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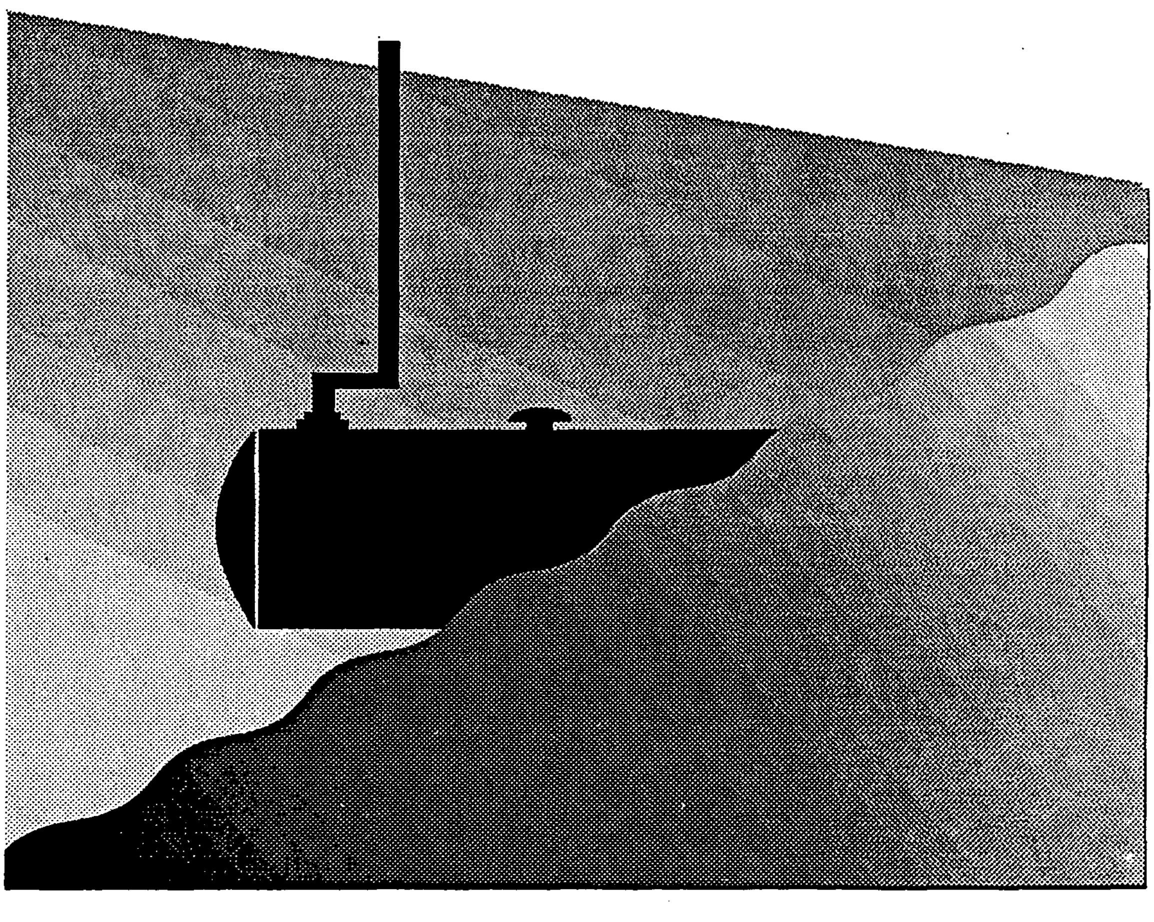
Petroleum Tank Releases Under Control

A Compendium Of Current Practices For State UST Inspectors



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A Compendium of Current Practices for State UST Inspectors

U.S. Environmental Protection Agency
Office of Underground Storage Tanks

June 1989

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Dana S. Tulis
Project Manager
June 1989

Table Of Contents

I. Purpose, Content, and Organization

II. Initial Response

III. Limited Site Investigation

Table Of Exhibits

I. Purpose, Content, and Organization

Purpose

Petroleum Tank Releases Under Control is intended to help States train inspectors of underground storage tanks (USTs); it also provides new and experienced inspectors with ways to evaluate options for controlling releases from leaking USTs. The document is flexible enough to be used by States regardless of their specific requirements, conditions, and practices.

The document is a compendium of general knowledge based on standard engineering practices; and, as such, it covers a wide range of activities. Remediating dissolved contamination in ground water is not addressed, however, because of the complexity of this topic and because of the ongoing work in this area.

As stated above, this document is a baseline of general knowledge. As developments and improvements evolve in the field, and as the Office of Underground Storage Tanks (OUST) continues to focus on specific project areas, this document will be updated.

Content

Chapter II contains descriptions of the first actions to take at a site with an UST that is leaking petroleum. In this document, we employ the commonly used phrase "initial response" to describe these activities. During this stage of the cleanup, State UST inspectors may need to gather information about the site to help determine the cause of the leak or release. In addition, UST inspectors might oversee the activities necessary to stop the flow of free product, to ensure that fire and safety hazards have been mitigated, and to determine whether other response actions (such as vapor migration control) are needed. Inspectors may also oversee the responsible party's investigation to determine whether an alternative drinking water supply is needed.

Chapter III provides a list of the actions to take once the initial response is completed. We call this a "limited site investigation." It begins with selection of a scenario based on review of available information and anticipated contaminant migration. The three scenarios are: Scenario A, Minimal Soil Contamination; Scenario B, Extensive Soil Contamination; and, Scenario C, Groundwater Contamination. Depending on site-specific conditions, the activities in one or more of the scenarios may be applicable. For example, if groundwater contamination is discovered at the outset, Scenarios A and B serve as the basis for investigating the release before continuing on to Scenario C.

Organization

Because it is a training tool, Petroleum Tank Releases Under Control is designed primarily for office use; however, certain pages (e.g., checklists and worksheets) can be photocopied and used in the field during inspections.

A step-by-step approach is used to present information. Not every step is necessary for every situation and the sequence of steps may vary depending on site conditions. We encourage State inspectors to use their discretion in determining which steps to take at each site.

In addition, we've used symbols (small icons) to help readers locate information quickly, to highlight added details, and to identify specific field and evaluation tools. The following icons identify Chapters II and III respectively and are placed at the bottom of the corresponding chapter page.

Fire Truck Initial Response; Chapter II

Detective Limited Site Investigation; Chapter III

The remaining icons highlight added detail or identify specific field and evaluation tools. These symbols and their meanings are:

Stop Signs Detailed information for you to know when implementing a step.

Checklists Reminders and progress tracking sheets you can use for supplementing other documentation.

Worksheets Tools to help you evaluate individual release incidents.

In addition to this document, OUST has developed other source materials for corrective action and tank closure. Ordering information for these materials can be found in the References.

II. Initial Response

The descriptions of initial response steps included in this chapter will help inspectors evaluate the selection and implementation of measures, taken by the owners/operators or contractors, to clean up leaking petroleum underground storage tanks (USTs). These steps address the suggested approaches on how to:

- Gather basic information about the site;
- Identify, monitor, and mitigate fire and safety hazards;
- Identify the source and cause of the release;
- Stop the flow of free product;
- Initiate vapor control, collection, and treatment by using either passive or active control systems;
- Determine if public and private water supplies have been contaminated;
- Provide alternative drinking water supplies, if necessary;
- Initiate the collection of free product in basements/sewers and surface waters;
- Secure the site in order to discourage unauthorized entrance or vandalism; and
- Report all required information on site activities to the implementing agency.

The need for some, or all, of these steps is contingent upon the site-specific situation.

Site Information

Step 1 Has information on site history, tank usage, and impacts of the release been compiled by an inspector or contractor?

In order for inspectors to begin evaluating a release situation, it is important to gather basic information about the site. Inspectors should try to answer the following types of questions concerning initial response to a release: Where is the release located? Who reported it? What appears to have taken place at the site? (Worksheets 1 and 2, in the Worksheet section, have been provided to assist with the gathering of this information.)

This initial information provides the foundation of an inspector's understanding and assumptions about a site. Therefore, it will be important to check these early assumptions (e.g., regarding potential sources and direction of groundwater flow) as additional information is gathered throughout the project.

Fire and Safety Hazards

Step 2 Have fire and safety hazards been identified, monitored and mitigated?

If vapors or liquids are detected or suspected in a confined area, a quick assessment is necessary to determine the presence of fire and explosion hazards. This type of assessment is based on volatility of the spilled substances, approximate amount released, and amount of time elapsed since the release. If a fire and safety hazard exists, it is important to ensure that proper health and safety measures have been performed. Step 5 and Appendix A provide more details on vapor control.

During initial response, inspectors may need to verify that the following steps have been taken (some of these measures may need to be repeated or maintained over a period of time, depending on specific site conditions).

2.1 Has the local fire department and/or State been alerted?

2.2 Has an operator trained in the use of a combustible gas indicator and an oxygen indicator (e.g., from the State and/or local fire department) determined if vapors are present at the site outdoors and/or indoors? And if present, at what concentrations?

2.3 Have all persons been evacuated from the areas where unsafe hydrocarbon levels have been found or suspected (except for properly trained and equipped persons)?

2.4 If flammable vapors or liquids have been detected at levels dangerous to human health or property (e.g., near the lower explosivity limit), have the following steps been performed?

- Notification of appropriate State and local authorities and the facility owner/operator;
- Enforcement of security measures such as posting of notices to warn the public of potential danger;
- Elimination of ignition sources that may be present in vapor contaminated spaces (e.g., vapor-fired heaters, light switches, non-explosion-proof motors, and electrical items); and
- Ventilation of confined areas by opening windows and doors and by using an explosion-proof exhaust fan to dilute concentrations (this may need to be done prior to entering the area).

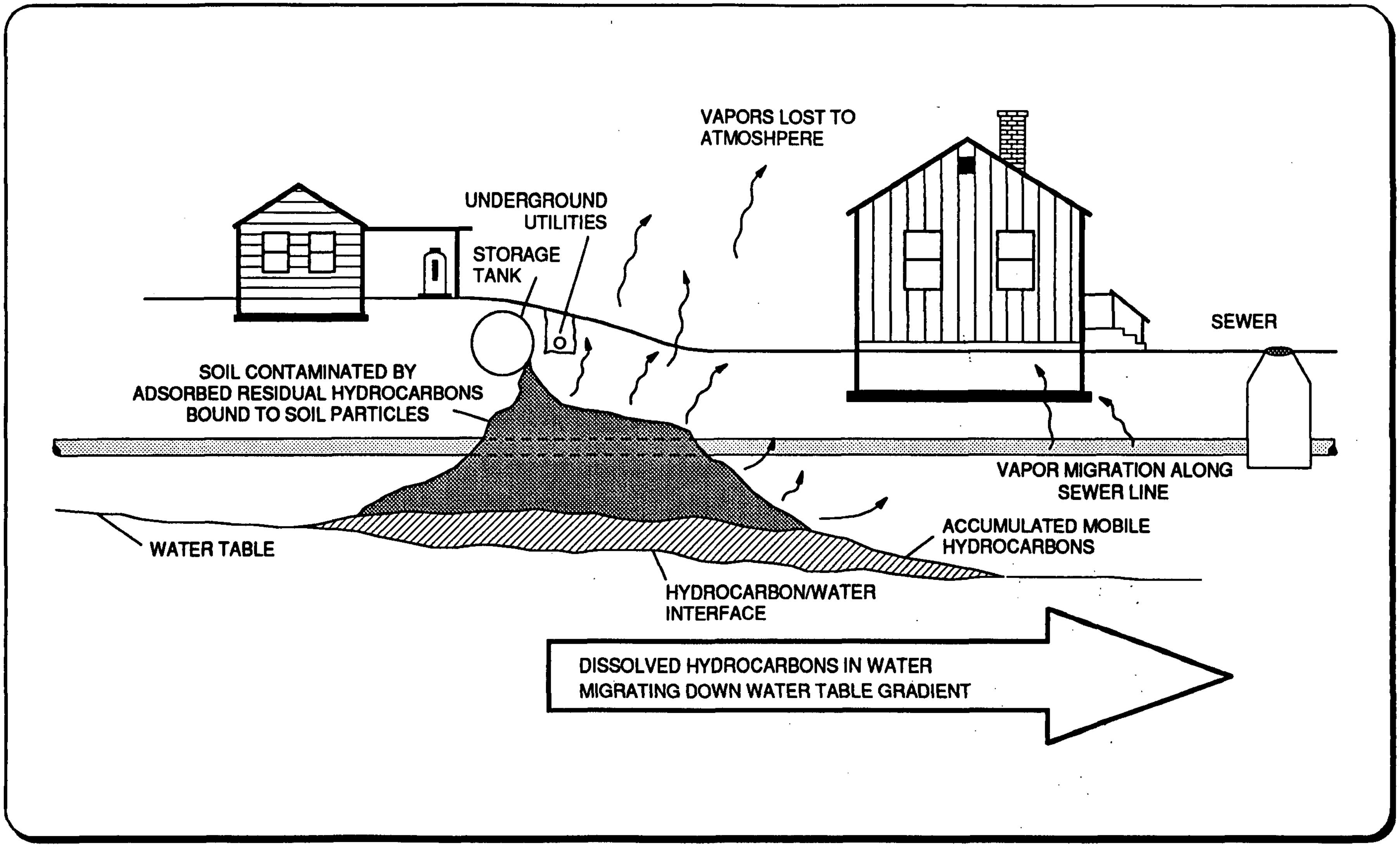
STOP

The following additional factors are important to consider when evaluating safety hazards:

- All gasoline vapors are heavier than air, therefore it is necessary to monitor air near the ground or foundation as well as in the breathing zone.
- Elevator shafts, telephone lines, electrical cables, subways, and sewers are common migration routes and collection points. (Exhibit 1 shows common migration pathways of a tank release.)
- In explosive situations, ignition sources may not always be obvious. Precautionary measures may need to be taken to prevent sparks and static, e.g., when starting cars or using metal objects.
- The selection and use of detection meters for hydrocarbon vapors should be based on their applicability to site-specific conditions. (See Exhibit 2 for descriptions of hydrocarbon vapor detection meters.) For example, explosimeters should be calibrated for the volatile compound of concern and are generally most effective when used with an oxygen indicator for determining high concentrations of contaminants and explosive conditions in confined spaces. A photoionization detector, on the other hand, is more suitable for identifying lower concentrations that are a concern because of the risk of long-term exposures.

EXHIBIT 1

Common Occurrences and Avenues of Hydrocarbon Migration Following a Leak



Source: Groundwater Technology Inc.

EXHIBIT 2

Hydrocarbon Vapor Detection Meters

Air Monitoring Meters (1)	Examples of Ranges of Detection (2)	Vapors in Soil	Danger of Fires and Explosions	Volatilization of Chemicals to Air	Vapors in Buildings	Vapors in Sewer Pipes	Vapors in Ambient Air	Approximate Cost	Limitations
Combustible Gas Indicator (CGI or Explosivity Meter) (3)	0-100% LEL (Response is relative to the calibration gas)		X	X	X	X		$500-$5,000	• Accuracy of reading depends on difference between calibration and ambient sampling temperatures, humidity, and atmospheric pressure • Calibration to methane and pentane may alter accuracy of readings of other substances • Certain chemicals (e.g., leaded gasoline) may damage the filament on "hot wire" models, reducing the sensitivity • Response is qualitative
Oxygen Indicator (3)	Indicates Oxygen Content 0-30% (variable)		X		X	X		(Often built into CGI)	• Does not detect fuel hydrocarbons • Accuracy affected by altitude and temperature. Instrument must be calibrated under condition of use
Flame Ionization Detector (FID) (4)	0.5-10,000 ppm approximate (Response is relative to the calibration gas)	X		X	X	X	X	$5,000-$7,500	• Does not detect inorganic gases or vapors • Requires identification of chemical before it can report its concentration • Can be affected by humidity and moisture • Qualitative data only
Photoionization Detector (PID) (4)	0-2,000 ppm approximate (Response is relative to the calibration gas)	X		X	X	X	X	$4,000-$5,000	• Does not detect methane • Presence of high concentrations of methane or humidity may alter reading drastically • Interference from power lines, water vapor, transformers, high voltage equipment, and radio wave transmissions may alter readings • Qualitative data only
Infrared	5 ppm-100%	X		X	X	X	X	$1,750-$9,000	• False positives may occur due to interference of other gases.
Colormetric Tube	Variable (e.g., 0.001-10,000 ppm, 0.1-10% by volume)	X	X	X	X	X	X	$2-5/tube	• Accuracy of readings subject to human error • Responses of different models of tubes may vary • Responses affected by humidity, temperature, other contaminants present, and age of tube
Portable Gas Chromatograph (can be equipped with PID or FID)	0.5-10,000 ppm (FID) 0.01-1,000 ppm (PID)	X		X	X	X	X	$7,000-$60,000	• Accuracy of results affected by ambient conditions when using some models • Reading is not direct • Portable units tend to be less accurate than lab-based GC • Lower detection limits can be obtained depending on manufacturer and detector

Notes:
(1) Meters are presented in order of typical usage at a site, e.g., explosive hazards must be identified first using the CGI.
(2) This information is provided for general reference purposes only. Ranges vary depending on the manufacturer and the specific detector. Refer to the detector's instructions and/or the manufacturer for additional discussion of instrument sensitivity.
(3) CGIs and O2 meters are frequently used in conjunction with each other.
(4) An example of a commonly used FID is the Century Systems Organic Vapor Analyzer (OVA). The HNU PI-101 meter is a commonly used PID.

Source: Adapted by ICF Inc.

Step 3 Have the source and cause of the release been satisfactorily identified?

A recent review of case studies from several States indicates that misidentification of the source of the release is a common problem leading to delays and costly cleanups. To avoid this error, an inspector should be aware that the nearest facility, tank, or line is not always the source. Therefore, it is important to review available information about the site and surrounding areas. The inspector may also want to visit the site as soon as possible to confirm initial assumptions.

3.1 Has information from the suspected facility, local and/or State officials, and from surrounding facilities been reviewed by the inspector or contractor (see Exhibit 3)?

Although a review of inventory records can be time-consuming, a quick review may be especially helpful in discovering large leaks or in determining which of several tanks is the most likely one to be leaking. See Exhibit 4 for an example of a tank inventory record. When reviewing inventory records and interpreting discrepancies, the following guidelines are helpful:

- If a facility owner/operator's daily stock readings, sales records, and/or delivery receipts are incomplete or missing, other investigative steps should be pursued.

- Daily records should be reconciled on a monthly basis. Looking at less than 30 days of information at a time can be highly misleading.

- Discrepancies in inventory data can be caused by several factors other than a leak. The most important of these are: 1) errors in delivery receipts, 2) temperature changes which cause the fuel to expand when heated or contract when cooled, creating the appearance of a leak, 3) errors in pump meter calibration, 4) product loss due to evaporation, and 5) theft. Each of these errors is more significant for larger tanks and larger sales volumes (throughput).

- Generally, a leak is suspected when monthly discrepancies exceed 1% of throughput plus 130 gallons. If a large discrepancy is found, the reconciliation should be reviewed for math errors and the calibration of pump meters should be checked. If these items are not found to be the source of the error, additional investigation of the tank with the discrepancy may be required.

EXHIBIT 3

Information to Help Identify the Source of the Release

The following items are examples of information that may be useful:

- Map or sketch of the area identifying operating and abandoned facilities with petroleum product storage
- Locations of active/inactive tanks in the area
- Records of past leaks on site
- Precision testing results
- Inventory and repair records
- Records of any water pump-outs from the tank(s)
- Observations by fire department and other local officials
- Information on past ownership and site uses (refer to old maps and atlases)
- Equipment installation and maintenance data
- Data from leak detection systems installed on suspicious tanks
- Well logs from on-site or nearby monitoring wells or water supply wells
- Boring logs from engineering studies
- Interviews with employees and neighbors

3.2 Has a site inspection been conducted to observe site conditions?

A site inspection may reveal information regarding:

- Evidence of leaks, spills or overfills (e.g., stained soils and irregular vegetation patterns);
- Tank locations upgradient and upstream of sewer or conduit flow;

EXHIBIT 4

Sample Tank Inventory Record

Tank ID #/Capacity #1 8,000 gal.
Product Unleaded
Month/Yr 10/88
Operator

Column 1	2	3	4	5	6	7	8	9	10	11	12
	Dipstick Inventory										
		Deliveries									
Day	Opening Dipstick Inventory (gallons)	Dipstick Inventory Before Del. (gallons)	Amount Delivered (gallons)	Dipstick Inventory After Del. (gallons)	Total (column 2) plus (column 4)	Closing Dipstick Inventory (inches)	Closing Dipstick Inventory (gallons)*	Gone From Tank (column 6) minus (column 8)	Meter Sales (gallons) (from sales report)	Column 10 less than (-) or greater than (+) column 9	Column 9 & 10. Subtract smaller from larger
1	3006				3006	33 1/2	2492	514	554	+	40
2	2492				2492	28 1/2	1994	498	513	+	15
3	1994				1994	24	1566	428	415	−	13
4	1566	1384	5988	7372	7554	78	6981	573	454	−	119
5	6981				6981	73	6546	435	512	+	77
6	6546				6546	67 1/2	6025	521	565	+	44
7	6025				6025	61	5376	649	687	+	38
8	5376				5376	55 1/2	4805	571	525	−	46
9	4805				4805	50 1/2	4276	529	461	−	68
10	4276				4276	47	3903	373	409	+	36
11	3903				3903	41	3268	635	485	−	150
12	3268				3268	38	2954	314	459	+	145
13	2954				2954	34 1/2	2542	412	390	−	22
14	2542	2441	4013	6454	6555	66	5879	676	657	−	19
15	5879				5879	61	5376	503	521	+	18
16	5376				5376	56 1/2	4910	466	477	+	10
17	4910				4910	51	4329	581	512	−	69
18	4329				4329	48 1/2	4064	265	339	+	74
19	4064				4064	44	3584	480	516	+	36
20	3584				3584	40	3163	421	421	−	−
21	3163				3163	34 1/2	2593	570	429	−	141
22	2593	2542	5038	7580	7631	80	7143	488	584	+	96
23	7143				7143	74	6636	507	522	+	15
24	6636				6636	70	6267	369	363	−	6
25	6267				6267	66 1/2	5928	339	373	+	34
26	5928				5928	61 1/2	5427	501	457	−	44
27	5427				5427	54	4647	780	507	−	273
28	4647				4647	52	4436	211	518	+	307
29	4436				4436	47 1/2	3957	479	471	−	8
30	3957				3957	42 1/2	3426	531	480	−	51
31	3426				3426	39	3058	368	473	+	105

WATER TEST	
Date	Inches Water
10-3	0
10-8	0
10-21	0

Total Gallons Over	1091
Total Gallons Short	969
Inventory Variance for Month (+ or -)	+121

* Charts converting dipstick readings (in inches) to gallons are specific for each type and size of tank. Consult the manufacturer for the appropriate chart if it is not already provided.

Source: ICF Inc.

- Evidence of other possible sources of contamination at surrounding facilities (see Exhibits 5 and 6);

- Recent excavation or signs that a tank or piping system has been repaired;

- Water in the underground tank; and

- Evidence of free product or dissolved constituents in samples from drinking water wells, observation wells (if available), collection sumps, or surface water.

STOP

Vapors and liquids from petroleum releases may not always be detectable in subsurface structures or in wells depending on the site-specific geology, hydrogeology, and recent weather conditions. For example, a gasoline spill in low permeability soil, such as clay, where depth to ground water exceeds 10 feet, may not appear for over a month. Rain can also sometimes mask the presence of contamination. As a result, it may be prudent to resample suspected locations on more than one occasion, i.e., after the aquifer system is expected to have returned to equilibrium. In general, the more permeable the soil, the more quickly it will return to relative equilibrium and yield representative data following precipitation.

3.3 If review of available information has failed to confirm the source, has a tightness test been performed on tanks and underground lines?

Due to the numerous types of tank tests available, it is necessary to evaluate a proposed test method based on its performance claim. It should be noted, however, that the accuracy of tank tests is variable and may be influenced by factors such as temperature, the elevation of the water table, tank shell deformation, product evaporation, tank and piping layout, wind vibration and noise, and operator error.

Product levels, for example, can fluctuate in a tank due to temperature disturbances that occur from opening the fill hole, the addition of product, and tank deformation. Therefore, it is important that there is an adequate waiting period to allow stabilization prior to starting a tank test. As a result of the variability, tank test results often cannot be considered to be conclusive and are best used in conjunction with the other available evidence such as historical records and available field data.

EXHIBIT 5

Types of Facilities with Petroleum USTs

The following facilities often store petroleum products on site:

- Service stations (existing, abandoned, or converted)
- Automobile dealerships and auto repair garages
- Municipal garages
- Fleet operators such as taxicab companies, bakeries, dairies, contractors, bus companies
- Industries, including refineries, terminals, and bulk plants
- Commercial operations (e.g., convenience stores, cleaning establishments), airports, schools, hospitals
- Abandoned oil and gas well sites
- Subsurface disposal systems (including drywells and deep injection wells)
- Machine shops
- Salvage yards

Stopping Free Product Flow

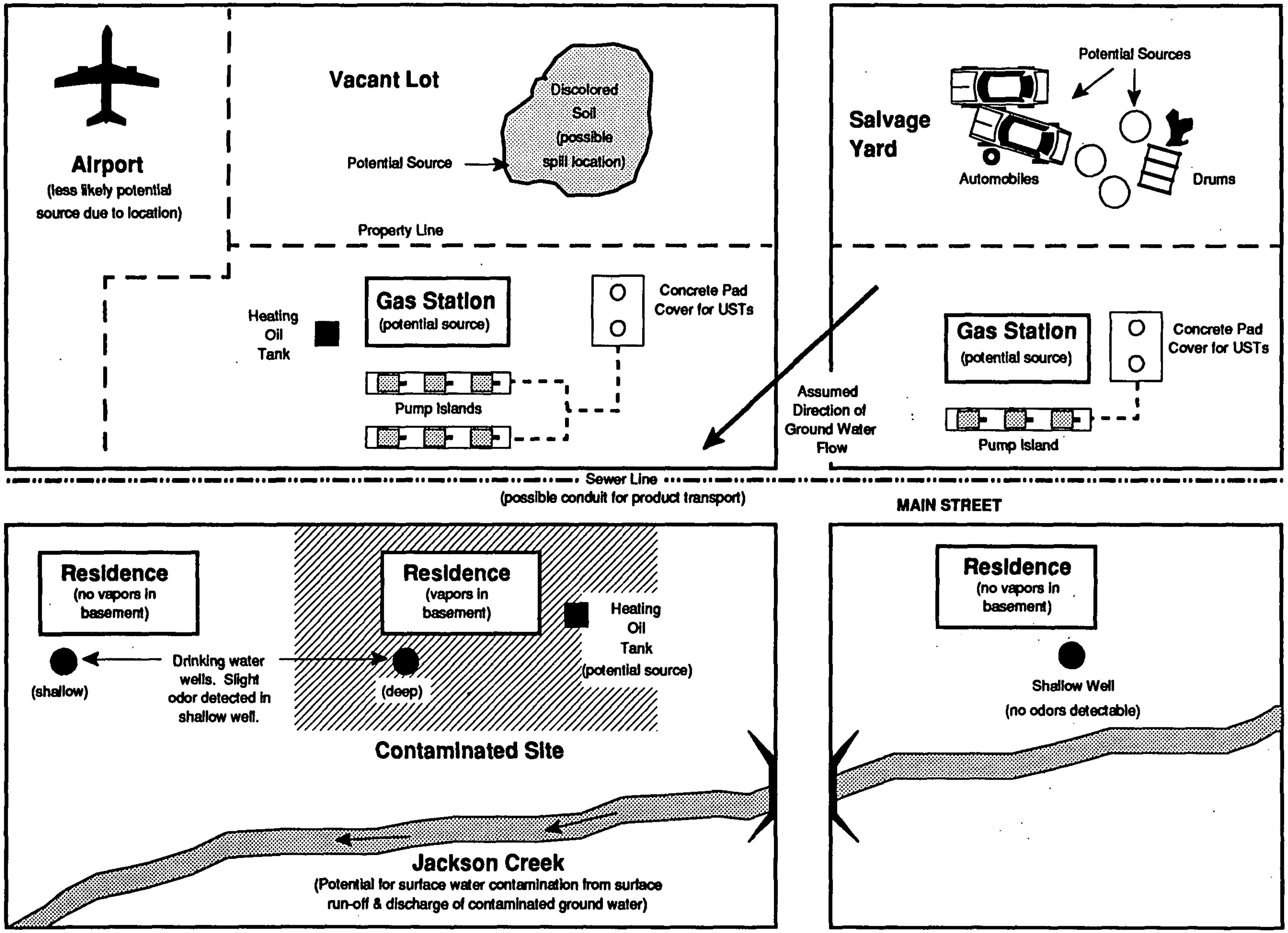
Step 4 Has the flow of free product into the environment been stopped?

Stopping the flow of product often requires the following steps:

- Shutting off product dispensing equipment (pumps and valves) during repair or replacement;
- Removing product from the tank and the lines;
- Monitoring and recording the amount and flow of product during suspension of use; and
- Shutting off power sources as necessary.

EXHIBIT 6

Identifying Possible Sources of Contamination



Source: ICF Inc.

Vapor Migration

Step 5 Has a determination been made as to the need for vapor migration control, collection, and treatment?

Hydrocarbon vapors and released petroleum products often enter confined structures such as buildings, sewers, telephone vaults, other utility lines, and tunnels. If vapors and/or liquids have been detected, a recovery system may be needed near the point of entry to intercept the product or vapors before they enter the confined structure.

Either passive or active vapor control systems may be selected depending on site-specific conditions (see Appendix A). Vapor control can extend over a substantial period of time, however, it is often necessary to determine the need for it, and begin the process during the initial response stage.

STOP

Structures and human health must be adequately protected during implementation of vapor control. Precautionary measures may entail isolating the area of concern, ventilating with equipment having explosion-proof motors and gears, and eliminating and/or controlling ignition sources.

Potentially Affected Community

Step 6 Has the potentially affected community (e.g., nearby well owners) been identified?

Before deciding if provision of alternative drinking water supplies is necessary, inspectors may need to complete or review an assessment of groundwater use.

6.1 Has information on the number, location and depth of public and private wells, and the number of people connected to these supplies been evaluated?

This step may involve the following:

- Reviewing available zoning or property plans for the nearby area to determine the location of residences, businesses, and municipal wells;

- Reviewing local Public Works and/or Water Department records to identify other potential well users;
- Conducting a field survey in the vicinity of the site (i.e., drive around neighborhood) to identify any other potential users;
- Reviewing available well logs to determine the depth and rate of pumping for the identified wells;
- Reviewing Health Department records for complaints registered for petroleum odor or taste in the area's water; and
- Surveying possible owners of wells and sampling their wells for evidence of contamination.

6.2 Based on the extent of contamination, has a determination been made as to whether or not water supplies need to be replaced or treated?

The following measures may need to be conducted in order to make this determination:

- Collecting water samples from the well or tap for analysis (i.e., testing for volatile organic compounds and/or petroleum hydrocarbons depending on the type of product — see Chapter III, Scenario B, Step 4); and
- Evaluating the analytical data using available State and Federal drinking water criteria.

Alternative Drinking Water Supplies

Step 7 Have alternative drinking water supplies been provided?

Depending on the extent of contamination and the feasibility of aquifer restoration, a temporary and/or emergency water supply may be needed until a permanent alternative is found or until the existing supply is restored.

7.1 Has a plan been initiated to determine how to inform residents of potential problems with their water supplies?

7.2 Have measures been taken to provide a temporary alternative water supply (if applicable)?

This may include using one of the following techniques:

- Providing bottled or bulk water;
- Providing point-of-entry home treatment units (e.g., carbon adsorption systems); and
- Installing rainwater collection systems.

> In general, if aquifer restoration can be accomplished within a few years, provision of temporary point-of-entry home treatment units may be practicable. As an initial response, point-of-entry systems or bottled sources will probably be required for a limited period of time before implementation of a permanent water supply. If aquifer restoration is not feasible in a reasonable timeframe, then a permanent alternative water supply should be developed as a long-term measure during remediation of ground water (see Chapter III, Scenario C, Step 8).

Containment of Free Product

Step 8 Has the containment of free product been initiated?

During the initial response to a release, free product may be encountered in sumps, tank pits, sewers, basements, elevator shafts, subway tunnels, telephone manholes, or seeping to surface waters. In such cases, containment of free product can be initiated as an interim measure until the limited site investigation can be completed.

Where seepage discharge to small streams occurs, the use of berms, dikes, booms, and/or sorbent materials may be used to contain the product. If free product has contaminated a river or large stream, the spill should be monitored to predict if and where it will reach the shore. Once this occurs, the floating spill can be contained with a boom. Encircling booms are useful when floating free product has contaminated a slow-moving body of water (e.g., lake, lagoon, pond, or large river). Recovery of free product is most often achieved by one of several pumping methods. See Chapter III, Scenario C, Step 6 for a discussion of longer-term free product removal from ground water.

Security of Site

Step 9 Has the site been sufficiently secured?

Sites often need to be secured to prevent unauthorized entrance and vandalism, particularly on abandoned sites and those with open excavations. Security measures may include the following: tightly closed and properly stored drums of recovered product and/or absorbent materials; plastic covers over any excavated soils; gates, buildings, and equipment locked; fencing or brightly colored tape around excavations and at entrances; and notices posted as warnings for the public.

Reporting Requirements

Step 10 Have all site activities been reported in accordance with State and Federal requirements?

Inspectors should ensure that owners/operators comply with State and Federal reporting requirements concerning initial response to petroleum UST releases. The requirements usually include provisions for reporting all suspected and confirmed releases, completed and planned initial response activities, and any resulting information and data.

Site Evaluation Checklist
Initial Response

SITE NAME/ID#: ______________________

SITE COORDINATOR: ______________________

		Date Completed/ By Whom
Step 1:	Has information on site history, tank usage, and impacts of the release been compiled by an inspector or contractor? (Use Worksheets 1 and 2.)	________
Step 2:	Have fire and safety hazards been identified, monitored, and mitigated?	________
Step 3:	Have the source and cause of the release been satisfactorily identified?	________
Step 4:	Has the flow of free product into the environment been stopped?	________
Step 5:	Has a determination been made as to the need for vapor migration control, collection, and treatment?	________
Step 6:	Has the potentially affected community (e.g., nearby well owners) been identified?	________
Step 7:	Have alternative drinking water supplies been provided?	________
Step 8:	Has the containment of free product been initiated?	________
Step 9:	Has the site been sufficiently secured?	________
Step 10:	Have all site activities been reported in accordance with State and Federal requirements?	________

Note: Not every task may be applicable in all situations, and the sequence of steps will vary somewhat from site to site.

III. Limited Site Investigation

This chapter presents three scenarios that correspond to the severity of contamination which may be found at various sites. Scenarios may also evolve sequentially at one site (that is, results of one scenario may lead the investigation into the next scenario). The three scenarios discussed in this chapter are:

- Scenario A: Minimal Soil Contamination
- Scenario B: Extensive Soil Contamination
- Scenario C: Groundwater Contamination

The decision as to what constitutes minimal soil contamination as compared to extensive soil contamination rests with the implementing agency. To select the appropriate scenario, it is important to review the available information from the Worksheets, the results of the initial response tasks, field observations, site history, hydrogeology, soil characteristics, and other site-specific data. See Exhibit 7 for descriptions of the type of site that may fall under each scenario. For determining the magnitude of potential impacts to soil and/or ground water, see Exhibit 8 which illustrates the general interrelationship between soil permeability and adsorptive capacity. (Additional information on one method to determine transport of contaminants is presented in Appendix B.)

The key to the limited site investigation process involves ongoing questioning and reevaluation of assumptions about site conditions. Typical questions to ask during the process include:

- Have all of the potential sources of contamination been identified?
- What additional information could be obtained and reviewed?
- Based on the new information received, are the owner/operator's or contractor's assumptions true?

EXHIBIT 7

Selecting a Scenario

Scenario A — Minimal Soil Contamination	Scenario B — Extensive Soil Contamination	Scenario C — Groundwater Contamination
Leaks or spills suspected to have occurred recently	Failure of tank or piping tightness test	Groundwater contamination observed during excavation of leaking tank or piping
Only small quantity release suspected	Discrepancy in inventory	Observations and records indicate significant loss of product
Presence of low permeable soils is expected to have minimized migration	Leak suspected due to age of tank or evidence of a previous underground storage tank leak	Odors detected in drinking water near source
Field screening indicates low concentrations present in soils	Field screening indicates positive reading above designated background levels*. Groundwater contamination observed during excavation of leaking tank or piping	High permeability of natural soils and/or high water table*
Visual observations of discoloration at surface or during excavation. Failure of tank or piping tightness test		

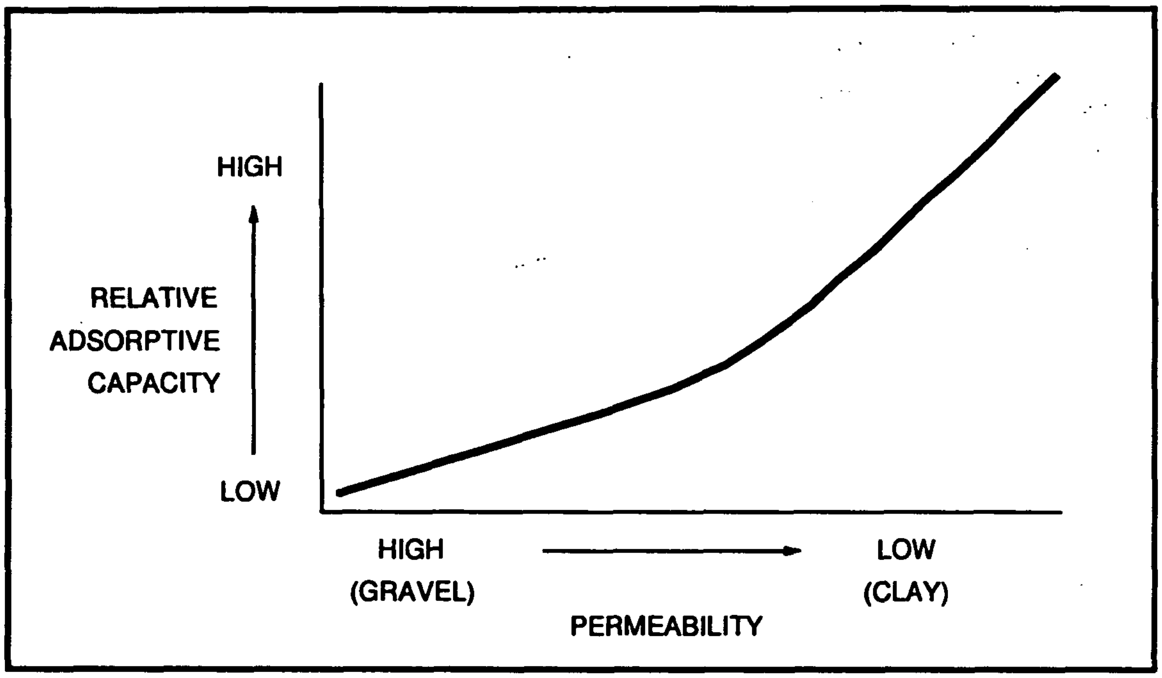
* NOTE: High readings in soils with low permeabilities (e.g., >100-1,000 ppm in clays) may indicate only localized contamination, whereas lower readings in high permeability soils (e.g., 10-50 ppm in sand and gravel) could indicate that contamination has rapidly migrated to greater depths.

Source: ICF Inc.

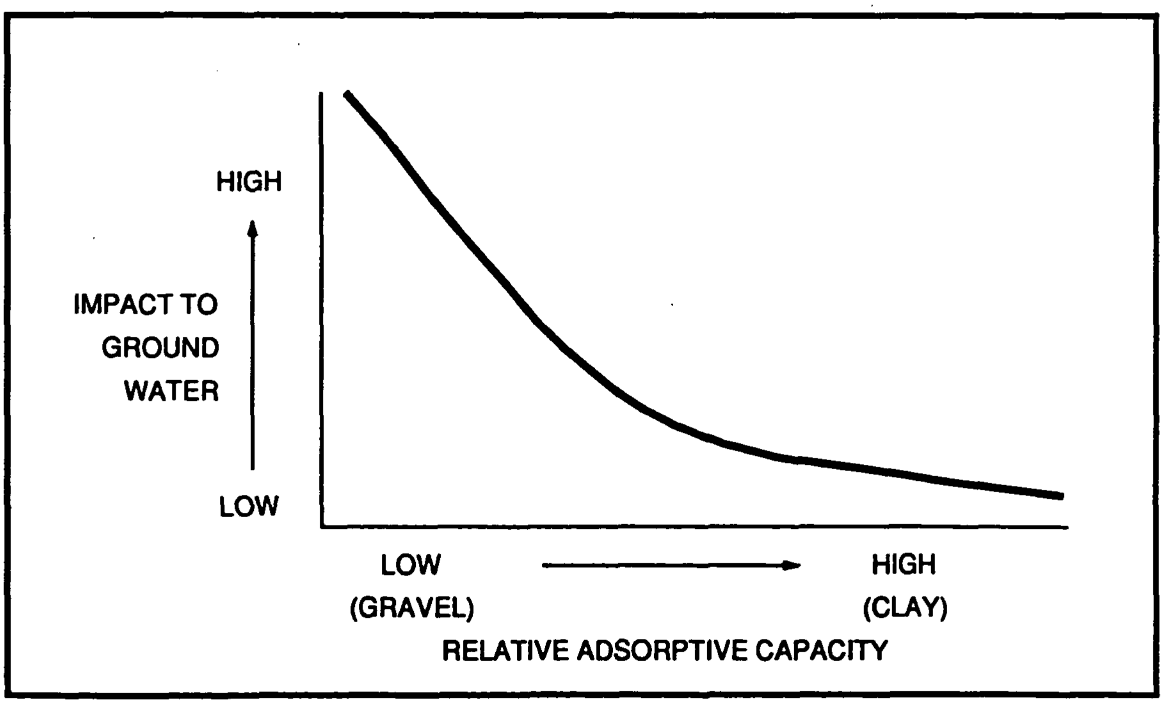
EXHIBIT 8

General Considerations Determining Magnitude of Potential Impacts

General Curve for Adsorptive Capacity versus Permeability



General Curve for Impact to Ground Water



Source: Groundwater Technology Inc.

Sites addressed under this scenario are locations where evidence gathered during initial response and a review of the site history indicate that minimal contamination to the soil has occurred. For example, minimal soil contamination may be expected in those cases where a release is recent and consists of a small quantity of product. In this scenario, inspectors may need to ensure that the following activities are conducted:

- Identification of locations of minimal soil contamination;
- Soil screening for hydrocarbon vapors to confirm the presence of minimal contamination or the need to continue to Scenario B;
- Management of contaminated soil (if necessary); and
- Submission by owner/operator of all information relating to the cause of the release and the status of the site to the State.

The need for some, or all of these steps is contingent upon the site-specific situation.

Locations of Contamination

Step 1 Have all of the locations of minimal soil contamination been identified?

The identification of these areas may be based on visual observations of discolored or saturated soils, detectable odors, and/or knowledge of historical activities (e.g., soils near a gas pump). Such evidence may be gathered during the initial response phase of a cleanup, and during the excavation and removal of a tank and lines. Tanks are often removed as a provision of a real estate transaction and are frequently the reason minimal contamination is discovered. (For more information on tank removal, closure or repair activities, see Appendix C.)

Soil Screening

Step 2 Have the soils been screened for hydrocarbons to confirm the presence of minimal contamination or the need to continue to Scenario B?

Field screening for hydrocarbons in soils can provide valuable information to help verify that only minimal contamination is present. Soil screening is typically accomplished by conducting a soil gas survey or by collecting shallow soil samples and testing them in the field. Soil gas surveys involve making a small diameter hole and either inserting a detection meter probe into the hole or extracting a vapor sample for screening. Shallow soil samples can be collected using a trowel, bucket auger, or shovel.

The following four factors can affect the accuracy of soil screening:

- Selection and operation of the detection meter;
- Consistency of screening procedures;
- Number and location of soil samples; and
- Interpretation of the results.

Details on these four factors are discussed in Substeps 2.1 to 2.4.

2.1 Has the appropriate type of instrument been selected based on anticipated concentrations?

See Exhibit 2 on page 9 for a list of types of meters. To some extent, meter selection will be dictated by State preferences, sensitivity requirements, and general equipment availability.

STOP

> The quality of the data is extremely variable depending on equipment maintenance, calibration, its operator, and climatic conditions. To obtain good quality data, the equipment manufacturer's instructions for maintenance and calibration should be carefully followed.

2.2 Have sampling procedures been consistent at the site?

The soil gas survey method is most frequently used for larger areas where more significant contamination is suspected. Hence, more detailed discussion of this method is presented in Scenario B, Substep 3.1.

Shallow soil samples can be collected in a number of ways. More important than the type of equipment used, however, is the consistency of the procedures across the site. (This ensures that the data can be compared.)

STOP

> One example of a soil sampling method is as follows:
>
> Soil is placed in a precleaned, airtight, glass jar and filled to approximately two-thirds of capacity. Screening procedures are as follows:
>
> - Close the jar tightly;
> - Place it in an area of controlled temperature;
> - Shake the jar vigorously after it reaches room temperature (approximately 15 minutes); and
> - Place the indicator probe in the jar to measure the concentration of organic vapors.
>
> Other methods for screening samples include:
>
> - Puncturing a hole in the jar lid to extract a known volume of sample with a needle (then injecting the needle into the detection meter); or
> - Immediately after sampling, covering the jar with foil and then capping it. When it is time to screen the sample, the cap is removed and the probe is inserted through the foil.
>
> Precautions need to be taken to prevent the volatilization of contaminants from the sample. In those cases where soil samples are allowed to aerate or are placed in warm locations, screening results will not be an accurate reflection of the actual level of contamination.

2.3 Have the number and the locations of soil samples been sufficient for the specific site conditions?

In general, samples are collected directly from the identified contaminated area and from one or more background locations around the perimeter of the release. By comparing the results from each of the locations, an evaluation can be made as to the relative amount of contamination. (State agencies may have specific policies on this matter.)

Samples obtained from tank removal excavations are usually collected where soils are discolored and where the backfill and the native soil meet. Additionally, soil may be sampled at the following locations within the excavation pit: the bottom center where stick testing may have worn through the tank, near the soil surface, and at the area previously adjacent to the fill end of the tank.

2.4 Have hydrocarbon vapor test results been correctly interpreted?

If test results show minimal contamination — based on State guidelines and/or the presence of such small amounts so as not to be a threat to human health and the environment — soils may need to be managed as described in Step 3. Following soil management, a repeat of soil screening may need to be conducted to confirm that cleanup was adequate.

If test results show significant soil contamination, as determined by the implementing agency, the investigation should proceed to Scenario B.

Minor Soil Contamination Management

Step 3 Has minor soil contamination been managed?

If soil contamination is minor and the release will be controlled upon completion of this scenario, contaminated soils may be left in place or excavated for disposal or treatment on or off site. Following removal or treatment, another soil screening test is usually conducted to verify that minor contamination is no longer present on site.

Managing soils in this scenario generally involves small scale removal and treatment operations as described in Scenario B, Step 6 and in Exhibit 14 on page 47. Those methods most applicable to this scenario include: leaving small quantities of soils with low concentrations on site to degrade naturally; excavating and removing small quantities of soils with relatively high concentrations for off-site disposal (e.g., at landfills or asphalt batching facilities); and using enhanced volatilization and soil venting for large quantities of soils with lower concentrations of total volatiles.

Reporting Requirements

Step 4 Have owners/operators submitted all information relating to the cause of the release and the status of the site to the State?

Owners/operators should comply with existing State and Federal reporting requirements concerning petroleum UST releases. At this stage of the process, owners/operators will likely be required to report all information on the cause of release, the estimated quantity of product released, the surrounding population, subsurface soil conditions, and locations of drinking water wells.

41-42X

Site Evaluation Checklist
Scenario A. Minimal Soil Contamination

SITE NAME/ID#: ______________________________

SITE COORDINATOR: ______________________________

		Date Completed/ By Whom
Step 1:	Have all of the locations of minimal soil contamination been identified?	__________
Step 2:	Have the soils been screened for hydrocarbons to confirm the presence of minor contamination or the need to continue to Scenario B?	__________
Step 3:	Has minor soil contamination been managed?	__________
Step 4:	Have owners/operators submitted all information relating to the cause of the release and the status of the site to the State?	__________

Note: Not every task may be applicable in all situations, and the sequence of steps will vary somewhat from site to site.

43-44x

An example of a Scenario B site is a location where a significant quantity of product was released relatively recently in permeable soils, and the contaminants have migrated through the subsurface with the percolation of rainwater. Alternatively, a release of product over time in less permeable soils (i.e., silts and clays) may also result in extensive soil contamination, since contaminants tend to adsorb to the material and migration to ground water may be limited. When information from the initial response and/or Scenario A activities reveals evidence of extensive contamination to soils, the inspector may consider the following:

- Identification of potential release sources, suspected areas of contamination, and site conditions;
- Preparation for field operations;
- Preliminary screening to confirm the presence of vapors and to identify areas of highest contaminant concentrations;
- Collection of subsurface soil samples to determine the vertical extent of contamination;
- Evaluation of soil data to determine the extent of soil contamination and the need to continue to Scenario C;
- Source control (if applicable) and soil management; and
- Submission of information concerning the cause of the release and the status of the site to the State.

The need for some, or all, of these steps is contingent upon the site-specific situation.

Potential Sources, Suspected Areas of Contamination, and Site Conditions

Step 1 Prior to initiating field work, have all potential sources, suspected areas of contamination, and site conditions been identified?

In order to evaluate a field program, inspectors need to understand a site's hydrogeologic conditions to help determine release sources and suspected areas of contamination. Worksheet 3 provides an outline of the type of information that could be reviewed in the beginning of this scenario. This is also a good time to review information gathered during Initial Response activities (see Chapter II, Step 3) and information gathered during the activities undertaken in Scenario A.

Field Preparation

Step 2 Have adequate field preparation measures been taken by contractors and oversight personnel?

Failure to adequately anticipate site conditions and prepare for field operations may result in costly delays or errors. For example, sampling locations should be sited to avoid underground utilities. See Worksheet 4 for information on field preparation. Delays can often be prevented if the involved parties are aware of the importance of careful planning before initiating field work.

STOP

> It is important that all of the involved parties maintain complete field notes. (See the Site Inspection and Telephone Logs accompanying Worksheet 1.) These notes provide the foundation for numerous project management activities such as budget tracking and report writing and can sometimes provide important materials in legal disputes.

Initial Screening

Step 3 Has initial screening been conducted to confirm the presence of vapors in soils and to identify areas of highest contaminant concentrations?

Initial soil screening methods may be used to further narrow the set of potential sources of a release and to help locate subsequent soil sampling points. The basic screening methods are the same as those described in Scenario A, Step 2 on page 28, and include soil gas surveys and shallow soil sampling.

Soil gas surveys measure the hydrocarbon vapors in the unsaturated (vadose) zone and are useful at this stage of an investigation to characterize a large area. As noted in Scenario A, the survey involves making a small diameter hole and either inserting a detection meter probe into the hole, or extracting a sample and analyzing it on or off site (using an FID, PID, explosimeter, or Draeger tubes).

Shallow soil samples can be collected to confirm the presence of contaminants in locations identified during the soil gas survey. Typically, these shallow samples are collected below the vegetative mat from depths ranging between 0 and 4 feet.

3.1 Has the soil gas survey been designed for site-specific conditions?

Design considerations may include the following:

- Spacing of sampling grid — close spacing is better in dense, clayey materials;
- Depth of holes — deeper holes (e.g., over 4 feet) may be necessary depending on thickness of soils; and
- Testing methods — on-site analyses can provide immediate results (or "real-time" results) which can be useful during the layout of the grid.

Soil gas surveys have several limitations that may need to be considered. For example, they are not as effective when the samples are taken at a distance from the source. They are also most reliable in permeable soils and have limited effectiveness in clayey soils. Furthermore, soil gas surveys can have limited results detecting older plumes whose more volatile compounds may have either evaporated, dissolved, or degraded.

3.2 Have shallow soil samples been obtained from strategic locations using an appropriate sampling technique?

To ensure that accurate, representative data is gathered, an inspector may want to check that the following occur:

- Using techniques described in Scenario A, Step 2;
- Selecting sampling locations so as not to miss areas of potential contamination (e.g., near tank lines and fill pipes);

- Recording odors and/or other observations in the field log; and

- Avoiding cleaners (e.g., solvents or gasoline) that could contaminate samples when cleaning the sampler or equipment.

Subsurface Soil Sampling

Step 4 Have subsurface soil samples been collected to determine the vertical extent of contamination?

Subsurface soil sampling is important because it provides information on soil characteristics necessary to estimate contaminant migration pathways, the depth to the water table, and the potential impact to ground water. Additionally, the data can be used to estimate the volume of contaminated soil which is useful when selecting clean-up alternatives.

Typically, field screening methods are used during soil sampling, although in some cases, laboratory analyses may be desired. See Exhibit 9 for more information on laboratory analyses and Exhibit 10 for examples of analytical options available for collected samples.

Some of the devices available for subsurface soil sampling include backhoes and clamshells for excavating test pits, and bucket augers, hollow stem augers, and other drilling methods for soil borings. (See Exhibit 11 for a summary of drilling methods.)

4.1 Have the following general sampling procedures been used for collecting subsurface soils from test pit excavations?

- Obtaining samples by using a clamshell or a backhoe (since entering an open excavation is hazardous);

- Collecting soil sample(s) from designated depths and locations of changes in strata;

- Using the general procedures described in Substep 3.2 of this scenario and in Scenario A, Step 2;

- Using a field screening meter to measure hydrocarbon vapors in the headspace of soil jars; and

- Completing test pit field notes, including information on location, orientation, and dimensions of excavation, as well as soil stratigraphy and screening results.

EXHIBIT 9

Laboratory Analysis of Samples

Field screening for hydrocarbon vapors provides enough information to determine the presence of contamination and the relative concentration. In many cases, screening information may be sufficient for decision-making purposes, for example, when there is no uncertainty about the type of contaminant (i.e., the source is from a known spill or identified leaking tank). There are instances, however, when laboratory analyses may be desired during an investigation. For example, analytical data from a laboratory may be used for the following reasons:

- To determine if a potable water supply has been affected and the need for an alternative water source;
- To identify contaminants that cannot be detected (or differentiated) by field screening techniques; and
- To meet State and local requirements (e.g., for verification of a cleanup).

Given the cost and time associated with laboratory analyses, it is important that certain measures are taken to ensure accurate results. In order to avoid resampling (which results in unnecessary delays and expenses), inspectors should be aware of the following common mistakes and possible solutions:

Mistakes	Solutions
• Selection of inappropriate type of analysis	• Consult with the laboratory and existing guidelines for recommended analyses. See Exhibit 10 for a summary of some common analytical options
• Use of improper container and preservative	• Consult with laboratory and use containers that they have approved and/or provided
• Samples unusable due to breakage or cross-contamination	• Collect duplicates or triplicates; place field blank in storage container with samples
• Samples unusable due to improper storage and excessive holding time	• Arrange with laboratory ahead of time for analysis to be run as soon as possible after delivery; store samples in ice-filled cooler immediately following collection
• Analytical results indicate improper labelling or sample misidentification	• Label samples very carefully in the field and; carefully fill out chain of custody forms prior to delivery to the laboratory

Source: ICF Inc.

EXHIBIT 10

Analytical Options

ANALYTICAL METHODS	GENERAL DESCRIPTION	APPLICABILITY	LIMITATIONS
TOTAL PETROLEUM HYDROCARBONS (TPH, PHC, or TRPH — for recoverable hydrocarbons)	• Uses GC/FID analysis to measure concentration of total petroleum hydrocarbons extracted from sample using a solvent • Must specifically request "fingerprint" analysis for identification of types of petroleum hydrocarbons	• Can be used to analyze water and soil samples • Most applicable for determining presence of oils (i.e., fuel oil, waste oil) • Can provide information on "weathered" product • Should specify if analysis of dissolved fraction of ground water is desired	• Need to specify to laboratory the type of data desired • Possible to use to identify presence of gasoline product but loss of gasoline can occur during extraction • Identification of product types can be approximate unless samples of pure product (i.e., from the suspected source) are analyzed
INFRARED (IR—EPA Method 418.1)	• Measures concentration of total petroleum hydrocarbons extracted from sample using freon	• Can be used to analyze water and soil samples • Most applicable for determining presence of oils • Can be used to measure lighter oils	• Does not provide identification of types of hydrocarbons • Subject to interference since analysis also measures non-petroleum hydrocarbons (e.g., organic acids) • Possible for gasoline sites, however, up to 1/2 of total gasoline concentration of the sample can be lost during extraction
OIL AND GREASE (Standard Method 503)	• Measures weight of oil and grease extracted from sample using freon	• Can be used to analyze soil and water samples • Better for heavy oils	• Inappropriate for gasoline or oils with volatile fraction (e.g. waste oils with solvent contamination) due to loss of volatiles during extraction
GAS CHROMATOGRAPHY (GC) (EPA Method 602-water; EPA Method 8020-soil)	• Measures purgeable aromatics (volatile fraction) using purge and trap method • Provides data on benzene, toluene, ethyl benzene, and total xylenes (BTEX). (May need to request xylene data specifically.) • Compound I.D. is not definitive, i.e., compared to mass spectrometry (MS) results which are verifiable	• Good for gasoline • Can detect some solvents in waste oils	• Not optimum for fuel oils, particularly heavier oils, since those compounds lack significant volatile fractions
GC (EPA Method 601-water; EPA Method 8010-soil)	• Measures purgeable halocarbons using purge and trap method • As with Method 602, compound I.D. cannot be confirmed	• Best for detecting presence of solvents in waste oils	• Not applicable for petroleum hydrocarbons

EXHIBIT 10

Analytical Options
(continued)

ANALYTICAL METHODS	GENERAL DESCRIPTION	APPLICABILITY	LIMITATIONS
GC/MASS SPECTROMETRY (MS) (EPA Method 624-water; EPA Method 8240-soil)	• Measures purgeable halocarbons and aromatics • Provides positive identification of BTEX constituents	• Most applicable for gasoline	• Not optimum for fuel oils (particularly heavier oils) since those compounds lack significant volatile fraction
GC/MS (EPA Method 625-water; EPA Method 8270—soil)	• Measures acid extractable semi-volatile organic compounds	• Applicable for sites with diesel oil contamination	• In general, limited applicability at petroleum UST sites
LEAD (EPA Method 239.2 or Standard Method 304)	• Measures concentration of metal extracted using a slightly acidic distilled water solution	• Can be used for water and soil samples • Generally used for gasoline • Also applicable for waste oils	• Data on lead concentration in background samples useful to assist with interpretation

NOTES: EPA 8000 methods were developed for solid waste analysis required under the Resource Conservation and Recovery Act (RCRA) and can be modified to analyze water samples. For UST sites, however, they are typically only used for analyzing soils.

There is currently no one standard method available for quantitative identification of petroleum products in soil and water samples, therefore, it is important to work closely with a laboratory when selecting analytical methods for a specific site.

Source: Adapted by ICF Inc.

EXHIBIT 11

Well Drilling Methods

DRILL TYPE	NORMAL DIAM. HOLE	MAX. DEPTH	AVERAGE TIME PER HOLE	NORMAL EXPENSE	ADVANTAGES	DISADVANTAGES
1. Rotary	4"-20"	Unlimited	Fast	Expensive	1. Good for deep holes 2. Can be used in soils and relatively soft rock 3. Wide availability 4. Controls caving	1. Need to use drilling fluid 2. Potential bore hole damage with drilling fluid 3. Requires drilling water supply
2. Stem Auger	4"-8"	30-50 ft.	Fast under suitable soil conditions	Inexpensive to moderate	1. Widely available 2. Very mobile 3. Can obtain dry soil samples while drilling	1. Difficult to set casing in unsuitable soils (caving) 2. Cannot penetrate large stones, boulders, or bed rock 3. Normally cannot be used to install recovery wells
3. Hollow Stem Auger	4"-8"	30-50 ft.	Fast under suitable soil conditions	Inexpensive to moderate	1. Good for sandy soil 2. Can set casing through hollow stem 3. Very mobile 4. Can obtain dry soil samples and split-spoon samples 5. Controls caving	1. Casing diameter normally limited to 2"-3" outside diameter 2. Cannot penetrate large rock, boulders, or bed rock 3. Limited availability 4. Normally cannot be used for recovery wells
4. Kelley Auger	8"-48"	90 ft.	Fast	Moderate to expensive	1. Can install large diameter recovery wells 2. Drills holes with minimum soil wall disturbance or contamination 3. Can obtain good soil samples	1. Large equipment 2. Seldom available in rural areas 3. May require casing while drilling
5. Bucker Auger	12"-72"	90 ft.	Fast	Moderate to expensive	1. Can obtain good soil samples 2. Can install large diameter recovery wells	1. Hard to control caving 2. At times must use drilling fluid 3. Normally very large operating area required
6. Cable Tools	4"-16"	Unlimited	Slow	Inexpensive to moderate	1. Widely available 2. Can be used in soil or rock	1. Slower than other methods 2. Hole often crooked 3. May require casing while drilling
7. Air Hammer	4"-12"	Unlimited	Fast	Expensive	1. Fast penetration in consolidated rock	1. Inefficient in unconsolidated soil 2. Very noisy 3. Control of dust/air release 4. Excessive water inflow will limit use
8. Casing Driving (well point)	2"-24"	60 ft.	Slow to moderate	Inexpensive	1. Very portable 2. Readily available	1. Limited to unconsolidated soil -- cannot penetrate large rocks, boulders, bedrock 2. Difficult to obtain soil samples 3. Generally inefficient method to install recovery well
9. Dug Wells	Unlimited	10-20 ft.	Fast	Inexpensive	1. Readily available 2. Very large diameter hole easily obtained	1. Caving can be severe problem 2. Limited depth 3. Greater explosive hazard during excavation into hydrocarbons

Source: Reprinted courtesy of the American Petroleum Institute, "Underground Spill Cleanup Manual" Publication #1628, First Edition, June 1980.

It may be necessary to consider the following before using test pits at a site:

- Test pits can disrupt normal site operations, and if left open, pose a safety hazard to persons and vehicles. Therefore, they are probably most applicable at large, undeveloped sites.
- Test pits are of limited value where contamination is expected to extend below the reach of the equipment (i.e., generally 15 to 20 feet).
- Volatilization of contaminants from open excavations can result in an increased short-term exposure pathway (e.g., to equipment operations).

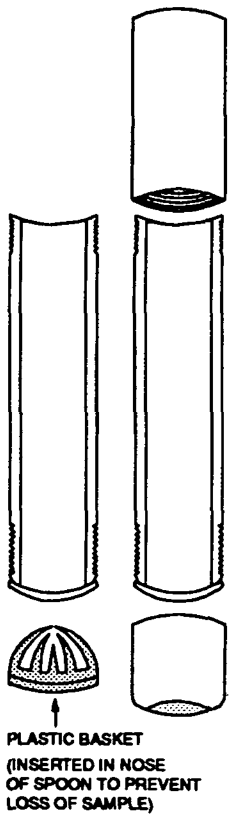
4.2 When collecting samples from soil borings, have soil sampling procedures been consistent?

A split-spoon sampler is one of the most common devices used for collecting a soil sample from a soil boring or test hole. As depicted in Exhibit 12, the split-spoon is a steel tube that can be opened to observe and collect an undisturbed soil sample. An inspector should be aware that subsurface sampling involves the following general procedures:

- Collecting samples from designated intervals depending on the desired information (e.g., every 5 or 10 feet, continuously, or at strata changes);
- Recording the number of hammer blows while the split-spoon sampler is being driven to determine the density or hardness of the soils;
- Noting any loss of soil during sampling (that is, the sampler may have penetrated 2 feet but only 1 foot of soils may have been recovered);
- Using a sharp edge to scrape across the length of the sample, and noting any changes in strata;
- Placing the samples in the proper containers immediately, capping them, and ensuring that they are airtight;
- Placing all containers in an ice-packed cooler after sampling until it is time to screen soils or send them to a laboratory for analyses;

EXHIBIT 12

Split-Spoon Sampler



Source: ICF Inc.

- Classifying the soil type according to the designated system, and noting any moisture, discoloration, odor, as well as field screening results; and

- Completing soil boring logs in accordance with standard engineering practices associated with the particular technique (see Exhibit 13). Include depth to ground water if encountered during drilling.

Evaluation of the Extent of Contamination

Step 5 Have soil data been accurately evaluated in order to determine the extent of contamination and the need to continue to Scenario C?

The information on soil characteristics and contaminant concentrations (gathered during Steps 3 and 4 of this scenario) needs to be compiled and evaluated in order to determine the lateral extent of contamination. Information on the vertical extent of contamination and the depth to the water table can be used to determine the likelihood of impact to ground water.

5.1 Did an evaluation of the soil data include the following, if applicable?

- If additional contaminants are found, determining whether or not they represent an isolated occurrence or relate to a separate problem which may require additional investigation;

- Comparing the screening and analytical results with background samples from areas that are not suspected of contamination;

- Plotting the screening and analytical data on a site plan to delineate the lateral extent of soil contamination; and

- Determining if additional sampling is necessary based on existing data gaps.

5.2 Did a determination of the potential impact to ground water include the following, if applicable?

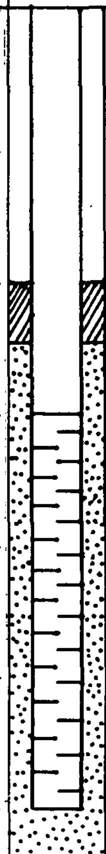
- Determining depth to the water table from ground surface based on observations from test pits or borings, or estimates from local/regional hydrogeologic data;

EXHIBIT 13

Typical Boring Log

PROJECT/LOCATION	PAGE 1 OF 1
CONTRACT CODE	LOGGED BY
DRILLER	DATE (START) 11/28/89 (FINISH) 11/28/89
BORING NUMBER MW-1	BORING DIAMETER 3 3/8"
EQUIPMENT TYPE	DRILLING FLUID USED NONE

CASING	SAMPLER	GROUND WATER
SIZE (HSA) 3 3/8"	TYPE Split Spoon (24")	DATE Upon Completion TIME 1600 DEPTH 17.6'
HAMMER ____ lb.	HAMMER 140 lb.	DATE 12/7/89 TIME (1 Week) DEPTH 15.2'
FALL	FALL 30"	GROUND ELEVATION/DATUM

DEPTH (FT.)	SMPL #	REC.	BLOWS/6"	DESCRIPTION	EQUIPMENT INSTALLED ①	SCREENING RESULTS /REMARKS ② (ppm)
0-2	S-1	5"	12-20 14-10	Medium dense, gray, medium to coarse GRAVEL	 0-10' Grout and Bentonite	20
5-7	S-2	19"	2-4 5-8	Loose, gray, SILT and CLAY little fine sand	0-15' 2" PVC Riser	3
10-12	S-3	16"	5-14 15-20	Medium dense, gray, SILT and CLAY, trace GRAVEL	10-12' Bentonite Seal; 12-32' Sand Filter Pack	3.5
15-17	S-4	24"	10-20 20-18	Dense, white, medium to coarse SAND and GRAVEL, little Clayey Silt		.5
20-22	S-5	12"	10-28 30-20	Very dense, orange brown, medium to coarse SAND and GRAVEL, little Clayey Silt	15-30' 2" PVC Slotted Screen	0
25-27	S-6	24"	1-2 2-4	Soft, gray, CLAY and SILT		0
30-32	S-7	24"	3-6 9-9	Medium dense, gray CLAY and SILT		0
				Bottom at 32'		

SIGNATURE ____________ CHECKED BY ____________

NOTES:
1. Wells were constructed immediately following drilling using a 2" diameter, schedule 40 PVC, with .01" slotted screen, bentonite pellets, cement, and clean sand. All wells were finished with a locking well cap and protective cover.
2. Field screening results represent total organic vapor levels measured with an HNu Model PI 101 photoionization detector, in the headspace of soil gas.
3. Groundwater encountered at 20' during drilling.

Source: ICF Inc.

- Developing a vertical profile showing soil stratigraphy and contaminant concentrations from samples;

- Considering other factors such as the solubility of the contaminant, porosity and adsorptive capacity of the soils, precipitation, and approximate amount of contaminant released (if known); and

- Proceeding to Scenario C if impact to ground water is likely to occur or may have already occurred.

Source Control and Soil Management

Step 6 Have effective clean-up measures been taken to control the source (if applicable) and to manage contaminated soils?

Source control most often involves removal of product from the leaking tank system, tank removal, tank closure, or tank repair. See Appendix C for more information on these activities. Once the source of the release has been adequately controlled, soil management usually begins. Inspectors may need to ensure that the following three basic steps have occurred in the soil management process.

6.1 Has a determination been made as to what extent soils need to be managed based on State requirements and criteria?

Examples of criteria used to determine cleanup include soils that are saturated (as measured by a paint filter test) and soils that exceed an established concentration level.

6.2 Have treatment or disposal methods been carefully selected and implemented?

These options include excavation and disposal, enhanced volatilization, soil venting, incineration, and biodegradation. (See Exhibit 14 for general descriptions of these technologies.)

6.3 Has the cleanup been confirmed to ensure that the goals or criteria have been met?

This may involve verification sampling to determine if treatment has met target clean-up levels as determined by the State. Such levels may be set based on background conditions, established concentrations, or groundwater criteria.

EXHIBIT 14

Soil Management Options

TECHNIQUE	GENERAL DESCRIPTION	ADVANTAGES	DISADVANTAGES
EXCAVATION AND DISPOSAL	• Conventional construction equipment (e.g., backhoe) is used to excavate and remove soils. • Often done in conjunction with tank removals. • Disposal options include approved landfills, asphalt batching plants, landfarming or other treatment facilities.	• Relatively quick and common. • Allows pollution problem to be removed from the site.	• Disrupts the site (excavating adjacent to buildings is not recommended). • Increases short-term exposure pathway to volatile hydrocarbons. • Disposal options may be limited by facility acceptance criteria and space availability. • Depth of excavation limited by equipment and presence of ground water.
ENHANCED VOLATILIZATION/ LANDFARMING	• Contaminated materials are excavated and spread over the ground surface. • Volatilization and degradation mechanisms are enhanced (e.g., by tilling or scarifying the soil and/or adding sorbents).	• Feasible when open land is available (usually UST site owner's land). • Organic soils and temperate climate conditions facilitate treatment.	• Can require air and soil monitoring. • Land availability limits use.
VENTING (IN SITU)	• Fans or vacuums are used to create a pressure gradient that forces air through the soils. • Vapors are directed to a vent and released with or without treatment.	• Feasible at most sites where trenches or wells can be installed. • Design can account for less permeable soil conditions (e.g., by vent spacing).	• Can take time (e.g., several weeks or more) to install and complete. • Air monitoring and treatment permits may be required.
INCINERATION	• Thermal destruction of contaminants in excavated soils can be achieved by a variety of types of available incinerators (e.g., rotary kiln, liquid injection, or circular bed).	• May be particularly beneficial at sites where petroleum products are mixed with other types of contaminants. • Mobile units are available and can be set up on site for long-term projects.	• Liability perceived by some when soils mixed with other waste types in the incinerator. (This can be controlled by segregating materials). • Can require significant permitting (Subtitle C facilities would meet the permit requirements.) • Still in the developmental stage.
BIOLOGICAL DEGRADATION	• Natural microorganisms degrade the contaminants in soils and can be used during cleanup by monitoring natural occurrences or by optimizing oxygen and nutrient conditions.	• Works well in conjunction with groundwater remediation. • Best suited for in-situ treatment. • Appropriate as a polishing technique for sites where other clean-up measures have also occurred.	• Effectiveness limited by microbial population, availability of nutrients, temperature, and type of hydrocarbons. • Controlling these factors can be difficult, costly, and time-consuming.

NOTE: Extensive discussion on these and other technologies has been developed in the existing literature. Please refer to the References for "Remediation" for more information.

Source: ICF Inc.

Step 7 Have owners/operators submitted all information relating to the cause of the release and the status of the site to the State?

Owners/operators should comply with existing State and Federal reporting requirements concerning petroleum UST releases. At this stage of the process, owners/operators will likely be required to report all data and information that characterizes the site and the cause of the release (if they have not already done so, see Scenario A, Step 4 on page 31). Additionally, owners/operators may be asked by the State to develop a Corrective Action Plan (e.g., for long-term soil management efforts).

Site Evaluation Checklist
Scenario B. Extensive Soil Contamination

SITE NAME/ID#: ______________________

SITE COORDINATOR: ______________________

		Date Completed/ By Whom
Step 1:	Prior to initiating field work, have all potential sources, suspected areas of contamination, and site conditions been identified?	________
Step 2:	Have adequate field preparation measures been taken by contractors and oversight personnel?	________
Step 3:	Has initial screening been conducted to confirm the presence of vapors in soils and to identify areas of highest contaminant concentrations?	________
Step 4:	Have subsurface soil samples been collected to determine the vertical extent of contamination?	________
Step 5:	Have soil data been accurately evaluated in order to determine the extent of contamination and the need to continue to Scenario C?	________
Step 6:	Have effective clean-up measures been taken to control the source (if applicable) and to manage contaminated soils?	________
Step 7:	Have owners/operators submitted all information relating to the cause of the release and the status of the site to the State?	________

Note: Not every task may be applicable in all situations, and the sequence of steps will vary somewhat from site to site.

This scenario addresses those sites where groundwater contamination is likely or has already been identified (e.g., based on visible product on the surface of the water or analytical results of samples from drinking water wells). At these sites, a State inspector may need to evaluate the following:

- Locations of monitoring wells;
- Installation of monitoring wells;
- Characterization of groundwater flow;
- Groundwater sampling procedures;
- Assessment of groundwater contamination;
- Initiation of removal of floating free product from ground water;
- Determination of the existing and future uses of ground water;
- Provision of additional alternative water supplies if necessary (temporary alternative water supplies typically would have been addressed during the initial response phase of the cleanup); and
- Information relating to the groundwater investigation and cleanup (in the form of reports and plans) submitted by the owner/operator to the State.

The purpose of conducting these activities is to determine the type of contamination (i.e., dissolved or floating product), the extent of contamination, and the need (if any) to protect additional groundwater users in an area. Information gathered under this scenario can help provide the basis for further remediation, as necessary.

The need for some, or all, of these steps is contingent upon the site-specific situation.

Monitoring Well Locations

Step 1 Have monitoring wells been sited in strategic locations so as to allow sampling upgradient and downgradient of the contamination source?

The location of wells should take into consideration the expected direction and rate of contaminant migration based on permeability and gradient (see transport discussion in Appendix B). Prior to siting well locations, it is also beneficial to evaluate the types of information outlined in the Worksheets as well as data gathered during soil sampling in Scenarios A or B.

Typically, the direction of groundwater flow in a water table aquifer will replicate the surface topography. (This is not necessarily true in confined aquifers.) In general, at least one well is placed in the assumed upgradient direction of the contamination source, two to three wells are located around the suspected source, and one or more is installed downgradient to determine the extent of contamination.

An investigation may also require at least one well to be installed at depth, below the shallow aquifer, to determine the vertical extent of migration into a deeper aquifer. The need for a deep well depends on the site geology, the age of the release, and the type of contaminants (e.g., "sinker" constituents such as No. 6 fuel oils can have densities greater than water).

Monitoring Well Installation

Step 2 Have monitoring wells been installed correctly?

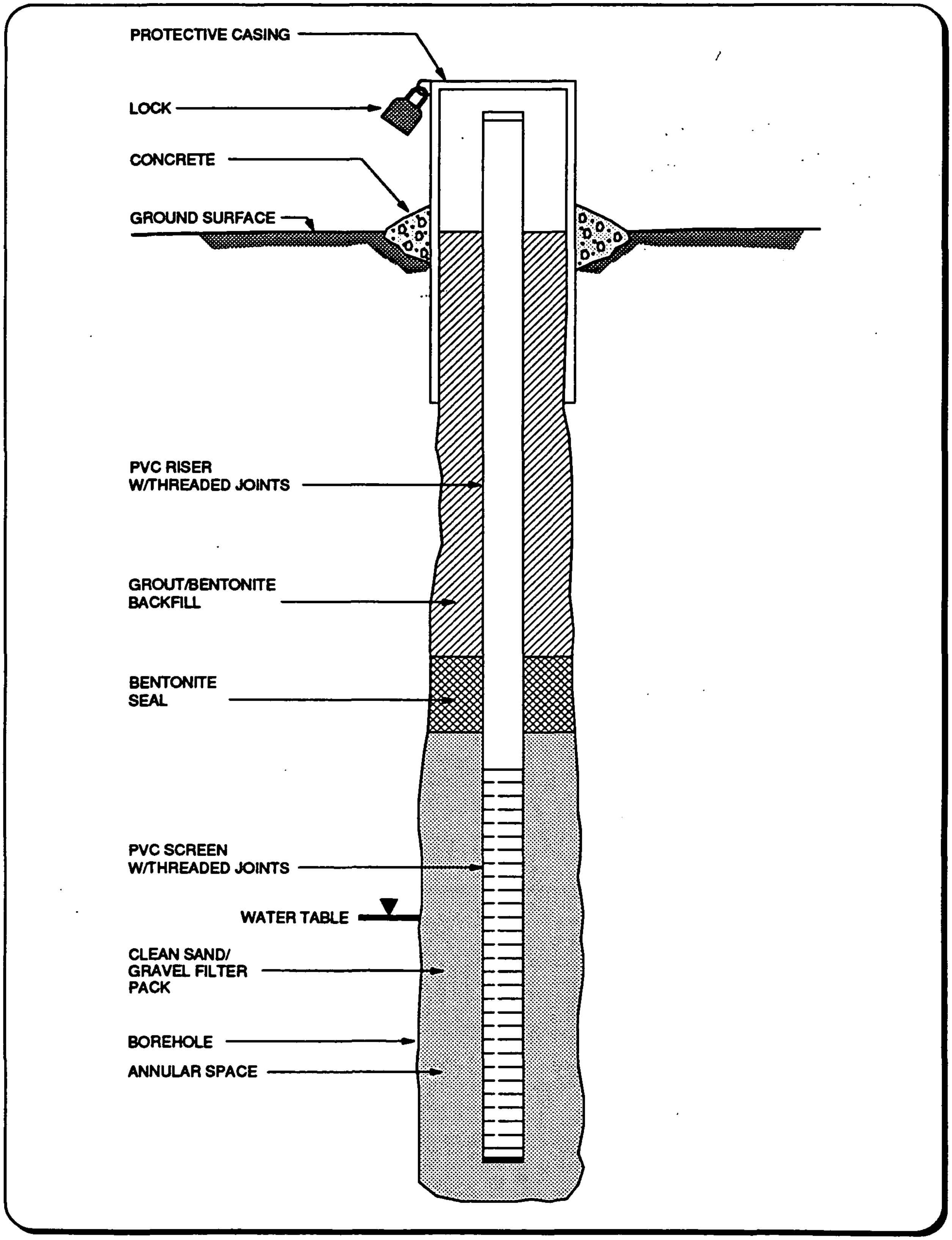
Monitoring wells are generally installed in soil borings, upon completion of drilling, when evidence (e.g., from soil screening) indicates a release of petroleum product has affected ground water. (See Scenario B, Substep 4.2 and Exhibit 11 on page 42 for soil sampling and drilling information.) For well installation purposes, dry drilling methods are preferable to those using water or mud, because drilling fluids can influence the quality of the groundwater sample.

2.1 Have the monitoring wells been designed to meet the following general criteria, as applicable? (See Exhibit 15.)

- Well screens have been placed at the depth appropriate for the information desired. For example:

EXHIBIT 15

Typical Monitoring Well



Source: ICF Inc.

- the screen intersects the water table when investigating a floating layer;

- the well screen extends sufficiently above and below the water table in order to account for anticipated seasonal fluctuations in the groundwater elevation; and

- the well screen is placed at the depth of primary migration when investigating dissolved constituents or "sinkers."

- The well diameter is wide enough to accommodate the intended sampling equipment. In some cases, however, small diameter wells will be used to minimize the volume of fluid that will need to be handled and disposed of during sampling.

- All well materials and sampling equipment are clean or decontaminated prior to use.

- The well has a bottom cap.

- A filter pack of clean, inert sand or gravel is placed in the annular space (between the sides of the boring and the outside of the well). Generally, a sand pack will extend two to five feet above the top of the well screen.

- Bentonite and/or grout seals are placed at appropriate depths (i.e., one to two feet above the sand and between significant strata) to prevent cross contamination between aquifiers and/or infiltration of sheet runoff from the ground surface.

- The well was developed upon completion to ensure proper operation. This is usually accomplished by pumping the well until the water is clear and until the rate of recovery between pumping is relatively constant. If gasoline is suspected or known to be present, development water must be drummed and handled as hazardous material (until laboratory results are available to indicate otherwise for suspected ground water).

- The well is equipped with a protective casing or road box and a locking cap to prevent vandalism.

2.2 Has all pertinent information been recorded on the boring log as shown in Exhibit 13 on page 45 (or in the field notebook), if applicable?

2.3 Have well locations and ID numbers been clearly marked so as to be sufficiently visible in all seasons (e.g., with colored flags staked into the ground or with spray paint)? Have well locations been sketched on a plan, using measured distances from stationary site features, to allow easy location in the future by surveyors and field personnel?

STOP

Other factors to remember about well installations include the following:

- Delays during installation can occur when the sand filter pack is put in place too quickly and forms a block or bridge between the well and the interior of the auger or casing. This is particularly apt to occur when the annular space is small (e.g., a 2-inch diameter well is placed in a 3.75-inch diameter auger or casing).
- Bentonite and grout can influence water quality if improperly placed. Bentonite should be wetted following placement and allowed to set, and grout should be well-mixed before placement. Interference from poor seals may be identified (i.e., by elevated conductivity readings from bentonite or by high pH readings in groundwater samples).
- Piezometers, i.e., monitoring wells whose primary purpose is to obtain water level data (typically used in clay materials), should be of small diameters such that head changes can be detected quickly.
- For more information, see the References for "Soil and Groundwater Investigations."

Groundwater Flow Characteristics

Step 3 Have groundwater flow charactericstics been determined?

In order to verify that wells are properly located both upgradient and downgradient of the suspected source, the direction of groundwater flow must be confirmed. To determine if sufficient data are available on groundwater flow, inspectors may evaluate the following.

3.1 Have experienced surveyors measured the elevation of the tops of wells or piezometers?

3.2 Based on the survey, have groundwater elevations been calculated? (For this calculation, it is best to use water table measurements that were all collected on the same day.)

3.3 Have elevations been plotted on a groundwater contour plan to determine:

- Direction of flow (perpendicular to the groundwater contour lines); and
- Hydraulic gradient (the distance between contour lines divided by the change in groundwater elevation)?

Elevation data from shallow and deep aquifers should be examined separately. This is important since the direction of flow in a deep aquifer may differ from, and can actually be the opposite of, the flow in a shallow aquifer.

3.4 Were data available on hydraulic conductivity and porosity of the soil (to estimate groundwater velocity or the rate of flow)? (See Appendix B for one method to calculate flow rate.)

Information on hydrogeologic characteristics of a site can be obtained from review of available literature or direct aquifer testing such as pump tests and slug tests (i.e., rising head and falling head tests). This information is important for estimating how quickly downgradient drinking wells may be affected as well as for future selection of treatment options.

Groundwater Sampling

Step 4 Have groundwater sampling procedures been correctly implemented?

Inspectors may want to review sample collection procedures to ensure that representative groundwater samples have been collected and no cross contamination occurred at the site.

4.1 If samples are to be sent to a laboratory, have the appropriate types of analyses been identified prior to sample collection? (See Exhibit 9 on page 39 for more discussion of laboratory analyses.)

The chosen laboratory analyses should provide data on the indicator parameters for the released product. For example, benzene, toluene, and xylene are major constituents of gasoline, and lead is an indicator parameter for regular, leaded gasoline. The type of analysis will influence how a groundwater sample is collected. Different analyses require different volumes of water and types of containers. (See Exhibit 10 on page 40 for additional information on analytical options.)

4.2 Were the necessary measurements obtained prior to purging the well to remove stagnant well water?

This may include the following:

- Using a weighted tape or electric water level reader to determine the depth to the water table from the top of the casing and/or ground surface (see Exhibit 16); and
- Determining the presence of floating free product on the water table. This determination may be made using a weighted tape with hydrocarbon detection pastes, an oil/water interface probe, a clear bailer, or obtaining a sample from the water table with a standard bailer.

STOP

The inspector should recognize that the thickness of floating product observed in a well is often greater than the actual thickness in the rock formation due to the influence of the well diameter and the capillary fringe. Product thickness in a well may also fluctuate seasonally and may even decrease to zero when the water table is high.

When a floating product layer is present, measurements of depth to the water table need to be corrected to account for the density difference of the product relative to water. For example, gasoline has a density approximately 75 percent that of water. Therefore, if a one-foot floating layer was present, 0.75 feet should be added to the elevation of the water/gasoline interface to obtain the true water table elevation.

4.3 Has the appropriate purging equipment been selected based on the depth to the water table, amount of water, well diameter, and the volume of water to be removed (usually three to five times the water standing in the well)? (See Exhibit 17 for more information on purging equipment).

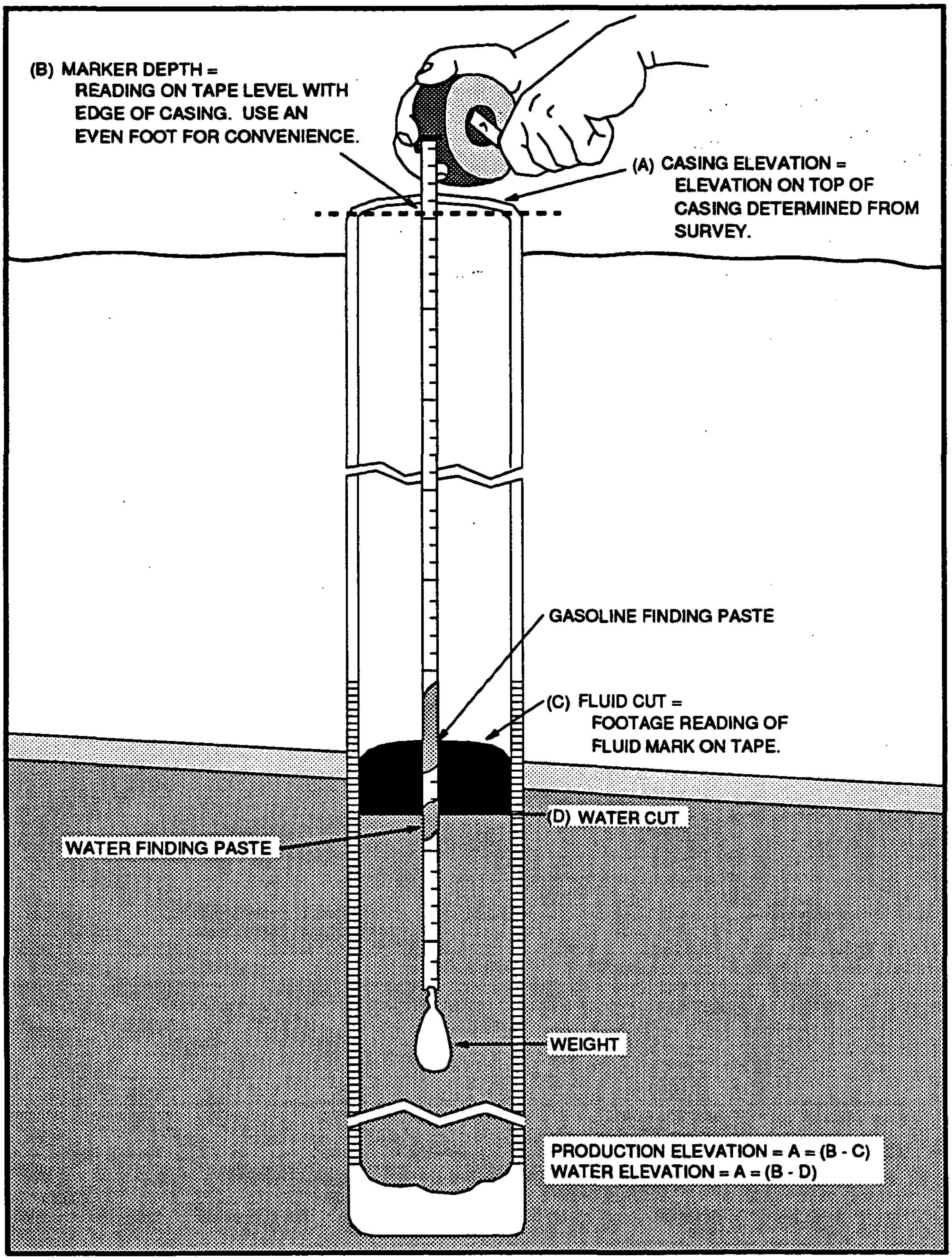
4.4 Were well water purging techniques satisfactory?

This may entail the following:

- Operating pumping equipment in accordance with manufacturer's instructions, or bailing the well a designated number of times using clean tubing and/or bailers; and

EXHIBIT 16

Method to Determine Water Table Elevation and Product Thickness



Source: Reprinted courtesy of the American Petroleum Institute, "Underground Spill Cleanup Manual," Publication #1628, First Edition, June 1980.

EXHIB[redacted] 17

Purging Equipment

Diameter Casing	Bailer	Peristaltic Pump	Vacuum Pump	Airlift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump with Packer
1.25 inch								
Water level <25 ft		x	x	x	x			
Water level >25 ft.				x				
2-inch								
Water level <25 ft.	x	x	x	x	x	x		
Water level >25 ft.	x			x		x		
4 inch								
Water level <25 ft.	x	x	x	x	x	x	x	x
Water level >25 ft.	x			x		x	x	x
6 inch								
Water level <25 ft.				x	x		x	x
Water level >25 ft.				x			x	x
8 inch								
Water level <25 ft.				x	x		x	x
Water level >25 ft.				x			x	x

Source: Barcelona, M.J., J.P. Gibb and R.A. Miller. A Guide to the Selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, IL. 1983.

- Disposing contaminated discharge water and free product appropriately. Options include treating discharge water on site (using an air stripper and/or carbon adsorption system), discharging to the sewer if allowed (a permit may be required), or collecting and hauling off site. Refer to the appropriate State regulatory standards for guidance.

Purging and sampling may be complicated if free product is present. Common options include the following: choosing not to sample; bailing, followed by use of sorbent material to swab the floating product off the surface of the well water; and installing dedicated wells/samplers below the free product (e.g., a cluster well or a gas-driven sampler which can be isolated to collect from a specific depth).

4.5 Have samples been obtained using the appropriate equipment and collection method?

Following the recharge of the well, samples should be collected using a pre-cleaned bailer (e.g., stainless steel, Teflon[R], or polyvinyl chloride — PVC) attached to a clean cable. (Samples obtained from a pump can compromise the quality of results since volatilization can occur prior to sampling.)

STOP

The quality of groundwater samples can be affected by the following:

- Excessive turbulence during sampling;
- Inadequate cleaning of sampling equipment (bailers) between wells;
- Incorrect selection, use, and labelling of sample containers; and
- Insufficient temperature and quality control during sample handling (e.g., samples should be transported and stored in ice-packed cooler).

4.6 Has all pertinent information been recorded in a field notebook and on the labels?

Typically this includes well number, date, time, sampler, project name/ID#, and for laboratory analyses the type of preservative and analytical method should be identified.

Assessment of Groundwater Contamination

Step 5 Has an accurate assessment of groundwater contamination been made?

Based on the analytical results, a determination can be made about the presence and extent of groundwater contamination. This assessment is necessary to help determine the need for additional sampling, protection of additional groundwater users, and/or cleanup.

Consult with State drinking water offices to determine if contamination levels exceed their criteria. Additionally, sample results can be compared to background data (representative of conditions around the site). The site data may then be plotted on a site plan to delineate the limits of the contaminant plume.

STOP

> If a nearby downgradient stream or river exists, it may be a good idea to collect a surface water sample. The results can provide valuable information on the downgradient extent of a plume assuming the ground water and surface water are interconnected (i.e., the ground water discharges to the stream).

Free Product Removal from Ground Water

Step 6 Has an effective means of removing free product from ground water been initiated?

To prevent free product from acting as an ongoing source of groundwater contamination (or flammable vapors which could lead to a health and safety hazard), free product removal can be implemented.

Generally, the preferred free product recovery technologies are the trench method and the recovery well method. Barriers may also be used in conjunction with recovery systems to enhance their effectiveness. For more information, see Exhibits 18, 19, and 20 and the References for "Remediation."

EXHIBIT 18

Free Product Recovery

Option A: Trenches or drains

Trenches function as relatively simple passive systems for the collection of free product (see Exhibit 19). They are particularly effective at sites with shallow ground water (at depths less than 10 to 15 feet), in open areas, and in soils with low permeability (e.g., 10^{-7} cm/sec). To determine if a trench has been properly located and installed, it is necessary to review the following: the depth to ground water; the direction of flow; observations of product ponding in the trench; the effect of any pumping of water from beneath the product; the length of the trench; and the soil conditions. (Crushed stone or gravel may need to be added for support in long-term trenches.)

Option B: Recovery wells

Recovery wells can also be used as retrieval systems and are best suited for confined spaces, where ground water is at depths greater than 20 feet, and where soils have moderate to high permeabilities.

When a single pump system is used, the drawdown created during pumping needs to be sufficient to control contaminant migration. Storage, treatment, and disposal of the removed fluids (which are a mix of product and water) must be addressed in accordance with State and Federal requirements. Special permits may be necessary for managing removed fluids (see Exhibit 19).

Dual pump systems employ separate pumps for water and for product and therefore reduce the amount of contaminated water which must be handled. As a result, these systems are advantageous for large volume spills (see Exhibit 19).

Option C: Barriers

As part of the retrieval system, barriers may be necessary to minimize withdrawals of large volumes of water (see Exhibit 20). Barriers may include:

- Sheet Piles - Due to substantial costs involved and unpredictable wall integrity, sheet piles are generally used for temporary dewatering during other construction efforts or as erosion protection where some other barrier, such as a slurry wall, intersects flowing surface water.

- Grouting - Generally used to seal voids in rocks.

- Hydraulic barriers - Can be used at sites directly over moderate or highly productive aquifers, as well as those with low permeability soils, as part of a manifolded system with automated controls.

- Slurry walls - Installation can be less expensive than alternatives. Most applicable at sites where the wall depth will be less than 80 feet; also, presence of bedrock or impermeable layer is beneficial for "keying" or connecting the bottom of the wall.

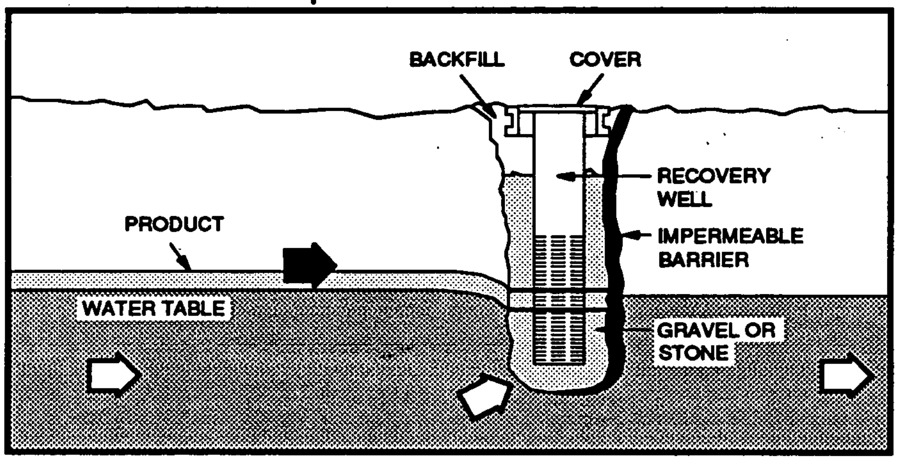
For more information see References for "Remediation".

Source: ICF Inc.

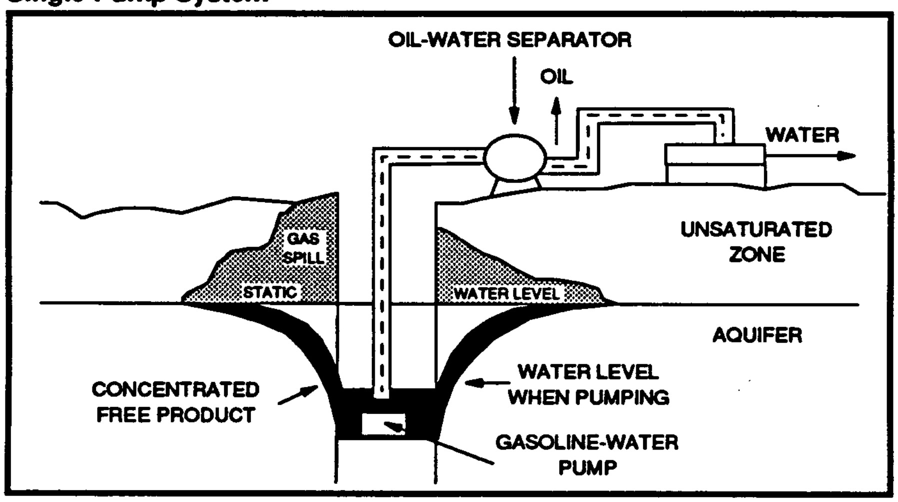
EXHIBIT 19

Trenches and Recovery Wells

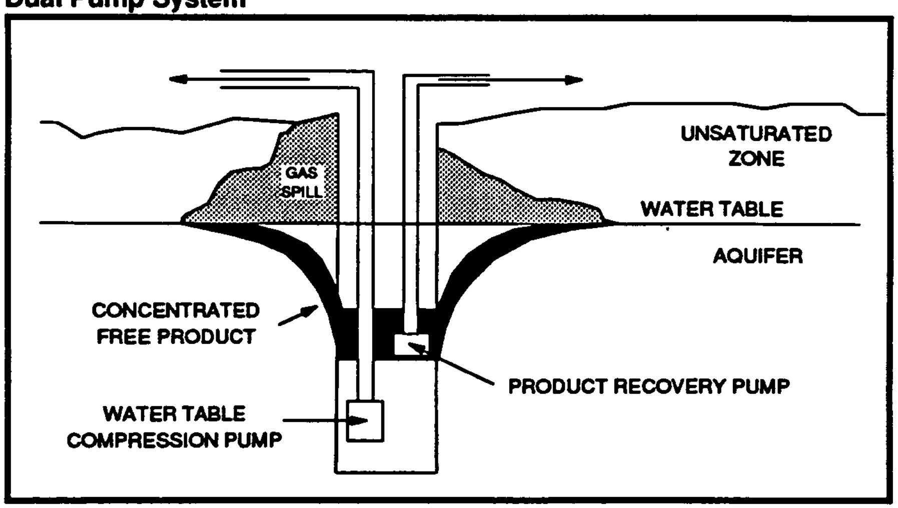
Cross Section of Interceptor Trench [1]



Single Pump System [2]



Dual Pump System [2]

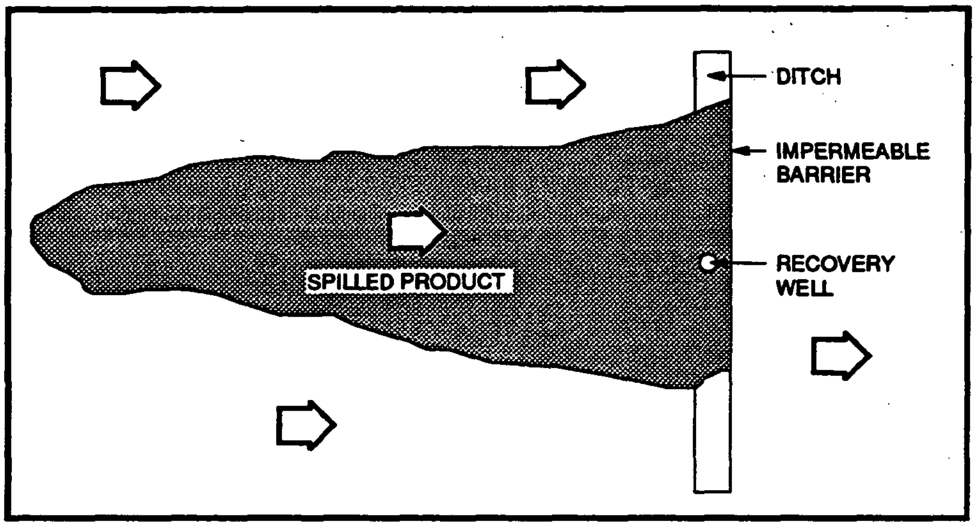


Sources:
1. Reprinted courtesy of the American Petroleum Institute,"Underground Spill Cleanup Manual," Publication #1628, First Edition, June 1980.
2. Cleanup of Releases from Petroleum USTs: Selected Technologies, U.S. Environmental Protection Agency, April 1988.

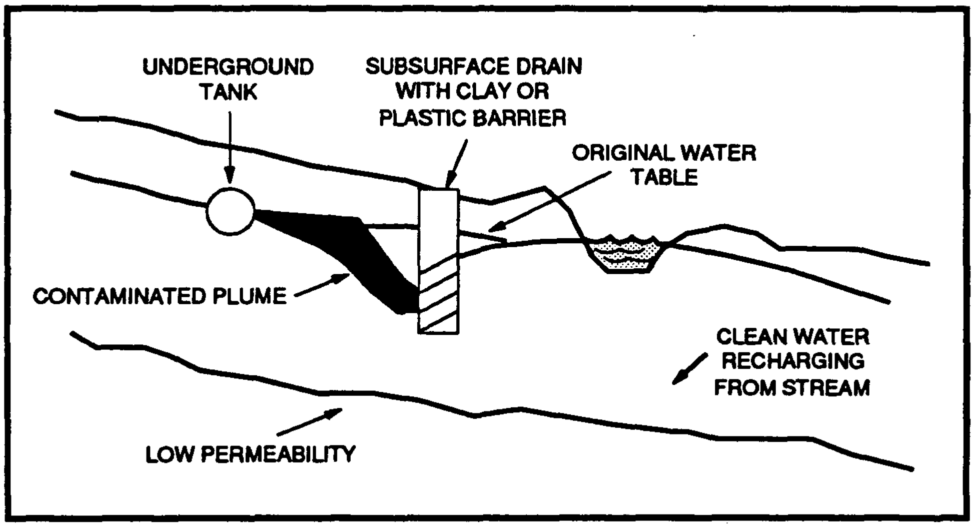
EXHIBIT 20

Barrier Installations

Plan View of Barrier with Recovery Well [1]



One-Sided Subsurface Drain with Clay or Plastic Barrier [2]



Sources:
1. Reprinted courtesy of the American Petroleum Institute,"Underground Spill Cleanup Manual," Publication #1628, First Edition, June 1980.
2. Underground Storage Tank Corrective Action Technologies, U.S. Environmental Protection Agency, reprinted from JRB Associates, January 1987.

Determination of Groundwater Uses

Step 7 Have both the existing and future uses of ground water been determined to further identify the potentially affected community?

Before deciding if additional alternative water supplies are necessary, inspectors may need to complete or review an assessment of groundwater use.

7.1 Have the designated or planned uses of the ground water been determined?

This may involve the following:

- Checking the State classification system;
- Reviewing regional and/or local classification systems and planning documents; and
- Identifying special restrictions pertaining to the designation.

7.2 Has existing groundwater use been evaluated by checking new information against that gathered in Chapter II, Initial Response, Step 6 on page 16?

Alternative Water Supplies

Step 8 Have additional alternative water supplies been provided, if necessary?

Depending on the extent of contamination and the feasibility of aquifer restoration, a temporary and/or emergency water supply may be needed until a permanent alternative water supply is found, or until the existing supply is restored. (See Chapter II, Initial Response, Step 7 on page 17 for more information on temporary alternative water supplies.)

If the situation is such that the existing water supply is irrevocably damaged, permanent alternative water supplies may be provided by one of the following techniques:

- Blending the existing municipal water supply with an alternative supply;

- Purchasing a new municipal water supply from a neighboring unit;
- Providing a new central municipal system using a surface water supply;
- Developing a new groundwater well for municipal or private supply systems; and
- Determining the feasibility of extending municipal water supply lines or developing new wells or surface water sources as alternatives for private wells.

Reporting Requirements

Step 9 Have owners/operators submitted all information relating to the groundwater investigation and cleanup to the State?

Owners/operators should comply with existing State and Federal reporting requirements concerning the investigation and subsequent remedial activities associated with groundwater contamination. Owners/operators should report the steps taken to delineate the extent of contamination, the estimated quantity, type, and thickness of free product observed and measured, the type of recovery system, and the extent of free product removal. Additionally, owners/operators may be required to develop a Corrective Action Plan for responding to contaminated ground water.

SITE NAME/ID#: ______________________________

SITE COORDINATOR: ______________________________

		Date Completed/ By Whom
Step 1:	Have monitoring wells been sited in strategic locations so as to allow sampling upgradient and downgradient of the contamination source?	__________
Step 2:	Have monitoring wells been installed correctly?	__________
Step 3:	Have groundwater flow characteristics been determined?	__________
Step 4:	Have groundwater sampling procedures been correctly implemented?	__________
Step 5:	Has an accurate assessment of groundwater contamination been made?	__________
Step 6:	Has an effective means of removing free product from ground water been initiated?	__________
Step 7:	Have both the existing and future uses of ground water been determined to further identify the potentially affected community?	__________
Step 8:	Have additional alternative water supplies been provided, if necessary?	__________
Step 9:	Have owners/operators submitted all information relating to the groundwater investigation and cleanup to the State?	__________

Note: Not every task may be applicable in all situations, and the sequence of steps will vary somewhat from site to site.

APPENDICES

A. VAPOR CONTROL AND TREATMENT OPTIONS

B. TRANSPORT OF CONTAMINANTS

C. TANK REMOVAL, CLOSURE, AND REPAIR ACTIVITIES

APPENDIX A -- VAPOR CONTROL AND TREATMENT OPTIONS

Passive and active vapor control systems can reduce the hazards associated with hydrocarbon vapor migration. These systems are designed to enhance or create a pressure gradient which causes the vapors to flow to a desired collection area (trench or well). From the collection point, vapors are then either released or treated (e.g., by adsorption or catalytic conversion).

It is important to remember that the first steps in any vapor control effort involve the following precautionary measures:

- Using explosion-proof equipment;
- Eliminating ignition sources; and
- Posting warning notices for security.

With both types of systems, inspectors need to be aware of the following:

- Worker health and safety controls are a consideration during installation;
- Preliminary testing may be necessary prior to design; and
- Periodic monitoring of subsurface vapors (and pressure for active systems) may be needed to ensure effectiveness.

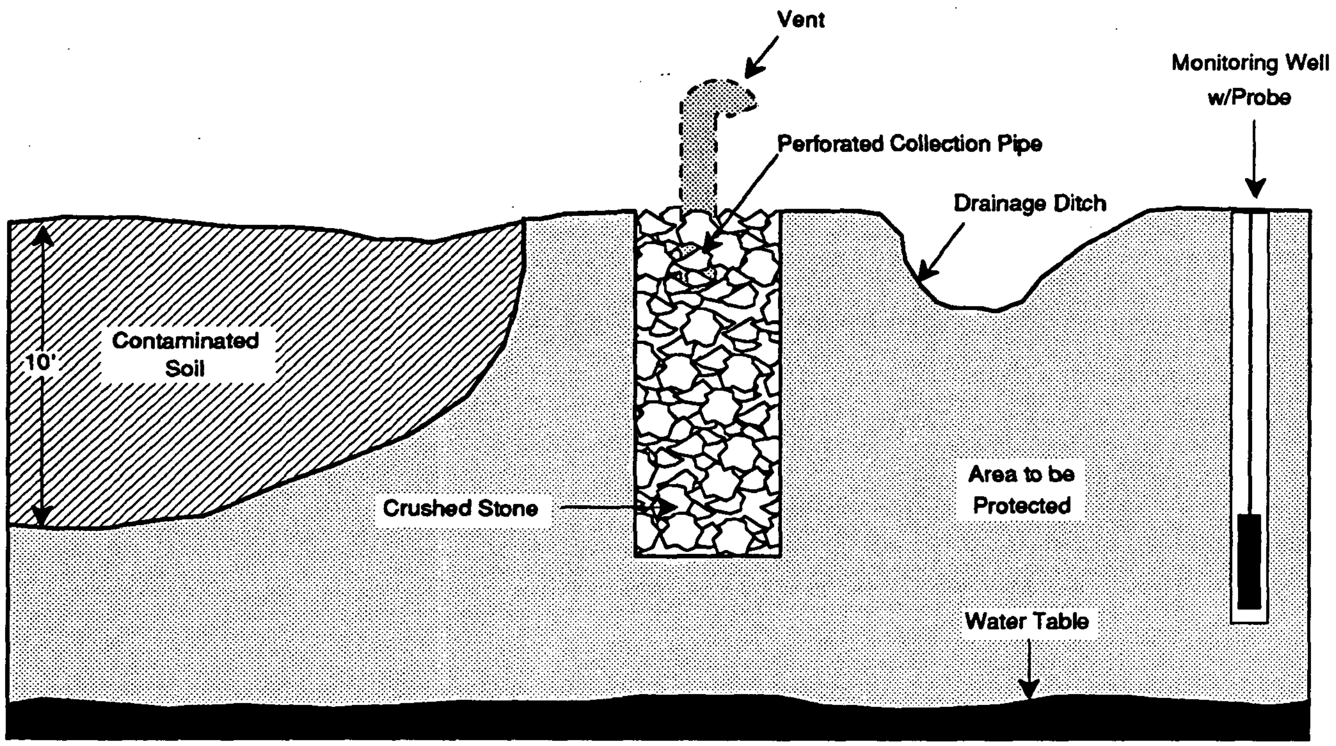
Passive Vapor Control Systems

Passive vapor control systems typically involve the installation of trenches or wells just outside the area of contamination. The trenches may be open or filled with permeable crushed stone. Perforated pipes and vent stacks may also be installed. (See Exhibit A-1.) Passive systems are most suitable for sites where small volume losses have occurred, soils have high permeabilities, and a perched water table is not present. Situations where the temperature of the ambient air is cooler than the soil temperatures are also suitable for passive systems.

The advantages of passive systems are that they are relatively quick and easy to install and that they do not require ongoing operation and maintenance. These systems may be limited,

EXHIBIT A-1

Passive Vapor Control System



Note: Vent pipe placement varies with the situation. State Fire Marshalls or local fire departments should be consulted for minimum vent pipe heights.

Source: ICF Inc.

however, by climatic conditions such as heavy rainfall or prolonged freezing, and by low permeability rock formations. The trench method also has limited applicability at sites where the depth to contamination exceeds the capabilities of the equipment (i.e., approximately 20 feet).

Active Vapor Control Systems

Active vapor control systems force the vapors to collection points (usually located within the contamination area) through the use of pumps (positive pressure) or vacuums (negative pressure). The system includes a series of vapor extraction wells, a gas collection unit, control valves, a vacuum or blower, and vents (see Exhibit A-2). Active systems may be used for most site conditions.

The advantages of active systems include: accelerated vapor removal; relatively quick and easy installation; reliability in heavy rainfall or prolonged freezing conditions; ability to isolate areas to be protected; and effectiveness in most geologic conditions (see Exhibit A-3). Negative pressure systems are also excellent for sub-slab venting where gravel fill exists. The disadvantages of active systems include ongoing operation and maintenance requirements, the potential need for treatment of contaminated air, and the potential to direct vapors to previously uncontaminated areas (using positive pressure).

Vapor Treatment Options

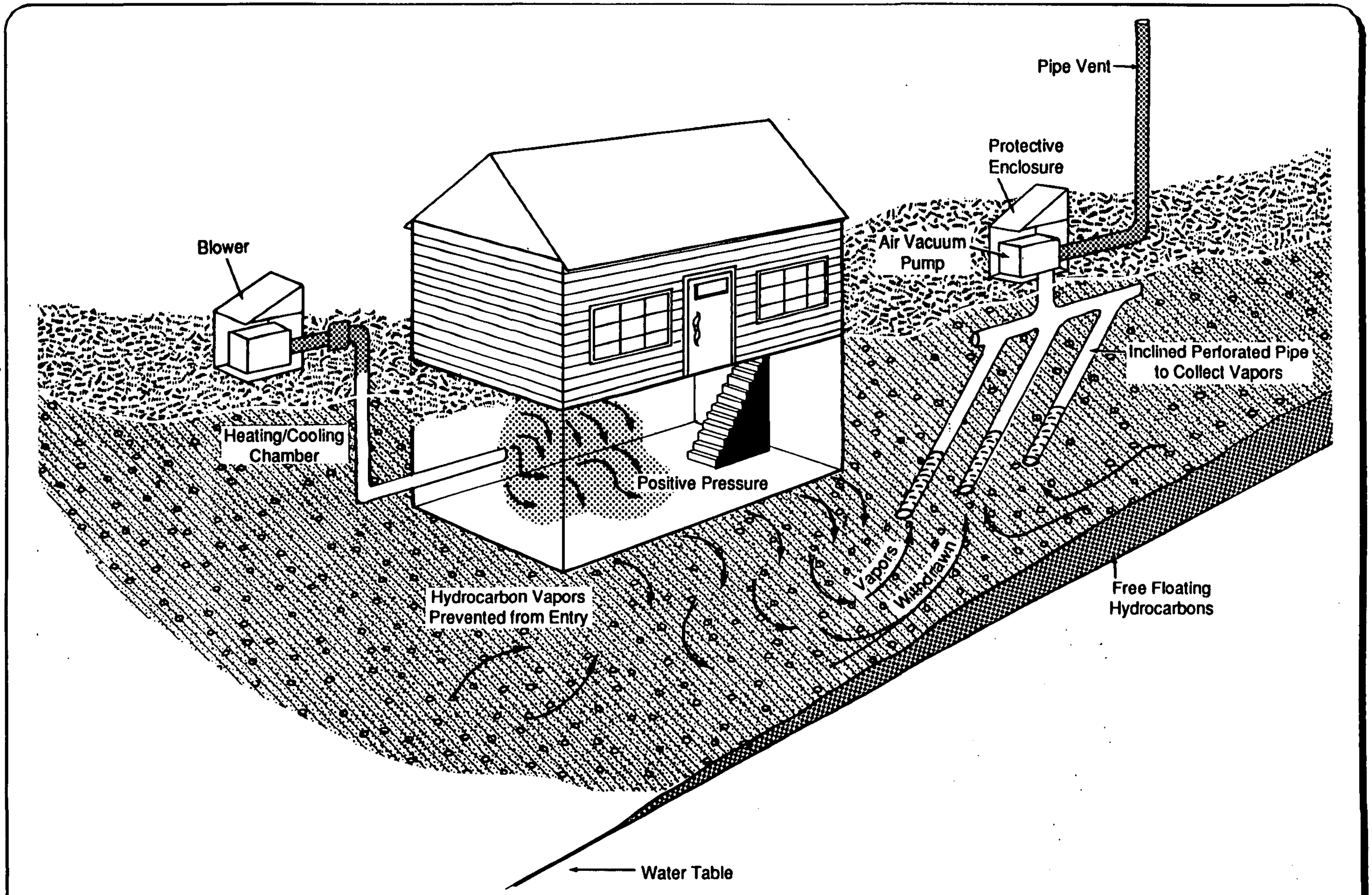
Depending on the specific site and State requirements, vapor treatment technologies may need to be included in the design of an active control system to further control the emissions of hydrocarbon vapors. Two of the more common technologies, adsorption and catalytic conversion, are described here.

Adsorption

Adsorption systems can be very effective at UST sites if they are properly designed and maintained. The selection of a type of adsorption media, i.e., carbon or synthetic resins, will vary depending on the contaminant. Factors to consider when designing an adsorption system include anticipated effectiveness, rate of breakthrough, and disposal/regeneration of the sorption media, as well as the volume of vapor. The actual adsorption capacity of contaminants varies with the material.

EXHIBIT A-2

Active Vapor Control Systems



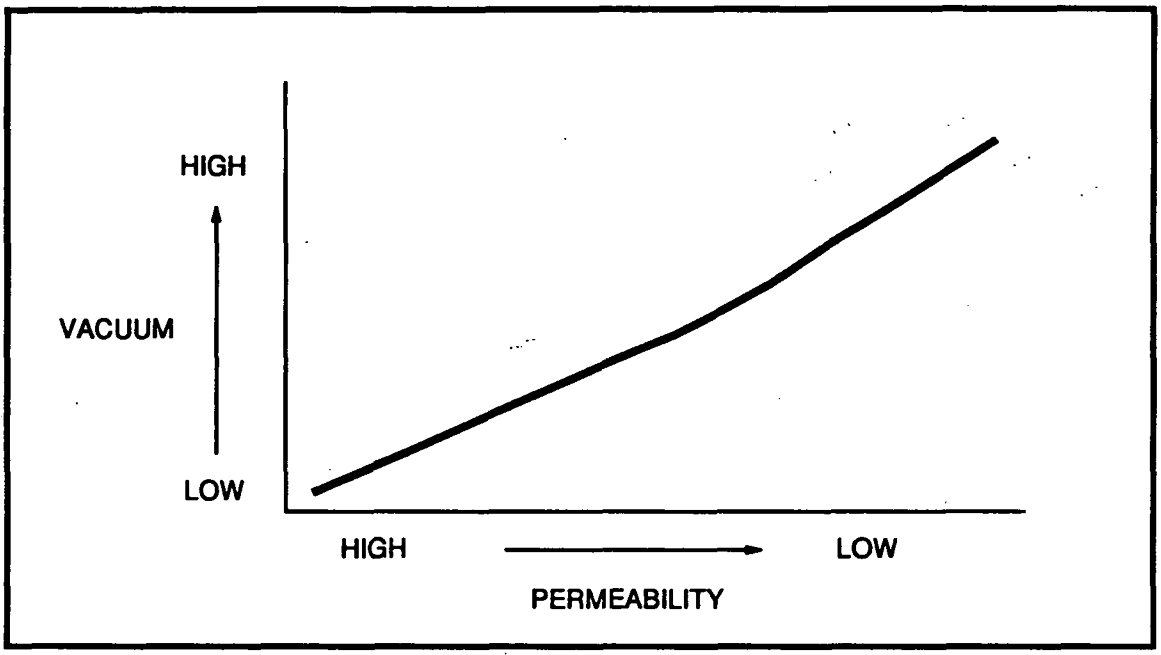
Note: Fire Marshalls or local fire departments should be contacted for regulations concerning active vapor systems.

Source: Groundwater Technology Inc.

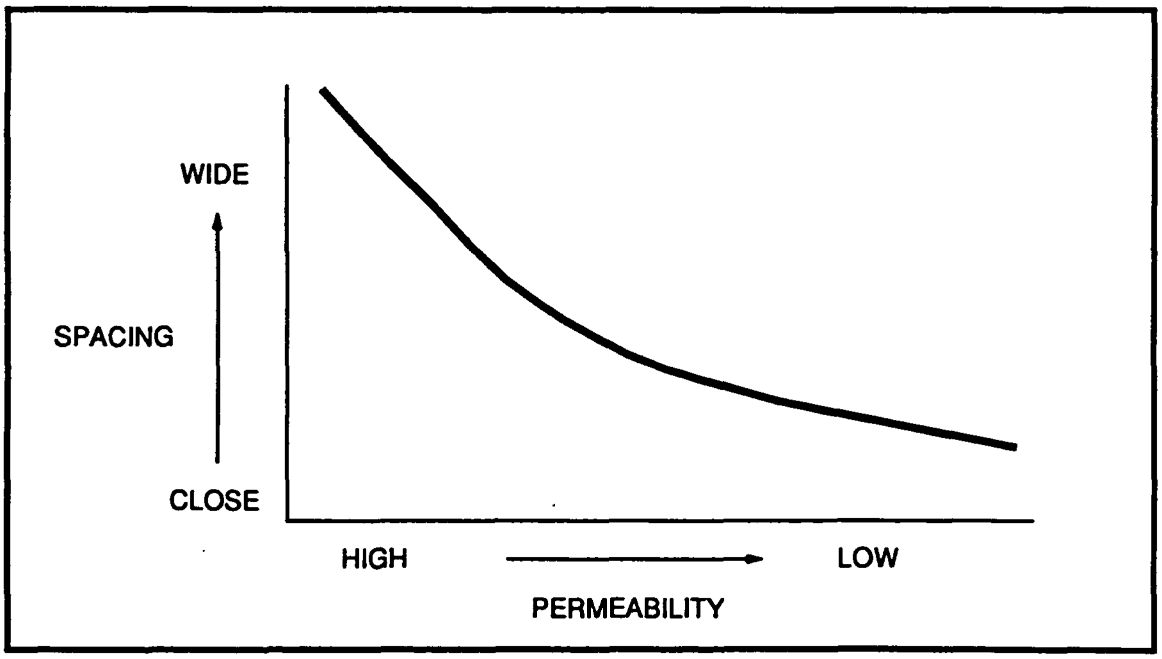
EXHIBIT A-3

General Considerations for Active Vapor Control Systems

General Curve for Vacuum versus Soil Permeability



General Scheme for Well-Point Spacing



Source: Groundwater Technology Inc.

The use of vapor phase carbon as an emergency response mechanism is generally on a finite short-lived basis. Normally, for longer duration use, a catalytic converter or natural diffusion to a soil vent system is more feasible and cost effective. Some of the general rules for carbon adsorption include:

- Vapor phase carbon adsorbs approximately 10 percent by volume of the organics to be collected. Multiple bed systems can be used to increase contact time.

- A small volume 55-gallon drum portable adsorber has approximately 5-6 gallons or 30 to 40 pounds maximum adsorption capacity.

- Under normal vapor input conditions, with 20-50 ppm vol./vol. and a 200 ft^3/minute flow, a typical unit might last 7-10 days before breakthrough.

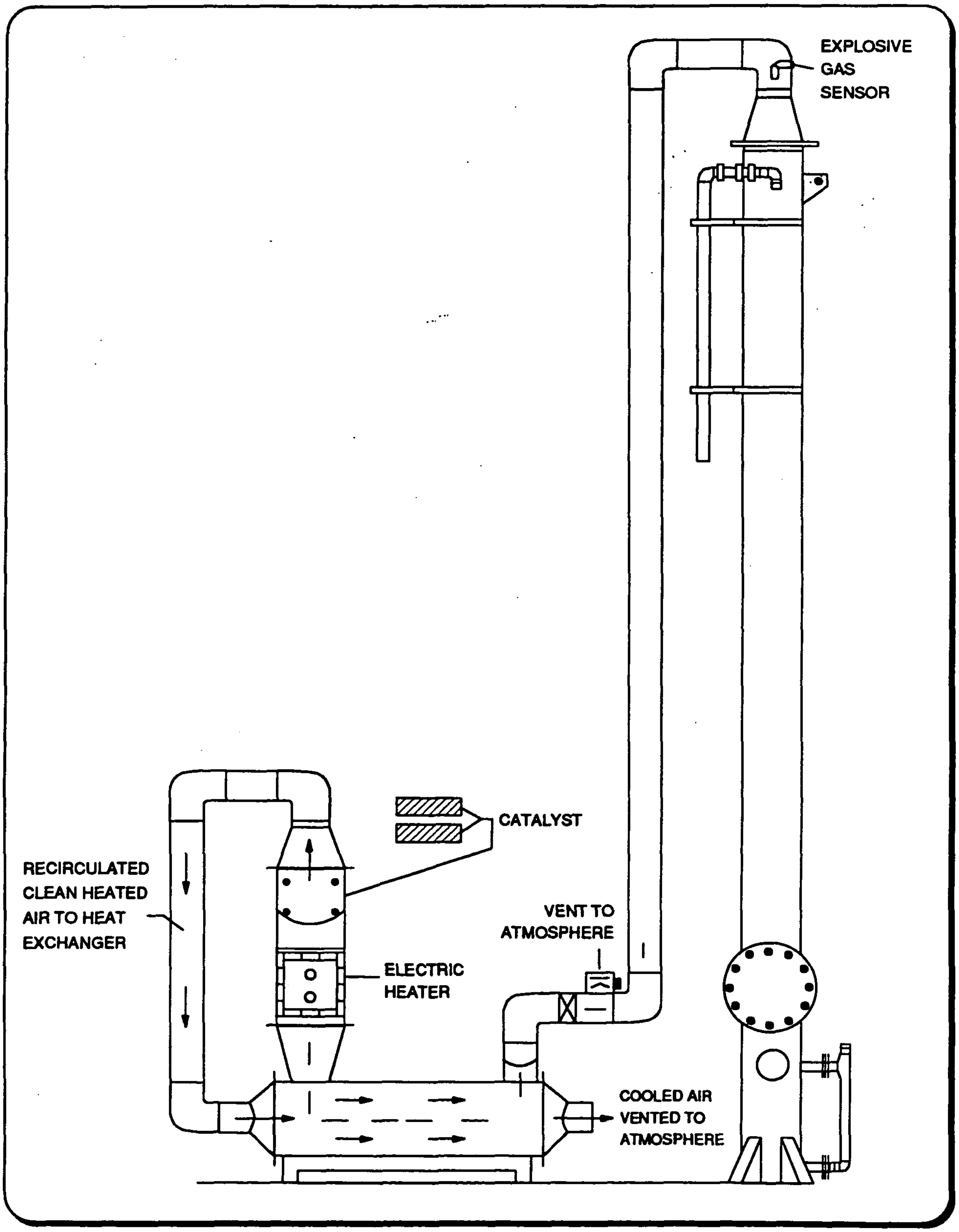
- Alarms and/or shutdown controls may be necessary for complex systems, sensitive locations, or populated areas.

Catalytic Conversion

The catalytic conversion option is an approach for vapor control at sites with low to high level vapor concentrations. Typically, a catalytic converter unit consists of three basic elements — a high efficiency air-to-air heat exchanger, an air heater (electric), and a precious metal catalyst (see Exhibit A-4). During operation, the vapor to be treated is preheated in the heat exchanger and is passed over the catalyst where combustion takes place. During the design phase, safety features and monitoring controls are of primary importance to consider and pilot studies may be necessary. (Flaring — the process of exposing vapors to an open flame with no special features to control temperatures or time of combustion — is another alternative for vapor control. Design and operating conditions for flaring are not readily available, however, and it is not a desirable method for many situations e.g., gas stations or densely populated areas.)

EXHIBIT A-4

Catalytic Converter System



Source: Groundwater Technology Inc.

Unsaturated Soils

The rate and pattern of seepage of petroleum products through unsaturated soils is primarily influenced by the geologic material, the volume, type of contaminant released, and the amount and type of precipitation. (Exhibit B-1 presents the seepage pattern for three hydrocarbon plumes.) To estimate the maximum depth of penetration, the following formula can be applied:

$$D = \frac{Rv\ V}{A}$$

where: D = maximum depth of penetration, m; V = volume of infiltrating product, m^3; A = area of spill, m^2; and Rv = constant for retention capacity and product viscosity based on the chart below.

TYPICAL VALUES FOR Rv*

Soil	Rv** Gasoline	Kerosene	Light Fuel Oil
Coarse Gravel	400	200	100
Gravel to Coarse Sand	250	125	62
Coarse to Medium Sand	130	66	33
Medium to Fine Sand	80	40	20
Fine Sand to Silt	50	25	12

* Source: Shephard, W.D., "Practical Geohydrological Aspects of Groundwater Contamination."
** A constant value representing capacity of soil and viscosity of product.

Saturated Flow

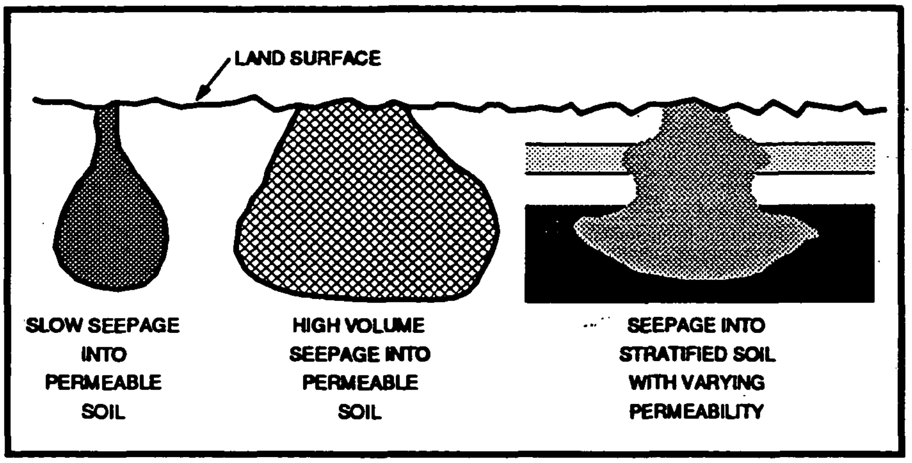
The migration of a plume of dissolved contaminants in the saturated zone is primarily controlled by the characteristics of groundwater flow. As expressed in Darcy's Law, the quantity of flow (Q) is a function of the hydraulic conductivity of the soil material (K), the gradient dh/dl (or I), and the cross-sectional area (A) expressed as:

$$Q = KIA$$

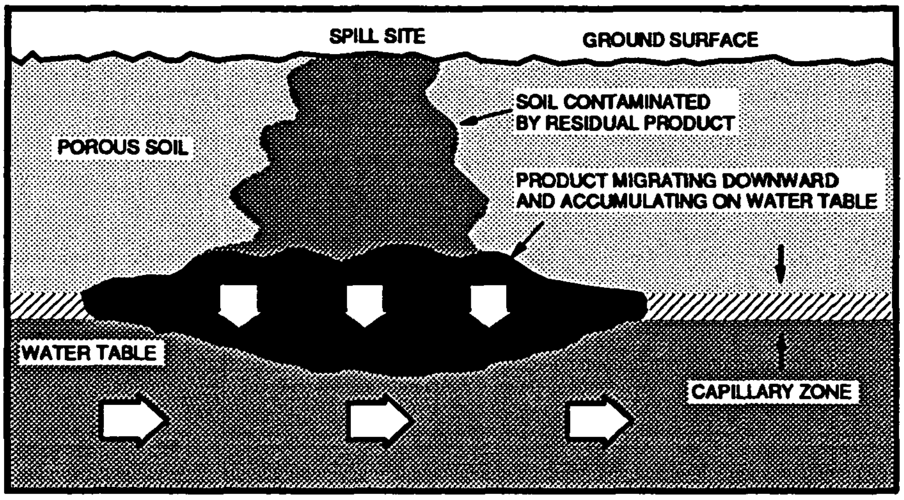
EXHIBIT B-1

Typical Seepage Patterns

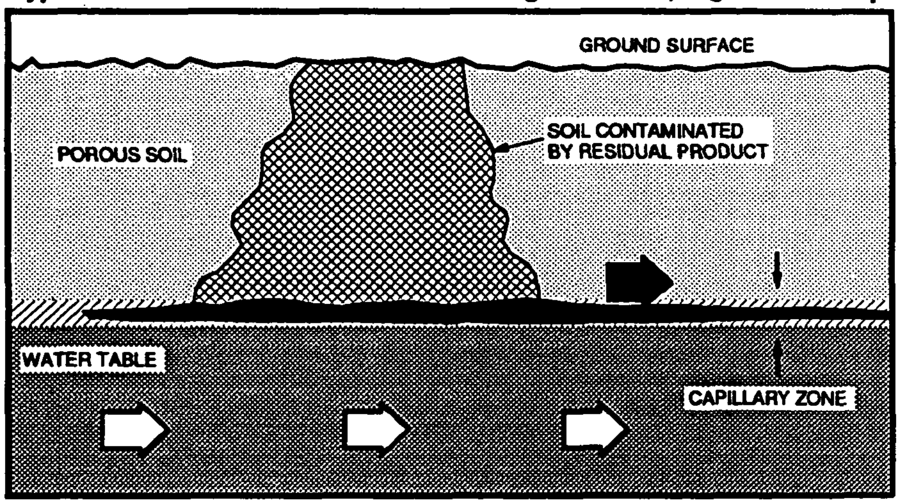
Product Seepage



Behavior of Product after Spill Has Stabilized



Typical Behavior in Porous Soil Following a Sudden, High Volume Spill



Source: Reprinted courtesy of the American Petroleum Institute, "Underground Spill Cleanup Manual," Publication #1628, First Edition, June 1980.

(See Exhibit B-2 for hydraulic conductivities of geologic materials.) Using Darcy's Law as the basis for further calculations, the rate or velocity of flow (v) can be calculated as:

$$v = \frac{KI}{n}$$

where n = porosity.

While Darcy's Law is commonly used to determine groundwater flow characteristics, other factors such as biological degradation, oxidation, and sorption must also be taken into account when determining contaminant transport or dispersion. Because these factors can vary significantly from site to site, dispersion must be calculated on a site-specific basis.

There are no established dispersion rate values, however, there are several methods currently used to estimate transport rates on a site by site basis. The two primary dispersion factors that need to be considered are the rate of longitudinal dispersion and the transverse to longitudinal ratio.

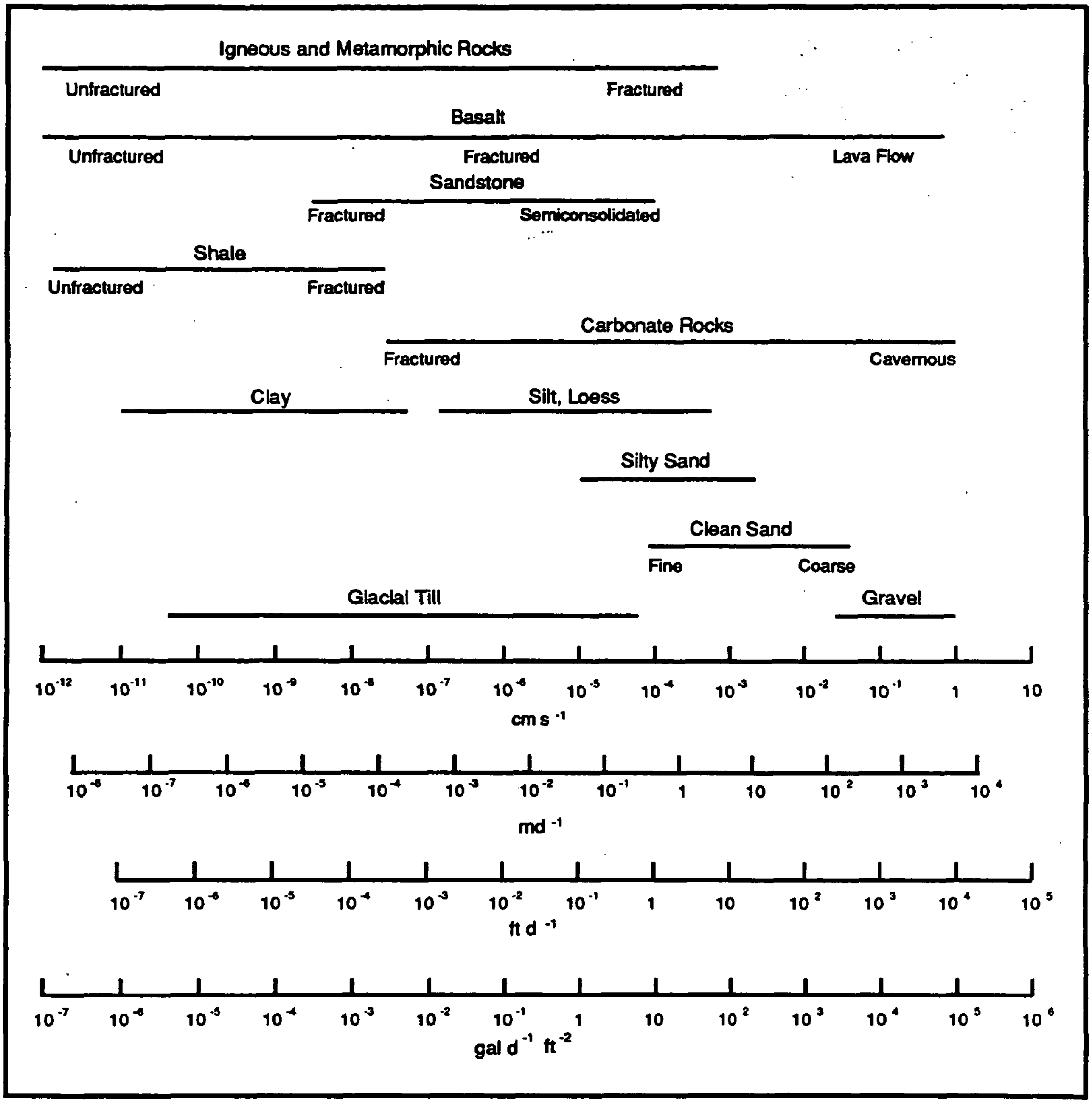
- In general, the rate of dispersion increases as the hydraulic conductivity of the aquifer increases. For example, in medium grained sands the dispersion rate is greater than in fine grained silty sands. (This premise may not be valid if a preferred migration pathway develops, e.g., through cracks in a clay formation or along subsurface manmade lines.)

- The ratio of dispersion in the longitudinal direction vs. the transverse direction decreases as the silt and clay content increases in soils. For example, depending on groundwater flow velocity, in a medium grained sand the ratio ranges from approximately 6:1 to 10:1, while silty and clay sands may have a ratio of about 2:1 to 3:1. (These ratios combine the affects of biodegradation and chemical degradation.)

For more information see the References for "Soil and Groundwater Investigations."

EXHIBIT B-2

Hydraulic Conductivity of Selected Rocks



Source: United States Geological Survey, 1983

The permanent removal or in-place closure of tank systems may be conducted for a number of reasons, including compliance with regulations, and as a condition of a real estate transaction. The determination of whether to excavate and remove a tank permanently, to close it in place, or to repair it depends on a number of factors, such as the location of the tank, State and local regulations, availability of equipment, labor, materials, and associated costs. State and local Fire Marshalls should be consulted to obtain information on specific requirements.

Tank Removal

An understanding of tank removal procedures is important, since site observations made during these removals can often provide the first direct evidence of leaks and the extent of soil contamination. The following steps may be followed during a tank removal:

- Drain the product from the piping into the tank;
- Pump the product from the tank;
- Clean residual sludge from the tank;
- Remove the fill (drop) tube; disconnect the product lines and the fill gauge, and cap or plug all open ends of lines (except vent lines);
- Eliminate explosive conditions in the tank, e.g., by placing dry ice inside (1.5 lbs. per 100 gallons of tank capacity) or by ventilating the tank with air by use of a small gas exhauster;
- Remove the tank and place it in a secure location (i.e., to prevent movement or obstruction);
- Check tank for explosive conditions;
- Remove soil accretion on the outside of the tank as much as possible;

- Check certain parts of the tank for evidence of leakage, i.e., the seams, the tank bottom (particularly the area beneath the fill pipe where stick tests frequently hit the tank), and the parts of the tank which are located near patches of stained soils;

- Plug or cap all openings, except the vent, after vapor removal; and

- Check for explosive conditions and secure the tank on a truck for transportation to the disposal site.

Note that, if possible, arrangements for a disposal site should be made prior to excavation. With the ongoing capacity shortages at landfills and recent regulations restricting land disposal, it may take time to finalize an agreement with a disposal site. In those cases, an open excavation or stockpiled soils could pose unnecessary risks during the negotiation period. Similarly, arrangements should be made for a supply of clean fill or security fencing for a site before beginning operations.

Managing soils during removal is another aspect of the project that should be planned. Some States prohibit any contaminated soils from being placed back in an excavation during a tank removal, even if more extensive soil removal will need to be conducted in the near future. In some situations, however, it is possible to place plastic sheeting between unexcavated contaminated soils and new clean fill. This helps facilitate partial separation of the soils so they can be placed in separate stockpiles when the comprehensive excavation is conducted.

Tank Closure

Tank closure (in place) is often a viable option when a tank removal would be extremely difficult (i.e., a tank is located directly underneath a building, and/or removal would severely disrupt a facility's operations). As with tank removals, in-place closures involve emptying the tank of all liquids and dangerous vapors and cleaning out the accumulated sludge. Additionally, a tank closed in place should be filled with a harmless, chemically inactive solid, such as sand, concrete or urethane foam.

In order to ensure that a tank being closed in place is not responsible for any contamination, a site assessment must be conducted prior to the completion of closure activities. If any contaminated soil and/or ground water or any free product is discovered during this assessment, the owner/operator will need to report the release and conduct appropriate clean-up measures.

Tank Repair

Tank repair is an alternative to tank removal or in-place closure. It is important that the person repairing the tank follow standard industry codes that explain the correct procedures for repairing tanks and demonstrating that the tank repair was successful. This demonstration is usually made by inspecting the tank internally with an electrical detector. Other methods include conducting a tightness test or conducting another leak detection test that is approved by the State regulatory authority. It is also required that USTs with cathodic protection be tested (within six months) to determine if the cathodic protection is continuing to work properly following the construction activities.

For more information on tank removal, closure, or repair activities, see the References for "Remediation."

Worksheets

1. Site History and Tank Information

2. Preliminary Review of Impacts of Release

3. Evaluation of Anticipated Site Conditions

4. Preparation for Field Operations

WORKSHEET 1 — SITE HISTORY AND TANK INFORMATION

SITE NAME/ID#: ______________________________

SITE COORDINATOR: ______________________________

DATE/TIME: ______________________________

SITE LOCATION/ADDRESS: ______________________________

____

____

____

COUNTY/CITY: ______________________________

SITE CONTACT: ______________________________

TELEPHONE: ______________________________

NAME AND ADDRESS OF OWNER/OPERATOR(S):

______________________________ ______________________________

______________________________ ______________________________

______________________________ ______________________________

______________________________ ______________________________

NOTIFICATION (name and date of incident report):

______________________________ ______________

DESCRIPTION OF LOSS:

____

____

____

____

____

LOCATION OF TANKS (attach site plan or sketch):

WORKSHEET 1 — SITE HISTORY AND TANK INFORMATION (Continued)

TANK DESCRIPTION:

Volume (gallons)	Fuel Type	Construction Material	Age
___	___	___	___
___	___	___	___
___	___	___	___
___	___	___	___

CAUSE OF RELEASE (Circle One):

A Catastrophic
B Long-Term Leakage
C Overfilling
D Unknown
E Other — Describe ______________________

LOCATION OF FAILURE(S) (sketch on plan):

A Tank
B Lines
C Connections
D Other
E Undetermined

TANK TEST RESULTS (recorded leakage rate, attach results):

____

____

____

INVENTORY LOSS (period of records, percent loss, and volume accounted for):

____

____

____

____

HISTORY OF TANK USAGE (on site and in the area around the site, e.g., could a removed or abandoned tank or an off-site tank have contributed to the problem?):

____

____

____

____

WORKSHEET 1 — SITE HISTORY AND TANK INFORMATION (Continued)

LOCAL CONTACTS (list individuals to contact):

Department/Affiliation	Name	Telephone Number
FIRE	______________________	______________
HEALTH	______________________	______________
EMERGENCY RESPONSE/ HAZARDOUS MATERIALS	______________________	______________
ENGINEERING	______________________	______________
PUBLIC WORKS/WATER AND SEWER	______________________	______________
ASSESSORS	______________________	______________
U.S.G.S. AND SOIL SURVEY	______________________	______________
SITE EMPLOYEES	______________________	______________
NEIGHBORS	______________________	______________
	______________________	______________
	______________________	______________

Note: Use the attached telephone and/or site inspection logs to record information on: past site use; availability of maps, soil borings, or well logs; proximity to drinking water supplies; waste oil disposal practices; and location of underground lines.

TELEPHONE LOG

SITE NAME/ID#: ____________________

SITE COORDINATOR: ____________________

DATE/TIME: ____________________

CONTACT: ____________________

DEPARTMENT/
AGENCY: ____________________

____

TELEPHONE NUMBER: ____________________

SUMMARY: ____________________

____

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SITE INSPECTION LOG

SITE NAME/ID#: ______________________________

SITE COORDINATOR: ______________________________

DATE/TIME: ______________________________

PURPOSE OF VISIT: ______________________________

____

____

SUMMARY OF SITE ACTIVITY: ______________________________

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SIGNATURE

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WORKSHEET 2 — PRELIMINARY REVIEW OF IMPACTS OF RELEASE

SITE NAME/ID#: ______________________________

SITE COORDINATOR: ______________________________

DATE/TIME: ______________________________

CURRENT SITUATION: ______________________________

____

____

____

AFFECTED AREA (Residential, Commercial, or Industrial?): ______________

NUMBER OF PERSONS AND/OR HOUSEHOLDS WITH AFFECTED DRINKING WATER:

____

SOURCE OF WATER SUPPLY: ______________________________

ALTERNATE WATER SUPPLY AVAILABLE (If yes, what type?): ______________

____

NUMBER OF PERSONS WITH POTENTIALLY AFFECTED WATER: ______________

NUMBER OF PERSONS KNOWN AND/OR POTENTIALLY AFFECTED BY VAPORS:

____

VAPOR TREATMENT (provide detail, if any): ______________________________

____

DEPTH TO GROUND WATER/METHOD TO DETERMINE: ______________________________

____

SOIL PERMEABILITY (circle one): Low Medium High

SOIL CHARACTERISTICS: ______________________________

____

DEPTH TO BEDROCK: ______________________________

SITE CONDITIONS WHICH COULD AFFECT PLUME MIGRATION: ______________

____

PRELIMINARY RECOMMENDATIONS FOR INVESTIGATIVE/REMEDIAL APPROACH:

____

____

____

WORKSHEET 3 — EVALUATION OF ANTICIPATED SITE CONDITIONS

To determine if a proposed scope of work satisfactorily addresses specific site conditions, an inspector may want to answer the following questions. Some questions addressed during the early stages of a cleanup may need to be reexamined later.

INITIAL RESPONSE

1. **What are the anticipated soil conditions? Is a sand and gravel layer present; if so how thick?**

2. **What is the estimated minimum depth from ground surface to the water table? What are the seasonal low elevations and possible tidal influences?**

3. **Do any man-made features exist which could act as conduits for contaminant migration?**

4. **What are the unique site features (e.g., on-site or nearby streams) which might influence site conditions?**

LIMITED SITE INVESTIGATION

5. **Is any contaminated soil found in past borings? Where? How far from the water table? What contaminants were identified?**

6. **Are any bedrock outcroppings located on or near the site?**

WORKSHEET 3 — EVALUATION OF ANTICIPATED SITE CONDITIONS (Continued)

7. Do any borings show indications of encountering bedrock? If so, are any fractures or joints identified which may provide conduits for contamination?

8. What is the hydraulic conductivity of the soils? (See Appendix B.) What is the anticipated time it will take for contaminants to reach the ground water?

9. Has a confining layer been identified? If so, is contamination expected to be present below? Were past deep borings adequately sealed between strata?

10. What is the anticipated direction of groundwater flow?

11. What are the locations and depths of nearby and downgradient drinking water wells?

WORKSHEET 4 — PREPARATION FOR FIELD OPERATIONS

Prior to initiating field work for a subsurface investigation, the following measures may be taken by the owner/operator/contractor:

1. Obtain permission from property owners, preferably in writing. ________

2. Notify the appropriate utility companies or central notification organization. (Record date and contact person). ________

3. Locate and mark the following lines:
   - gas ________
   - telephone ________
   - sewer ________
   - power ________
   - water ________
   - oil ________

4. Check available site plans to identify the additional utility lines not marked by the utility companies (e.g. connecting service lines branching off from the main lines). ________

5. Review available information on site conditions (such as type of soil, anticipated depth to ground water, and proximity to nearby surface water bodies) as well as information on history of site and adjoining properties as identified in Worksheets 1 & 2. ________

6. Sketch boring/excavation location plan. Select general locations and depths for test pits or (at least three) test borings and/or observation wells based on the available information. Check locations to verify that overhead and underground obstructions are avoided. Typically, at least one boring/well should be located upgradient. ________

7. Choose the appropriate sampling/excavation technique based on the anticipated conditions at the selected locations. (See Exhibit 11 on page 42 for Well Drilling Methods.) Test pits or trenches may be used when visual observation of a continuous area is desired. However, test pits have limited depth; for example, they typically can only extend a few feet below the water table. ________

WORKSHEET 4 — PREPARATION FOR FIELD OPERATIONS (Continued)

8. Address the following miscellaneous issues:

   a. Confirm the following with contractors: site location and directions, meeting time, and necessary equipment (drilling equipment request should include estimated quantities of rods, augers, casing, well screen, grout, and lock boxes). ________

   b. If decontamination is required, make provisions for steam-cleaning equipment and collection and disposal of rinse water. Check with the appropriate implementing authority on rinsewater disposal. ________

   c. Confirm availability of drilling water if rotary drilling is to be used. ________

   d. Develop health and safety information (including the locations of the nearest hospitals) and maintain on the site. ________

9. Gather all the equipment and materials necessary for field inspection identified on the attached Equipment List. ________

EQUIPMENT LIST

In order to minimize errors and delays, prepared field personnel will typically be equipped with the following items:

- Field Notebook
- Weighted tape (may also need chalk, paste, interface probe, and/or electric water level reader)
- Protective gloves
- Clean sample containers
- Labels
- Waterproof markers
- Cooler (with ice or dry ice)
- Spray paint/stakes/flagging
- Log sheets
- Decontamination fluid
- Paper towels
- Camera and film
- Bailers and cable and/or pump with tubing
- Plastic bags (e.g. for duplicate samples and contaminated equipment)
- Key to protective casing or road box over well
- Jackknife, large screwdriver, hammer, channel lock pliers
- Directions to site, site plan, emergency telephone numbers
- Hard hat and steel-toe boots

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VIDEO ORDERING INFORMATION

"Tank Closure Without Tears: An Inspector's Safety Guide"

- Focuses on the problems of explosive vapors, safe tank removal and closure (30 minutes).

Purchase: Video and companion booklet: $25.00 prepaid
Booklet only: $5.00 prepaid
Order from: New England Interstate Water
Pollution Control Commission
Attn: VIDEOS
85 Merrimac Street
Boston, MA 02114

VIDEO ORDERING INFORMATION (CONTINUED)

Loan: Video and companion booklet: $5.00 prepaid

Order from: New England Regional
Wastewater Institute
2 Fort Road
South Portland, ME 04106

PURPOSE, CONTENT, AND ORGANIZATION

References