that result from erosion of bedrock), soils, and fill (any material used to backfill excavated areas such as soil, sand, and pea gravel).

Two physical properties of earth materials that may affect fluid movement through the subsurface environment are porosity (the ratio of volume of void space to the total volume of material) and permeability (a measure of a material's ability to transmit fluid).

Subsurface Water Characteristics. The characteristics of subsurface water are also important. Before a petroleum release occurs, the voids of shallow earth materials are occupied with air and water. The distribution of air and water in the subsurface is important to understand (see Figure 2 for example of air and water distribution in the subsurface). The "unsaturated zone" is found immediately below the land surface; its pore spaces contain both water and air. The "saturated zone" underlies the unsaturated zone; its pore spaces are filled with water. The water table lies between the two zones. The term "ground water" denotes all water in the saturated zone.

Properties of Petroleum. Important properties of petroleum (hereafter referred to as "hydrocarbons") include its mobility in soil, which varies with the viscosity and density, and its solubility in water, which varies with the

---

* *This article is based upon* A Guide to the Assessment and Remediation of Underground Petroleum Releases, *API Publication 1628, Second Edition, August 1989. Cost is $16 nonmember/$14 member. All API Recommended Practices may be ordered from API Publications, 1220 L St. N.W., Washington, D.C. 20005, (202) 682-8375.*

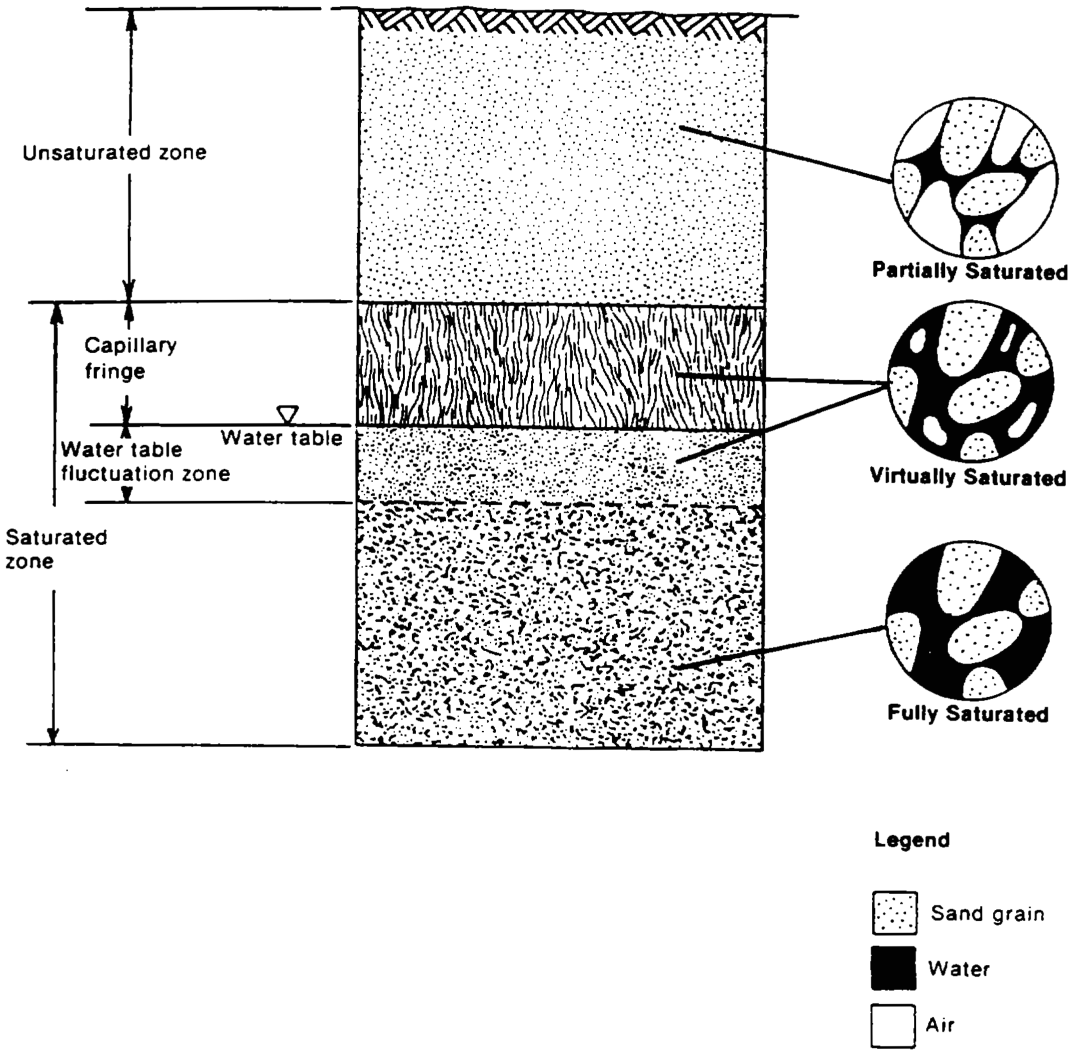


Figure 1 —Distribution of Water and Air in the Subsurface

chemical quality of water and the presence of additives in the gasoline itself. Gasoline movement in the subsurface is generally the same as water, but other hydrocarbon liquids (e.g., middle distillates and heavier fuel oils) move more slowly.

Subsurface Migration. Hydrocarbons can be present in the subsurface in the vapor phase, the liquid phase, and the dissolved phase. In the vapor phase, most vapor exists in void spaces in the unsaturated zone that are not already occupied by water or liquid hydrocarbons.

In the liquid phase, hydrocarbons move downward by force of gravity, and some horizontal spreading will also occur because of attractive forces between the liquid hydrocarbon and solid granular surfaces.

In the dissolved phase, soluble hydrocarbons are transferred to water until an equilibrium is achieved. Transport in the dissolved phase depends on ground-water velocity, adsorption of the hydrocarbon to soil particles, volatilization to the unsaturated zone, and biodegradation by bacteria. Figure 2 illustrates the vertical distribution and degrees of mobility of hydrocarbon phases in earth materials.

Health & Safety

CHAPTER 5
Site Safety

GENERAL SITE HEALTH AND SAFETY

Health and safety on a LUST site is of paramount importance for numerous reasons including:

- Prevents of work-related injuries, illnesses, and property damage.
- Prevents of exposure of the public to harmful substances.
- Increases overall productivity and maintains project schedules.

Petroleum products are toxic, carcinogenic and flammable. Therefore, these products should be handled with a great deal of care. Petroleum products can enter the body through the typical four routes of exposure:

- Inhalation
- Ingestion
- Injection
- Skin or eye absorption

Maintaining a safe work environment is essential whether the tasks be soil and groundwater sampling, UST removal, or remediation. All tasks need to be assessed in light of the degree of potential hazard and the possible routes of exposure. This hazard assessment should form the basis of the health and safety plan to be discussed later.

Whereas petroleum products may pose a significant health hazard due to chronic health effects, the general safety hazards associated with LUST sites frequently pose much greater risk of acute health effects.

HEALTH AND SAFETY REGULATIONS

It is important to realize that LUST work is covered by various regulations at the federal level, including the OSHA Hazardous Waste Site Operations and Emergency Response (HAZWOPER) Standard, 29 CFR 1910.120. The work may also be covered by various state and local regulations. These regulations may be triggered depending upon the degree of hazard posed, for example if the UST leaked and there is a significant exposure to airborne contaminants, respiratory protection may be required.

Exposure to airborne contaminants is covered by the OSHA Respiratory Protection Standard, 29 CFR 1910.134. If entry into a tank is required, or if the excavation is considered a confined space, the work may be covered by the OSHA Confined Space Entry Standard, 29 CFR 1910.146. Most standards require that the employer:

- Develop a written program to address the hazards in a general manner as part of an employer program, and also site-specific procedures.
- Conduct a hazard assessment to identify the site-specific hazards and then respond to them appropriately.
- Provide employee training.
- Provide appropriate personal protective equipment.
- Establish emergency response procedures.

CHAPTER 5
Site Safety

The employer should search the OSHA Web Page at: www.OSHA.gov for guidance on these and other subjects, including specific applicability of the requirements listed below.

SPECIFIC HEALTH AND SAFETY REQUIREMENTS

The following section describes how to reduce the hazards on a UST site. These are also issues that are covered as requirements under the OSHA HAZWOPER Standard, 29 CFR 1910.120.

Training

Employees can not be expected to perform site work properly if they are not properly trained. The HAZWOPER standard requires employers to provide 40 hours of hazard training at the time of initial assignment, 8 hours of refresher training annually, and a minimum of 3 days actual field experience under the direct supervision of a trained, experienced supervisor [29 CFR 1910.120 (e)(3) and (4)(i)]. This training must cover items such as:

- Components of the Standard
- Medical surveillance
- Hazard assessment
- Personal protective equipment
- Site control
- Site characterization
- Air quality monitoring
- Excavation and trenching
- Hazard communication
- Decontamination
- Drum handling
- Illumination
- Emergency response procedures

This training must then be supplemented by site-specific training at the time of assignment to a project. This is essential to provide employees with the actual hazards to be encountered and the exposure control strategies to be followed.

Although the content of the annual refresher training can vary, it should provide a meaningful update of the initial training. Items that might be included:

- OSHA news.
- The previous year's injuries and illnesses and steps taken to minimize recurrence.
- Changes in monitoring equipment.
- Review of hazard assessment.
- Addressing contractor issues.

Additional initial training is required for employees who may perform management or supervisory roles, or emergency response activities. The supervisory worker must attend a least 8 additional hours of specialized training at the time of job assignment. [29 CFR 1910.120(e)(4)]. Emergency response workers shall be trained in how to respond to expected emergencies [29 CFR 1910.120(e)(7)].

CHAPTER 5
Site Safety

Medical Surveillance

The HAZWOPER Standard requires that certain categories of employees receive physical examinations at a minimum of three milestones: at initial assignment, annually (unless an occupational physician working closely with the company believes that the physical examination could be performed every other year and still sufficiently monitor employee health status), and at termination. The physical examination must be at no cost to the employee.

Firms should work closely with an occupational physician that understands the firm's area of work and the hazards that employees are likely to face. The physical examination should then be tailored to address those exposures. If the firm's work involves potential silica exposure such as during drilling, then a chest X-ray should be included. Other items to be considered include spirometry for lung function, blood tests, urine screening, hearing testing, and perhaps drug and alcohol screening, as may be required by the US Department of Transportation. Other tests for "wellness" such as cholesterol may be also included by conscientious employers.

There are basically three determinations the physician may provide to the employer: pass, fail, or pass with limitations. As the responses imply, a “pass” response means that the employee may perform the work outlined by the employer to the physician without limitations on activity. A “fail” response indicates that the employee's condition does not allow him/her to perform the assigned duties. “Pass with limitation(s)” indicates that the physician believes that the employee's duties should be limited in some way. It is essential that the employer understand these limitations to be sure that the employee is not directed to overstep these limitations (or overstep them on his or her own). Other professionals such as safety or industrial hygienists may need to be involved in determining permissible activities. Of course, employee relations or human resources professionals may also need to be involved to ensure that the employee's rights are not compromised.

UST SITE HEALTH AND SAFETY PLAN

The HAZWOPER Standard requires employers working on sites with hazardous substances and wastes to develop site-specific health and safety plans (HASPs). The HASP is composed of various sections that outline the work and the address the associated hazards.

The following paragraphs briefly explain the sections of the HASP. An UST HASP should include a discussion of the following topics:

General Information

General Information should include the name and location of the facility, work plan objectives, and proposed date(s) of work. This section lists the names of all the main project participants. This is a most important reference page in times of emergency as well as during routine business.

CHAPTER 5
Site Safety

Planned Site Activities

A brief description of planned activities should be included in this section. The HASP should be revised if significant changes in these activities occur. In this section the general scope of work should be briefly described. This should explain the purpose of the work. The tasks to be performed during the work should be listed in the order in which they will occur. This section forms the basis of the hazard assessment. Next to each task, list the hazard and proposed means of avoiding the hazard. This section should be expanded if needed. Site workers should be aware of the possible dangers associated with drilling, excavation, free-product recovery, and groundwater sampling.

Contaminant Characteristics

List contaminants of concern, type of contaminant, physical and chemical properties, and the hazards it poses to human health and the environment. It is important to consider contaminants that might be emitted by facilities adjacent to the work site. Previous sampling media, *e.g.*, soil, groundwater, air, and the results should be noted.

Site Description

A site description should include the current and historical use of the site and surrounding area. In this section, issues adjacent to the work site should be described. Keep in mind that these aspects may not only be influenced by the work on the work site; they may also influence the work site. The sites that could be impacted by the work site include receptors, such as neighborhoods, schools, lakes, etc. Potential sources, such as adjacent factories or leaking tanks from other sites might impact the work site. These should not be overlooked because they may influence the ambient conditions being monitored on the work site.

Hazard Evaluation and Mitigation

This section should include a listing of known visible hazards, man-made or natural, and any unseen-but-suspected hazards. Site workers should be aware of the possible dangers associated with LNAPL recovery and groundwater sampling. All aspects of hazard mitigation pertinent to the site should be addressed. These may include fire and personal exposure to petroleum hydrocarbons or other organic vapors; heat and cold stress; noise; and heavy equipment use. As noted earlier, these hazards may pose the greatest hazards to workers on the site. They should be very carefully considered and precautions to be taken should be described. This section should be expanded as necessary. Also include fire suppression procedures.

Site Safety Work Plan

The site safety work plan should include a discussion of general safety, worker training, and medical surveillance requirements; and relevant documentation.

CHAPTER 5
Site Safety

Excavations and Trenching

Excavation and trenching are integral to much of the UST work. Excavations and trenches can pose confined space and fall hazards. Confined space and fall restraint procedures should be included. Shoring regulations must also be addressed to avoid collapsing of the sides. Shoring should be considered even when individuals will not enter the excavation. Depending upon the types of soils, sidewalls can collapse at distances of 5 to 10 feet or more from the edge of the excavation. Competent persons must design shoring plans and in some jurisdictions these plans must be approved and stamped by licensed Professional Engineers. The OSHA informational booklet entitled Excavations, OSHA Publication 2226, (2002), explains ways to protect workers from excavation hazards. The publication on excavations can be located on OSHA's website at: http://www.osha.gov/SLTC/trenchingexcavation/recognition.html.

Personal Protection Equipment

A listing and description of the personal level of protection required for each activity or work. The level and types of personal protective equipment (PPE) which will be used to address personal exposures must be described. This section should be specific with respect to makes and model numbers of PPE should be included in this section. A change in on-site conditions may also dictate a change in PPE.

Monitoring/Surveillance Equipment

This section should include a listing of all monitoring and surveillance equipment to be used at the site with a discussion of exposure and explosive concerns. This portion of the plan should explain how airborne contaminants will be monitored at the site. There are a number of aspects to be considered when developing the air monitoring plan. These include:

- Employee exposures within the work (exclusion) zone.
- Potential contaminants leaving the exclusion zone or site that could impact adjacent sites.
- Airborne contaminants that might enter the site from adjacent facilities.
- Note recognized exposure limits and action levels. Describe what will happen if either the action level or exposure limits are surpassed, *e.g.*, upgrade PPE, evacuate the site, notify regulators, etc.
- The types of instruments that will be used and their limitations.
- Confined space monitoring issues, if applicable.
- Note also the measurement of percent lower explosive limit (LEL) to avoid fire hazards.

CHAPTER 5
Site Safety

Decontamination

Personnel and equipment decontamination procedures should be addressed in this section. For site personnel, contamination-reduction phases and personal hygiene for site operations, cleanup operations, and soil/groundwater sampling operations would be needed. Decontamination procedures for equipment used during well installation, tank removal, and groundwater sampling should also be addressed. Equipment as well as personnel decontamination should be explained in detail in a stepwise fashion. Do not overlook equipment used to conduct air sampling, or clean-up activities. Note also presence of personal hygiene facilities.

Safety Equipment Checklist

This section should include a listing of all personal protection, monitoring and surveillance, and decontamination equipment to be used at the site. Any other miscellaneous equipment that may be needed and used on site should also be listed.

Site Safety Briefing Attendance Sheet

This section will document the personnel assigned to be on site and personnel from agencies, utilities, or other companies who have read, reviewed, or attended the on-site safety briefing. The sheet should include the date and time of the briefing and the individual conducting the meeting, and the name and company of each attendee. All subcontractors and clients involved in the operation should be included. It is helpful to obtain and include cellular phone numbers as well as traditional telephone numbers. Documentation of proper training and medical surveillance should also be obtained.

Investigation-Derived Waste Disposal

This section should discuss the disposal procedures for all drill cuttings, soil, wastewater, and disposable protective clothing generated during site operations. It would also be appropriate to describe the disposition of decontamination water and any other special concerns. This section must describe the types of waste expected to be generated from the site work, be they solid or liquid. Note the types of containers to be used. It would be appropriate to list the waste haulers and facilities to which the waste will be sent. Temporary staging areas and precautions can also be included in this section.

Emergency Information

Emergency information should include applicable phone numbers, names, and addresses of local and emergency resources; and emergency contacts including CHEMTREC, National Response Center, and RCRA Hotline. Any work limitations and required notification should also be discussed.

CHAPTER 5
Site Safety

Evacuation/Emergency Response Plan

This section should be clearly labeled to allow for quick reference in the event of an emergency. One should be very clear about how evacuation would take place. Written as well as pictorial directions must be included. These directions must be tested prior to starting the project to be sure they “work.” The locations of hospitals, shelters, and barriers to evacuation such as fences, security stops, one-way streets all should be shown and discussed in the HASP.

Attachments

The health and safety plan should include a map to the nearest medical facility. Forms and other relevant information should be attached to the HASP. This may include material safety data sheets (MSDSs), injury investigation, air and groundwater sampling forms, site audit checklists, site equipment checklists, daily safety meeting agenda and minutes forms, etc.

SAFETY MEETINGS

Several meetings should be planned to discuss safety. These need not necessarily be stand-alone meetings. These may be incorporated into other job meetings. In fact, this is encouraged so that workers see safety as an integral part of production and not something extra to be discussed if there is time. These meetings are described below:

Pre-Start-up Meeting

This meeting should be used to discuss all aspects of the project well in advance of the start. This allows time for details to be worked out and additional safety equipment to be obtained if necessary. Special attention should be given to working out the personnel who will be responsible for enforcing safety and attending to health and safety issues at the site. Note who will be contacted in the event of an emergency.

Start-up Meeting

This meeting, often held on the day the job starts or day before, discusses the final safety staff and contacts, describes the emergency response procedures, lays out the PPE, air monitoring and other relevant issues.

Daily Meetings

A safety meeting should be held at the beginning of every day the project continues. The scope of the day’s work should be described along with the associated hazards and safety precautions. This offers workers the opportunity to ask questions before proceeding with work.

Project Close-out Meeting

Projects that last several weeks should have a project close-out meeting to discuss issues that have occurred during the course of the job. This meeting gives participants the opportunity to discuss how to improve safety and general work performance on future jobs.

INCIDENT INVESTIGATION

All companies should have a program to avoid work-related injuries and illnesses. This program should include the writing of standard operating procedures and job safety analyses. These documents should be used as training tools to teach employees the hazards of doing work and how to avoid them. Employees should be encouraged by training to stop before they begin each task in the field and consider potential hazards and how to avoid them. Companies should investigate “near misses” with the same intensity as actual incidents because the next time the “near miss” might in fact be an incident. This approach tends to improve procedures and practices so that “near misses” are prevented. If all “near misses” were eliminated, then actual incidents would be all but avoided in their entirety.

In the event of an incident, whether property damage or personal injury, the investigation must focus on establishing the route cause of the incident. It should not focus on placing blame as this is usually an ineffective means of avoiding similar incidents in the future. Nearly all incidents occur as a result of insufficient training, tools, time management, motivation, or in rare situations.

United States
Environmental Protection
Agency

Solid Waste and
Emergency Response
(OS-420)WF

EPA/910/B-92/001
June 1992

EPA

Health and Safety Training for Underground Storage Tank Inspectors

Student's Guide

Printed on Recycled Paper

EXPLOSIONS

- Rapid chemical reactions producing large quantities of gas and heat
- Explosivity is expressed as percent by volume of material in air, with levels the same as for flammability (that is, LEL/UEL)
- Not always result of combustion; may occur when compressed vapors expand and burst a container

EXPLOSIONS

NOTES

Explosions are rapid chemical reactions that produce large quantities of gas and heat, a shock wave, and noise. **Explosivity** is expressed as a percentage of a given material in a volume of air. The lower explosivity limit (LEL) is the lowest concentration of a product that is explosive. The upper explosivity limit (UEL) is the highest concentration of a product that is explosive.

UEL and LEL, for all intents and purposes, are the same as UFL and LFL.

Generally, explosions can do serious harm much more rapidly than toxic exposure. Explosions and fires are the most immediate hazard during tank removal or closure activities, and when release investigation techniques are performed in a confined space.

Bear in mind that the difference between a fire and explosion is not a large one. It can simply be the speed of the reaction. Any material that can burn, if placed under sufficient heat, and confined as in a tank, can explode with tremendous force.

Explosions are not necessarily the result of combustion. In a closed container (such as an UST), flammable liquids expand when heated. Gasoline, for example, expands about 0.06 percent in volume for every 10°F increase in temperature. When the pressure inside the UST exceeds the designed pressure resistance, a "pressure release explosion" can occur.

NOTES

Although not directly related to standard petroleum products, **Boiling Liquid Expanding Vapor Explosions (BLEVEs)** are important due to their tremendous destructive force. BLEVEs occur when compressed gases, such as LPG, are stored as liquids at temperatures above their normal boiling points. If the vessel is exposed to a fire, the rapid buildup of pressure coupled with heat-induced weakening of the tank sides, results in a sudden and violent rupture, with the superheated liquid vaporizing and creating a fireball.

WORKING NEAR EXPLOSIVE VAPORS OR IGNITABLE LIQUIDS

- Use only explosion-proof cameras
- Remove flash camera batteries, or do not use
- Do not smoke or use matches or lighters
- Immediately change oil-saturated clothing

WORKING NEAR EXPLOSIVE VAPORS OR IGNITABLE LIQUIDS

NOTES

If an inspector discovers that vapors or liquids are present in a confined structure and a rapid assessment indicates the potential for an explosion or fire, the inspector should take general safety measures at once.

- All persons should be kept away from the danger area, except those properly trained and equipped.
- The local fire department should be alerted.
- A trained operator of a combustible gas indicator should determine the concentration of vapors present. Oxygen levels must also be monitored.
- Persons in the area should not smoke, start or use vehicles or equipment with internal combustion engines, or touch electrical switches or extension cords.
- Instruments used at UST sites must not contribute to the potential for an explosion or fire. Insurance and safety organizations have developed codes for testing electrical devices used in hazardous situations, and an electrical instrument certified for use in hazardous locations will indicate this. If an instrument does not have an approved rating, it should not be used in a hazardous or potentially hazardous situation.

PURGING

- Controls "fuel" point of fire triangle
- Replaces flammable vapors with air
- Reduces flammable vapors (<LEL)
- Assure procedure's effectiveness with monitoring equipment

PURGING

NOTES

Purging is an effective method for controlling the fuel point of the fire triangle. The goal of purging a tank is to reduce the flammable vapors in the tank well below the lower explosive limit. Purging or ventilating the tank dilutes the tank's flammable vapors with air, reducing the mixture of fuel and oxygen.

An eductor-type air mover, typically driven by compressed air, draws vapors out of the tank and forces fresh air into the tank. The fill (drop) tube should remain in place to ensure proper ventilation of the tank bottom. Discharge vapors should be dispersed 12 feet from the tank in order to ensure that flammable vapors are being vented effectively into the upper atmosphere.

Most petroleum products have a flammable range of 1 to 10 percent by volume in air, the amount of fuel vapor necessary to become flammable in the presence of oxygen and an ignition source. Below a fuel vapor level of 1 percent (the lower explosive limits or LEL), the mixture of fuel and oxygen is too small to support combustion.

<u>Purging should not be undertaken on hot, humid, or still days</u> because the still air will not disperse the flammable vapors. In order to maintain safe conditions, site work should be put off for a day.

<u>Purging is a temporary procedure.</u> Product trapped in bottom sludge and wall scale regenerates flammable vapors inside the tank. Therefore, when purging, lower the flammable

NOTES

concentration to 20 percent of the accepted LEL value of the mixture. The tank should be constantly monitored to ensure that LEL value does not exceed 20 percent.

Use a Combustible Gas Indicator (CGI) to measure the reduction in the concentration of flammable vapors during purging. Periodically test the percentage LEL inside the tank, in the excavation, and any other below grade areas.

CAUTION: In air purging, with plenty of oxygen present, the concentration of vapors in the tank begin in the flammable range, or may go from too rich through the flammable range before a safe concentration is achieved. It is especially important to ensure all ignition sources have been removed from the area before beginning this process.

INERTING

- Controls "oxygen" point of fire triangle
- Displaces oxygen with inert gas
- Reduces oxygen below the combustion level
- Common inerting materials: dry ice (CO_2) and compressed nitrogen
- Assure procedure's effectiveness with oxygen meter

INERTING

NOTES

Inerting controls the oxygen element of the fire triangle. Inerting reduces the concentration of oxygen needed to support combustion (below 12 to 14 percent oxygen by volume) by replacing the oxygen with an inert gas.

Common inerting materials include dry ice (CO_2) and compressed nitrogen. During the inerting process, gases should be introduced under low pressure in order to avoid producing static electricity. CO_2 is best applied in solid, dry ice form, rather than as a compressed gas.

It is important to recognize that the inert gas does not "neutralize" the flammable vapors in the tank; it simply displaces the oxygen. To measure the effectiveness of the inerting procedure, test the air inside the tank with an oxygen indicator. Eight percent or less oxygen by volume is a safe and acceptable level.

IGNITION SOURCES

- Static electricity
- Electrical appliances
- Open flame
- Smoking cigarettes
- Lightning
- Sparks

IGNITION SOURCES

NOTES

The Ignition Source is the easiest point of the fire triangle to control.

There are many possible sources of ignition during handling and transfer of petroleum products. These sources include static electricity, sparks generated by tools, monitoring equipment and engines in the area, lit cigarettes, or even electrical appliances and lightning. Any one of these ignition sources is enough to complete the fire triangle.

SPARK GENERATION

Sparks can be generated by:

- Static electricity
- Striking tank with a metal instrument (hammer, backhoe)
- Striking rock with metal during excavation
- Electrical instruments (camera, drill)

SPARK GENERATION

NOTES

Sparks can be generated at an UST site by static electricity, striking metal on metal, such as a hammer on the tank, or striking metal on rock, as when digging with a backhoe. Sparks are also created by the ignition of electrical or combustion engines and pumps, use of non-intrinsically safe monitoring instruments, and lightning. Precautions need to be taken to eliminate the possibility of these activities causing fire and explosions.

STATIC ELECTRICITY SOURCES

- Tank filling (by splashing and movement against piping surface)
- Settling of rust or sludge particles
- Motorized equipment
- Self-generation by humans
- Induction

STATIC ELECTRICITY SOURCES

NOTES

The primary manifestation of static electricity is the discharge or sparking of accumulated charges. Under the right conditions, these sparks can be the ignition source for a fire or explosion. Sparks can also be self-generated by humans or created through induction.

The static charge resulting from flowing liquids is of primary importance during the transfer of petroleum products. Static electricity is generated by the separation of like and unlike bodies. When liquid flows, charging occurs because absorbed ions are separated from free ions that are carried into the body of the liquid by turbulence. For example, static results from liquid dropping into a tank during product deliveries, liquid flowing through a hose when product is pumped from the tank, or compressed gas or air being released into the tank atmosphere.

During product transfer, static electricity can be generated by the flow of fuel through small holes into the tank. The movement of the fuel against the pipe also generates a static charge. Furthermore, static electricity can be generated by the settling of rust or sludge particles.

Motorized equipment used during tank installation, testing, and closure may generate static electricity. In order to minimize such risk personnel should ground all equipment during operation.

REDUCING STATIC ELECTRICITY AND SPARKING

Two effective methods

Bonding

- equalizes static electricity
- creates conductive connection between two entities (such as UST and tank truck)

Grounding

- diverts static electricity into earth
- eliminates static buildup

REDUCING STATIC ELECTRICITY AND SPARKING

NOTES

Bonding and **grounding** are effective methods to reduce the potential for electrostatic charge generation and sparking, and the subsequent chance of fires and explosions.

Bonding entails running a conductive line from one metal object to another. This equalizes static electricity by creating a conductive connection between two objects, reducing the likelihood of sparks jumping from metal to metal. Cargo tanks should be electrically bonded to the fill stem, piping, or steel loading rack. Also, all metal parts of the fill pipe assembly should form a continuous electrically conductive path downstream from the point of bond connection.

Bonding insures that individual components of a system do not build up charges. In essence, you slow down the charge buildup by distributing it over a bigger area. However, the entire bonded system will eventually build a significant charge. Bonded systems should also be grounded.

Grounding entails running a conductive line from a metal object to the ground. This will dissipate any charge on the outside surface of the tank by having it flow into the ground.

FIRE AND EXPLOSION POTENTIAL

Potential greatest when handling or transferring product

Installation/Upgrades	Explosion can occur during pressure testing
Release Investigation	Spilled product or vapors
Leak Detection Testing	Presence of leaking product or vapors
Installation of Monitoring Wells/Sampling	Drilling into buried utility lines

FIRE AND EXPLOSION POTENTIAL

NOTES

Assuming an UST is well-maintained, the greatest fire and explosive hazard occurs during the transfer of the product to or from storage and during the cleaning and removal of USTs.

Although petroleum products have been handled and transferred safely for decades, UST inspectors should not believe that this transfer is risk- and hazard-free.

The transfer of flammable and explosive products (liquids and vapors) may occur during tank testing or repair, tank upgrades, tank closure or removal, tank re-filling or corrective actions. UST inspectors should be aware of the risks associated with these activities.

Due to the danger of violent rupture, use extreme caution when performing pipe and tank testing during tank installation. Do not pressure-test any piping or tanks that contain flammable or combustible liquids. Do not exceed internal tank pressures of 5 pounds psig during pressure testing. Install a pressure relief valve at 6 pounds psig. Use a pressure gauge with a range of 10 to 15 psig, and test

FIRE AND EXPLOSION POTENTIAL (con.)

Closures and removals	Product or vapors present while draining tank If vapors removed, product may remain trapped in sludge Vapors can regenerate in inert or purged tank

both the inner and outer shells of double-wall tanks. Outer wall should be filled by bleeding off pressure from the inner tank. Do not pressurize directly. Avoid standing near endcaps of an UST. The endcaps are the most vulnerable to explosion.

Whether a tank is to be removed from the ground, or closed in place, product trapped in the sludge at the bottom of the tank, absorbed in the tank walls, or trapped under the scale is a continuous source of vapor regeneration. Cleaning the tank will decrease the amount of vapor regeneration.

To make it safe for handling, after the tank is purged or inerted the sludge can be washed to one end of the tank and pumped out while the tank is still in the excavation. If the scale is stubbornly caked on, the contractor may have to enter the tank for manual cleaning. Make sure appropriate safety procedures are followed (see Confined Space Entry in Section 3), and a continuous stream of fresh air is introduced into the tank. Make sure the contractor blocks the tank to prevent any movement. If tank sludge contains sufficient lead or other substances to be considered a hazardous waste, it must be handled and disposed of consistent with the Resource Conservation and Recovery Act (RCRA), Subtitle C requirements.

Tanks should be removed from the site as promptly as possible after purging or inerting procedures have been completed, preferably the same day. If the tank remains on-site overnight or longer, additional vapor may be

NOTES

regenerated from any liquid, sludge, or wall scale remaining in the tank. Regardless of when they are removed, tanks should be checked with an explosimeter to ensure that 20 percent of the lower explosivity limit (LEL) is not exceeded.

If a leak has occurred, contaminated soil and free product will also generate vapors outside of the tank. An explosimeter should be used to check explosive levels in the excavation as well as in the tank itself.

Exhibit 2-1 provides examples of actual accidents that have occurred during the handling and transfer of petroleum products.

EXPOSURE ROUTES

- Inhalation
- Skin Absorption
- Ingestion

EXPOSURE ROUTES

NOTES

There are a number of general symptoms which result from toxic exposure to most of the compounds found at petroleum UST sites. These symptoms include irritation of the eyes, mucous membrane and respiratory tract as well as depression or excitation of the central nervous system.

Petroleum products generally enter the body through inhalation of vapors, absorption (skin or eye contact), or ingestion. Of these three routes, inhalation is the quickest and most efficient route into the body. <u>The adverse affects of inhalation of toxins can be almost instantaneous because the lungs quickly transfer the toxin into the bloodstream.</u> The toxic effect will be proportional to the concentration of the toxin, its toxicity, and the individual's sensitivity to the toxin.

The symptoms of **inhalation** can be vague. Headaches, nausea, dizziness, insomnia, and tremors should not be overlooked.

Exposure via **ingestion** of contaminated water is generally limited, as petroleum in water can be detected by most people in levels as low as 1 ppm.

Visual and olfactory clues as well as site safety screening instruments should be used to assess exposure hazards. Visual cues include seeing stained soils, vapors, or iridescence in water.

Vapors from petroleum products can be smelled when they are at levels far below those considered toxic to humans. <u>However, UST inspectors should not rely solely on their senses to detect toxic levels of vapors,</u>

NOTES

particularly since noses become desensitized to some odors after prolonged exposure. Olfactory sensitivity also decreases with age.

Table 2-8 summarizes the various types of petroleum products and their exposure potentials, exposure target organs and acute and chronic symptoms. Each of these areas is discussed in detail throughout this section.

TYPES OF EXPOSURE

Acute exposure

- short-term, high-level exposure
- effects are usually immediate

Chronic exposure

- long-term, low-level exposure
- effects may take years to appear

TYPES OF EXPOSURE

NOTES

An inspector can face either chronic or acute exposure at a site. **Chronic** is defined as long-term, low-level exposure, while **acute** is defined as short-term, high-level exposure. Both are dangerous and have immediate and long-term health implications. UST-associated work can also expose workers to multiple chemicals which may have **synergistic** effects. This means that the effect of two chemicals together may be greater than the sum of their separate effects. All exposures should be kept as low as reasonably achievable.

Many materials stored in USTs are very common, and many have very low acute toxicity. However, the exposures of the UST inspector are more frequent, of longer duration, and higher than those of the average person. It is this repeated, low-level exposure that is so dangerous, as effects may not be seen for many years. Avoiding unnecessary exposure now can help you enjoy your later years, instead of combatting a chronic illness.

Most exposure can be eliminated if common clues, such as strong odors and instrument readings, are heeded.

TOXICITY OF GASOLINE CONSTITUENTS

Aromatics and alkanes may be responsible for most adverse health effects

- carcinogenic properties are attributed to aromatic fractions, particularly benzene (4 to 10 percent of gasoline)
- other aromatics of concern are ethylbenzene, xylene, toluene, and naphthalene
- alkanes have relatively low toxicity
- some alkanes are associated with central nervous system depression, kidney damage (n-hexane and octane)

TOXICITY OF GASOLINE CONSTITUENTS

NOTES

All petroleum products share the characteristic of causing central nervous system depression. The early symptoms of acute over-exposure can include dizziness, drowsiness, impaired coordination, nausea, euphoria, convulsions, coma, and death, in high enough doses.

The primary route of exposure for these products is **inhalation**. If the products are ingested, do not induce vomiting, since the product may be aspirated into the lung easily. Activated charcoal, followed by "stomach pumping," is the preferred treatment.

Skin contact is not typically an immediate hazard. Prolonged contact will cause burning and blistering. Repeated exposures to skin will result in defatting and possible dermatitis.

ALKANES

Hexane may be the most toxic member of the alkanes. It comprises 11 to 13 percent of gasoline by weight. **Acute exposure** to hexane occurs primarily through inhalation. Vertigo, headaches and nausea are the first symptoms of exposure to be noticed. At high concentrations, central nervous system (CNS) depression results in a narcosis-like state.

Pre-narcotic symptoms occur at vapor concentrations of 1,500 to 2,500 ppm as the central nervous system is depressed. Skin contact primarily causes fat removal and irritation. Hexane also irritates the eyes and mucous membranes with even a fairly short-term exposure, for example, 880 ppm for 15 minutes.

Chronic exposure to hexane vapors causes nerve damage. The first clinical sign of nerve damage is a feeling of numbness in the toes and fingers. Further exposure leads to increased numbness in the extremities and to loss of muscular stretching reflexes. Paralysis develops with varying degrees of impaired grasping and walking. In the most severe cases nerve conductivity is neutralized and cranial nerve involvement is also observed and may require several years to recover. In mild or moderate cases, recovery begins six to 12 months after exposure ceases.

Octane, if it is taken into the lungs, may cause rapid death due to cardiac arrest, respiratory paralysis, and asphyxia. It has a narcotic potency similar to heptane. Prolonged skin contact results in a blistering and burning effect.

TOXICITY: AROMATICS

Acute Exposure

- central nervous system effects
- may cause dermatitis, vertigo, headache, nausea, and vomiting

Chronic Exposure

- benzene is a carcinogen, linked to leukemia
- increased risk of kidney cancer and lymphoma
- nerve damage, possible paralysis

TOXICITY OF AROMATICS

NOTES

It is almost impossible to assign a fuel product's acute effects to any given component, since they all have similar actions. Worrying about air concentrations of specific components is not practical. We typically look at total organics.

Benzene is found at concentrations up to 4 percent by weight in gasoline. Older gasolines may contain as much as 13 to 15 percent benzene. **Acute exposure** will depress the central nervous system (CNS) and may cause acute narcotic reactions. The lowest observed threshold for acute exposures is 25 ppm. Headaches, lassitude, and dizziness may become increasingly evident at exposures between 50-250 ppm. Concentrations of 3,000 to 7,500 ppm may result in toxic signs within the hour. Depending on the concentrations and duration of exposure, these effects range from mild symptoms such as headaches and light-headedness to more severe effects such as convulsions, respiratory paralysis, and death. Skin absorption is not considered to be as important a route of entry as inhalation or ingestion because skin absorption is extremely low, with the highest absorption through the palm. Direct contact with the liquid may cause redness and dermatitis.

NOTES

Benzene is a known carcinogen. Chronic exposure to benzene has been linked to leukemia and irreversible chromosome damage. At the early stages, reversible leukemia, anemia, or a decrease in the blood platelet count may occur. Continued exposure leads to severe bone marrow damage, which results in a deficiency of all cellular elements of the blood. The direct, life-threatening consequence of this is an increased susceptibility to infection and hemorrhaging. The lowest air levels of benzene capable of producing these effects are in the range of 40 to 50 ppm. Effects of high exposure levels (>100 ppm) may persist for many years after exposure has been discontinued. The most important effect resulting from chronic benzene exposure is its hematotoxicity, the targets being the cells of the bone marrow. UST workers may be exposed to as much as 10 ppm in their everyday activities.

Toluene is found in concentrations of up to 4 to 7 percent in gasoline. The primary hazard of acute inhalation exposure is CNS depression. Reaction times will begin to be impaired after exposures of 20 minutes at 300 ppm. Toluene will also cause eye irritation, and prolonged or repeated skin contact may cause dermatitis. As concentrations increase, symptoms can include: muscular fatigue, confusion, tingling skin, euphoria, headache, dizziness, lacrimation, dilated pupils, eye irritation, nausea, insomnia, nervousness, and impaired reaction time. Occupational exposure to toluene has been linked to a higher reported incidence of menstrual disorders. Children born to these women may experience more frequent fetal asphyxia and be underweight.

Xylenes are found in concentrations of 6 to 8 percent in gasoline. Short-term inhalation exposures are associated with narcotic effects on the central nervous system, and high concentrations may lead to CNS depression. Both liquids and vapors are irritating to the skin, eyes, and mucous membranes. Skin absorption of xylenes occurs readily and xylenes can also be transferred across the placenta. Incomplete brain development has been reported in the fetuses

NOTES

of mothers exposed to xylene. **Chronic**, high-level human inhalation exposure results primarily in CNS effects, lack of coordination, nausea, vomiting, and abdominal pain. There are variable effects on the liver, kidneys, and gastro-intestinal tract. Chronic effects of xylenes resemble the acute effects but are more severe. They include headache, irritability, fatigue, digestive and sleep disorders, CNS excitation followed by depression, tremors, apprehension, impaired memory, weakness, vertigo, and anorexia. Xylenes are skin irritants and prolonged contact may cause formation of blisters.

Ethylbenzene is known to be toxic to the liver and kidneys. It will irritate the skin, eyes, and upper respiratory tract. Inhalation of small amounts may exacerbate the symptoms of obstructive airway diseases and cause extensive fluid buildup and hemorrhaging of lung tissue. Although a tolerance to the eye and respiratory effects may develop after a few minutes, CNS effects will usually begin at this stage, leading to CNS depression.

TOXICITY: GASOLINE ADDITIVES

- Tetramethyl and tetraethyl lead (TML and TEL)
- Ethylene dibromide (EDB) and ethylene dichloride (EDC)
- Tri-ortho-cresyl-phosphate (TOCP)

TOXICITY OF ADDITIVES

NOTES

Gasoline often contains substances that have been added to improve the fuel's performance properties. Gasoline additives of general concern for leaded gasolines are tetramethyl lead (TML) and tetraethyl lead (TEL), as well as ethylene dibromide (EDB) and ethylene dichloride (EDC). Both TML and TEL are used as anti-knock agents; EDB and EDC are used to prevent lead deposition. These compounds are present in low concentrations in gasoline (relative to benzene, toluene, and xylene), but they are quite toxic.

TML and TEL can be absorbed through the skin, ingested, or inhaled. TEL intoxication is caused by inhalation or absorption through the skin. Acute intoxication can occur through absorption of a sufficient quantity of TEL either through brief exposure at a very high rate (100 mg/m^3 for 1 hour) or for prolonged periods at lower concentrations. Exposure can cause acute intoxication, liver and thymus damage, and possibly death from a combination of depression of the central nervous system, respiratory irritation, and bronchiolar obstruction.

Most severe exposure to TEL and TML have resulted from sniffing gasoline. Some victims have shown the symptoms listed as well as fluid buildup in the brain, resulting in swelling and increased intracranial pressure.

NOTES

The signs and symptoms of exposure are often vague and easily missed. The onset of symptoms may even be delayed up to 8 days after exposure and include weakness, fatigue, headache, nausea, vomiting, diarrhea, anorexia, insomnia, and weight loss. Symptoms peculiar to TEL exposure are the sensation of hairs in the mouth and the feeling of insects crawling on the body.

As intoxication worsens, there is confusion, delirium, manic excitement, and catatonia. Nightmares, anxiety, and anorexia are also seen. Loss of consciousness and death may follow after several days. Severe intoxication causes recurrent or continuous episodes of disorientation and intense hyperactivity which may rapidly convert to convulsions that may terminate in coma or death. TEL is likely to have adverse effects on human reproduction and embryonic development.

GASOLINE ADDITIVES: ACUTE EXPOSURE

- Affects central nervous system
- Irritating to mucous membranes, eyes, and skin
- Severe respiratory tract irritation
- Vomiting, diarrhea, abdominal pain
- Delayed lung damage

GASOLINE ADDITIVES: ACUTE EXPOSURE

NOTES

Acute exposure to gasoline additives is a serious health threat. In general, brief exposure to additives (100 mg/m^3 for 1 hour) can cause acute intoxication and depress the central nervous system. Symptoms include insomnia, confusion, headaches, and tremors, and may be delayed for up to 8 days. Specifically, both EDB and EDC are highly toxic and identified as carcinogenic, although EDC has a much lower potency.

Acute exposure also causes vomiting, diarrhea, abdominal pain and, in some cases, lung damage. The vapor is irritating to the eyes and mucous membranes and may cause liver, kidney, and lung damage, including delayed pulmonary lesions. The liquid form is highly irritable to the skin, causing redness and blistering. Death has occurred following ingestion of 4.5 ml. Recent studies by NIOSH have shown adverse reproductive effects in men.

GASOLINE ADDITIVES: CHRONIC EXPOSURE

- Weight loss, anemia, emotional instability, and toxic psychosis
- Adverse effects on central nervous system, peripheral nerves, and vascular system
- Adverse effects on reproductive and embryonic development
- Liver and kidney damage.

GASOLINE ADDITIVES: CHRONIC EXPOSURE

NOTES

Chronic exposure to additives has equally serious health effects. In general, chronic human exposure is associated with adverse effects on the central nervous system, peripheral nerves, kidneys, and vascular system. Adverse effects are also likely on the human reproductive system and embryonic development.

Symptoms of chronic exposure include weight loss, anemia, emotional instability, and toxic psychosis. Recovery may take months to years, and 25 to 30 percent of cases never recover.

TOXICITY: MIDDLE DISTILLATE FUELS

- Kerosene, aviation fuels, diesel fuels, and Fuel Oils Nos. 1 and 2
- Oral, dermal, and inhalation exposure
- Major systemic reaction: central nervous system depression
- Skin and mucous membrane irritation
- Constituents of concern: polyaromatic hydrocarbons (PAHs), cresols, phenols

TOXICITY OF MIDDLE DISTILLATES

NOTES

The **middle distillates** include kerosene, aviation fuels, diesel fuels, and Fuel Oil Nos. 1 and 2. They are referred to as the middle distillates because of the similarity in their degree of volatility during the distillation process. They can be taken into the body by ingestion, absorption, or inhalation.

Kerosene has the least amount of aromatic hydrocarbons of the middle distillate fuels, with benzenes, indanes, and naphthalenes being the major aromatic components. Kerosene and related hydrocarbons are irritating to the skin and mucous membranes, and skin absorption may be significant.

Jet and aviation fuels are mixtures of distillate hydrocarbons that vary in composition from those similar to motor gasoline to kerosene-based fuels used in commercial aircraft. Jet fuels contain additives such as anti-oxidants, metal deactivators, and de-icing agents.

Diesel fuels contain high amounts of naphthalenes, acenaphthalenes, phenanthrenes, and anthracenes. Dermal exposure to diesel oil is toxic to the kidneys.

Generally, No. 2 fuel oil (heating oil) contains a higher volume percentage of benzenes and naphthalenes compared to kerosene and diesel fuels.

NOTES

Polynuclear Aromatic Hydrocarbons (PAHs) are present in higher concentrations in middle distillate fuels than in gasoline, but less than in the residual fuels. Specific PAHs detected in the middle distillates include naphthalene, benzo(a)anthracene, and benzo(a)pyrene. Benzo(a)anthracene and benzo(a)pyrene are known to be very **carcinogenic** (cancer-causing). PAHs have been shown to cause cytotoxicity in rapidly proliferating cells throughout the body, apparently inhibiting DNA repair. Cytotoxicity causes changes in the cytoplasm of the cell. The vascular system, lymphoid system, and testes are frequently noted as targets of PAHs.

No information about the carcinogenicity of middle distillates in humans is available. However, several members of the middle distillate family, in particular Fuel Oil No. 2 and diesel, have been shown to be weak to moderate carcinogens in animals. **Teratogenic** compounds affect fetal development. No teratogenic effects have been observed in animal tests using kerosene, diesel fuel, and Fuel Oil No. 2.

The chief systemic reaction to the middle distillates is depression of the central nervous system. Effects of exposure are expected to resemble those of kerosene, that is, low oral, moderate dermal, and high inhalation hazard. Symptoms include irritation to the skin and mucous membranes as well as headaches and nausea.

MIDDLE DISTILLATE FUELS:
SYMPTOMS OF ACUTE EXPOSURE

- Headache, nausea, mental confusion
- Irritation of respiratory tract, skin, and mucous membranes
- Hemolytic anemia
- Cardiovascular disturbances

MIDDLE DISTILLATE FUELS: SYMPTOMS OF ACUTE EXPOSURE

Acute exposure to middle distillate fuels can lead to headaches, nausea, mental confusion, and irritation of the respiratory system. Further exposure can cause hemolytic anemia and cardiovascular disturbances; in some extreme cases, loss of consciousness can occur. The compounds in the middle distillate fuels that are most likely to be of toxicological concern are non-carcinogenic PAHs, such as naphthalene; the carcinogenic PAHs, benzo(a)-anthracene and benzo(a)-pyrene; and cresols and phenols.

Ingestion or inhalation of naphthalene produces nausea, vomiting and disorientation. It is irritating to the skin and eyes and may cause cataracts. Benzo(a)-anthracene and benzo(a)-pyrene have been detected in Fuel Oil No. 2 and have been classified as probable human carcinogens.

Cresols are highly irritating to the skin, mucous membranes and eyes. They can impair liver and kidney function and cause central nervous system and cardiovascular disturbances. Phenol is toxic to the liver and kidneys.

Several of the components of gasoline are also found in the middle distillate fuels. For example, toluene, xylenes, and ethylbenzene are found in the middle distillates, although in much lower concentrations than in gasoline. Octane on the other hand, is present at much higher concentrations in aviation fuels than in motor gasoline. Additionally, a number of other substances may be found in the middle fractions of petroleum derivatives. These are

NOTES

NOTES

not covered in this course due to their numbers and complexity. These include components of jet fuel as well as jet and diesel fuel additives, such as Dodecane, Methylcyclopentane, N,N-Dimethylformamide, Manganese Compounds, peroxides, and Alkyl Nitrate and Nitrate/Nitro and Nitroso compounds.

MIDDLE DISTILLATE FUELS:
IMPACTS OF CHRONIC EXPOSURE

- Neurological effects
- Bronchopneumonia
- Toxic to liver and kidneys
- Toxic to vascular and lymphoid systems, and testes
- Probable human carcinogens

MIDDLE DISTILLATE FUELS: IMPACTS OF CHRONIC EXPOSURE

Chronic exposure to middle distillate fuels causes neurological effects. One study of aircraft workers consistently exposed to aviation fuel found that a majority experienced recurrent symptoms such as dizziness, headaches, and nausea. Feelings of suffocation, coughs, and palpitations were also prevalent. Inhalation of high concentrations of these vapors can lead to an acute and often fatal bronchopneumonia.

NOTES

TOXICITY: RESIDUAL FUEL OILS

Fuel Oil Nos. 4, 5, and 6

Cracked bunker fuel and catalytically cracked clarified oil:

- both carcinogenic in animals
- cracked clarified oil is one of the most carcinogenic materials in petroleum refining

Contain higher concentration of polyaromatic hydrocarbons (PAH) than middle distillates, gasolines

TOXICITY OF RESIDUAL FUEL OILS

Fuel Oils Nos. 4, 5, and 6 are commonly referred to as the residual fuels. They are very viscous and have low water solubilities.

Residual fuels are blends of predominately high molecular weight compounds and tend to have a higher concentration of PAHs than gasoline and middle distillates. These fuels often contain blending agents including cracked bunker fuel and catalytically cracked clarified oil. Both of these blending agents have been classified as animal carcinogens. Catalytically cracked clarified oil is recognized as one of the most carcinogenic materials in a petroleum refinery. Acute oral effects of exposure to Fuel Oil No. 6 in animals include lethargy, congestion of liver and kidneys, and intestinal irritation. The heavy metals arsenic, lead, and zinc have been detected in samples of Fuel Oil Nos. 4 and 6.

NOTES

TOXICITY: USED OILS

- Composition varies: may include lead, chromium, cadmium, chlorinated solvents
- PCBs detected in 18 percent of analyses
- Automotive used oils: higher concentrations of heavy metals
- Industrial used oils: higher concentration of chlorinated solvents and PCBs
- No difference in concentration of aromatic solvents or PAHs

TOXICITY OF USED OILS

Used oils are the byproduct of using oil as a lubricant. Through this use, the oils pick up a number of substances, such as lead, chromium, cadmium, and chlorinated solvents which are hazardous to human health. Analysis also indicates that PCBs contaminate 18 percent of used oils.

Automotive used oils tend to have a higher concentration of heavy metals, while industrial used oils tend to have a higher concentration of chlorinated solvents and PCBs.

No differences in the concentration of aromatic solvents or PAHs were found.

NOTES

TOXICITY: USED OILS (con.)

NOTES

Heavy metals typically found in used oil include:

• Lead	
Pre-1980 stock up	20,000 ppm
1980s stock 100	1,200 ppm
• Barium	50 to 500 ppm (4,000 ppm)
• Cadmium	2 to 10 ppm
• Chromium	3 to 30 ppm
• Arsenic	5 to 25 ppm
• Zinc	100 to 1,220 ppm

Other contaminants include:

• Toluene and xylene	500 to 10,000 ppm
• Benzene	100 to 300 ppm
• Benzo(a)pyrene and benzo(a)anthracene	50 to 1,000 ppm
• Naphthalene	100 to 1,400 ppm

Chlorinated solvents commonly detected in used oil include:

• Dichlorodifluoromethane	<1 to 2,200 ppm
• Trichlorotrifluoroethane	<20 to 550,000 ppm
• 1,1,1-Trichloroethane	<1 to 110,000 ppm
• Trichloroethylene <1 to 40,000 ppm	
• Tetrachloroethylene	<1 to 32,000 ppm

Table 2-3
SUMMARY OF TOXILOGICAL EFFECTS

	Exposure Potential	Exposure Pathway	Target Organs	Symptoms:	
				Acute	Chronic
Motor Gasoline	54.5% of U.S. Petroleum Market	Ingestion Inhalation Absorption	Lungs, Intestinal organs, Kidneys	Low Exposure; drowsiness, vertigo, vomiting. High Exposure: Unconsciousness, hemorrhaging of lungs and intestines, death	Kidney Damage Probable human carcinogen
Middle Distillate Fuels	32.7% of U.S. Petroleum Market	Ingestion Inhalation Absorption	Central Nervous System, Mucous membranes, skin, eyes, liver kidneys	Headache, nausea, mental confusion, irritation of respiratory tract, skin and mucous membranes. Hemolytic anemia, cardiovascular disturbances	Neurological effects, broncho-pneumonia, toxic effect in cells, hemotopoitic system, lymphoid system, and testes. Probable human carcinogen
Residual Oil Fuels	11.7% of U.S. Petroleum Market	Ingestion Inhalation Absorption	Liver, Kidneys, intestines	Oral effects of No. 6 fuel oil in animals include lethargy, congestion of liver and kidneys, and intestinal irritation.	N/A
Constituents: AROMATICS-Benzene	4% of Gasoline (by weight)	Ingestion Inhalation Absorption	Central nervous system, skin, kidneys, bone marrow	Low Exposure: dermatitis, headache, light headedness. High Exposure: dizziness, nausea, vomiting, convulsions, respiratory paralysis, death	Benzene is a known human carcinogen. Anemia, leukemia, and decrease in blood packet count. Severe bone marrow damage resulting in deficiency of all cellular elements of the blood, increased susceptibility to infection and hemorrhagic conditions. Irreversible chromosome damage
Toluene	4-7% of Gasoline (by weight)	Ingestion Inhalation Absorption	Central nervous system, eyes, skin	Muscular fatigue, confusion, tingling skin, euphoria, headache, dizziness, lacrimination, dilated pupils, eye irritation, nausea, insomnia, nervousness, impaired reaction time	Dermititus Higher reported incidence of menstrual disorders, low birthweight and fetal asphyxia. Incomplete fetal brain development due to placental transfer.

Table 2-3 (con.)
SUMMARY OF TOXILOGICAL EFFECTS

	Exposure Potential	Exposure Pathway	Target Organs	Symptoms:	
				Acute	Chronic
Xylenes	6-8% of Gasoline (by weight)	Ingestion Inhalation Absorption Placental transfer	Central nervous system, skin, liver, kidneys, gastrointestinal tract, eyes, nose, throat, mucous membranes, placenta	Narcotic effects on the central nervous system, CNS depression at high concentration Irritation of the skin, eyes, nose, throat, and mucous membranes Impaired reaction time, manual coordination, and body balance Nausea, vomiting, abdominal pain, loss of appetite Placental transfer has resulted in incomplete fetal brain development	Central nervous system excitation followed by depression, tremors, apprehension, irritability, impaired memory, incoordination, fatigue, dizziness, headache, anorexia, sleep disorders Variable effects on liver and kidneys, irritant effects on gastrointestinal trace, abdominal pain, nausea, digestive disorders Prolonged skin contact may cause formation of vesicles
Ethylbenzene		Ingestion Inhalation Absorption	Liver, kidney, skin, eyes, upper respiratory tract, lung tissue, and central nervous system	Irritates the skin, eyes, and upper respiratory tract Inhalation of small amounts causes extensive edema and hemorrhage of lung tissues Skin contact may yield inflamation Eye irritation and lacrimation are immediate and severe at 2000 ppm, accompanied by moderate nasal irritation -- tolerance develops after several minutes; CNS effects begin at roughly six minutes At 5000 ppm irritation to eyes, nose and throat is intolerable	Known to be toxic to liver and kidneys Depresses central nervous system Irritation and damage to lung tissue may exacerbate the systems of other obstructive airway diseases
Trimethylbenzenes	NA	Ingestion Inhalation Absorption	Central nervous system, lungs, blood	Nervousness, tension, anxiety, asthmatic bronchitis, hypochromic anemia, and impacts on blood coagulation	Unknown

Table 2-3 (con.)
SUMMARY OF TOXILOGICAL EFFECTS

	Exposure Potential	Exposure Pathway	Target Organs	Symptoms: Acute	Symptoms: Chronic
ALKANES & ALKENES - Hexane	11-13% of gasoline (by weight)	Ingestion Inhalation Absorption	Central nervous system, skin, eyes, mucous membrances, (kidneys?)	Initially dizziness, headaches, nausea Pre-narcotic symptoms occur at vapor concentrations of 1500 to 2500 ppm CNS depression yields a narcosis-like state at high concentrations Skin, eye, and mucous membrane irritation observed at fairly 880 ppm for 15 minutes	Nerve damage, initially as numbness in the extremeties, increasing to loss of muscular stretching reflexes, eventual paralysis in varying degrees, with neutralized nerve conductivity and cranial nerve involvement in most severe cases Recovery begins 6-12 months after exposure ceases in mild/moderate cases; severe cases may require several years to recover
Octane		Ingestion Inhalation Absorption	Central nervous system, lungs, respiratory system, skin	Direct aspiration into the lungs may cause rapid death due to cardiac arrest, respiratory paralysis, and asphyxia Narcotic potency similar to heptane	Although narcotic effects can be expected from octane exposure, the CNS effects observed with heptane are not found with octane Prolonged dermal exposure results in blistering and burning effects
Isopentane	NA	Ingestion Inhalation Absorption	Central nervous system skin, eyes	Exhilaration, dizziness, headache, nausea, confusion, inability to do fine work, persistent taste of gasoline, loss of consciousness in extreme cases Inhalation of up to 500 ppm appears to have no effect in humans, higher concentrations cause irritation to skin and eyes	Repeated or prolonged skin contact will dry and defat skin resulting in irritation and dermatitus

Table 2-3 (con.)
SUMMARY OF TOXILOGICAL EFFECTS

	Exposure Potential	Exposure Pathway	Target Organs	Symptoms:	
				Acute	Chronic
ADDITIVES - Tetraethyl & Tetramethyl Lead		Ingestion Inhalation Absorption	Central nervous system, peripheral nerves, liver, kidney, thymus, human reproductive system, and hematopoietic system	Weakness, fatigue, headache, apllor, tremors, nausea, vomiting, diarrhea, anorexia, weight loss, insomnia, irritability, delirium Peculiar sensation of hair in the mouth, feeling of insects on skin Progressive vegetative disturbances: hypotonia, hypothermia, and bradycardia Higher intoxication: confusion, delirium, manic excitement, and catatonia	Loss of consciousness and death may follow after several days Severe intoxication: recurrent or continuous episodes of disorientation and intensive hyperactivity, rapidly coverting to convulsions, terminating in coma or death Death may occur from a combination of CNS depression, respiratory irritation, and bronchiolar obstruction TEL is likely to adversely affect human reproduction and embryonic development
Ethylene Dibromide & Ethylene Dichloride		Ingestion Inhalation Absorption	Central nervous system, liver, kidneys, lungs, eyes, mucous membranes, skin, human reproductive system	Inhalation exposure causes vomiting, diarrhea, abdominal pain, delayed lung damage and CNS depression Vapor is irritating to eyes and mucous membranes Liquid forms are highly irritating to skin resulting in marked erythema and vesiculation Ingestion has led to death Exposure may result in lung, liver, and kidney damage	EDB and EDC are highly toxic Both EDB and EDC are identified as carcinogens, although EDC has a much lower potency Exposure causes liver and kidney damage and often results in delayed pulmonary lesions Recent studies by NIOSH have shown adverse male reproductive effects
Tri-ortho-cresyl Phosphate (TOCP)		Ingestion Inhalation Absorption	Spinal cord, peripheral nervous system	Nausea, vomiting, diarrhea, and abdominal pain	Acute symptoms followed by a latent period of 3 to 30 days of muscle soreness, numbness of ingers, calf muscles, and toes progressing to foot and wrist drop Recovery may take months to years; 20-25% of cases never recover

TYPES OF SAMPLE COLLECTION

- Saturated/unsaturated surface or subsurface soil
- Ground or surface water
- Free product
- In-tank samples

Degree of hazard depends on degree of contamination, age, and type of product

TYPES OF SAMPLE COLLECTION

NOTES

All three types of sample collection–soil, water, and product–have some inherent potential hazards. This section addresses the hazards associated with sample collection and focuses primarily on situations where contamination is suspected. Professional judgment should be used when determining the appropriate protective clothing for the sampling you will conduct.

Samples may be taken from soil or water in the excavation area or even the tank itself. UST inspectors must plan for this activity and have not only the required sampling equipment (sample bottles and shipping containers, labels, and chain of custody forms), but also the required monitoring equipment and personal protective equipment available.

SOIL SAMPLING

- Involves subsurface sampling in vicinity and down-gradient of USTs
- Generally obtained by hand augering, drilling, or excavating
- Potential hazards include chemical exposure and physical injury (drilling)

SOIL SAMPLING

UST inspectors may routinely take soil samples via hand augering, any use of power drills or backhoes to collect samples will probably be confined to the contractors on-site.

While the chemical hazards of the three operations are basically the same, there is an increased hazard during drilling or excavation because of the larger amounts of subsurface materials brought up during these two procedures. During drilling or excavation operations, drilling personnel should conduct air monitoring using direct reading instruments including flame or photoionization detectors and CGI/O_2/H_2S meters. UST inspectors should stand upwind and at least 25 feet away from drilling or excavating operations and should use care when operating hand augers.

NOTES

SOIL SAMPLING: HAZARDS

Chemical exposure from vapors varies depending on soil type:

- wet, compact = vapors exposure
- dry, dusty = particulate exposure (PCBs, heavy metals)

Conduct continuous air monitoring and sample screening

SOIL SAMPLING HAZARDS

Based on the nature of the soils, the sample may be wet or dry, compact, sandy, or dusty. Unless the sample is dry and dusty, the major health and safety concern is toxic exposure due to inhalation of volatile vapors and direct contact. Dry and dusty samples provide an additional potential hazard for inhalation of particulates that may include PCBs, dioxins, heavy metals, and other materials. To insure accurate readings, samples should be immediately screened with direct reading instruments, visually examined to determine gross contamination as indicated by staining, then collected and preserved.

NOTES

SOIL SAMPLING: HAZARDS (con.)

Physical hazards associated with drilling and excavating:

- moving parts and equipment
- hot engine parts
- filing equipment (pipe stacks)
- flying projectiles
- breaking air compressor hoses, chains or ropes
- electricity hazards (overhead and buried lines)

NOTES

The **physical hazards** involved in soil sampling include moving parts in machinery; hot/burning engine parts; falling equipment, such as pipe stacks; flying metal; the breakage of air compressor hoses, ropes or chains; and electrical hazards from hanging or buried utility lines.

Safety guidelines for working around mechanical equipment and in excavations are described in the heavy equipment section presented earlier.

SOIL SAMPLING: MINIMUM PPE

- Hard hat
- Eye protection
- Steel toe/shank boots
- Cotton or treated Chem-Resist coveralls
- Surgical latex gloves
- Nitrile overgloves
- Respiratory protective equipment, if air monitoring indicates

SOIL SAMPLING: MINIMUM PPE

NOTES

Personal protective equipment (PPE) should always be used when taking soil samples. Appropriate PPE includes steel toe and shank boots as well as appropriate garments. Also, surgical latex gloves should be worn with nitrile overgloves. Hard hats and eye protection are mandatory. Respiratory equipment should also be worn if atmosphere monitoring equipment indicates that it is needed. More detailed information on PPE can be found in Section 3 of this manual.

Uncoated **tyveks** provide almost no protection against materials with a low surface tension, like petroleum products. They become soaked almost immediately. They also melt and burn. Tyvek is not recommended for use with petroleum products. **Nomex** is fire-resistant, but also expensive and subject to contamination. The best option is simply to use cotton or treated Chem-Resist coveralls.

WATER SAMPLING

Surface water sampling: Relatively hazard free, unless floating product exists

Ground-water sampling: Possible volatile organic exposure

- use respiratory protection when opening monitoring wells
- once open, check vapor levels with flame or photoionization detector and CGI/O_2 meter

WATER SAMPLING

NOTES

Surface water sampling is a relatively hazard-free operation unless petroleum product is found on the surface of the water. If this is the case, inhalation, direct contact, and fire/explosion hazards are possible. Appropriate caution, monitoring, and PPE are required.

Ground-water samples are usually taken through established monitoring wells, via bailers or pumps. With this activity, there is an increased likelihood of exposure to volatile compounds. For this reason, intrinsically safe pumps and respiratory equipment should be used when opening the wells. Once the well is open, check vapor levels with flame photoionization detectors and CGI/O_2 meters.

Experience at well sampling has shown two constants:

- Volatile and semi-volatile fractions of organic contaminants tend to accumulate in the well stems.
- These organics tend to escape the well stem as a vapor once the cap is removed, and subsequently decrease in concentration rapidly over time, usually reaching background concentrations within 30 minutes. In highly contaminated areas, the concentration may not decrease.

Based on the above, the following procedures for initial well opening should be used where the potential for ground water and/or subsurface soil contamination exists:

NOTES

1. Proceed with initial well opening in Level C respiratory protection. Standing upwind when opening a well with respirator equipment on hand is an effective approach as well. Do not hang your head over the well until it has vented, and has been checked with an organic vapor detector.

   Level C respiratory protection is not usually necessary because in reality a ground-water well that generates significant vapors in the breathing cone is unusual.

2. Wells should be screened with a flame or photoionization detector and CGI/O_2 meter. (Note that activities that disturb the water column may liberate volatiles not otherwise observable and as such, it may be desirable to "bounce" a bailer a few times).

3. If initial readings are of such magnitude to indicate a potential health hazard from a brief exposure period to monitoring personnel or to the adjacent community from the venting process, the wells should be immediately recapped and locked.

4. If positive results are obtained (but to a lessor extent than that described above), the well should be allowed to vent passively for approximately 15 to 30 minutes and monitored again.

5. If negative (that is, background) results are obtained, sampling activities can be initiated in Level D respiratory protection.

6. If positive results have not diminished in the allotted time frame, sampling should be conducted in a minimum of Level C protection.

7. Because the volatiles that are anticipated to be present at UST sites are restricted to petroleum fractions, action levels based on petroleum should be used.

FREE PRODUCT AND IN-TANK SAMPLING

- High potential for both chemical exposure and fire hazards
- Delegated to contractor with specialized training and experience, if possible
- Respiratory protection is recommended
- Avoid in-tank sampling unless no alternative
- Level B protection recommended for in-tank sampling

FREE PRODUCT AND IN-TANK SAMPLING

NOTES

Of all the sampling that may be conducted by an UST inspector, product sampling is the most hazardous and should be delegated to personnel specifically trained for the operation. It may be possible to forgo tank or free product sampling if the owner/operator is able to furnish full information on the contents of the tank.

Pure product presents both toxic contamination and fire hazards. Sampling of spilled or leaked source materials, that is, pure petroleum and petroleum products, presents similar hazards to contaminated media sampling except that both toxic and fire/explosive hazards are significantly increased due to the presence of pure, undiluted product. Extreme caution and the use of respiratory equipment is recommended.

Samples may be taken by surface sampling (ponding in depressions, floating on surface water, and so on), subsurface sampling (accumulations in excavations and ground water), and in-tank sampling. Although not as dangerous as sampling from inside a tank, continuous monitoring and Level C protection is recommended during free product sampling activities.

Think smart. It is not necessary to wade and wallow in contaminated soils or water to get a sample. Use remote sampling probes (otherwise known as "sticks") to obtain samples.

NOTES

Sampling operations involving extraction of product or sludge samples of unknown composition and concentrations from an UST presents toxic exposure hazards (including inhalation and direct contact) as well as those of fire/explosivity. To the extent feasible, UST inspectors should not be performing this type of sampling. Should no other alternative exist, UST inspectors must use the maximum level of protection as assurance against exposure to unknown hazards. Level B protection is therefore recommended for this type of operation.

There are very few good reasons for an UST inspector to enter a tank.

Sticks and poles are not affected by oxygen deficiency and toxic atmospheres, and they are expendable. Use them whenever possible.