PARTIAL CLOSURE PLAN
FOR
HAZARDOUS WASTE TANKS
SAFETY-KLEEN CORPORATION SERVICE CENTER
OAKLAND, CALIFORNIA

4-89

APRIL 1989

GROUNDWATER TECHNOLOGY, INC.
CONCORD, CALIFORNIA

PARTIAL CLOSURE PLAN
FOR
HAZARDOUS WASTE TANKS
SAFETY-KLEEN CORPORATION SERVICE CENTER
OAKLAND, CALIFORNIA

APRIL 17, 1989

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FOR
HAZARDOUS WASTE TANKS
SAFETY-KLEEN CORPORATION SERVICE CENTER
OAKLAND, CALIFORNIA
MARCH 14, 1989

I. INTRODUCTION

Safety-Kleen Corporation is planning to remove the existing underground storage tanks located at their Oakland Service Center for replacement with double-walled tanks in accordance with Part 265.193(a)(3), Title 40, Code of Federal Regulations (40 CFR). This partial closure plan is being submitted to the California Department of Health Services (DHS) and the U.S. Environmental Protection Agency (EPA) and describes the procedures which will be implemented during the removal and replacement. The applicable regulations governing this closure are included in Sections 23 and 25 of Title 22, California Administrative Code (CAC) and Part 265 of 40 CFR. As required by Sections 67212(b), Title 22, CAC and 40 CFR Part 265.112(a), a copy of the approved closure plan will be maintained at the facility until closure is certified complete.

REGULATORY STATUS

The Safety-Kleen Oakland Service Center has been operating as an interim status hazardous waste storage facility. No hazardous waste treatment or disposal activities are conducted at the site.

The regulated waste management units at the Oakland Service Center include a container storage area for used immersion cleaner, dry cleaning wastes and mineral spirits dumpster sludge, as well as, two underground storage tanks for used mineral spirits. It should also be noted that there is a third underground tank located at the site which is used to store clean mineral spirits. This tank is regulated as a hazardous materials underground tank by the Alameda County Health Care Services Agency, Department of Environmental Health and California Regional Water Quality Control Board, San Francisco Bay Region.

CLOSURE PERFORMANCE STANDARD

Safety-Kleen will be performing a partial closure of their hazardous waste facility. The two underground storage tanks will be closed and replaced with new, double-walled tanks. The container storage area will remain in operation.

A pre-closure assessment was performed by Groundwater Technology, Inc. (GTI) during the period of June through September 1988. This work included a soil-gas survey, precision testing of the underground tanks and lines, soil sampling, installation of monitoring wells, and groundwater sampling. This work was documented in GTI's Interim Update Report dated September 9, 1988. Although the tanks themselves were found to not be leaking, several piping and fitting leaks were discovered and subsequently repaired. Soil contamination, free-floating product and dissolved product were detected in on-site borings located around the underground tank area.

As discussed in detail in Section IV of this Closure Plan, the closure of the underground storage tanks will involve physical removal of the tanks and associated piping as well as some of the contaminated soil. Remediation procedures will also be conducted to remove the free-floating product and treat the contaminated groundwater and soil. In this manner, all waste residues, system components, and contaminated soils will be removed or decontaminated during closure in accordance with 40 CFR Part 265.197 (a) and Section 67260, Title 22, CAC (i.e. clean closure).

In accordance with 40 CFR Part 265.197 (c), contingent closure and post-closure plans are required because the underground tanks do not have secondary contaminant. These plans assume that all of the wastes cannot be removed or decontaminated, and the site is then closed as a landfill. As stated above, Safety-Kleen intends to perform a clean closure. However, the required contingent plans are provided in Sections V and VI of this closure plan and will be implemented if the remedial activities do not decontaminate the site within the allotted closure period.

NOTIFICATION OF CLOSURE

By submittal of this closure plan, Safety-Kleen is notifying the DHS and EPA of their intent to close the hazardous waste tanks at the Oakland Service Center. 40 CFR Part 265.112(d) specifies that the closure plan must be submitted at least 45 days before closure is expected to begin (for tank systems only). However, Section 67212(e) of Title 22, CAC, specifies that this notification shall occur at least 180 days before closure is expected to begin. Safety-Kleen plans to remove and replace the tanks as soon as the closure plan has been approved.

II. FACILITY INFORMATION

Following is general information pertaining to the facility.

- Owner/Operator of tanks: Safety-Kleen Corporation
  777 Big Timber Road
  Elgin, Illinois 60123
- Corporate Contact: Robert Wachsmuth
  Environmental Engineer
  Safety-Kleen Corporation
  2750 Thompson Creek Road
  Pomona, CA 91767
  (714) 593-3985
- Facility Location: 404 Market Street
  Oakland, CA 94607
- Facility Contact: Steve Vague
  Branch Manager
  (415) 832-7942
- EPA ID Number: CAD 053044053
- SIC Codes: 7399, Business Services, N.E.C.
  5172, Petroleum Product Wholesalers
  5084, Industrial Machining & Equipment
  5013, Automotive Parts & Supplies

DESCRIPTIONS OF OPERATIONS

Safety-Kleen Corporation is a service-oriented company which leases mineral spirits, chlorinated solvents and small parts washing equipment. The business is conducted from local service centers that warehouse the products and equipment required for their sales area. The service representatives for the service centers furnish clean solvent to the customers, pick up the used solvent and check that the leased equipment is in good working order. Safety-Kleen handles two types of solvent. About 97

percent consists of a mineral spirits solvent and the remainder is a special blend of chlorinated and water-phase solvent known as immersion cleaner. The solvents are distributed to and collected from the client in covered drums. Once at the service center, the mineral spirits are stored in bulk storage tanks while the immersion cleaner remains in drums.

The solvents from the Oakland Service Center are regenerated at the Safety-Kleen Recycle Center in Reedley, California. The solvent cycle is essentially a closed loop going from the service center to the customer, from the customer to the service center, from the service center to the regeneration center, and then from the regeneration center back to the service center. Figure II-1 summarizes the concept of the closed loop solvent management system.

SITE LOCATION AND MAPS

The facility is located in an urban area which is zoned for general commercial and light industrial use (City of Oakland M-30). The Oakland Inner Harbor lies less than a mile south of the facility. The latitudinal and longitudinal coordinates of the service center are 37 degrees, 48 minutes, 5 seconds North and 122 degrees, 16 minutes, 56 seconds West. Figure II-2 is a USGS map showing the site location in Township 2S, Range 3W, Section 34.

The land occupied by the facility is essentially flat with the maximum difference in surface elevations being approximately one foot. Generally, surface water from the facility drains southeast from the front (south side) of the building and south from the east side of the building to 4th Street.

The soils underlying the site consist of the Pleistocene - Quaternary Age Merritt Sand to a depth of approximately 65 feet. The Merritt Sand consists of silty sand and silty, clayey sand and are the major water yielding units in the area. Unconfined groundwater has been encountered at the site at depths ranging from 10- to 17-feet below grade.

The location of the underground storage tanks at the Oakland Service Center are shown on Figure II-3. The underground tanks are located east of the buildings beneath the paved loading/ unloading area. Access to this area is from 4th Street. The unloading dock is located north of the east end of the tanks.

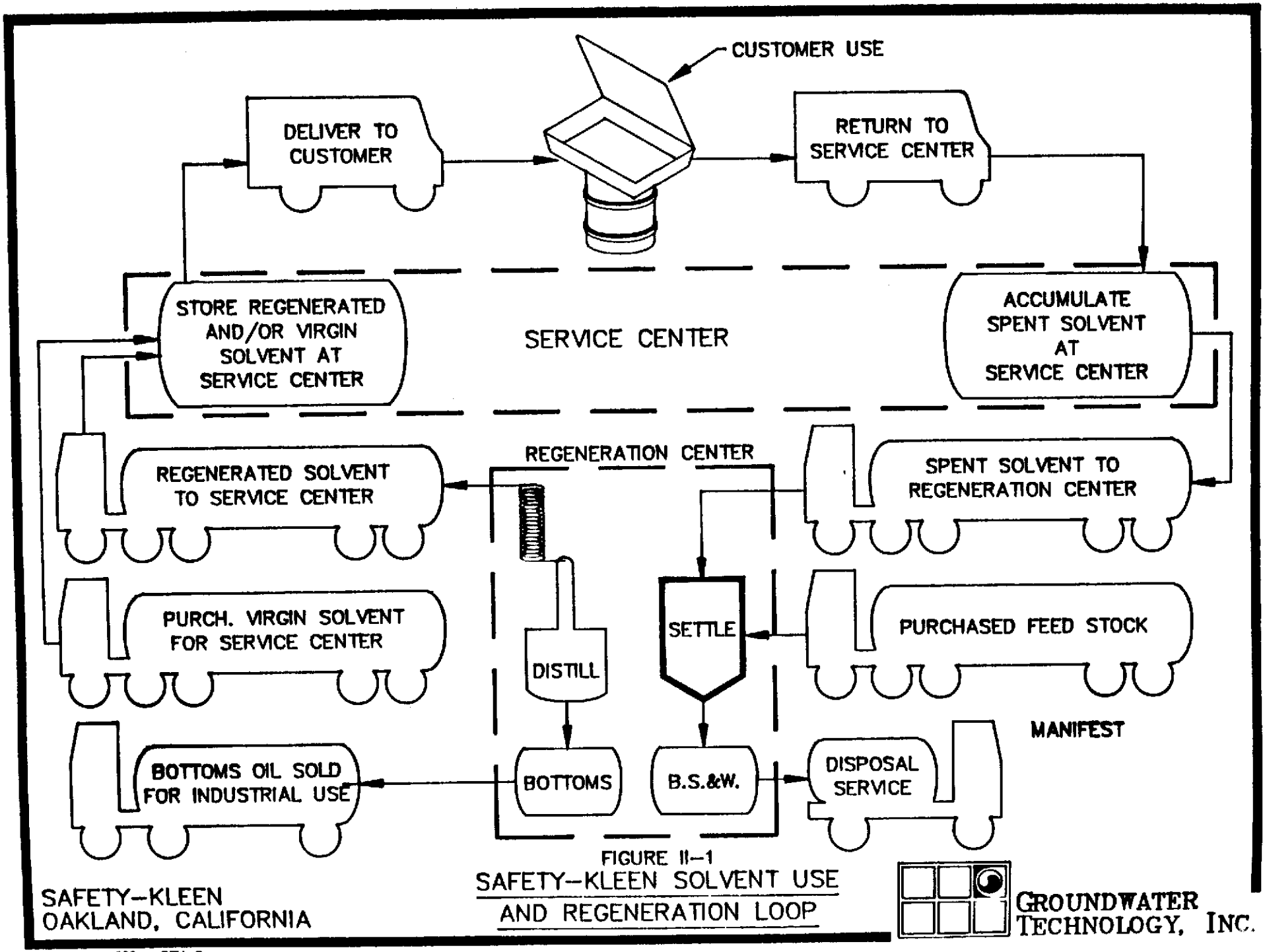

FIGURE II–1

SAFETY–KLEEN SOLVENT USE AND REGENERATION LOOP

SAFETY–KLEEN
OAKLAND, CALIFORNIA

GROUNDWATER TECHNOLOGY, INC.

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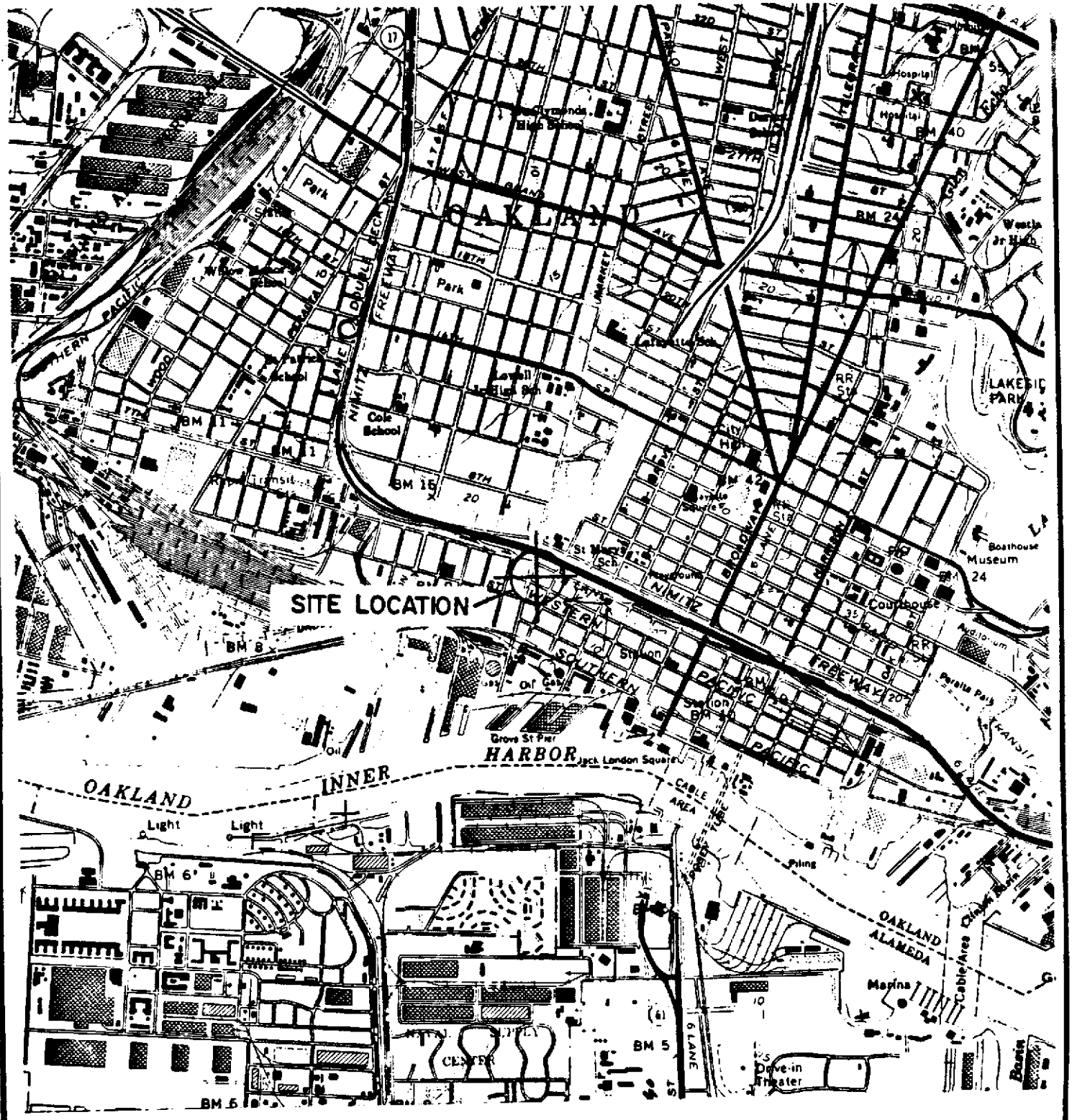


Figure II-2. Site Location Map

SAFETY-KLEEN
OAKLAND, CALIFORNIA

0 MILES 1

GROUNDWATER TECHNOLOGY

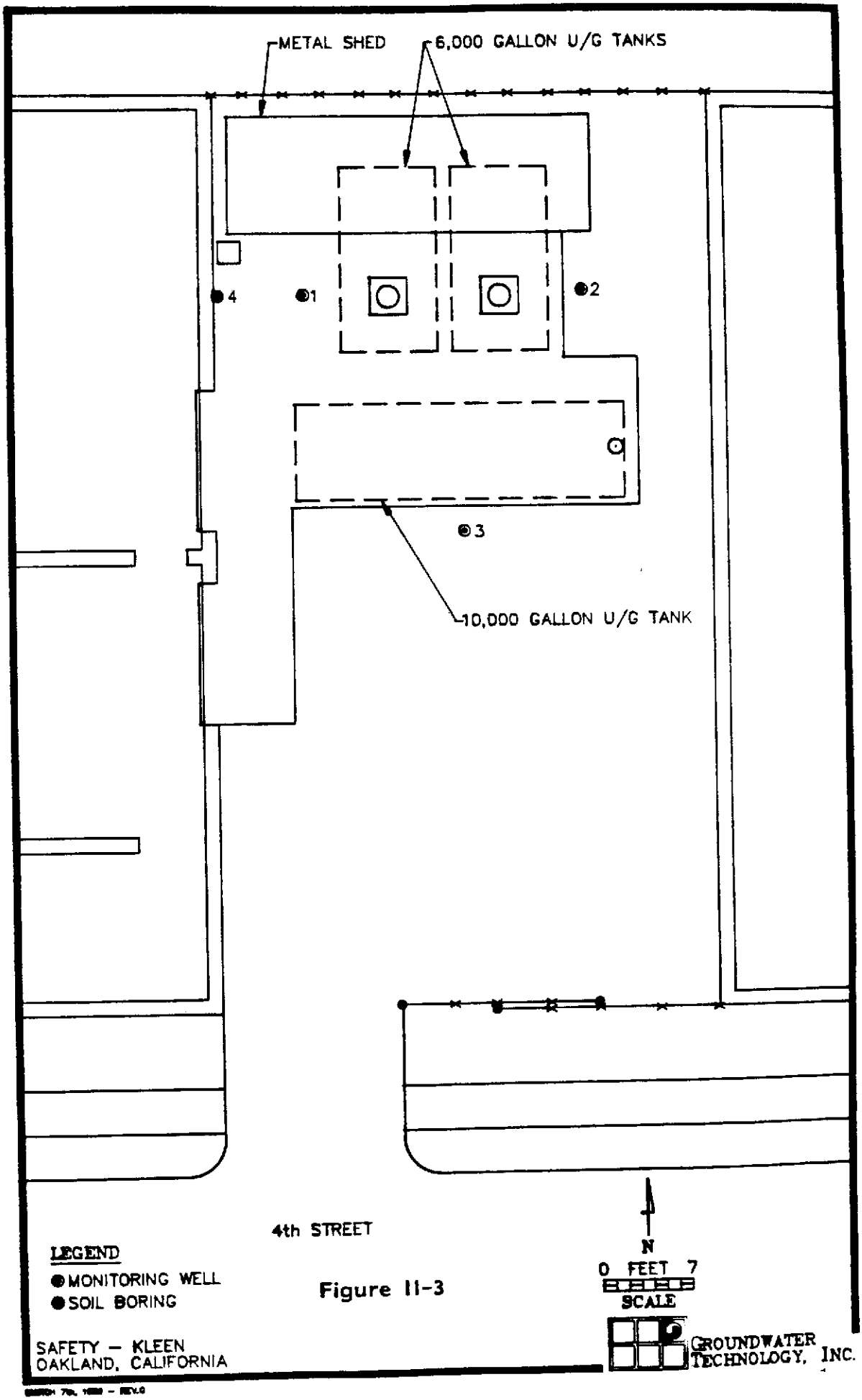

METAL SHED
6,000 GALLON U/G TANKS
4
1
2
3
10,000 GALLON U/G TANK
4th STREET
LEGEND
MONITORING WELL
SOIL BORING
N
0 FEET 7
SCALE
SAFETY – KLEEN
OAKLAND, CALIFORNIA
GROUNDWATER TECHNOLOGY, INC.

Figure 11-3

III. CHARACTERISTICS AND QUANTITY OF WASTE

The two underground hazardous waste tanks to be closed store used mineral spirits. Therefore, this section addresses the characteristics of used mineral spirits, mineral spirits bottom sludge and dumpster mud.

CHARACTERISTICS OF MINERAL SPIRITS

Safety-Kleen's clean mineral spirits (Stoddard Solvent) is known goes by the trade name of "Safety-Kleen 105 Solvent," so-named because it has a minimum flash point of 105 degrees fahrenheit. The solvent primarily consists of petroleum hydrocarbons in the C9 to C11 range. Impurities such as lighter hydrocarbons and chlorinated hydrocarbons usually contribute less than one percent to the total volume. Appendix A contains a Material Safety Data Sheet for Safety-Kleen 105 solvent.

The spent mineral spirits solvent has been used for degreasing operations at facilities primarily engaged in automotive repair and industrial maintenance. Therefore, the spent mineral spirits consist of the Safety-Kleen 105 solvent with water, oil and grease, solids, and small amounts of other solvents (chlorinated hydrocarbons). Based on past experience, the amount of oil and grease may range from 2 to 10 percent by volume in the used solvent. The range of flash point is from 95 degrees fahrenheit to 115 degrees fahrenheit based on analysis of 21 samples using a Pensky-Martens Closed Cup Tester. Because the flash point is less than 140 degrees fahrenheit, the used solvent is considered an ignitable hazardous waste (EPA Waste Code D001, CA Waste Code 213).

CHARACTERISTICS OF BOTTOM SLUDGE AND DUMPSTER MUD

There is some accumulation of sludge in the bottom of the underground storage tanks. It consists of solids, oil and grease, water, and a small amount of mineral spirits. Previous analyses have determined that the sludge meets the ignitability criteria. In addition, the sludge sometimes contains toxic levels of lead and/or cadmium.

Sludge also accumulates in the wet dumpster where the mineral spirits is transferred from drums into the underground storage tanks. The "dumpster mud" is similar to the bottom sludge except it may contain small metal parts and typically contains less mineral spirits. It is therefore classified as ignitable waste and sometimes toxic waste due to the presence of lead and/or cadmium.

MAXIMUM INVENTORY OF WASTE

It is anticipated that the tanks will be empty at the time that closure begins. However if the tanks were both full (i.e. 90 percent of capacity), the maximum inventory of used mineral spirits would be 10,800 gallons. A tanker truck from the Safety-Kleen Recycle Center in Reedley, California would pick up the mineral spirits for reclamation in accordance with their standard operating procedures.

The sludge in the underground tanks was pumped out and the tanks were cleaned on April 10, 1989. Therefore, the amount of sludge at the time of closure should be minimal. Any pumpable sludge would be transported in a vacuum truck with a Uniform

Hazardous Waste Manifest to the Reedley Recycle Center for reclamation of the solvent. The thermally-treated solids are eventually disposed of at Chemical Waste Management's Kettleman Hills hazardous waste facility. As described in detail in Section IV, the unloading dock including the dumpsters will be cleaned and dismantled. It is anticipated that a small amount of dumpster mud (less than 55 gallons) will be removed since the dumpsters are periodically cleaned out. However, if both dumpsters were full of mud, the maximum inventory would be 337 gallons.

IV. CLOSURE PROCEDURES

This section describes the procedures that will be followed in order to close the two underground used solvent tanks at the Safety-Kleen Oakland Service Center. At this same time, a third tank used to store clean mineral spirits will also be removed. The purpose of the procedures will be to remove or decontaminate all waste residues, system components, and contaminated soils and groundwater in accordance with 40 CFR Part 265.197(a) and Section 67260, Title 22, CAC. Therefore, there will be no need for further maintenance, no threat to human health and the environment, and no post-closure escape of hazardous wastes or hazardous constituents to groundwater, surface water, or the atmosphere. New underground tanks with secondary containment and monitoring devices will be installed after the old tanks have been removed.

During closure, a Site Safety Plan (SSP) will be followed to ensure that the potential for chemical and physical hazards are minimized. This will include the use of protective equipment and clothing as well as air monitoring. Procedures are also specified for entering confined spaces and decontaminating equipment. The SSP is included in Appendix A. All project personnel will be required to review and sign the SSP prior to working on the closure.

All current security measures will be continued throughout closure. The operating area outside of the building is surrounded by a 6-foot high, chain-link fence with three strands of barbed wire at the top. The doors to the building are locked at all times when the facility is not in operation.

The following is a summary of the closure procedures:

1. Clean and dismantle the unloading dock.
2. Clean underground tanks.
3. Excavate and remove underground tanks and piping.
4. Remove free product from tank excavation.
5. Install new underground tanks.
6. Backfill tank pit.
7. Initiate free-product recovery and groundwater treatment.
8. Initiate in situ soil treatment.
9. Conduct periodic sampling and analysis.
10. Submit certification of closure by owner and independent registered engineer.

TANK AND UNLOADING DOCK REMOVAL

The underground tanks and unloading dock will be cleaned prior to removal. The purpose of the cleaning will be to remove dirt, oil and grease and solvent residues but not to completely decontaminate the structures. The tanks will be handled as hazardous wastes and transported to an authorized disposal facility (H & H Ship Service, CAD 04771168) accompanied by a Uniform Hazardous Waste Manifest. The unloading dock will be reused with the new tanks.

The dumpsters will first be rinsed with clean mineral spirits. The dumpsters and unloading dock will then be steam-cleaned. All of the cleaning fluids will drain into the underground tanks through the existing piping and containment system. The unloading dock will then be disassembled. The pieces will be labeled and stored on site for use with the new tanks.

The solvent which will drain into the underground tanks when the unloading dock is cleaned will be removed using a Safety-Kleen vacuum truck. The vacuum truck will transport the liquid to the Reedley Recycle Center where it will be reclaimed. The water will be treated on site using activated carbon or transported to an authorized treatment facility. Any sludge in the bottom of the tanks will be pumped or shoveled out manually. The confined space entry procedures in the SSP will be followed during this procedure. The sludge will be transported in drums to the Reedley Recycle Center for reclamation and eventual disposal of the thermally treated solids at an authorized facility (Chemical Waste Management, Kettleman Hills).

The next step will be to excavate and remove the underground tanks and associated piping. Prior to excavation, the need for shoring will be assessed by a registered civil engineer and installed if necessary. The asphalt paving above the tanks will be saw cut. The asphalt and backfill will then be excavated to expose the tops of the tanks. All piping except the vent pipe will be disconnected from the tanks and their openings closed with bungs. Ninety pounds of dry ice will then be introduced into each tank through its manway to ensure that any flammable vapors are purged prior to removal.

After the tanks have been purged of flammable vapors as determined using a portable combustible gas meter or photoionization detector, the vent line will be removed and the opening capped with a plug with a 1/8-inch vent. The backfill will then be excavated until the tanks are approximately halfway exposed. Due to the known soil contamination in the vicinity of the tanks, all excavated soil will be loaded directly into a

hauler or placed on a waterproof liner and covered until on-site treatment or off-site disposal can occur.

The tanks will be removed using a crane. After the removal, each tank will be thoroughly inspected for holes and corrosion. As discussed in the certification section, photographs and notes on the condition of the tanks will be included in the closure report. The tanks will then be transported by a registered hazardous waste hauler to H&H Ship Service in San Francisco accompanied by a Uniform Hazardous Waste Manifest. At H & H Ship Service, the tanks will be steam cleaned and cut up for scrap.

REMOVAL OF FREE PRODUCT, INSTALLATION OF NEW TANKS AND BACKFILL OF TANK PIT

As discussed in GTI's Interim Update Report, dated September 1988, the depth to groundwater in the vicinity of the underground tanks was approximately 9- to 12-feet below grade in August 1988. The depth to free product was approximately 7- to 8-feet below grade. Therefore, it is likely that free product and groundwater will seep into the excavation after the tanks have been removed. The free product will be removed using a vacuum truck or an explosion-proof product recovery pump (e.g. Filter Scavenger^{TM}). The recovered free product will be transported to the Reedley Recycle Center.

After the free product has been recovered, two new 12,000-gallon tanks will be installed in the existing tank pit. One tank will be used to store spent mineral spirits (hazardous waste), and the other will be used to store clean mineral spirits (hazardous material). Both tanks will be double-walled and constructed of fiberglass-steel composite. Construction drawings reviewed by a registered civil engineer are included in Appendix

B. The tanks will be tested and installed in accordance with the manufacturer's instructions and American Petroleum Institute (API) Recommended Practice 1615 (Appendix C). The monitoring and operation of the new tanks is discussed in the latest revision of the operation plan.

Concrete deadmen will be used to anchor the tanks. At least one foot of bedding material will be placed in the excavation before the tanks are installed. The remainder of the backfill material will be carefully placed to provide even support for the tanks. The backfill material will be compacted to 90 percent relative compaction up to one foot below the pavement subgrade and 95 percent above that. Maximum compaction will be determined by ASTM Test Method D-1557-78. Repaving will consist of 4 inches of asphaltic concrete underlain by approximately one foot of Class 2 aggregate base.

SITE REMEDIATION

Once the unloading dock, underground tanks and associated piping have been removed, the remainder of the closure will focus on decontaminating the subsurface soils and groundwater. Two separate remediation systems will be installed to address soil and groundwater contamination. The groundwater recovery and treatment system will consist of one or more recovery wells, equipped with free product and water table depression pumps (WTDP), and an air-stripping tower to remove hydrocarbons from the recovered groundwater. A soil-vent system, designed to address soil contamination, will draw air through the subsurface using a high-vacuum blower to volatilize the trapped hydrocarbons. Both of these remediation methods have proven to be effective for mineral spirits contamination (Groundwater Tech

nology, Inc., October 1988). In-situ biodegradation may also be used to expedite the remediation. Vapor or liquid-phase carbon may also be used, if necessary, to meet air or water discharge requirements. All remediation equipment will be installed on a reinforced concrete pad surrounded by a 6-foot high, chain-link fence.

Groundwater Recovery and Treatment. Based on the results of additional assessment work which will be performed prior to closure, one or two groundwater recovery wells will be installed on or in the vicinity of the site. The optimal location and pumping rates will be determined by modeling pump test data using the computer programs "Graphical Well Analysis Package (GWAP), Version 1.2 (Groundwater Graphics of San Diego, California) and "Single Layer with Wells and Lines-Sinks" (Otto Strack of Groundwater Mechanics, Minneapolis, Minnesota). Each recovery well will be equipped with an explosion-proof, submersible WTDP. An intrinsically safe level sensor probe will maintain the groundwater level in the well at the predetermined depth by controlling the WTDP. In addition, the level sensor will shut down the system automatically if free product approaches the pump intake.

If free product is present in the well(s), a product recovery pump (e.g. Probe Scavenger^{TM}) will also be installed. The product recovery pump will be explosion-proof, and controlled by a probe that ensures that only water-free hydrocarbons are recovered. The floating product will be pumped to the new mineral spirits tanks on site for eventual reclamation at the Reedley Recycle Center.

The recovered groundwater will be treated by an air stripper. The basic concept of air stripping is to bring the water into intimate contact with air so that the volatile compounds undergo a phase change and are transferred to the vapor phase. The air-stripping tower will be sized based on the flow rate produced by the WTDP(s) and the desired removal efficiencies established by the National Pollutant Discharge Elimination System (NPDES) permit or sewer discharge permit (depending on whether the treated water is discharged to a storm drain or sewer). The tower will be packed with high-efficiency, polypropylene Jaeger Tri-Pack™. The groundwater from the WTDP will be sprayed through a dispersion nozzle at the top of the tower. Ambient air will flow counter current to the cascading water by means of a forced-draft blower. The blower will be equipped with a pressure switch which turns off the WTDP if the blower shuts down.

Figure IV-1 is a process schematic showing a dual-pump recovery system and air-stripping tower. Based on GTI's past experience, emission controls on the tower will probably not be required. The need for emission controls will be determined during the permitting process with the Bay Area Air Quality Management District (BAAQMD).

Soil-Vent System. Soil-venting is a process that removes vapor-phase and adsorbed-phase hydrocarbons from contaminated soils. The soil-venting system operates by drawing air through contaminated soil and volatilizing the trapped liquid hydrocarbons. Figure IV-2 illustrates the mechanism of soil decontamination.

Vertical vapor extraction points or trenches will be used to withdraw contaminants from the subsurface. Based on previous assessment work, the extent of soil contamination appears to be on site in the vicinity of the underground tanks. The vapor extraction points or trench would therefore be located in this area. The points or trench will be manifolded to an explosion-proof, high vacuum blower. A liquid-knockout system will be installed to remove water droplets from the air stream prior to entering the blower. The components of a typical soil-vent system are shown in Figure IV-3. As with the air-stripping tower, the need for emission controls on the blower exhaust will be determined during the permitting process with the BAAQMD.

SAMPLING AND ANALYSIS PLAN

In order to document the effectiveness of the remediation systems, periodic sampling will be conducted. The sampling results will also be used to verify that the site has been decontaminated at the end of the closure period. All laboratory analyses will be performed by GTEL Environmental Laboratories (GTEL) in Concord, California. GTEL is a DHS-certified hazardous waste laboratory (certificate number 194).

Initial Soil Sampling. Soil samples will be collected when the groundwater recovery well(s) and vapor extraction points or trench are installed. This data, along with data collected during the assessment phase, will define the degree and extent of soil contamination before remediation begins. All borings will be continuously cored where possible. Soil samples will be collected from the borings where contamination is apparent in the core but no more than every five feet. Samples will be collected in brass tubes. The ends of the tubes will be covered with foil

and plastic caps and then sealed with duct tape immediately after collection. The samples will then be stored on ice and transported to GTEL accompanied by a chain-of-custody record.

The samples will be analyzed for total petroleum hydrocarbons (TPH)-as-mineral spirits using a modified U.S. Environmental Protection Agency (EPA) Method 5030/8015. This method uses a flame ionization detector with total area integration within the mineral spirits spectrum. GTI has investigated various methods of analyzing for mineral spirits and has concluded that the modified Method 8015 produces the most valid results (Groundwater Technology, Inc., May 1988). The samples will also be analyzed for halogenated hydrocarbons using EPA Methods 5030/8010.

Groundwater Monitoring and Sampling. The groundwater monitoring wells will be gauged and sampled on a monthly basis during closure. The depth to water readings will allow GTI to verify the capture zone of the recovery well(s). The analytical results of sampling will document the decontamination of the groundwater. The influent and effluent to the air stripper will also be sampled to verify the efficiency of the air stripper and to document compliance with the NPDES or sewer discharge permit. The air-stripper influent and effluent will be sampled once a day for the first week of operation, once a week for the remainder of the first month, and monthly thereafter.

All water samples will be collected in 40-milliliter volatile organic analysis (VOA) vials. Samples will be stored on ice and transported to GTEL with a chain-of-custody record. Analyses will be run performed for TPH-as-mineral spirits using

modified EPA Method 8015 and halogenated hydrocarbons using EPA Method 601. If the discharge from the air stripper is to a storm drain, the NPDES permit may specify that the effluent be analyzed for additional parameters.

Air Monitoring and Sampling. Air emissions for the air stripper will be calculated using the influent and effluent water concentrations. Air emissions from the soil-vent system will determined from measurements taken with a portable photo-ionization detector (PID) and air bag samples analyzed by GTEL. The air samples from the soil-vent system will document that the system is operating in accordance with the permit issued by the BAAQMD. Also as the concentrations of hydrocarbons in the soil decreases, the concentrations in the air stream going to the blower will also decrease. Therefore, the status of the soil decontamination during closure will be assessed using the air analyses. As described below, confirmation soil samples will be collected at the end of the closure period.

The air samples will be collected in 2-liter Tedlar™ bags. The bags will be stored on ice and transported to GTEL with a chain-of-custody record. The samples will be analyzed for TPH-as-mineral spirits and halogenated hydrocarbons using modified EPA Method 8015 and EPA Method 601, respectively.

Confirmation Sampling. At the end of the closure period, confirmation samples of the soil and groundwater will be collected to verify that the site has been decontaminated. Groundwater samples will be obtained from each monitoring well and the air-stripper influent. These samples will be collected and analyzed as described previously. The groundwater will be considered decontaminated when the mineral spirits and

halogenated hydrocarbon concentrations reach a risk-assessment based standard approved by the DHS.

A soil-gas survey was initially performed at the service center in June 1988 (Groundwater Technology, Inc., September 1988). The survey was performed by GTI's mobile laboratory equipped with a gas chromatograph with a flame-ionization detector. The mobile laboratory will be used at the end of the closure period to verify that the soil has been decontaminated. Soil samples from several locations on and around the site will be obtained from small diameter borings and analyzed by the mobile laboratory. Selected soil samples to confirm the results of the mobile laboratory will also be analyzed by GTEL for TPH-as-mineral spirits and halogenated hydrocarbons. The soil will be considered decontaminated if these parameters reach a risk-assessment based standard approved by DHS.

CLOSURE CERTIFICATION

During closure, Safety-Kleen Corporation's consultant, GTI, will maintain a complete record of activities. This will include field notes of day-to-day procedures, photographs, chain-of-custody records, laboratory analysis reports, and documentation of discussions with the DHS, EPA and Safety-Kleen. After the confirmation sampling results are received, a closure report will be prepared for submittal to the DHS and EPA. The closure report will include a description of steps taken during closure including any deviations from the approved closure plan that had to be made. Analytical results of sampling presented in tabular and graphical format, chain-of-custody records, and copies of Uniform Hazardous Waste Manifests for all waste taken off site will also be included.

In accordance with Section 67215, Title 22, CAC, and 40 CFR Part 265.115, a certification of closure will be submitted with the closure report. This certification will be submitted within sixty days of completion of closure. The certification will be signed by Safety-Kleen's authorized representative and a GTI California registered civil engineer.

CLOSURE SCHEDULE

In accordance with Section 67213(a), Title 22, CAC, and 40 CFR Part 265.113(a), closure of the underground storage tanks at the Oakland Service Center will begin within ninety days after receiving the final volume of hazardous waste or within ninety days after approval of the closure plan, whichever is later. Safety-Kleen plans to begin closure as soon as the DHS and EPA approve the closure plan.

The 180-day time period allotted for closure is specified in Section 67213(b), Title 22, CAC, and 40 CFR 265.113(b). Due to the need for groundwater and soil remediation at the site, an extension of this time period will be required. The unloading dock, tanks, and associated piping will all be removed during the 180-day time period. In addition, the groundwater recovery and treatment system and soil-vent system will be installed and put into operation during this period. However, the time required to decontaminate the soil and groundwater to non-detectable levels is determined by the subsurface dynamics. Although both of these technologies have proven to be very effective in removing mineral spirits and associated halogenated hydrocarbons from the environment, the time required to complete remediation will exceed 180 days. Safety-Kleen requests an extension of an additional 720 days to complete remedial activities and document a clean closure

of the site. During this extended time, there would be no threats to human health or the environment because the hazardous waste management units will have been removed and the remedial systems will be operated in accordance with air and water discharge permits.

The proposed schedule for completing each of the closure steps is shown on Figure IV-4.

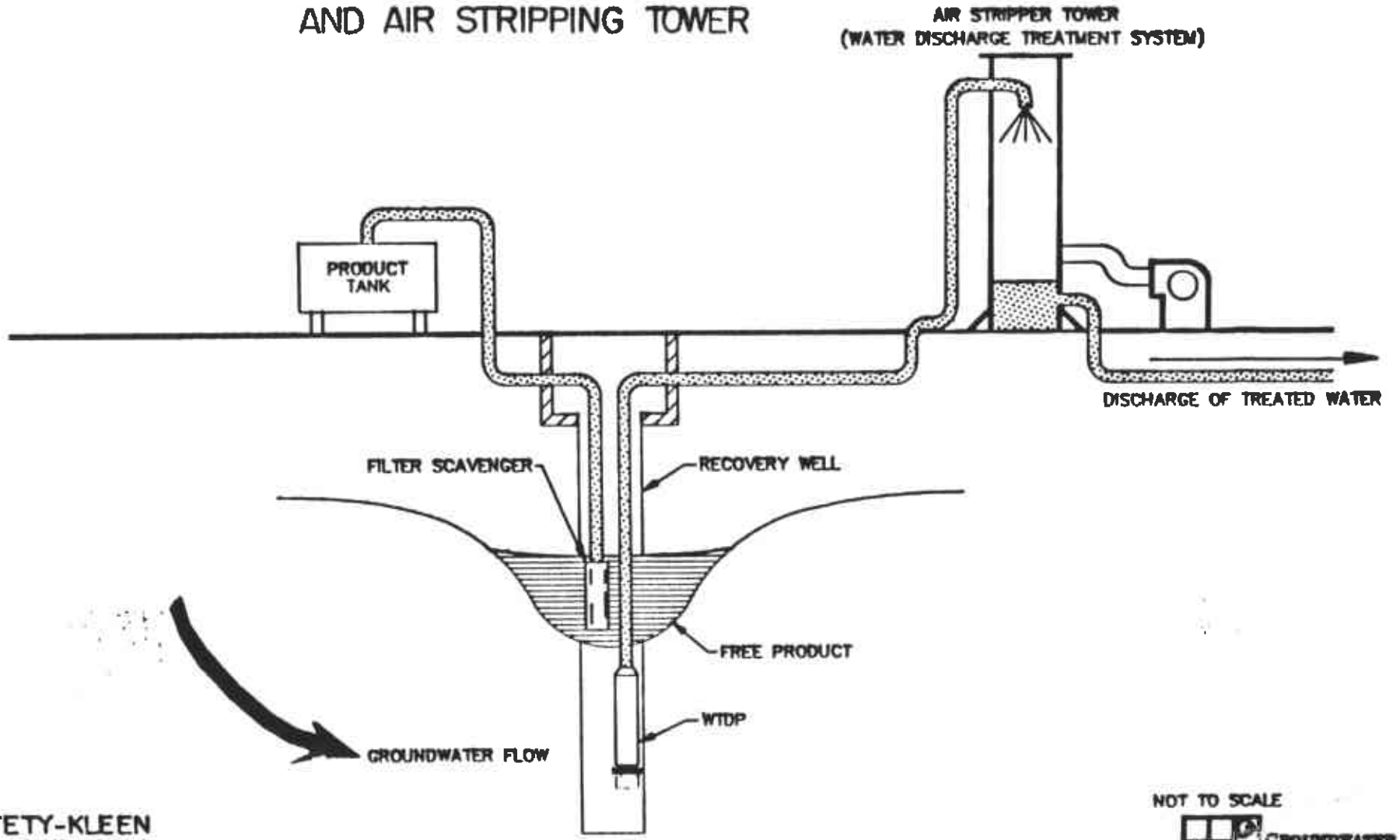
CLOSURE COST ESTIMATE

The following is an estimate of the costs to close the two hazardous waste storage tanks at the Oakland Service Center. The costs are based on worst-case assumptions regarding the quantity of wastes to be removed. The value of product that is reclaimed at the Reedley Recycle Center is assumed to off-set the transportation and treatment cost. All costs presented represent 1988 dollars. A breakdown of the estimated costs is provided in Appendix D. The financial responsibility demonstration to cover the estimated costs is discussed in Section VII.

Tank and Unloading Dock Removal	$ 96,150.00
Removal of Free Product	685.00
Backfill of Tank Pit	6,428.00
Groundwater Recovery and Treatment System	72,500.00
Soil-Vent System	69,000.00
Sampling and Analysis	91,330.00
Closure Report and Certification	5,240.00
Health and Safety	20,480.00
TOTAL COST ESTIMATE	**$361,800.00**

FIGURE IV-1

DUAL PUMP GROUNDWATER RECOVERY SYSTEM AND AIR STRIPPING TOWER



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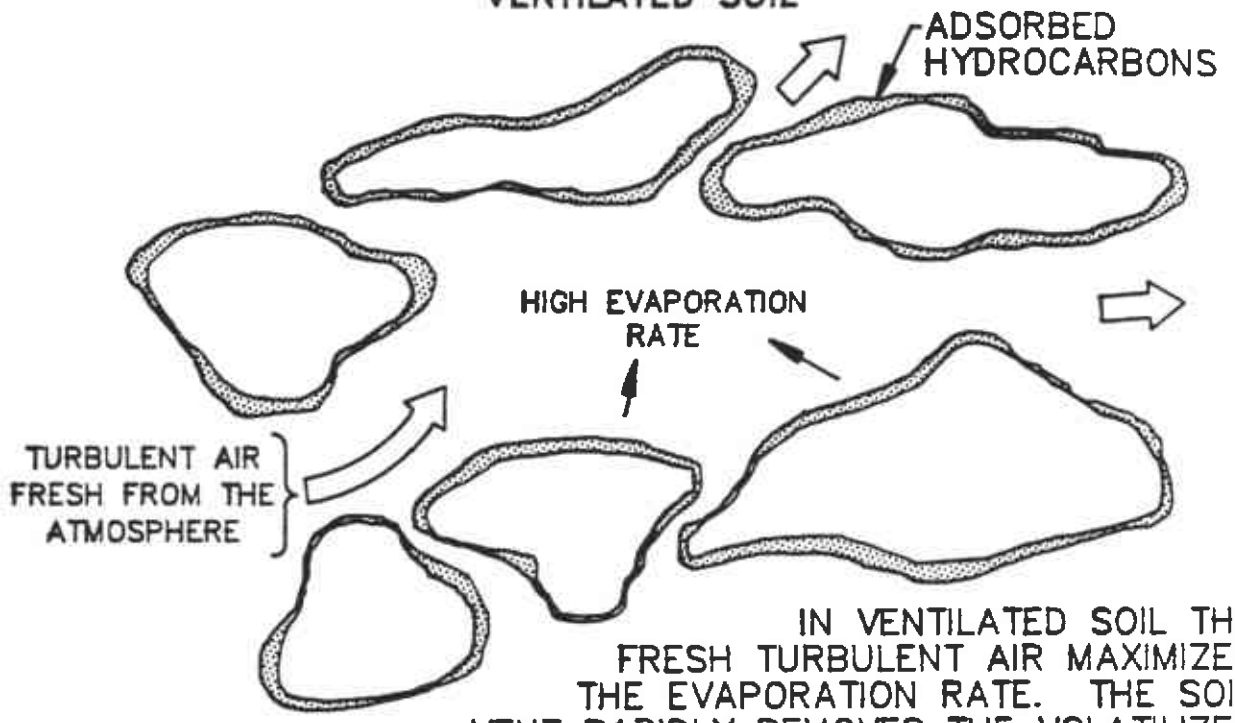
OAKLAND, CALIFORNIA

GROUNDWATER TECHNOLOGY, INC.

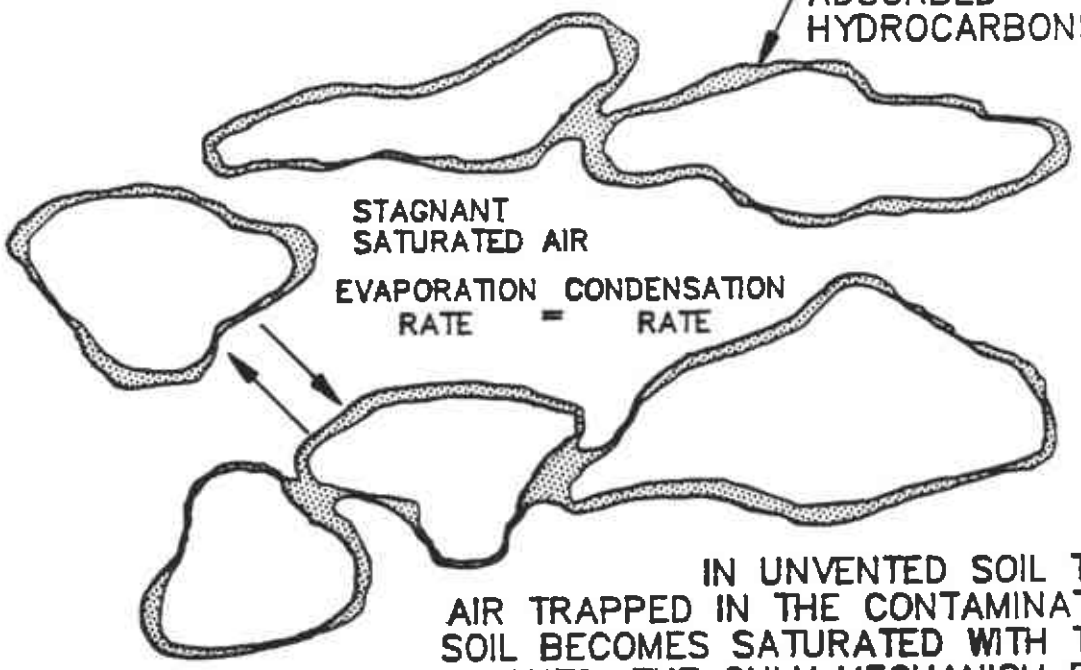
MECHANISMS FOR SOIL DECONTAMINATION

VENTILATED SOIL



IN VENTILATED SOIL THE FRESH TURBULENT AIR MAXIMIZES THE EVAPORATION RATE. THE SOIL VENT RAPIDLY REMOVES THE VOLATILIZED CONTAMINATE FROM THE SOIL.

UNVENTILATED SOIL



IN UNVENTED SOIL THE AIR TRAPPED IN THE CONTAMINATED SOIL BECOMES SATURATED WITH THE CONTAMINANTS. THE ONLY MECHANISM FOR DECONTAMINATION IS A SLOW DIFFUSION FROM PORE TO PORE.

Figure IV-2.

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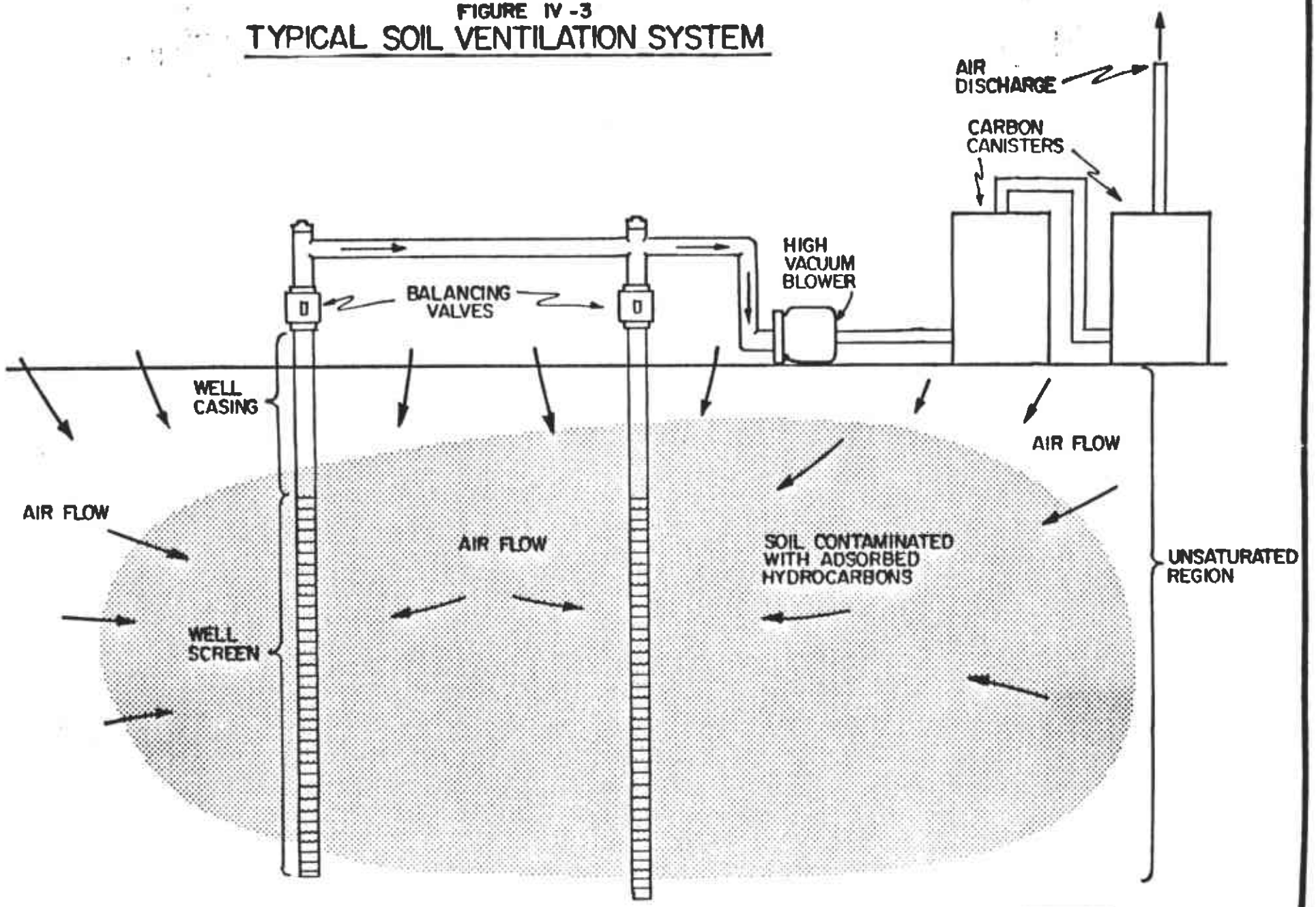
FIGURE IV -3

TYPICAL SOIL VENTILATION SYSTEM



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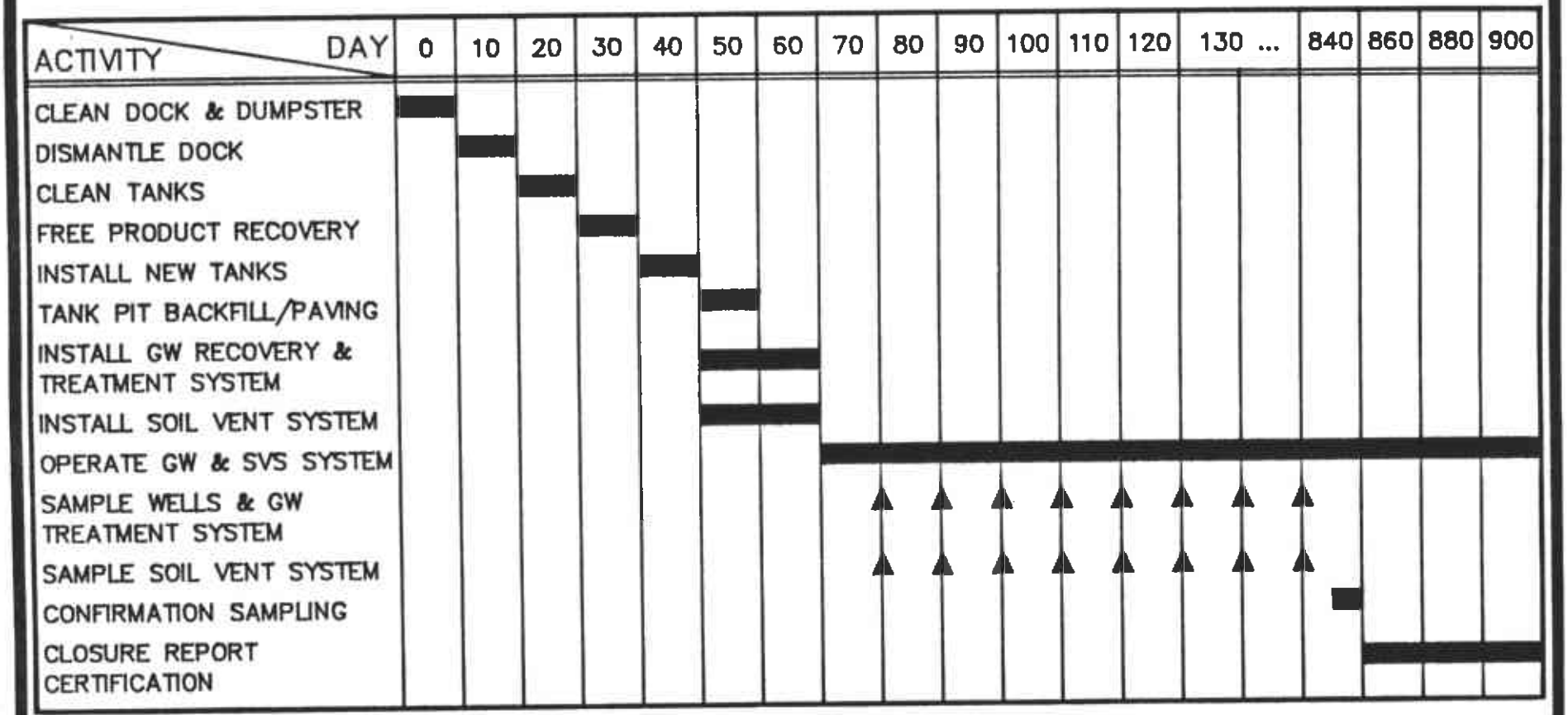
GROUNDWATER TECHNOLOGY

FIGURE IV–4

CLOSURE SCHEDULE



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OAKLAND, CALIFORNIA

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V. CONTINGENT CLOSURE PROCEDURES

As stated in the introduction, Safety-Kleen intends to perform a clean closure of the underground storage tanks at the service center. The existing tanks and all associated piping will be removed. In addition, remedial actions will be implemented to decontaminate the subsurface soil and groundwater. However, since the tanks are not equipped with secondary containment and are not exempt from this requirement, contingent closure and post-closure plans must be prepared in accordance with 40 CFR Part 265.197(c).

Safety-Kleen is requesting an extension of the time allotted for closure so that the remedial actions can be completed. If the confirmation sampling at the end of the extended closure period indicates that contamination is still present, the contingent closure and post-closure procedures will be implemented. These contingent procedures will follow the requirements for the closure as a landfill.

The following is a summary of the contingent closure steps:

1. Remove tanks and associated piping as specified in Section IV.
2. Continue operation of the remedial systems.
3. Assess condition of final cover.
4. Prepare survey plat.
5. Submit closure certification.

REMEDIATION SYSTEMS

The groundwater recovery and treatment system, and soil vent system will be installed during the initial closure period (refer to Section IV). These systems will be designed to operate with periodic maintenance. All treatment equipment will be located in a designated, secure compound at the service center. Operation of the equipment will be in accordance with air and water discharge permits.

FINAL COVER

All of the outside areas of the service center are paved with asphaltic concrete. Similarly, the industrial area surrounding the service center is mostly paved. As described in Section IV, the tank pit area will be backfilled, compacted, and resurfaced after the tanks have been removed. The edges of the asphalt patch sealed to prevent infiltration.

At the end of the closure period, a California registered civil engineer will examine the pavement on and around the site for cracks, subsidence, or deterioration. The engineer will verify that the cover meets the following criteria:

1. Provides long-term minimization of migration of liquids through the cover.
2. Functions with minimum maintenance.
3. Promotes drainage and minimizes erosion or abrasion of the cover.
4. Accommodates settling and subsidence so that the cover's integrity is maintained.

5. Has a permeability less than or equal to the natural subsoils.

SURVEY PLAT

At the end of the closure period, a survey plat will be prepared indicating the locations still containing contaminants. The locations will be surveyed relative to a permanent benchmark by a professional land surveyor registered in California. The survey plat will be submitted to the City of Oakland zoning authority. The plat will include a prominently displayed note which states that Safety-Kleen is required to restrict disturbance of this area.

CLOSURE CERTIFICATION

Within 60 days of the completion of closure, a closure report will be submitted to the EPA and DHS. The closure report will contain a description of steps taken during closure, analytical sampling results, chain-of-custody records, Uniform Hazardous Waste Manifests, and the survey plat. It will also include a certification of closure signed by Safety-Kleen's authorized representative and GTI California registered civil engineer.

SCHEDULE

The proposed schedule for the contingent closure procedures will be the same as for the closure procedures described in Section IV (refer to Figure IV-4). The two additional steps, examination of the final cover and preparation of the survey plat, will be performed during the final month of closure while the closure report is being prepared.

COST ESTIMATE

The cost estimate for the contingent closure procedures includes the amount detailed in Section IV and the costs for the following two steps:

Examination of Final Cover:

PE $93/hr x 8hr	$ 744.00
Travel and supplies	50.00
SUBTOTAL	$ 794.00

Preparation of Survey Plat:

Identification of contaminated areas	$ 300.00
Licensed survey of area	500.00
Preparation of survey plat	200.00
SUBTOTAL	$ 1,000.00

TOTAL CLOSURE $361,800.00

TOTAL CONTINGENT CLOSURE $363,600.00

VI. CONTINGENT POST-CLOSURE PROCEDURES

If the subsurface soils and groundwater are not decontaminated during the allotted closure period, the additional contingent closure procedures described in Section V will be followed. The contingent post-closure procedures will then be followed. These procedures will include monitoring and maintenance for the next 30 years in accordance with Section 67217(b) Title 22, CAC, and 40 CFR Part 265.117(a).

The remediation systems will continue to operate during the post-closure period. When the groundwater and soil are decontaminated as evidenced by confirmation sampling (See Section IV), Safety-Kleen will request permission to discontinue post-closure maintenance and monitoring. According to Section 67217(b)(2)(A), Title 22, CAC, and 40 CFR Part 265.117(a)(2)(i), the DHS and EPA may shorten the post-closure care period if human health and the environment will be protected.

MAINTENANCE

The Oakland Service Center will remain in operation after the underground tanks are closed. The Safety-Kleen branch manager will therefore remain the site contact during post-closure. The normal security procedures will be maintained during post-closure. In addition, the final cover (pavement) at the site will be maintained by Safety-Kleen.

MONITORING

During the post-closure period, the remediation systems will continue to be monitored as described in Section IV. Because

contaminants have already been detected in the groundwater and the gradient will be influenced by the groundwater extraction system, a typical groundwater indicator evaluation program as specified in Section 67194, Title 22, CAC, and 40 CFR Subpart F cannot be implemented. The purpose of the groundwater monitoring program will be to verify that the groundwater recovery and treatment system is operating effectively and to document the groundwater clean up.

The groundwater monitoring network will continue to be developed and evaluated prior to and during closure. All well installations, monitoring, and sampling will be conducted in accordance with GTI's standard operating procedures. Copies of the applicable operating procedures are provided in Appendix E.

The groundwater monitoring wells will be gauged and sampled on a quarterly basis throughout the post-closure period. The air-stripper influent and effluent will be sampled in accordance with the NPDES or sewer discharge permit but no less frequent than quarterly. Samples will be analyzed for TPH-as-mineral spirits and halogenated hydrocarbons using modified EPA Method 8015 and EPA Method 601, respectively.

The soil-vent system will continue to be monitored using a portable photo-ionization detector in accordance with the permit issued by the Bay Area Air Quality Management District. On a quarterly basis, air bag samples will be collected to quantitate the amount of contaminants being removed from the subsurface. The air bag samples will be analyzed for TPH-as-mineral spirits and halogenated hydrocarbons.

DEED NOTATION

Within 60 days after the post-closure period has started, a notation will be recorded on the deed to the service center property. The notation will state that the land has been used to manage hazardous wastes, that its use is restricted under Section 67217(c), Title 22, CAC, and 40 CFR Subpart G regulations, and that a survey plat has been filed with the City of Oakland zoning authority. Safety-Kleen will then submit a certification statement to the DHS and EPA that the deed notation has been recorded.

SCHEDULE

The post-closure period shall begin at the end of closure and continue for 30 years if necessary. As stated previously, the site will most likely be decontaminated in less than 30 years, and the post-closure period should therefore be considerably shorter. Monitoring and sampling of the groundwater wells and remediation systems will occur on a quarterly basis throughout closure. Maintenance of the final cover will be performed as needed by Safety-Kleen.

COST ESTIMATE

As specified Section 67014(a), Title 22, CAC and 40 CFR Part 265.144(a)(2), the following cost estimate is based on the estimated annual monitoring costs multiplied by the specified 30-year post-closure period.

Groundwater Monitoring and Sampling:

Labor $400/quarter x 4 quarter.....	$ 1,600.00
10 samples/quarter x 4 quarter x $225/sample....	9,000.00

Air Monitoring:

Labor $100/quarter x 4.....	400.00
PID rental $95/day x 4.....	380.00
2 samples/quarter x 4 quarter x $225/sample.....	1,800.00
ANNUAL MONITORING COST (30 years)	**$ 13,180.00**
TOTAL FOR POST-CLOSURE PERIOD	**$ 395,400.00**

VII. FINANCIAL RESPONSIBILITY

Safety-Kleen must demonstrate and maintain financial responsibility for the closure of several of their facilities which have interim status to store hazardous wastes. In addition, Safety-Kleen must demonstrate financial responsibility for sudden and non-sudden accidental occurrences at these facilities. In accordance with 40 CFR Part 265.197(c)(4), financial assurance for the closure of the underground tanks at the Oakland Service Center must be based on the contingent closure and post-closure estimates ($363,600 and $395,400, respectively).

APPENDIX A
SITE SAFETY PLAN

SITE SAFETY PLAN

SAFETY-KLEEN OAKLAND SERVICE CENTER

404 MARKET STREET

OAKLAND, CALIFORNIA 94607

MARCH 17, 1989

Prepared by:

GROUNDWATER TECHNOLOGY, INC.
4041 Pike Lane, Suite F
Concord, California 94520

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SAFETY-KLEEN OAKLAND TERMINAL
404 MARKET STREET
OAKLAND, CALIFORNIA 94607
MARCH, 1989

INTRODUCTION

BACKGROUND

Safety-Kleen Corporation has retained Groundwater Technology, Inc., (GTI) to manage and supervise the removal and replacement of underground storage tanks at their facility in Oakland, California. These tanks previously contained clean and spent mineral spirits solvent. A site safety plan for the assessment phase of work on this site was prepared previously (GTI, March 21, 1988). This document amends the previous plan to cover the removal of three underground tanks.

PURPOSE

Safety-Kleen wishes to take the steps discussed herein in order to partially close this hazardous waste facility. All work will comply with the OSHA Standard, "Hazardous Waste Operations and Emergency Response," (29 CFR 1910.120) and various state and local procedures which require that a site-specific safety plan be developed and implemented.

The purpose of this Site Safety Plan (SSP) is to provide GTI field personnel and subcontractors with an understanding of the potential chemical and physical hazards that exist or may arise while the tasks of this project are performed:

- Excavating/Trenching
- Tank Removal

To ensure the well-being of all field personnel and the community surrounding this facility, project staff and approved sub-contractors must adhere to the policies and procedures established herein. Accordingly, all personnel assigned to this project must read this site safety plan and sign the Certification and Acknowledgment Statement (Appendix A.a) to certify that they have read, understood and agreed to abide by its provisions. All field personnel are also required to have 40 hours of hazardous waste training prior to working at this site.

Any changes in the work scope of this project and/or site conditions must be amended in writing on the Site Safety Plan Amendment Sheet (Appendix A.b).

SITE SAFETY RECOMMENDATIONS

Hazard Determination

Serious ____ Moderate __X_ Low ____ Unknown ____

Level of Protection

Level D with provisions to upgrade to modified level C if air contaminant levels exceed 50 ppm. The minimum acceptable level of protection is a Modified Level D.

Amendments

Any changes in the scope of work of this project and/or site conditions must be amended in writing on the Site Safety Plan Amendment Sheet (Appendix A.b) and approved by Regional Safety Manager.

Proposed dates of site work: Upon approval of closure plan by regulatory agencies

Contaminant: mineral spirits

Recommendation: Hard hats, steel-toe workboots, on-site monitoring equipment, air purifying respirators (cartridge 7500-3), goggles, Tyvak coveralls, eye wash station, portable sprayer for decontamination, containment tub for cleaning equipment.

Emergency equipment to include: Self contained breathing apparatus (SCBA), personal harness, and excavation shoring material.

EMERGENCY RESPONSE

In the event of an accident or emergency situation, immediate action must be taken by the first person to recognize the event. First aid equipment is located on site inside the GTI truck. Notify the Project Manager and Site Safety officer about the situation immediately after emergency procedures are implemented.

EMERGENCY TELEPHONE NUMBERS:

Immediate Emergencies:

Local Police:	911
State Police:	911
Fire:	911
Ambulance:	911

Medical:

Nearest Hospital: Providence Hospital
Telephone: (415) 835-4500
Directions to: 3100 Summit Street, Oakland
Take 4th Street east to Broadway; make a left on Broadway; going North make a left at 30th Street.

Poison Control Center: (415) 476-2845 1-800-535-0525

Emergency Environmental:

National Response Center: (U.S., EPA (24-hours hotline)	1-800-424-8802
Office of Emergency Services:	1-800-852-7550
CA Dept. of Health Services:	(415) 540-3485
Alameda Environmental Health Dept.	(415) 271-4320
Groundwater Technology, Inc.:	(415) 671-2387
	(415) 685-9250

FACILITY INFORMATION

Following is general information pertaining to the facility.

- Owner/Operator of tanks: Safety-Kleen Corporation
  777 Big Timber Road
  Elgin, Illinois 60123

- Corporate Contact: Robert Wachsmuth
  Environmental Engineer
  Safety-Kleen Corporation
  2750 Thomas Creek Road
  Pomona, CA 91767
  (714) 593-3985

- Facility Location: 404 Market Street
  Oakland, CA 94607

- Facility Contact: Steve Vague
  Branch Manager
  (415) 832-7942

- EPA ID Number: CAD 053044053

SITE SAFETY SUMMARY

ENCOUNTERING EMERGENCY SITUATIONS

Personnel encountering a hazardous situation shall instruct others on site to evacuate the vicinity immediately and call the Project Manager, the Site Safety office, or, in their absence, the Regional Health and Safety Manager for instructions.

The site must not be re-entered until the situation has been corrected.

PROCEDURES FOR INJURY

1. Call for ambulance/medical assistance, if necessary. Notify the receiving hospital of the nature of physical injury or chemical overexposure.

2. Notify the Project Manager and Site Safety Officer.

3. If the injury is minor, proceed to administer first aid.

CHEMICAL OVEREXPOSURE

In all cases of chemical overexposure, follow standard procedures for poison management, first aid, and, if applicable, cardiopulmonary resuscitation. When transporting an injured person to a hospital, bring this SSP to assist medical personnel with diagnosis and treatment. Four different routes of exposure and their respective first aid/poison management procedures are outlined below:

1. Ingestion

   CALL THE POISON CONTROL CENTER AT: (415) 476-2845 or 911 FOR INSTRUCTIONS.

   IF VOMITING IS NOT RECOMMENDED, (often the case with chemical contaminants such as mineral spirits) Dilute the poison by making the person drink one or two glasses of water or milk. Do Not use Carbonated Beverages.

   IF VOMITING IS RECOMMENDED, (Vomiting must not be induced if the person is unconscious or having convulsions), give two tablespoons (one ounce) of syrup of Ipecac (located in the glove compartment of the GTI truck), followed by at least one cup of water. After Ipecac has been administered, promptly have the person transported to the hospital. If vomiting does not occur within 20 minutes, repeat this procedure once.

2. Inhalation

   Move the person from the contaminated environment. Initiate CPR if necessary. Call for medical assistance. Refer to MSDS information. If necessary, transport the victim to the nearest hospital.

3. Skin Contact

   Wash off skin with a large amount of water immediately. Remove any contaminated clothing and rewash skin using soap, if available. Transport person to a medical facility if necessary.

4. Eyes

Hold eyelids open and rinse the eyes immediately with large amounts of water for 15 minutes. If possible, have the person remove his/her contact lenses (if worn). Never permit the eyes to be rubbed. Transport person to a hospital.

SCOPE OF WORK

Safety-Kleen will be performing a partial closure of their hazardous waste facility. The underground storage tanks used to store clean and spent mineral spirits will be closed and replaced with new, double-walled tanks. A pre-closure assessment was performed by GTI during June through September 1988. This work included a soil-gas survey, precision testing of underground tanks and lines, soil sampling, installation of monitoring wells, and groundwater sampling. This work is documented in GTI's Interim Update Report dated September 9, 1988. Although the tanks themselves were found to be not leaking, several piping and fitting leaks were discovered and subsequently repaired. Soil contamination, free-floating product and dissolved product were detected in on-site borings located around the underground tank area.

As discussed in detail in Section IV of the Closure Plan, the closure of the underground storage tanks will involve physical removal of the tanks and associated piping as well as some of the contaminated soil. Remediation procedures will also be conducted to remove the free-floating product and treat the contaminated groundwater and soil. In this manner, all waste residues, system components, and contaminated soils will be removed or decontaminated during closure in accordance with 40 CFR Part 265.197 (a) and Section 67260, Title 22, CAC (i.e. clean closure).

The following is a summary of the closure procedures:

1. Clean and dismantle the unloading dock.
2. Clean underground tanks.
3. Excavate and remove underground tanks and piping.
4. Remove free product from tank excavation.
5. Install new tanks.
6. Backfill tank pit.
7. Initiate free-product recovery and groundwater treatment.
8. Initiate in situ soil treatment.
9. Conduct periodic sampling and analysis.
10. Submit certification of closure by owner and independent registered engineer.

CHARACTERISTICS OF WASTE

There is some accumulation of sludge in the bottom of the underground storage tanks. It consists of solids, oil and grease, water, and a small amount of mineral spirits. Previous analyses have determined that the sludge meets the ignitability criteria. In addition, the sludge sometimes contains toxic levels of lead and/or cadmium.

Sludge also accumulates in the wet dumpster where the mineral spirits is transferred from drums into the underground storage tanks. The "dumpster mud" is similar to the bottom sludge except it may contain small metal parts and typically contains less mineral spirits. It is therefore classified as ignitable waste and sometimes toxic waste due to the presence of lead and/or cadmium.

It is anticipated that the tanks will be empty at the time that closure begins. However, if the tanks were both full (i.e. 90 percent of capacity), the maximum inventory of used mineral spirits would be 10,800 gallons. A tanker truck from the Safety-Kleen Recycle Center in Reedley, California would pick up the mineral spirits for reclamation in accordance with their standard operating procedures.

HAZARD EVALUATION

SUBSURFACE CONTAMINANTS

As indicated by previous work at this site (GTI, September, 1988) the principal contaminant is mineral spirits (see MSDS in Appendix A.c) with small amounts of impurities (<1%) which consist of lighter hydrocarbons and chlorinated solvents.

EXCAVATION HAZARDS

The most serious and common hazard from working around an excavation is a cave-in. The following safety rules should be followed to prevent any mishaps:

- Have the on-site professional engineer evaluate soil stability before and after tank removal.
- Keep spoil at least 20 feet from the edge of an excavation.
- Guard an excavation 5 feet deep or more (or any shallower excavation with unstable soil conditions), into which workers will enter, by a shoring system, sloping the ground or other equivalent methods.
- Support heavy equipment properly.
- Secure excavation from entry during non-working hours.

TANK REMOVAL HAZARDS

The following rules should be applied to prevent injury or accidents:

- Vapor free the tank prior to removal using dry ice.
- Avoid standing on top of the tank (slippery or rusty surface).
- Use proper, not undersized, equipment to remove the tank.
- Secure the tank at an assigned location after extraction.
- Look for falling objects, slipping, and tripping hazards. (Visqueen sheet used to hold excavated soil can be slippery.
- Keep a safe distance from the excavation and from heavy equipment, especially during the removal.
- Be aware that a heat stress situation may develop when impermeable protective clothing is worn.

- Limit exposure time to noisy equipment, such as Jack Hammers, scrapers, compressors, or vacuum trucks. The noise level can be as high as 100 dbl at the source.

- Secure the site with fences or post warning signs to prevent the exposure of unauthorized, unprotected people to site hazards.

POTENTIAL HAZARDS

A review of previous hydrogeological studies, recent water quality data and existing site conditions indicate that there are no immediately dangerous to life or health (IDLH) conditions. The following potential exposures have been identified:

1. Volatilization of mineral spirits and chlorinated hydrocarbons during all operations poses a potential hazard via the inhalation of vapors.

2. Skin and eye contact with the soil may occur during excavation and sampling.

3. The excavation and tanks are confined spaces that may lack adequate ventilation and trap organic vapors.

4. Atmospheres that contain a level of oxygen greater than 25% pose an extreme fire hazard (the ambient oxygen level is approximately 20.5%). This is compounded by the fact that the vapors are flammable.

5. Skin and eye contact with methanol can occur while cleaning remediation and sampling equipment.

6. Volatilization of PVC pipe primer and PVC pipe glue can occur during any required plumbing operation.

7. Some monitoring wells are located in areas of traffic flow. This poses a physical hazard.

8. The excavation must conform to standard construction practices and no one should enter the excavated area unless authorized by the on-site professional engineer and site safety officer.

PROCEDURES FOR REDUCING EXPOSURES

GENERAL

1. The oxygen in confined spaces must be monitored with an oxygen meter prior to entry. If oxygen monitoring indicates that the level of oxygen is less than 19.5%, personnel entering such spaces must wear air supplied respirators.

2. A buddy system should be implemented whenever possible to ensure that no one works alone on site. In situations where a buddy system is not possible, personnel entering the site shall check in with the Manager and/or the Project Manager before entering and upon leaving the site. No one shall enter a confined space if working alone.

3. Eating, smoking, drinking and/or application of cosmetics is prohibited on site.

4. Personnel encountering atmospheres that contain a level of oxygen greater than 25% must evacuate the site immediately and must notify the Fire Department.

5. When performing tasks in the immediate vicinity of monitoring wells situated in areas of traffic flow, a security barricade must be put in place to provide a safeguard.

CHEMICAL SPECIFIC

1. The health effects produced by each hydrocarbon of potential concern are enhanced by the effects produced by the others. It is, therefore, necessary to determine a permissible exposure limit of airborne concentrations for the mixture, rather than to base the level of respiration protection on the exposure limits assigned by government agencies to particular chemicals. Using the American Conference of Governmental Industrial Hygienists (ACGIH) guidelines for determining the permissible exposure limits for mixtures, the exposure limit for the mixture encountered at this site was calculated to be 50 ppm. The application of this value in the field is described below (Exposure Reduction Method #3).

2. At a minimum, a protective level equivalent to Level D is required for all operations:

    - o Coveralls (Tyvek suits or other suitable clothing)
    - o Steel-toed work boots
    - o Inner vinyl or latex surgical gloves
    - o Outer neoprene work gloves
    - o Goggles or safety glasses
    - o Hard hat

3. While conducting all field operations, the ambient air in the near vicinity and in confined spaces (prior to entry), must be monitored periodically for organic vapors with photo-ionization detector with a lamp of >11 ev or similar organic vapor analyzer according to GTI's Standard Operating Procedure (Appendix E in Closure Plan). If, under any circumstance, the level of organic vapors exceeds the ambient reading by 50 ppm (the permissible level for the mixture), field personnel must upgrade the level of protection to Level C. That is, in addition to the protective equipment listed above, an air-purifying respirator equipped with organic vapor cartridges must be worn provided the level of oxygen is greater than 19.5%.

4. The presence or absence of explosive vapors must be determined before entering any confined space. If the explosimeter readings are greater than 10% of the lower explosive limit (LEL), confined spaces must not be entered. Note that the accuracy of explosimeters is compromised when used in atmospheres that contain less than 19.5% oxygen.

5. Field personnel using any process chemical must review the Material Safety Data Sheet (MSDS) supplied by the specific manufacturer prior to use and follow the recommendations for safe use and first aid (if necessary). MSDS's must be attached to the inside back cover of this Site Safety Plan on an as-used basis.

CHEMICALS OF CONCERN - HEALTH EFFECTS

Mineral spirits (also called Stoddard Solvent), is a colorless liquid with a kerosene like odor. It is composed of C_9 to C_{11} aliphatic and cyclic hydrocarbons. At high concentrations it causes irritation to eyes, nose and throat and eventually dizziness and nausea. Permissable daily dosage through inhalation (TWA - 8 hour) is 500 ppm (OSHA - PEL). Soap and water can remove it from the skin. If ingested seek immediate

medical attention - DO NOT CAUSE VOMITING. This material is not a known or potential carcinogen. In case of fire use CO_2, foam or dry chemical extinguisher. A Material Safety Data Sheet for Safety-Kleen's grade of mineral spirits solvent is included in Appendix A.c.

Spent mineral spirits solvent which has been used for degreasing operations is also stored at the site. The spent solvent consists of mineral spirits with water, oil and grease, solids and small amounts of other solvents. The amount of oil and grease may range from 2 to 10 percent by volume in the spent solvent. The other solvents are primarily chlorinated hydrocarbons, and their composition and quantity vary depending on the type of business using the mineral spirits.

Chemical analyses of groundwater and soils at the site are included in Appendix A.d. Material Safety Data Sheets (MSDS) for some of the predominant volatile organics are included in Appendix A.c. It should be noted, however, that most of the information provided on the MSDS applies to concentrations much higher than those previously encountered at the site.

HEALTH AND SAFETY REQUIREMENTS

MEDICAL MONITORING PROGRAM

All GTI field personnel are required to have medical examinations in accordance with the Company's Health and Safety Program Policy Manual. Re-evaluation and testing shall be considered in the event chemical overexposure occurs while working on this facility.

The chemicals of toxicological concern are typical of most of GTI's sites, affect the same organ systems and produce similar health effects. In the event of over exposure, medical examinations will focus on the liver, kidney, nervous system and skin. Laboratory testing will include: complete blood count, platelet count and applicable kidney and liver function tests.

SITE ACCESS/WORK ZONES

Access within a 25-foot radius of any on-site operation is prohibited to all but GTI field personnel and authorized subcontractors (Figure 1). Zones of prohibited entry shall be clearly marked. Space and facilities for the decontamination of personnel and equipment shall also be clearly delineated.

DECONTAMINATION PROCEDURES

All operations conducted at this site have the potential to contaminate field equipment and personal protective equipment (PPE). To prevent the transfer of any contamination to vehicles, administrative area and other personnel, the following procedures must be followed.

1. Field equipment should be decontaminated with a solution of Alconox or Green soap (available at most hardware stores) and thoroughly rinsed with water prior to leaving the site. This must be done outside a 25-foot radius of any work area. In situations where it is not possible to decontaminate field equipment on site, double-bag each piece of equipment and transport back to home base for immediate decontamination in designated area.

2. Disposable PPE (for example, Tyvek suits and inner latex gloves) must be bagged and disposed of at the site. Non-disposable PPE (such as respirators and outer gloves) must be individually bagged, transported back to the home base and properly decontaminated with a solution of Alconox or Green soap.

EXCAVATION

Any excavation (or trench) must be supported or tested for wall stability if it is over six feet in depth and requires entry. The excavated area must be surrounded by fence, barricaded or otherwise protected. The excavated area should also be lighted at night with electrically-powered lights or reflectors. It is the responsibility of the on-site professional engineer to determine whether shoring of the excavation is necessary.

DRILLING

During any drilling operations, two persons (one designated as "driller" and the other as "helper") must be present at all times. The area where the operation is taking place shall be cordoned off with barricades or fencing. Every attempt must be made to keep unauthorized personnel from entering the work area. However if it occurs, the operation should be shut down until the area is cleared. The Site Safety Officer or the Project Manager has the authority to shut down the drilling operations whenever a hazardous situation is deemed present.

ELECTRICAL EQUIPMENT

All electrical equipment and power cables used in wells or structures containing petrochemical contamination must be explosion-proof (intrinsically-safe) and equipped with a three-wire ground lead.

RECOGNIZING EMERGENCY SITUATIONS

Personnel encountering a hazardous situation shall instruct others on site to evacuate the vicinity immediately and call the Project Manager, the Site Safety Officer, or in their absence, the Regional Health and Safety Manager for instructions. The site must not be re-entered until the situation has been corrected.

Field personnel must be watchful for evidence of changes in their general state of health and that of others on site. Symptoms of overexposure to petrochemicals include dizziness, tingling in hands or feet, skin irritations, skin discoloration, eye irritations, muscular soreness, fatigue, nervousness or irritability, intolerance to heat or cold, and/or loss of appetite.

PROJECT PERSONNEL

Groundwater Technology, Inc. will oversee and act accordingly during all phases of the project. The following management structure will be instituted for the purpose of successfully and safely completing this project.

- coordinating the activties of all subcontractors,
- selecting a Site Safety Officer and field personnel for the work to be undertaken on site,
- ensuring that the tasks assigned are being completed as planned and on schedule,
- providing authority and resources to ensure that the Site Safety Officer is able to implement and manage safety procedures,
- preparing reports and recommendations about the project to clients and affected Groundwater Technology, Inc. personnel,

- ensuring that all personnel allowed to enter the site (i.e., EPA, contractors, state officials, visitors) are made aware of potential hazards associated with the substances known or suspected to be on site,

- ensuring that the Site Safety Officer is aware of all of the provisions of this site safety plan and is instructing all personnel on site about the safety practices and emergency procedures defined in the plan, and

- ensuring that the Site Safety Officer is making an effort to monitor site safety.

Regional Safety Director - Peter Kroopnick, Ph.D

The Regional Safety Director shall be responsible for the overall coordination and oversight of the site safety plan. Specific duties will include:

- approving the selection of the types of personal protective equipment (PPE) to be used on site for specific tasks,

- monitoring the compliance activities and documentation processes undertaken by the Site Safety Officer,

- evaluating weather and chemical hazard information and making recommendations to the Project Manager about any modifications to work plans or personal protection levels in order to maintain personnel safety,

- coordinate upgrading or downgrading PPE with Site Safety Officer, as necessary, due to changes in exposure levels, monitoring results, weather, other site conditions, and

- approving all field personnel working on site, taking into consideration their level of safety training, their physical capacity, and their eligibility to wear the protective equipment necessary for their assigned tasks (i.e.: Respirator Fit Testing Results).

Site Safety Officer - Peter Kroopnick, Ph.D

The Site Safety Officer shall be responsible for the implementation of the site safety plan on site. Specific duties will include:

- monitoring the compliance of field personnel for the routine and proper use of the PPE that has been designated for each task,
- routinely inspecting PPE and clothing to ensure that it is in good condition and is being stored and maintained properly,
- stopping work on the site or changing work assignments or procedures if any operation threatens the health and safety of workers or the public,
- monitoring personnel who enter and exit the site and controlled access points,
- reporting any signs of fatique, work-related stress, or chemical exposures,
- dismissing field personnel from the site if their actions or negligence endangers themselves, co-workers, or the public,
- reporting any accidents or violations of the site safety plan to the Project Manager, and documenting the same for the project in the project records,
- knowing emergency procedures, evacuation routes and the telephone numbers of the ambulance, local hospital, poison control center, fire and police departments,
- ensuring that all project-related personnel have signed the personnel agreement and acknowledgments form contained in this site safety plan, and
- coordinate upgrading and downgrading PPE with the Regional Safety Director, as necessary, due to changes in exposure levels, monitoring results, weather, and other site conditions.

PROFESSIONAL ENGINEER

Name: Lynn Pera

The Professional Engineer (P.E.) is responsible for assessing the stability of any excavation. In addition, the P.E. is responsible for keeping all the closure records and certifying when closure is complete (refer to the Closure Plan).

In the event that the Project Manager or Site Safety Officer are not on site, the P.E. will assume all responsibility for enforcing safety procedures.

MEDICAL/TECHNICAL ADVISERS

Frank H. Lawrence, M.D., Envirologic Data
ENVIROLOGIC DATA, Portland, Maine ..... (207) 773-3020

Marilyn Grant, R.N., B.S.,, C.O.H.N.
ENVIROLOGIC DATA, Portland, Maine ..... (207) 773-3020

Lori St. Pierre, I.H.
ENVIROLOGIC DATA, Portland, Maine ..... (207) 773-3020

The specific duties of the Medical/Technical Advisors include:

- providing technical input into the design of the site safety plan,
- addressing worker exposure potential along with appropriate hazard reduction methods, and
- recommending a suitable medical monitoring program for the site workers.

Other Field Personnel

All field personnel shall be responsible for acting in compliance with all safety procedures outlined in the site safety plan. any hazardous work situations or procedures should be reported to the Site Safety Officer so that corrective steps can be taken.

Client Contact

Bob Wachsmuth
Safety-Kleen Corporation
2750 Thompson Creek Road
Pomona, California 91767
(714) 593-3985

Site Contact

Steve Vague
Safety-Kleen Corporation
404 Market Street
Oakland, CA 94607
*415) 832-7942

APPENDIX A.a

CERTIFICATION AND ACKNOWLEDGEMENT STATEMENT

APPENDIX A.a

CERTIFICATION AND ACKNOWLEDGMENT STATEMENT

SAFETY PLAN CERTIFICATION

All Groundwater Technology, Inc. project personnel and subcontractor personnel are required to make the following certification prior to conducting work at the Safety-Kleen Service center located on 404 Market Street, Oakland, California.

I, _____, of _____
Name

_____ certify that:
Company

1. I have read and fully understand the Health and Safety Plan and my individual responsibilities.

2. I agree to abide by the provisions of the Health and Safety Plan.

_____
Signature

_____
Date

APPENDIX A.b

SITE SAFETY PLAN AMENDMENT SHEET

APPENDIX A.b

SITE SAFETY PLAN AMENDMENT SHEET

Project Name: Safety-Kleen Corporation, Oakland

Project Number: 203 5016.02

Location: 404 Market Street, Oakland, CA 94607

CHANGES IN FIELD ACTIVITIES OR HAZARDS:

PROPOSED AMENDMENT:

Proposed by: _____ Date: _____

Approved by: _____ Date: _____

Declined by: _____ Date: _____

Amendment Number: _____

Amendment Effective Date: _____

APPENDIX A.c

MATERIAL SAFETY DATA SHEETS (MSDS)

MATERIAL SAFETY DATA SHEET

SAFETY-KLEEN CORP.
777 Big Timber Rd.
Elgin, IL 60120

safety-kleen corp

IDENTITY (As Used on Label and List)	Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.
Safety-Kleen 105 Solvent-MS	

Section I Part #6617

Manufacturer's Name Safety-Kleen Corp.	Emergency Telephone Number 312/697-8460
Address (Number, Street, City, State, and ZIP Code) 777 Big Timber Road	Telephone Number for Information 312/697-8460
Elgin, Illinois 60120	Date Prepared 11/6/85
	Signature of Preparer (optional)

Section II — Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Mineral Spirits	500 ppm	100 ppm	-	99.9+
Dye	Unk.	Unk.	-	0.003
Anti-Static Agent	Unk.	Unk.	100 est.	1 ppm

Section III — Physical/Chemical Characteristics

Boiling Point	310-400°F	Specific Gravity (H_2O = 1)	0.775-0.795
Vapor Pressure (mm Hg.) @ 68°F	2	Melting Point	N/A
Vapor Density (AIR = 1)	4.9	Evaporation Rate (Toluene = 1)	0.2

Solubility in Water: Negligible.

Appearance and Odor: Clear green liquid with characteristic hydrocarbon odor.

Section IV — Fire and Explosion Hazard Data

Flash Point (Method Used) 105°F TCC	Flammable Limits	LEL 0.7	UEL 6.0

Extinguishing Media: CO_2, foam, dry chemical, water (mist only)

Special Fire Fighting Procedures: None.

Unusual Fire and Explosion Hazards: None.

Section V — Reactivity Data

Stability			Conditions to Avoid
	Unstable		
	Stable	X	Heat, sparks, flame and fire.

Incompatibility (Materials to Avoid): Strong oxidizing agents.

Hazardous Decomposition or Byproducts: Normally none; however, incomplete burning may yield carbon monoxide.

Hazardous Polymerization			Conditions to Avoid
	May Occur		
	Will Not Occur	X	

Section VI — Health Hazard Data

Route(s) of Entry: Inhalation? yes | Skin? no | Ingestion? yes

Health Hazards (Acute and Chronic): Skin - can cause drying of skin. Eyes - severe irritant. Inhalation - excessive inhalation can cause headache, dizziness and nausea. Ingestion - harmful or fatal if swallowed.

Carcinogenicity: NTP? | IARC Monographs? | OSHA Regulated?

Not a known or potential carcinogen.

Signs and Symptoms of Exposure: Drying of skin, eye irritation, headache, dizziness, nausea.

Medical Conditions Generally Aggravated by Exposure: Unknown.

Emergency and First Aid Procedures: Skin - Wash with soap and water. Eyes - Irrigate with water. Inhalation - Remove to fresh air source and call a physician. Ingestion - DO NOT induce vomiting. Call a physician.

Section VII — Precautions for Safe Handling and Use

Steps to Be Taken in Case Material Is Released or Spilled: Catch and collect for recovery as soon as possible. Avoid exposure to sparks, fire, flame, hot surfaces.

Waste Disposal Method: Dispose of in accordance with company, local, state and federal regulations.

Precautions to Be Taken in Handling and Storing: Combustible. Keep away from heat, sparks, flame. Use with adequate ventilation. Avoid long and repeated contact with skin. If clothes are inadvertently saturated with solvent-

Other Precautions: DO NOT SMOKE- keep away from ignition sources. Keep out of reach of children.

Section VIII — Control Measures

Respiratory Protection (Specify Type): Self-contained breathing apparatus for concentrations above TLV limits.

Ventilation			
	Local Exhaust: Normal room ventilation.	Special: None.	
	Mechanical (General): None.	Other: None.	

Protective Gloves: In cases of prolonged contact, wear rubber gloves. | Eye Protection: Yes - eyeglasses, safety glasses.

Other Protective Clothing or Equipment: N/A

Work/Hygienic Practices: Do not smoke while using this solvent.

1,1,1-TRICHLOROETHANE

MATERIAL SAFETY DATA SHEET

Prepared by Envirologic Data
Portland, ME (207) 773-3020
September 1984

EMERGENCY TELEPHONE NUMBER: Massachusetts Poison Information Center
Boston, MA 1-800-682-9211

SECTION I. IDENTIFICATION

Material Name: 1,1,1-trichloroethane
CAS No.: 71-55-6
Synonyms: Methyl chloroform; chloroethane; methyltrichloromethane; chlorothene; chloroetene; chloroethene NU; α-trichloroethane; 1,1,1-trichloroethane stablized
Molecular Formula: CH_3CCl_3

SECTION II. FIRST AID PROCEDURES AND EMERGENCY TREATMENT

In all cases of poisoning, follow standard procedures for poisoning, first aid, and cardiopulmonary resuscitation. Whenever transporting a poisoned person to a hospital, bring the container, label, or other information concerning the product (without delaying transport) to assist medical personnel with diagnosis and treatment. Four different routes of exposure and their respective first aid/poison managements are outlined below:

Ingestion:

- Call the Massachusetts Poison Information Center (1-800-682-9211).
- Make person vomit, UNLESS person is unconscious or having convulsions.

INSTRUCTIONS FOR INDUCING VOMITING: For adults, give two tablespoonfuls (1 ounce) of syrup of ipecac. The ipecac should be followed with at least one cup of water. After ipecac has been given, transport person immediately. Transport person promptly to a medical facility. If vomiting does not occur within 20 minutes, the original dose may be repeated once.

- Notify your supervisor or health and safety officer of this or any poison exposure.
- FURTHER MANAGEMENT: In some cases, activated charcoal (U.S.P.) may be indicated. Only give activated charcoal upon the recommendation of a Poison Information Center, Emergency Department, or physician.

Inhalation:

- Stop exposure by moving person from contaminated area to clean air area.
- Call the Massachusetts Poison Information Center (1-800-682-9211).
- Have someone call a rescue unit or medical professional.
- If necessary, transport person to an emergency medical facility promptly.

Skin:

- If material is a powder, brush away using a cloth.
- Wash off skin immediately with a large amount of water; use soap if available.
- Remove any contaminated clothing and rewash skin.
- Call the Massachusetts Poison Information Center (1-800-682-9211).
- Transport person to a medical facility as necessary.

Eyes:

- Gently rinse eye immediately, using large amounts of water, for fifteen minutes, if possible, with eyelids held open.
- If possible, have person remove contact lenses if worn; never permit the eyes to be rubbed.
- Call the Massachusetts Poison Information Center (1-800-682-9211).
- Transport person to an emergency medical facility promptly as necessary.

SECTION III. ACUTE TOXICITY

ELD Rating (Oral Toxicity): 2

Inhalation man LC_{LO}	27 g/m^3 (for 10 min)
Inhalation man TC_{LO}	350 ppm
Inhalation human TC_{LO}	920 ppm (for 70 min)
Oral human TD_{LO}	670 mg/kg
Oral rat LD_{50}	10,300 mg/kg
Inhalation rat LC_{LO}	1,000 ppm
Oral mouse LD_{50}	11,240 mg/kg

Signs and Symptoms:

Ingestion: May cause symptoms similar to inhalation. In addition may cause mouth, throat, and stomach irritation.

Inhalation: Vapor is a narcotic and depresses central nervous system, headache, dizziness, drowsiness, incoordination, impaired judgement unconsciousness, irregular heart beat, and death.

- o Any clothing which becomes wet with liquid or non-impervious clothing which becomes contaminated with liquid should be removed immediately and not reworn until the chemical is removed from the clothing.
- o Where exposure of an employee's body to liquid chemicals may occur, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- o An eyewash fountain should be provided within the immediate work area for emergency use where there is any possibility that employee's eyes may be exposed to liquids or solids.

SECTION XI. SPECIAL PROCEDURES AND PRECAUTIONS

Procedures and Precautions to be Taken in Handling and Storing: Requires inhibitor content to prevent corrosion of metals; when inhibitor is depleted, decomposes rapidly by reaction with finely divided white metals, such as aluminum, magnesium, zinc, etc. Monitor inhibitor level. Do not use these metals for storage containers or in pressurized spraying equipment. Store in closed containers in a cool, well-ventilated area. Keep water-free. Monitor inhibitor level for vapor degreasing use.

Other Precautions: Liquid methyl cholorform attacks some plastics, rubber and coatings. Avoid drinking alcoholic beverages shortly before, during, or soon after exposure. Individuals with impaired cardiovasuclar function, especially cardiac arrhythmias, may have exacerbation of symptoms. Individuals with pre-existing skin condition may be more susceptible to chemical.

TRICHLOROETHYLENE

MATERIAL SAFETY DATA SHEET

Prepared by Envirologic Data
Portland, ME (207) 773-3020
September 1984

EMERGENCY TELEPHONE NUMBER: Massachusetts Poison Information Center
Boston, MA 1-800-682-9211

SECTION I. IDENTIFICATION

Material Name: Trichloroethylene
Synonyms: Trichloroethene; ethinyl trichloride; trilene; acetylene trichloride; 1,1-dichloro-2-chloroethylene; trichloran
CAS No.: 79-01-6
Molecular Formula: C_2HCl_3

SECTION II. FIRST AID PROCEDURES AND EMERGENCY TREATMENT

In all cases of poisoning, follow standard procedures for poison management, first aid, and cardiopulmonary resuscitation. Whenever transporting a poisoned person to a hospital, bring the container, label, or other information concerning the product (without delaying transport) to assist medical personnel with diagnosis and treatment. Four different routes of exposure and their respective first aid/poison managements are outlined below:

Ingestion:

- Call the Massachusetts Poison Information Center (1-800-682-9211).
- Make person vomit, UNLESS person is unconscious or having convulsions.
  INSTRUCTIONS FOR INDUCING VOMITING: For adults, give two tablespoonfuls (1 ounce) of syrup of ipecac. The ipecac should be followed with at least one cup of water. After ipecac has been administered, promptly transport person to a medical facility. If vomiting does not occur within 20 minutes, the original dose may be repeated once.
- Notify your supervisor or health and safety officer of this or any poison exposure.
- FURTHER MANAGEMENT: In some cases, activated charcoal (U.S.P.) may be indicated. Only give activated charcoal upon the recommendation of a Poison Information Center, Emergency Department, or physician.

Inhalation:
- o Stop exposure by moving person from contaminated area to clean air area.
- o Call the Massachusetts Poison Information Center (1-800-682-9211).
- o Have someone call a rescue unit or medical professional.
- o If necessary, transport person to an emergency medical facility promptly.

Skin:
- o Wash off skin immediately with a large amount of water; use soap if available.
- o Remove any contaminated clothing and rewash skin.
- o Call the Massachusetts Poison Information Center (1-800-682-9211).
- o Transport person to a medical facility as necessary.

Eyes:
- o Gently rinse eye immediately, using large amounts of water, for fifteen minutes, if possible, with eyelids held open.
- o If possible, have person remove contact lenses if worn; never permit the eyes to be rubbed.
- o Call the Massachusetts Poison Information Center (1-800-682-9211).
- o Transport person to an emergency medical facility promptly as necessary.

SECTION III. ACUTE TOXICITY

ELD Rating (Oral Toxicity): 2

Toxic Effect Levels:

Oral human LD_{LO}	7,000 mg/kg
Inhalation human TC_{LO}	6,900 mg/m^3 (10 min)
Inhalation human TC_{LO}	160 ppm (83 min)
Inhalation human TC_{LO}	812 mg/kg
Inhalation man TC_{LO}	110 ppm (8 h)
Inhalation man LC_{LO}	2,900 ppm
Oral rat LD_{50}	4,920 mg/kg
Inhalation rat LC_{LO}	8,000 ppm (4 h)
Oral mouse LD_{50}	2,402 mg/kg
Inhalation mouse LC_{LO}:	3,000 ppm (2 h)

Signs and Symptoms

Ingestion: Inebriety, vomiting, diarrhea, coma. May be pulmonary edema, hepatic and renal necrosis.

Inhalation: Irritates nose and throat, dizziness, drowsiness, headache, nausea, and loss of consciousness. Rapid coma may be followed by eventual death from renal or hepatic failure.

Skin: Irritant. Prolonged exposure may cause dermatitis.

Eyes: Irritation and lacrimation (tearing).

Exposure Limits

OSHA Standard(s): 100 ppm

NIOSH Recommended Limit(s): 25 ppm

ACGIH Recommended Limit(s): 50 ppm

STEL: 200 ppm

SECTION IV. LONG-TERM ORGANISM THREAT POTENTIAL

Carcinogenicity
IARC: Limited evidence of positive carcinogenic response in mice. Inadequate evidence for carcinogenicity in humans.
NTP/NCI: Positive evidence of carcinogenicity in mice.
EPA/CAG: Substantial evidence of carcinogenicity.
RTECS: Positive tumorigenic effects in mice. Equivocal tumorigenic agent in rats and hamsters.

Mutagenicity
IARC: Positive mutagenic response in bacteria and yeast. Limited evidence of mutagenicity in mice.
RTECS: Positive mutagenic response in bacteria, yeast, animals, and human lymphocytes.

Teratogenicity
IARC: IARC Monographs have not reported teratogenic effects.
RTECS: Positive teratogenic effects in rats.

Reproductive Effects
IARC: IARC Monographs have not reported reproductive effects.
RTECS: Positive reproductive effects in rats.

SECTION V. CHRONIC TOXICITY

Addiction and intolerance to alcohol, giddiness, nervous exhaustion. Repeated contact with the hands may cause dryness, cracking, burning, loss of sense of touch, and temporary paralysis of the fingers.

SECTION VI. PHYSICAL DATA

Molecular weight: 131.38
Boiling Point (at 760 mm Hg): 87°C (188°F)
Melting Point (at 760 mm Hg): -73 - -86°C (-99 - -123°F)
Vapor Pressure (mm Hg) [at 20°C (68°F)]: 58
Vapor Density (Air=1): 4.54
Specific Gravity (water=1): 1.45 - 1.47
Percent Volatile By Volume: ca 100
Evaporation Rate (butyl acetate =1): 0.69
Solubility in Water: 0.1 percent
Solvent Solubility: Highly soluble in lipids, acetone, ethanol, ether, and vegetable oils.
Appearance and Odor: Colorless liquid witn sweet ether-like odor. Threshold is 21.4 ppm in air.

SECTION VII. FIRE AND EXPLOSION HAZARD DATA

Flash Point (Method Used): 32°C (90°F)
Extinguisher Media: CO_2, foam, or dry chemical. Use appropriate media for surrounding fire as TCE is considered noncombustible.

	Lower	Upper
Flammable Limits in Air, percent by vol.:	12.5	90

Autoignition Temperature: 420°C (788°F)
NFPA Fire Hazard: 1 (practically nonflammable)
Special Fire Fighting Procedures: Use self-contained breathing apparatus.
Unusual Fire and Explosion Hazards: Heat causes decomposition to form phosgene (a highly toxic substance) and chloride ion.

SECTION VIII. REACTIVITY DATA

Stability: When exposed to sunlight or heated requires stabilization. When moist, it is decomposed by light. Susceptible to oxidation, degradation and polymerization. Subject to autoxidation.
NFPA Reactivity: 0
Incompatibilities (Materials to Avoid): NaOH, KOH or other strong alkalies may form explosive mixtures of chloroacetylenes. Magnesium or aluminum powder may react.
Hazardous Decomposition Products: May decompose via heat or soda lime to chlorine, hydrochloric acid, phosgene (CCl_2O), carbon monoxide, dichloroacetylene.
Hazardous Polymerization: Catalyzed by aluminum chloride to produce heat, hydrogen chloride, and phosgene.

SECTION IX. SPILL, LEAK OR DISPOSAL PROCEDURES

Actions To Take in Case of Spills or Leaks: Restrict from areas of spills or leaks persons not wearing protective equipment and clothing. Eliminate sources of ignition. Ventilate area. Inform supervisor or health and safety officer of any spill or leak. While protecting against eye and skin contact and inhalation of vapors, take the following steps:

- Solid: Shovel or sweep solid into suitable container, and cover.
- Liquid: Contain spill. Prevent leakage into confined spaces or sewer drains. Where feasible, absorb liquid with paper towels, vermiculite, sand, or other non-combustible absorbent material. Collect in suitable container and cover.
- Gas: Ventilate area to keep gas concentration below flammability limit. Stop the gas flow. If leak cannot be stopped, move container to safe place in open air and allow to empty.

Disposal Methods: Federal laws and regulations impose highly specific requirements for disposal of toxic and otherwise hazardous materials. Consult with your supervisor or health and safety officer regarding the proper, legal disposal procedures for this substance. Do not dispose of potentially toxic or otherwise hazardous substances without appropriate authorization. Prior to receiving institutional authorization, it may be necessary to store spilled materials. To do so safely, carefully label containers of materials, store in a cool, dry location, and maintain security of the storage area until official guidance is obtained. May be processed to recover trichloroethylene.

SECTION X. SPECIAL PROTECTION INFORMATION

Respiratory Protection: Only NIOSH or MSHA approved equipment should be used. Use self-contained breathing apparatus for levels >1,000 ppm. Full face cartridge or canister respirators for limited time for levels greater than ceiling or TLV limit.
Ventilation: Provide adequate ventilation to maintain TLV requirements.
Protective Clothing or Equipment:

- To prevent repeated or prolonged skin contact with liquid and solid chemicals, use impervious clothing, gloves, face shields (eight-inch minimum), splash-proof safety goggles, and other appropriate protective clothing.
- Place clothing contaminated with liquids or solids in closed containers for storage until clothing can be discarded or decontaminated. If the clothing is to be laundered or otherwise cleaned to remove the chemical, the person(s) performing the operation should be informed of the chemical's hazardous properties and of ways to minimize exposure.
- A safety shower should be provided within the immediate work area for emergency use where liquids may contact the employee's body.
- An eyewash fountain should be provided within the immediate work area for emergency use where liquids or solids may contact the employee's eyes.

SECTION XI. SPECIAL PROCEDURES AND PRECAUTIONS

Procedures and Precautions to be Taken in Handling and Storing: Avoid breathing vapors and contact with skin. Store in cool ventilated areas in sealed, light resistant containers or glass tubes. Avoid exposure to heat.
Other Precautions: Trichloroethylene has been shown to produce cancer of the liver in animals.

XYLENE

MATERIAL SAFETY DATA SHEET

Prepared by Envirologic Data
Portland, ME (207) 773-3020
Revised January 1986

EMERGENCY TELEPHONE NUMBER: Pittsburgh Poison Information Center
Children's Hospital of Pittsburgh
Pittsburgh, PA 1-412-681-6669

SECTION I. IDENTIFICATION

Material Name: Xylene
Synonyms: Dimethylbenzene; xylol
CAS No.: 1330-20-7
Molecular Formula: $C_6H_4(CH_3)_2$

SECTION II. FIRST AID PROCEDURES AND EMERGENCY TREATMENT

In all cases of poisoning, follow standard procedures for poison management, first aid, and cardiopulmonary resuscitation. Whenever transporting a poisoned person to a hospital, bring the container, label, or other information concerning the product (without delaying transport) to assist medical personnel with diagnosis and treatment. Four different routes of exposure and their respective first aid/poison managements are outlined below:

Ingestion:

- Dilute the poison by offering and encouraging the person to drink one or two glassfuls of water or milk. Do not use carbonated fluids. Do not attempt to make the person vomit.
- Call the Pittsburgh Poison Information Center (1-412-681-6669). If you cannot reach the Poison Information Center, call or take the person to the nearest hospital emergency department.
- Notify your supervisor or health and safety officer of this or any poison exposure.

Inhalation:

- Stop exposure by moving person from contaminated area to clean air area.
- Call the Pittsburgh Poison Information Center (1-412-681-6669).
- Have someone call a rescue unit or medical professional.
- If necessary, transport person to an emergency medical facility promptly.

Skin:
- o If material is a powder, brush away using a cloth.
- o Wash off skin immediately with a large amount of water: use soap if available.
- o Remove any contaminated clothing and rewash skin.
- o Call the Pittsburgh Poison Information Center (1-412-681-6669).
- o Transport person to a medical facility as necessary.

Eyes:
- o Gently rinse eye immediately, using large amounts of water, for fifteen minutes, if possible, with eyelids held open.
- o If possible, have person remove contact lenses if worn: never permit the eyes to be rubbed.
- o Call the Pittsburgh Poison Information Center (1-412-681-6669).
- o Transport person to an emergency medical facility promptly as necessary.

SECTION III. ACUTE TOXICITY

Exposure Routes: The primary routes of exposure are inhalation of vapor and direct skin or eye contact with the liquid.

Toxic Effect Levels:

Inhalation human TC_{LO}	200 ppm
Inhalation man LC_{LO}	10,000 ppm (for 6 h)
Oral rat LC_{50}	4,300 mg/kg
Inhalation rat LC_{50}	5,000 ppm (for 4 h)

Signs and Symptoms

Ingestion: Burning sensation in the mouth and throat. Other symptoms are the same as those for inhalation (see below), except that lung congestion will not usually develop.

Inhalation: Irritation of the eyes, nose, and throat. At concentrations above 200 ppm nausea, vomiting, abdominal pain, dizziness, staggering, drowsiness, severe breathing difficulties, and unconsciousness may occur. Vapor levels above 200 ppm may have an anesthetic effect.

Skin: Irritation and defatting.

Eyes: Irritation at concentrations of 200 ppm.

Exposure Limits

OSHA Standard(s):	100 ppm, 8-h TWA (skin)*
NIOSH Recommended Limit(s):	100 ppm, 8-h TWA 200 ppm, Ceiling (for 10 min)
ACGIH Recommended Limit(s):	100 ppm, 8-h TLV-TWA 150 ppm, STEL

*Skin absorption may contribute to overall exposure.

SECTION IV. LONG-TERM ORGANISM THREAT POTENTIAL

Carcinogenicity

IARC, NTP/NCI, CAG, RTECS: No indication of carcinogenic effects was found in standard references.

Mutagenicity
IARC: IARC Monographs have not reported mutagenic effects.
RTECS: Mutagenic response in yeast.
Teratogenicity
IARC: IARC Monographs have not reported teratogenic effects.
RTECS: Teratogenic effects in mice and rats.
Reproductive Effects
IARC: IARC Monographs have not reported reproductive effects.
RTECS: Reproductive effects in mice.

SECTION V. CHRONIC TOXICITY

Reversible damage to the kidneys and liver may occur from exposure to high concentrations.

SECTION VI. PHYSICAL DATA

Molecular weight: 106.2
Boiling Point (at 760 mm Hg): 144.4°C (292°F) (o)*
138.9°C (282°F) (m)*
138.3°C (281°F) (p)*
Melting Point (at 760 mm Hg): -25°C (-12°F) (o)
-48°C (-54°F) (m)
13°C (55°F) (p)
Vapor Pressure (mm Hg) [at 20°C (68°F)]: 7(o), 9(m), 9(p)
Vapor Density (Air=1): 3.7
Specific Gravity (water=1): 0.88(o), 0.86(m), 0.86(p), mixture about 0.86
Percent Volatile By Volume: ~ 100
Evaporation Rate (butyl acetate =1): 0.7 (o, m, p)
Solubility in Water: 0.00003 g/100 g of H_2O, at 20°C (68°F) (o, m, p).
Solvent Solubility: Miscible with absolute alcohol, ether, and other organic liquids.
Appearance and Odor: Colorless or light colored aromatic liquid with an unfatigued odor threshold of 0.3 ppm in air. Para-xylene may be a crystal at low temperatures.

*o = ortho isomer, m = meta isomer, p = para isomer

SECTION VII. FIRE AND EXPLOSION HAZARD DATA

Flash Point (Method Used): 27.2 to 32°C (81 to 90°F) (closed cup)
Extinguisher Media: Foam, carbon dioxide, dry chemical.

	Lower	Upper
Flammable Limits in Air, percent by vol.:	1.0 to 1.1	6 to 7

Autoignition Temperature: 465 to 530°C (869 to 986°F)
NFPA Fire Hazard: 3
Special Fire Fighting Procedures: Firefighters should use self-contained breathing apparatus with a full facepiece operated in pressure-demand or positive-pressure mode.
Unusual Fire and Explosion Hazards: When exposed to heat or flame, xylene is a significant fire and explosion hazard. Vapors may travel a distance along surfaces to ignition sources and then flash back.

SECTION VIII. REACTIVITY DATA

Stability: Stable in closed containers at room temprature.
NFPA Reactivity: 0
Incompatibilities (Materials to Avoid): Can form explosive mixtures with air. Xylene should be kept away from sources of heat and ignition and strong oxidizing agents.
Hazardous Decomposition Products: Degradation in air due to heat may yield toxic vapors and gases, incluoing carbon monoxide ano oxides of nitrogen.
Hazardous Polymerization: Does not occur.

SECTION IX. SPILL, LEAK OR DISPOSAL PROCEDURES

Actions To Take in Case of Spills or Leaks: Restrict from areas of spills or leaks persons not wearing protective equipment and clotning. Eliminate sources of ignition. Ventilate area. Inform supervisor or health and safety officer of any spill or leak. While protecting against eye and skin contact and inhalation of vapors, take the following steps:

- Solid: Shovel or sweep solid into suitable container, and cover.
- Liquid: Contain spill. Prevent leakage into confined spaces or sewer drains. Where feasible, absorb liquid with paper towels, vermiculite, sand, or other non-combustible absorbent material. Collect in suitable container and cover.

Disposal Methods: Federal laws and regulations impose highly specific requirements for disposal of toxic and otherwise hazardous materials. Consult with your supervisor or health and safety officer regaroing the proper, legal disposal procedures for this substance. Do not dispose of potentially toxic or otherwise hazardous substances without appropriate authorization. Prior to receiving institutional authorization, it may be necessary to store spilled materials. To do so safely, carefully label containers of materials, store in a cool, dry location, and maintain security of the storage area until official guidance is obtained.

SECTION X. SPECIAL PROTECTION INFORMATION

Respiratory Protection: Only NIOSH or MSHA approved equipment should be used. Minimum respiratory equipment required for vapor:
>100 and ≤1,000 ppm: Chemical cartridge respirator witn full facepiece and organic vapor cartridge(s).
≤5,000 ppm: Gas mask with chin-style or front- or back-mounted organic vapor canister; or supplied-air respirator with full facepiece, helmet, or hood; or self-contained breathing apparatus with full facepiece.
≤10,000 ppm: Type C supplied-air respirator with full facepeice operated in pressure-demand or other positive pressure mode or with full facepiece, helmet or hood operated in continous-flow mode.

>10,000 ppm or entry and escape from unknown concentrations: Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode; or combination respirator including Type C supplied-air respirator with full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

Ventilation: Provide general and local exhaust ventilation to comply with OSHA standards. For exhaust hood, use >100 lfm face velocity.

Protective Clothing or Equipment:

- To prevent repeated or prolonged skin contact with liquid and solid chemicals, use impervious clothing, gloves, face shields (eight-inch minimum), splash-proof safety goggles, and other appropriate protective clothing.
- Place clothing contaminated with liquids or solids in closed containers for storage until clothing can be discarded or decontaminated. If the clothing is to be laundered or otherwise cleaned to remove the chemical, the person(s) performing the operation should be informed of the chemical's hazardous properties and of ways to minimize exposure.
- A safety shower should be provided within the immediate work area for emergency use where liquids may contact the employee's body.
- An eyewash fountain should be provided within the immediate work area for emergency use where liquids or solids may contact the employee's eyes.

SECTION XI. SPECIAL PROCEDURES AND PRECAUTIONS

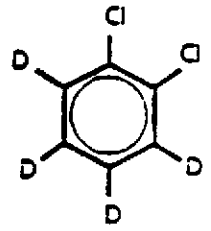
Procedures and Precautions to be Taken in Handling and Storing: Store in a well-ventilated area in closed containers away from sources of heat and ignition and strong oxidizing agents. Protect containers from physical damage. Electrically ground metal containers when transferring liquid. Detached storage is preferable.

Other Precautions: Do not smoke in areas of use or storage. Wash hands before eating, smoking, or using toilet facilities.

0733X

EPA THE EPA REPOSITORY FOR TOXIC AND HAZARDOUS MATERIALS

ANALYTICAL STANDARD DATA SHEET



IDENTIFIERS

COMPOUND NAME: 1,2-Dichlorobenzene-d_4

SYNONYMS:

CAS NUMBER: Not available

MOLECULAR FORMULA: $C_6D_4Cl_2$

REPOSITORY NUMBER: EL-000776-01

STANDARD SOLUTION

CONCENTRATION: 150 ± 15 µg/mL

Reference Chromatogram (see reverse side)

SOLVENT: Methanol

STANDARD CODE: 776-01-01

DATE PREPARED: 16 JUNE 83

STORAGE & PRESERVATION: Store at 5°C; allow to equilibrate to room temperature before use; transfer to tightly sealed vial with Teflon-lined septum or cap after opening.

PURITY

PURITY ASSAY OF NEAT COMPOUND: QAS 99.6%

HAZARDS

NIOSH REGISTRY NUMBER: Not available

LD_{50}: 500 mg/kg oral-rat

TOXIC EXPOSURE ROUTES: Not available

HAZARDS: Can cause injury to liver, kidneys; high concentrations cause central nervous system depression; flammable (MEOH).

PERSONNEL PROTECTION: Wear impervious laboratory apron, gloves or clothing while handling this standard. Open only in a fume hood or glovebox. Do not breathe vapors.

For comments or questions concerning those standards please contact:

Mr. Harry Kolde
U.S. Environmental Protection Agency-EMSL
26 West St. Clair Street
Cincinnati, OH 45268

(513) 684-7327

MATERIAL SAFETY DATA SHEET
March 14 1987

SECTION I PRODUCT SPECIFICATIONS
Ca[redacted] No. F25
CA[redacted] No. 95-50-1
Other name- 1,2-Dichlorobenzene
Supplied by CHEM SERVICE INC., PO Box 3108, West Chester, PA 19381 (215)692-3151

SECTION II TOXICITY HAZARD
Ra[redacted] or mouse LD50 = 500 mg./kg
OSHA PEL 50 ppm(300 mg/m3) ACGIH TLV 50 ppm(300 mg/m3)

SECTION III PHYSICAL DATA
Me[redacted]ting point: -15 C Boiling point: 180 C Density: 1.306

SECTION IV FIRE AND EXPLOSION HAZARD DATA
Fl[redacted]sh point: 66 C
Combustible chemical
Extinguishing media- Carbon dioxide, dry chemical powder or water spray

SECTION V HEALTH HAZARD DATA
Poison by skin absorption, ingestion or inhalation
Ha[redacted]rmful if inhaled and/or absorbed through skin
Ca[redacted] cause blood disorders, nervous system damage,
or adverse reproductive damage
Al[redacted] chemicals should be considered hazardous -avoid direct physical contact
FI[redacted]RST AID- In case of eye or skin contact, flush with copious
quantities of water. If inhaled remove to fresh air- give
oxygen if necessary. Contact physician.

SECTION VI REACTIVITY DATA
No known incompatibility with other chemicals except strong oxidizing agents
Lo[redacted] reactivity

SECTION VII SPILL OR LEAK PROCEDURES
Sp[redacted]ills or leaks: Evacuate area. Wear appropriate OSHA-regulated
equipment. Ventilate area.
Absorb on vermiculite or similar material. Sweep up and place
in an appropriate container. Hold for disposal.
Wa[redacted]sh contaminated surfaces to remove any residues
DISPOSAL: Burn in a chemical incinerator with an afterburner and scrubber

SECTION VIII PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE
Th[redacted]is chemical should be handled only in a hood. Eye shields should be worn
Use appropriate OSHA/MSHA approved safety equipment. Avoid contact with skin,
ey[redacted]es and clothing. Keep tightly closed and store in cool dry place
St[redacted]ore only with compatible chemicals.

SECTION IX SPECIAL PRECAUTIONS AND COMMENTS
Th[redacted]e above information is believed to be correct on the date it is published and
must not be considered all inclusive. The information has been obtained only by a
search of available literature and is only a guide for handling the chemical
OSHA regulations require that if other hazards become evident, an updated MSDS
must be made available to the employee within three months. Responsibility for
updates lies with the employer and not with Chem Service Inc. Persons not
specifically and properly trained should not handle this chemical or its contain-
This MSDS is provided without any warranty expressed or implied including merchant-
ability or fitness for any particular purpose.

APPENDIX A.d

CHEMICAL ANALYSES

GTEL Environmental Laboratories
A division of Groundwater Technology, Inc.

Western Region
4080-C Pike Lane
Concord, CA 94520

(415) 685-7852
(800) 544-3422 *from inside California*
(800) 423-7143 *from outside California*

07/14/88 JP

CLIENT: Steve Fischbein
Groundwater Technology, Inc.
4080 Pike Ln.
Concord, CA 94520
PROJECT#: 203-680-5016.01-6
LOCATION: Oakland, CA
SAMPLED: 06/30/88 BY: S. Fischbein
RECEIVED: 06/30/88 BY: J. Floro
ANALYZED: 7/1-11/88 BY: L. Hinson
MATRIX: Water
UNITS: ug/L (ppb)

V.O.A.
A TEST RESULTS

COMPOUNDS	MDL	LAB # / I.D.#	26387 MW-2A	26388 MW-2B		
Chloromethane	10		<10	<10		
Bromomethane	10		<10	<10		
Vinyl Chloride	10		14	<10		
Chloroethane	10		<10	<10		
Methylene Chloride	5		44	57		
Acetone	10		62	<10		
Carbon Disulfide	5		<5	<5		
1,1-Dichloroethene	5		47	69		
1,1-Dichloroethane	5		190	270		
Trans-1,2-Dichloroethene	5		<5	<5		
Chloroform	5		6.8	<5		
1,2-Dichloroethane	5		18	18		
2-Butanone	10		30	<10		
1,1,1-Trichloroethane	5		290	480		
Carbon Tetrachloride	5		<5	<5		
Vinyl Acetate	10		<10	<10		
Bromodichloromethane	5		<5	<5		
1,2-Dichloropropane	5		<5	<5		
cis-1,3-Dichloropropene	5		<5	<5		
Trichloroethene	5		<5	12		
Dibromochloromethane	5		<5	<5		
1,1,2-Trichloroethane	5		<5	<5		
Benzene	5		74	91		
Trans-1,3-Dichloropropene	5		<5	<5		
2-Chloroethylvinylether	10		<10	<10		
Bromoform	5		<5	<5		
4-Methyl-2-Pentanone	10		71	61		
2-Hexanone	10		<10	<10		
Tetrachloroethene	5		31	7		
1,1,2,2-Tetrachloroethane	5		<5	<5		
Toluene	5		930	620		
Chlorobenzene	5		120	48		
Ethylbenzene	5		320	120		

GTEL
Environmental
Laboratories
A division of Groundwater Technology, Inc.

Western Region
4080-C Pike Lane
Concord, CA 94520
(415) 685-7852
(800) 544-3422 *from inside California*
(800) 423-7143 *from outside California*

CLIENT: Steve Fischbein
PROJECT#: 203-680-5016.01-6
LOCATION: Oakland, CA
MATRIX: Water
UNITS: ug/L (ppb)

COMPOUNDS	MDL	LAB # / I.D.#	26387 MW-2A	26388 MW-2B		
Styrene	5		<5	<5		
1,2-Dichlorobenzene	5		1200	380		
1,3-Dichlorobenzene	5		46	<5		
1,4-Dichlorobenzene	5		400	18		
Total Xylenes	5		2700	1100		
Trichlorofluoromethane	5		<5	<5		
Dichlorodifluoromethane	5		<5	<5		

See attached list of tentatively identified compounds.

MDL = Method Detection Limit; compound below this level would not be detected.
METHODS: EPA 624.

Safy Khalifa

SAFY KHALIFA, Ph.D., Director

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 624 (GC-MS)

Project number: 301-680-8576
Work order number: C902397
Sample number: 02
Sample ID: SS7-D
Matrix: Soil

Date received: 07-Feb-89
Date analyzed: 24-Feb-89

COMPOUND NAME	SCAN NUMBER	ESTIMATED CONCENTRATION (RELATIVE %)
Dimethylcyclohexane	635	0.27
Dimethylheptane	748	0.27
C3 substituted cyclohexane	768	0.59
C3 substituted cyclohexane	790	2.70
C3 substituted cyclohexane	828	1.90
C3 substituted cyclohexane	900	0.85
Nonane	924	4.70
C3 substituted cyclohexane	934	5.00
p- & m-Xylene	966	2.20
C3 substituted cyclohexane	988	2.70
Dimethyloctane	1002	1.90
Trimethyldecane	1028	2.00
o-Xylene	1039	0.19
C10-C12 aliphatic hydrocarbon	1099	1.10
C3 substituted benzene	1208	7.70
C3 substituted benzene	1250	4.70
C3 substituted benzene	1275	5.30
C4 substituted cyclohexane	1286	1.70
C3 substituted benzene	1355	2.70
1,3-Dichlorobenzene	1360	2.00
Decahydronaphthalene	1383	9.50
C4 substituted benzene	1394	1.90
C4 substituted benzene	1411	3.80
1,2-Dichlorobenzene	1421	1.50
C4 substituted benzene	1435	1.70
C4 substituted benzene	1458	2.00
C4 substituted benzene	1463	2.50
C4 substituted benzene	1478	2.90
C4 substituted benzene	1502	5.60
C5 substituted benzene	1523	1.00
C4 substituted benzene	1543	3.20
C4 substituted benzene	1557	5.00
C5 substituted benzene	1572	0.80
C4 substituted benzene	1636	5.00
C4 substituted benzene	1650	3.50
Tetrahydronaphthalene	1689	0.50
C4 substituted benzene	1734	0.40
		101.27 %

Total number of compounds: 37

Emma P. Popek

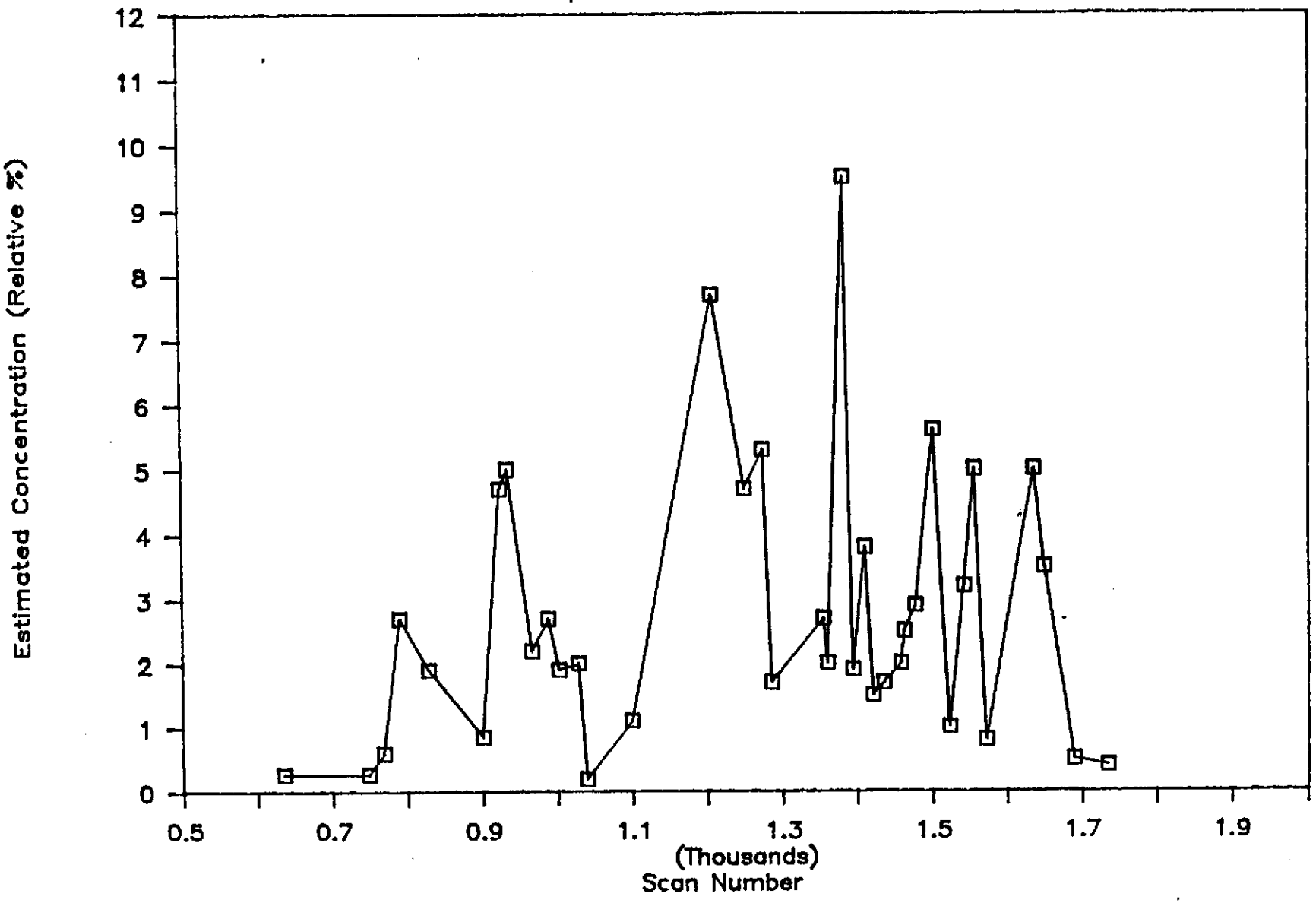
Emma P. Popek, Laboratory Director

3-9-89

Date

RELATIVE DISTRIBUTION OF VOA TICs

Sample Number C902397-02



VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS
EPA METHOD 624 (GC-MS)

Project number: 301-680-8576
Work order number: C902397
Sample number: 01
Sample ID: PS2
Matrix: Soil

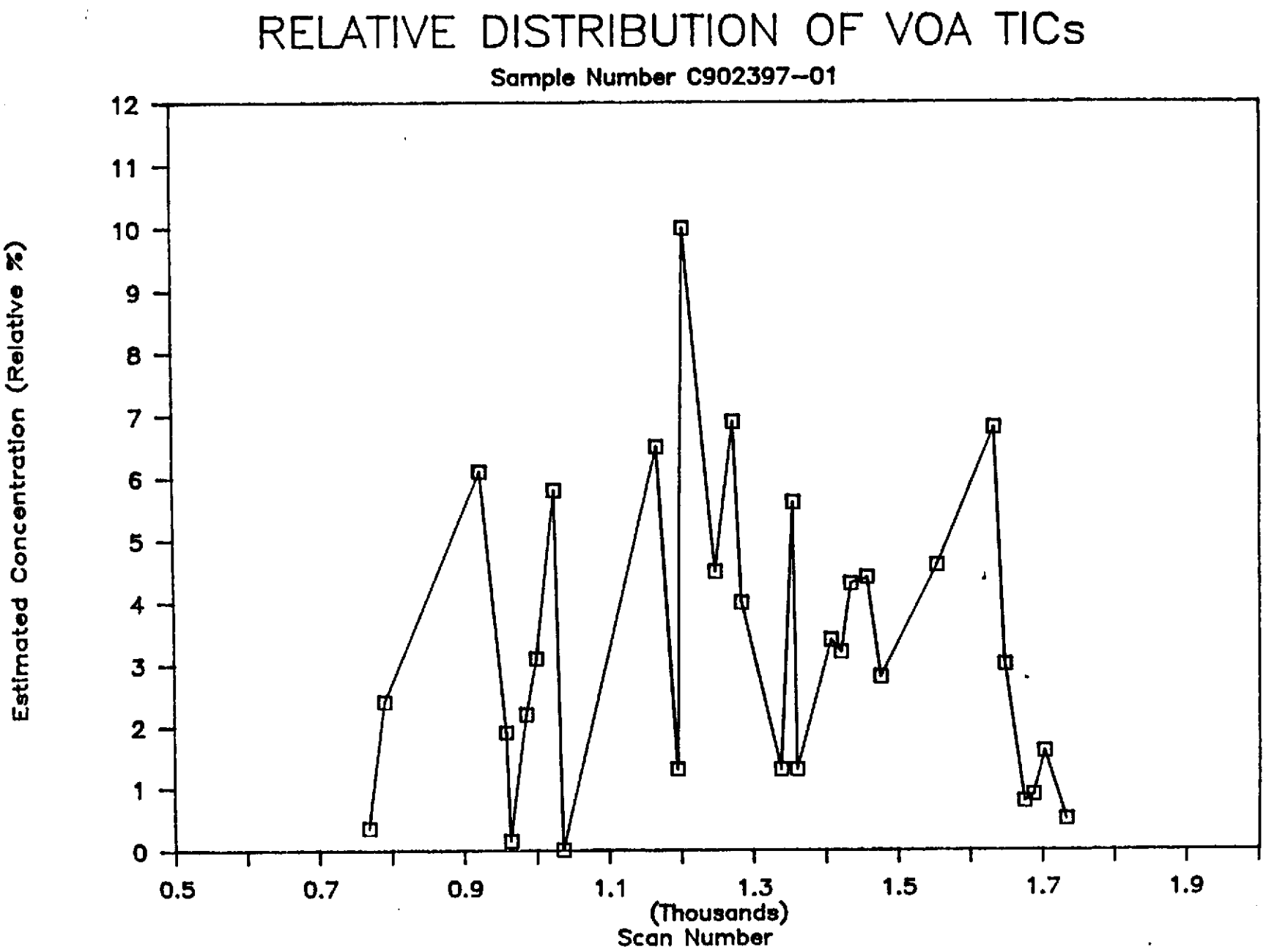
Date received: 07-Feb-89
Date analyzed: 24-Feb-89

COMPOUND NAME	SCAN NUMBER	ESTIMATED CONCENTRATION (RELATIVE %)
C3 substituted cyclohexane	768	0.36
C3 substituted cyclohexane	790	2.40
Nonane	924	6.10
C4 substituted cyclohexane	958	1.90
p- & m-Xylene	963	0.15
C3 substituted cyclohexane	986	2.20
Dimethyloctane	1000	3.10
Methylethyloctane	1026	5.80
o-Xylene	1036	0.01
C12 aliphatic hydrocarbon	1168	6.50
C3 substituted benzene	1195	1.30
C3 substituted benzene	1205	10.00
C3 substituted benzene	1249	4.50
C3 substituted benzene	1274	6.90
C4 substituted cyclohexane	1285	4.00
1,4-Dichlorobenzene	1338	1.30
C3 substituted benzene	1356	5.60
1,3-Dichlorobenzene	1360	1.30
C4 substituted benzene	1408	3.40
1,2-Dichlorobenzene	1422	3.20
C4 substituted benzene	1436	4.30
C4 substituted benzene	1458	4.40
C4 substituted benzene	1477	2.80
C4 substituted benzene	1555	4.60
C4 substituted benzene	1634	6.80
C4 substituted benzene	1649	3.00
C6 substituted benzene	1675	0.79
Tetrahydronaphthalene	1688	0.90
C5 substituted benzene	1703	1.60
C5 substituted benzene	1733	0.50
		99.71 %

Total number of compounds: 30

Emma P. Popek
Emma P. Popek, Laboratory Director

3-9-89.
Date


RELATIVE DISTRIBUTION OF VOA TICs
Sample Number C902397-01
Estimated Concentration (Relative %)
12
11
10
9
8
7
6
5
4
3
2
1
0
0.5
0.7
0.9
1.1
1.3
1.5
1.7
1.9
(Thousands)
Scan Number

APPENDIX B
NEW TANK DESIGN DRAWINGS

LARGE MAP REMOVED

APPENDIX C
NEW TANK INSTALLATION INSTRUCTIONS

Installation of Underground Petroleum Storage Systems

API RECOMMENDED PRACTICE 1615
FOURTH EDITION, NOVEMBER 1987

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005

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FOREWORD

The prevention and detection of product releases from underground petroleum storage and handling systems are important to both industry and the public. In preparing this recommended practice, careful consideration was given to the following:

a. Promoting safety.
b. Protecting human health and the environment.
c. Preventing storage-system leaks and failures.
d. Detecting petroleum product releases.
e. Protecting product quality.
f. Minimizing maintenance.
g. Minimizing installation costs.

Every effort was made to ensure consistency with the applicable sections of NFPA 30 and NFPA 30A. In addition, consistency was maintained with the provisions of NFPA 329 for the testing of underground storage systems. (See 1.4 in text for further reference information.) Standards that apply to specific materials and equipment are referenced as necessary in text.

This edition of Recommended Practice 1615 supersedes API Publication 1615, *Installation of Underground Petroleum Storage Systems* (November 1979) in its entirety.

At the time this recommended practice was written, legislation and regulations related to the installation, operation, maintenance, abandonment, and removal of underground petroleum storage systems were under development at the federal, state, and municipal levels. The appropriate government agencies should therefore be consulted about regulations that apply to the area of installation before any action suggested in this recommended practice is taken.

Petroleum equipment installations are unique in the construction industry, and contractors selected for work should be experienced in this area. In highly technical areas, such as vapor recovery, cathodic protection, and underground-tank flotation calculations, professional assistance should be obtained. Such assistance may be available from manufacturers of petroleum equipment, installers of petroleum equipment, engineers, or petroleum suppliers.

For further safety information, see API Publications 1628, 2005, 2015, and 2217. (See 1.4 in text for further reference information.)

Suggested revisions are invited and should be submitted to the director of the Marketing Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

CONTENTS

Installation of Underground Petroleum Storage Systems

SECTION 1—INTRODUCTION

1.1 General

Petroleum product releases from underground storage systems are a problem that can affect safety, health, and the environment. Releases may be caused by improper installation and maintenance of a storage system. Success in preventing releases depends on a number of factors, including the following:

a. Sound design of installations.
b. Proper selection of materials for specific locations.
c. Installation in accordance with sound engineering specifications, practices, and manufacturers' instructions.
d. Capable, adequate supervision and quality assurance during installation.
e. Thorough testing at appropriate stages during installation and operation.
f. Appropriate monitoring and maintenance programs.

1.2 Purpose and Scope

1.2.1 This recommended practice is a guide to procedures and equipment that should be used for the installation of underground petroleum storage systems. It is intended for use by architects, engineers, marketers, jobbers, and contractors.

1.2.2 The primary application of this recommended practice is in connection with the underground storage of bulk petroleum products and used oil at retail and commercial facilities. It is not intended to cover specialized installations, such as fuel storage systems at marinas and airports, heating oil storage systems (either residential or bulk), or systems to be installed inside buildings. This recommended practice does not apply to the installation of in-ground and aboveground bulk storage systems. The reader is referred to the following standards for information on specialized storage systems:

a. For marinas, NFPA 30A.
b. For residential storage of heating oil, NFPA 31.
c. For bulk storage of heating oil, API Standard 650.
d. For storage inside buildings, NFPA 30.
e. For aboveground tankage, NFPA 30 and API Standard 650.

1.2.3 This recommended practice applies to underground storage tank systems (see 1.3.38) that are used to store petroleum products at retail and commercial facilities. The stored products include gasoline, diesel fuel, kerosene, lubricating oils, used oil, and certain alcohol/gasoline blends. (For information on alcohol/gasoline blends, see API Recommended Practices 1626 and 1627.) This recommended practice may not apply to other petroleum products. The product manufacturer and the authority having jurisdiction (see 1.3.1) should be consulted with regard to the proper storage of other products. (For recommendations on system management, see API Recommended Practice 1635.)

1.2.4 Anyone preparing to design or install an underground storage tank system in a U.S. Environmental Protection Agency Air Quality Control Region should investigate the federal, state, and local requirements and current methods of compliance for vapor recovery in that region. Vapor recovery (see 1.3.40) is covered in greater detail in Section 12 of this document. For more information on the design and installation of vapor recovery systems, see NFPA 30A.

1.3 Definitions

Terms used in this recommended practice are defined in 1.3.1 through 1.3.43.

1.3.1 The *authority having jurisdiction* refers to the one or more federal, state, or local government agencies or individuals responsible for approving equipment, installations, and procedures associated with underground storage tank systems.

1.3.2 An *automatic tank gauging system* is an automated device used to measure the level of petroleum product in an underground storage tank and/or to measure the rate of change in the level of petroleum product over a period of time.

1.3.3 *Cathodic protection* is a process that prevents or inhibits corrosion of steel surfaces by managing or redirecting natural or man-made underground electrical currents.

1.3.4 *Corrective action* is action taken to identify, report, contain, treat, and/or remove petroleum hydrocarbons that have been released underground.

1.3.5 A *double-wall pipe* is a form of secondary containment in which a pipe is constructed with two shells, or walls, with an interstice between to contain a release from the primary pipe.

1.3.6 A *double-wall tank* is a form of secondary containment in which a storage tank is constructed with two shells, or walls, with an interstice between to contain a release from the primary tank.

1.3.7 *Equivalent* means "similar" or "equal," as the term pertains to effectiveness, sensitivity, or accuracy.

1.3.8 A *flexible joint* is a joint in the piping system that allows differential movement of the piping system without imposing undue stress or physical damage on the system.

1.3.9 *Generally accepted engineering practices* are techniques or methods that are commonly applied by qualified engineers.

1.3.10 An *impermeable barrier* is a natural or manmade barrier that impedes the vertical migration of released product.

1.3.11 An *impervious liner* is a form of secondary containment in which a natural or synthetic material prevents transmission of petroleum product. An impervious liner is usually placed in the ground around a tank system to contain released petroleum product and provide secondary containment.

1.3.12 *Impervious soil treatment* refers to the treatment of natural soils with a material or materials that decrease their permeability, causing them to act as a barrier that prevents the transmission of released petroleum product.

1.3.13 A *leak* is a perforation, hole, crack, or other opening in an underground storage tank system that will allow product to escape the system or its secondary containment.

1.3.14 A *limited-access manhole* is a manhole used with an observation well to which entry is restricted by requiring the use of a special tool to open the manhole.

1.3.15 *Monitoring* refers to the periodic checking or testing of an underground storage tank system's equipment, detection devices, and monitoring or observation wells for evidence of released petroleum product or for assistance in verifying the integrity of the system.

1.3.16 A *monitoring well* is a cased in-ground well that (a) is located outside the excavation of an underground storage tank system, (b) is in contact with groundwater, and (c) is designed to assist in detecting releases of liquid product from an underground storage tank system.

1.3.17 A *municipal water well* is a well that is operated by a public agency and provides the public with potable water.

1.3.18 A *noncorrosive material* is a material that resists all forms of electrochemical corrosion.

1.3.19 An *observation well* is a cased well within the tank excavation that is designed to assist in detecting releases of liquid or vapor product from an underground storage tank system.

1.3.20 The *operational life* of an underground storage tank system is the period beginning when the system is first placed in service and ending when the system is properly removed or abandoned.

1.3.21 *Petroleum products* are hydrocarbons, including crude oil and crude oil fractions, that are liquid at 60°F and 14.7 pounds per square inch absolute.

1.3.22 A *pipe tightness test* is an air pressure test of underground product-handling piping and associated valves and fittings that is conducted before the product is introduced and the piping is covered with backfill. A pipe tightness test is conducted as follows:

a. The piping to be tested is isolated and pressurized with compressed air to 150 percent of the maximum system operating pressure (or a minimum of 50 pounds per square inch gauge) for 1 hour.
b. All valves, fittings, and surfaces are coated with a soap solution and inspected for bubbles.
c. Leaks, as indicated by bubbles, are repaired, and the piping is retested as necessary.

If the piping to be tested is installed and operational, a hydrostatic test of piping, as specified in NFPA 329, should be conducted.

CAUTION: Extreme care should be exercised in conducting the pipe tightness test. *Pressurized piping is potentially dangerous because of the possibility of violent rupture.* This test should be conducted with minimum exposure of personnel and without moving or disturbing the piping being tested. When the test is completed, the piping pressure and monitor-line pressure must be reduced during the remainder of construction to ensure that the lines are not damaged during backfilling and paving.

1.3.23 A *precision test* is a test of the liquid-product-handling portion of an underground storage tank system, or a portion of the system, that meets the criteria of NFPA 329.

1.3.24 A *private potable water well* is a well on private property that supplies potable water to on-site facilities.

1.3.25 A *product-line leak detector* is a device that detects leaks or pressure losses in the pressurized piping of a remote pumping system.

1.3.26 A *qualified person* is an individual, company, agency, or organization deemed qualified, based on education and/or experience in the area of interest, to perform a particular task or tasks.

1.3.27 *Release* refers to any spill, leak, or escape of petroleum product from an underground storage tank system into groundwater, surface water, or soil.

1.3.28 A *remote pumping system* (also known as a *submerged pumping system*) is a system in which one or more pumping units push petroleum product, via a pressurized piping system, to one or more points away from the tank or tanks.

1.3.29 *Secondary containment* refers to any system in which an outer, or secondary, container or impervious liner prevents releases of petroleum product from the primary container from reaching the surrounding environment for a time sufficient to allow detection of the released product.

1.3.30 A *sole-source aquifer* is an aquifer designated by the U.S. Environmental Protection Agency as being the only source of drinking water for a segment of the public.

1.3.31 *Storage* refers to the deposition of a petroleum product in a container for later use. The term does not include collection of (a) overflows, drips, or spills in auxiliary containers (for example, sumps, catch basins, and drip-collection devices) or (b) hydraulic fluids or similar substances within machines (for example, hydraulic lifts and elevators).

1.3.32 *Structure-to-soil potential* is the difference in electrical potential (measured as voltage) between a steel underground petroleum storage tank system and its surrounding soils.

1.3.33 *Structure-to-structure potential* is the difference in electrical potential (measured as voltage) between adjacent underground steel structures.

1.3.34 A *suction pumping system* is a system in which a pump at a dispensing island reduces pressure in the product line to the underground storage tank to less than atmospheric pressure, causing product from the tank to be pulled to the island via the product suction line.

1.3.35 A *tank tightness test* is an air pressure test of an underground storage tank that is conducted before the tank's installation and the introduction of product. A tank tightness test is conducted as follows:

a. All factory-installed bungs are removed from the tank, and a pipe-thread sealant certified for petroleum service is applied to them. The bungs are then replaced and tightened to ensure that no air is released during testing. Any temporary bungs should be replaced with solid bungs. Care should be taken to avoid cross-threading when the bungs are replaced.
b. A compressed-air source is applied to raise the internal tank pressure to between 3 and 5 pounds per square inch gauge. A pressure gauge with a maximum range of 10-15 pounds per square inch gauge should be used to confirm proper pressurization. Prior to pressurization, the external surface of the tank should be inspected for defects.
c. When the internal pressure is achieved, the compressed-air source should be disconnected from the tank, and the entire tank shell, as well as all seams, bungs, and manholes, should be uniformly coated and recoated as necessary with a soap solution. Leaks are detected by the presence of bubbles.
d. If bubbles are observed around fittings, the fittings should be checked for tightness and repaired as necessary. If leaks are detected in seams or the shell, the supplier and/or the manufacturer should be notified.
e. When the inspection is complete, the air pressure should be released.

CAUTION: A tank tightness test is a potentially dangerous procedure and should therefore be conducted with the following safety precautions:

a. Before any of the procedures described in 1.3.35 are initiated, the tank manufacturer's instructions should be consulted regarding specific testing requirements.
b. The internal tank pressure must not exceed 5 pounds per square inch gauge. *Personal injury and tank damage can result from overpressuring.*
c. A pressure gauge with a range of 10–15 pounds per square inch gauge is recommended so that the tester can accurately determine small pressure differences. *It is essential that neither a vacuum gauge nor a pressure gauge with a maximum range exceeding 15 pounds per square inch gauge be used.* Pressure gauges should be checked for proper operation and accuracy before being used.

d. In case of failure when the tank is pressurized, personnel should be kept well away from the ends of the tank, the bungs, and the manholes.

e. A pressure relief device, capable of relieving the total output of the compressed-air source at a pressure of not more than 6 pounds per square inch gauge, should be used to prevent overpressuring.

f. Piping or tanks that contain flammable or combustible liquids should not be pressure tested, either with air or with other gases. *Such testing would create a severe danger of rupture and consequent release of product to the environment, as well as the possibility of explosion and fire.*

1.3.36 *Underground pipes* are pipes that are buried underground and connected to an underground storage tank. Underground pipes do not include vent pipes, fill pipes, or vapor recovery pipes.

1.3.37 An *underground storage tank* is a container that has a capacity of more than 110 gallons, is used to store petroleum products for later use, and is buried completely underground.

Note: This definition applies only to this recommended practice and is not to be confused with the U.S. Environmental Protection Agency's definition of an underground storage tank.

1.3.38 An *underground storage tank system (USTS)* is a petroleum product storage system that is completely underground. An underground storage tank system is generally composed of one or more storage tanks, product lines, pumps, vent lines, tank fill lines, vapor recovery pipes, and other appurtenances for storing, using, and/or dispensing petroleum products.

1.3.39 An *underground transit structure* is a partially or totally buried structure designed to convey vehicles such as subway cars, trains, or motor vehicles.

1.3.40 *Vapor recovery* refers to the control, containment, and/or disposition of petroleum product vapors from an underground storage tank system during product delivery and dispensing operations.

1.3.41 *Vaulting* refers to the total or partial enclosure of an underground storage tank system (except vent lines) with a rigid material such as concrete or steel to retain released product until it can be detected.

1.3.42 *Visual inspection* refers to examination, with the naked eye, of a liquid sample removed from an observation or monitoring well to detect the presence of petroleum product.

1.3.43 A *wellhead zone of influence* is the subsurface area surrounding a municipal water well through which petroleum products are reasonably likely to reach the well in the time necessary to detect the release, terminate the source, and restrict further movement of the product plume.

1.4 Referenced Publications

The editions of the following standards, codes, and specifications that are in effect at the time of publication of this recommended practice are cited herein:

API	
Std 650	*Welded Steel Tanks for Oil Storage*
RP 1604	*Removal and Disposal of Used Underground Petroleum Storage Systems*
RP 1621	*Bulk Liquid Stock Control at Retail Outlets*
RP 1626	*Storing and Handling Ethanol and Gasoline-Ethanol Blends at Distribution Terminals and Service Stations*
RP 1627	*Storage and Handling of Gasoline-Methanol/Cosolvent Blends at Distribution Terminals and Service Stations*
Publ 1628	*Underground Spill Cleanup Manual*
RP 1631	*Interior Lining of Existing Steel Underground Storage Tanks*
RP 1632	*Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems*
RP 1635	*Management of Underground Petroleum Storage Systems at Marketing and Distribution Facilities*
RP 1637	*Using the API Color-Symbol System to Mark Equipment and Vehicles for Product Identification at Service Stations and Distribution Terminals*
Publ 2005	*Service Station Safety*
Publ 2015	*Cleaning Petroleum Storage Tanks*
Publ 2217	*Guidelines for Confined Space Work in the Petroleum Industry*
Publ 2219	*Safe Operation of Vacuum Trucks in Petroleum Service*
ASME[1]	
B16.3	*Malleable Iron Threaded Fittings, Class 150 and 300*

[1]American Society of Mechanical Engineers, 345 East 47th Street, New York, New York 10017.

B16.39 *Malleable Iron Threaded Pipe Unions, Class 150, 250 and 300*
B36.10M *Welded and Seamless Wrought Steel Pipe*

ASTM[2]
C 33 *Specification for Concrete Aggregates*
D 2996 *Specification for Filament-Wound Reinforced Thermosetting Resin Pipe*
D 4021 *Specification for Glass Fiber-Reinforced Polyester Underground Petroleum Storage Tanks*
G 57 *Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method*

EPA[3]
530-SW-85-023 *The Interim Prohibition: Guidance for Design and Installation of Underground Storage Tanks (August 1986)*

NACE[4]
RP-01-69 *Control of External Corrosion on Underground or Submerged Metallic Piping Systems*
RP-02-85 *Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems*

NFPA[5]
30 *Flammable and Combustible Liquids Code*
30A *Automotive and Marine Service Station Code*
31 *Installation of Oil Burning Equipment*
329 *Underground Leakage of Flammable and Combustible Liquids*

OSHA[6]
Safety and Health Regulations for Construction (29 CFR 1926.652)

STI[7]
Standard for Dual-Walled Underground Storage Tanks

UL[8]
58 *Steel Underground Tanks for Flammable and Combustible Liquids*
87 *Power-Operated Dispensing Devices for Petroleum Products*
1316 *Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products*

SECTION 2—PREINSTALLATION SITE ANALYSIS

2.1 General

2.1.1 Because many site-specific factors related to soil conditions and drainage affect the operational life of a USTS, it may be necessary to conduct a preinstallation site analysis. Such factors include but are not limited to soil resistivity, acidity (pH), moisture content, sulfide content, structure, and the possible presence of contamination. API Recommended Practice 1632 and NACE RP-01-69 and RP-02-85 provide further information on the effects of these and other site-specific factors. The preinstallation site analysis should also include an evaluation of possible requirements for secondary containment (see 2.2 and 6.3).

2.1.2 The purpose of the preinstallation site analysis is to characterize the corrosivity and stability of the soil at the selected site and to evaluate the site-specific needs for groundwater protection. Soil corrosivity need not be evaluated if tanks and piping to be installed are made of fiberglass-reinforced plastic (FRP). The preinstallation site analysis should also include the location and identification of nearby structures, such as utility lines and sewer lines, that may influence the location and design of the USTS.

2.1.3 When a USTS is to incorporate bare or coated metallic components in physical contact with surrounding backfill, the preinstallation site analysis should

[2]American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.
[3]U.S. Environmental Protection Agency, Office of Underground Storage Tanks, 401 M Street, S.W., Washington, D.C. 20460.
[4]National Association of Corrosion Engineers, P.O. Box 218340, Houston, Texas 77218.
[5]National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269-9990.
[6]Occupational Safety and Health Administration, U.S. Department of Labor, Washington, D.C. 20402.
[7]Steel Tank Institute, 728 Anthony Trail, Northbrook, Illinois 60062.
[8]Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, Illinois 60062.

include a determination of the soil conditions described in 2.1.1 to assist in the design of a cathodic protection system. If USTS components are to be installed with factory-installed, preengineered cathodic protection systems, the manufacturer or a qualified person should be consulted to determine the adequacy of the preengineered system to protect against corrosion, given the subsurface conditions at the installation site.

2.1.4 The preinstallation site analysis should include a determination of the soil stability and soil structure with respect to all systems to be installed.

2.1.5 Determination of normal and expected high water tables and site drainage characteristics, as well as the potential for flooding at the site, is an important part of the preinstallation site analysis, since it aids in assessing the need for underground tank anchorage (see 6.2). The expected high water table may determine the method of release detection (see Section 8). Determination of these site characteristics is necessary regardless of whether steel or FRP tanks are to be used.

2.2 Secondary Containment

2.2.1 Secondary containment provides additional protection against product releases to the environment. Secondary containment is designed for application in areas or situations in which petroleum product releases would present immediate health and safety hazards or produce severe environmental damage (see 6.3).

2.2.2 Secondary containment or equivalent protection is recommended for new installations when sole-source aquifers that underly the location of the USTS are determined to warrant such protection, when groundwater below the location is within a wellhead zone of influence, when a private potable water well is within 300 feet of the location, or when the USTS is within 100 feet of an underground transit structure. The authority having jurisdiction should be consulted regarding specific requirements for secondary containment.

SECTION 3—MATERIALS AND EQUIPMENT

3.1 General

The choice of the materials to be used in a USTS depends on many factors, including site and climatic conditions; risk presented to the public and the environment; availability of qualified personnel for installation, inspection, and maintenance of the system; and initial and operating costs. The authority having jurisdiction should be consulted regarding any requirements concerning materials. Manufacturers can also provide information related to material specifications and performance.

3.2 Federal Requirements

3.2.1 When this edition was being prepared, new federal legislation was in effect that specified materials and performance criteria for USTSs. These provisions, termed *The Interim Prohibition* (EPA 530-SW-85-023), apply to USTSs installed after May 8, 1985, and include the following requirements:

a. USTSs shall be made of or coated with a noncorrosive material or shall be cathodically protected against corrosion.
b. USTSs shall be constructed to prevent the release of their contents during their operational life.
c. USTSs shall be compatible with their contents.

EPA 530-SW-85-023 should be consulted for further information on these provisions, which will remain in effect until EPA develops specific regulations.

3.2.2 Subtitle I of the Federal Resource Conservation and Recovery Act requires each owner to register every new underground tank within 30 days after the tank is brought into use. Federal, state, and local registration requirements should be reviewed when new tanks are installed.

3.3 Material Specifications

3.3.1 The materials used in USTSs should meet the following criteria:

a. Steel tanks should meet the requirements of UL 58 and the STI *Standard for Dual-Walled Underground Storage Tanks.*
b. FRP tanks should meet the requirements of UL 1316 and ASTM D 4021.
c. Steel pipe should meet the requirements of ASME B36.10M, Schedule 40, for either galvanized or wrapped black iron.
d. FRP pipe should meet the requirements of ASTM D 2996.
e. Threaded fittings should meet the requirements of ASME B16.3 for 150-pound malleable iron.

f. Unions should meet the requirements of ASME B16.39 for 150-pound malleable iron.

3.3.2 When FRP tanks and piping are specified, the manufacturer should be asked to certify that the equipment is safe for use with the particular product grades to be handled (see API Recommended Practices 1626 and 1627).

3.4 Handling

3.4.1 To prevent damage to coatings and structure, tanks should be handled with care during transit, storage, and installation. Tanks should not be rolled, dropped, or dragged.

3.4.2 Chains, cable, or other lines should not be placed around the tank to lift or move it; however, rope or strapping that will not damage the coating may be used to secure the tank during transit.

3.4.3 Lifting lugs attached by the manufacturer provide a safe and effective means of lifting or moving the tank. To lift or move a tank with multiple lifting lugs, chains or cable of sufficient length should be attached to the lugs and the lifting equipment so that the angle between the vertical and one side of the chain to a lifting lug is not greater than 30 degrees. A spreader bar can be used to ensure that the angle does not exceed 30 degrees. Handlines should be attached to the tank to provide a means of manually controlling its movement and placement.

3.4.4 Tanks stored temporarily at the installation site should be located away from areas of activity where the coating or structure could be damaged. Efforts should be made to ensure that stored tanks do not interfere with the normal flow of vehicles or pedestrians. The tanks should be placed in a location that will minimize the need for further movement prior to installation.

3.4.5 Nonabrasive chocks (such as rubber tires) should be used to prevent the tank from moving during storage. If high winds are expected, tanks should be tied down with nylon rope at least ½ inch in diameter. The rope should be secured to stakes large enough to provide adequate restraint. Tie-down ropes should be secured through the lifting lugs.

3.4.6 Piping should be handled with care to prevent damage to coatings or structure. Bending, crushing, or otherwise stressing pipe should be avoided during transit, storage, and installation.

3.4.7 Single-wall FRP tanks should be vented to the atmosphere during storage and installation. Double-wall FRP tanks are shipped and stored with a vacuum on their interstice. This vacuum should be maintained until the tank tightness test is conducted.

3.5 Preinstallation Inspection and Testing

3.5.1 GENERAL

3.5.1.1 Upon delivery at the installation site and just prior to installation, tanks and piping should be carefully inspected to ensure that they comply with applicable specifications and to detect any evidence of damage to coatings or structure.

3.5.1.2 When possible, damaged coatings should be repaired at the installation site with manufacturer-supplied materials and in accordance with the manufacturer's instructions. If this is not possible or if significant damage, such as denting, puncturing, or cracking, has occurred, the manufacturer should be employed to repair the equipment or coatings and to recertify or replace the tank as required.

3.5.1.3 Before a tank is installed, its inside diameter should be measured to confirm the specification supplied by the manufacturer. The measurement should be permanently recorded for comparison with post-installation measurements and for future reference. The inside diameter of an installed tank should be measured from outside the tank.

CAUTION: Tanks should not be entered for any purpose unless proper safety precautions, as outlined in API Publication 2217, are taken.

3.5.2 TESTING OF SINGLE-WALL TANKS

Prior to installation, each underground tank should be subjected to a tank tightness test (see 1.3.35).

3.5.3 TESTING OF DOUBLE-WALL TANKS

3.5.3.1 Double-wall tanks provide a form of secondary containment in that they contain an internal volume, called an *interstice,* between the tank walls. This space may also be referred to as an *interstitial space,* an *annulus,* or an *annular space.* The interstice is a feature that provides for containment and detection of releases and is not meant to provide permanent storage of product.

3.5.3.2 When this edition was being prepared, the NFPA had not yet established procedures for preinstallation tightness testing of double-wall tanks. Nevertheless, both the inner and the outer shell should be tested for tightness prior to installation. It is therefore

important that the manufacturer's instructions be followed during preinstallation tightness testing of double-wall tanks.

3.5.4 TESTING OF PIPING AND OTHER EQUIPMENT

3.5.4.1 Piping and other product-handling equipment are not generally subjected to preinstallation tightness testing at the jobsite. Instead, when the piping is installed and before the backfill is placed, the piping should be isolated from the tanks and tested (see 10.2).

3.5.4.2 If impervious liners are used in installations as secondary containment, they should be carefully inspected for damage and should be tested at the jobsite after they are installed in the excavation but before tanks or backfill is placed. The manufacturer's testing instructions should be followed, with special attention given to the liner seams. Any repairs should be conducted in accordance with the manufacturer's instructions.

SECTION 4—REMOVAL AND DISPOSAL OF USED STORAGE SYSTEMS

4.1 Safety Considerations

In some cases, an existing USTS must be partially or totally removed before a new system is installed. Because of the fire and safety hazards related to the removal of existing systems, specific safety precautions must be taken. API Recommended Practice 1604 and API Publications 2217 and 2219 provide appropriate safety information and procedures. Local fire officials should be consulted before any action is taken.

4.2 Considerations for Partial System Removal

If only part of an existing USTS is to be removed, care should be taken not to disturb backfill or components of the system that will remain in place. The following specific precautions should be taken:

a. Product should be removed from all existing USTSs at the jobsite, and the tanks in these systems should be made vapor free before excavation is initiated. (API Recommended Practice 1604 describes vapor-freeing procedures.)

b. Care should be taken when existing equipment and backfill are removed so that other existing tanks and piping are not damaged or undermined. Removing and replacing backfill around existing piping and tanks can cause stresses that may damage coatings and/or structure.

c. If the existing tanks that will be left intact and the new equipment that will be installed are both steel, consideration should be given to minimizing the electrochemical corrosion effect that the existing tanks might have on the new equipment. This effect is of increased concern when all the adjacent USTSs are not cathodically protected and electrically connected or when one of the USTSs has impressed-current cathodic protection and is not electrically connected with adjacent USTSs. Newer tanks can become anodic to older steel tanks and can corrode much faster than expected if a properly designed cathodic protection system is not installed (see API Recommended Practice 1632 and NACE RP-02-85). The following actions can be taken to minimize this effect:

1. Using nonmetallic materials (such as FRP) in the system to be replaced.
2. Employing cathodic protection devices on the new and existing systems (see API Recommended Practice 1632).
3. Replacing all adjacent USTSs with new equipment, using either steel or nonmetallic materials.

d. The authority having jurisdiction should be consulted regarding any regulations that cover the proposed work.

4.3 Repair of Underground Tanks

If a steel tank is to be repaired by applying an interior lining, all other steel underground storage tanks at the facility should be similarly treated. Before any work is begun, the authority having jurisdiction should be consulted regarding any regulations that cover the repair plans. (See API Recommended Practice 1631 for further information on procedures and safeguards for interior tank repair and lining.)

4.4 Contaminated Backfill

4.4.1 When an existing USTS is partially or totally removed, a small amount of contaminated backfill may be encountered. Backfill can be contaminated by minor spills and drips during previous operation of the facility or by minor spills and drips during removal of equipment, despite efforts to drain and pump product from the equipment before removal (see API Recommended Practice 1604). Contaminated backfill may be a fire and environmental hazard.

4.4.2 Spills and drips should be contained to the maximum extent possible to minimize contamination during removal. If severe contamination has occurred, local environmental officials, the fire marshal, or the EPA must be notified. Local officials may require isolation and special handling and/or disposal of contaminated backfill materials (see API Publication 1628).

4.5 Disposal of Used Equipment

API Recommended Practice 1604 suggests appropriate disposal methods for used petroleum product storage and handling equipment. The authority having jurisdiction should be consulted before any action is taken.

SECTION 5—EXCAVATION

5.1 Safety Considerations

5.1.1 Any earth excavating procedure presents safety hazards related to the presence of unstable soils, water, released product, and moving equipment. Personnel involved in excavation, equipment installation, and backfilling should be knowledgeable about and should follow the safety standards given in OSHA's *Safety and Health Regulations for Construction* (29 CFR 1926.652).

5.1.2 The excavation should provide adequate space for the installation of tanks, piping, and ancillary equipment. Special attention should be given to sloping or shoring the sides of the excavation to make them stable.

CAUTION: Personnel should not enter an unshored or unsloped tank excavation unless the excavation has been determined to be stable.

5.2 Location of Tanks

5.2.1 Tanks should be located to minimize the amount of maneuvering necessary for the tank truck making the product delivery to reach the fill openings. Whenever possible, the delivery should be able to be accomplished without having to move the truck (see Figures 1 and 2).

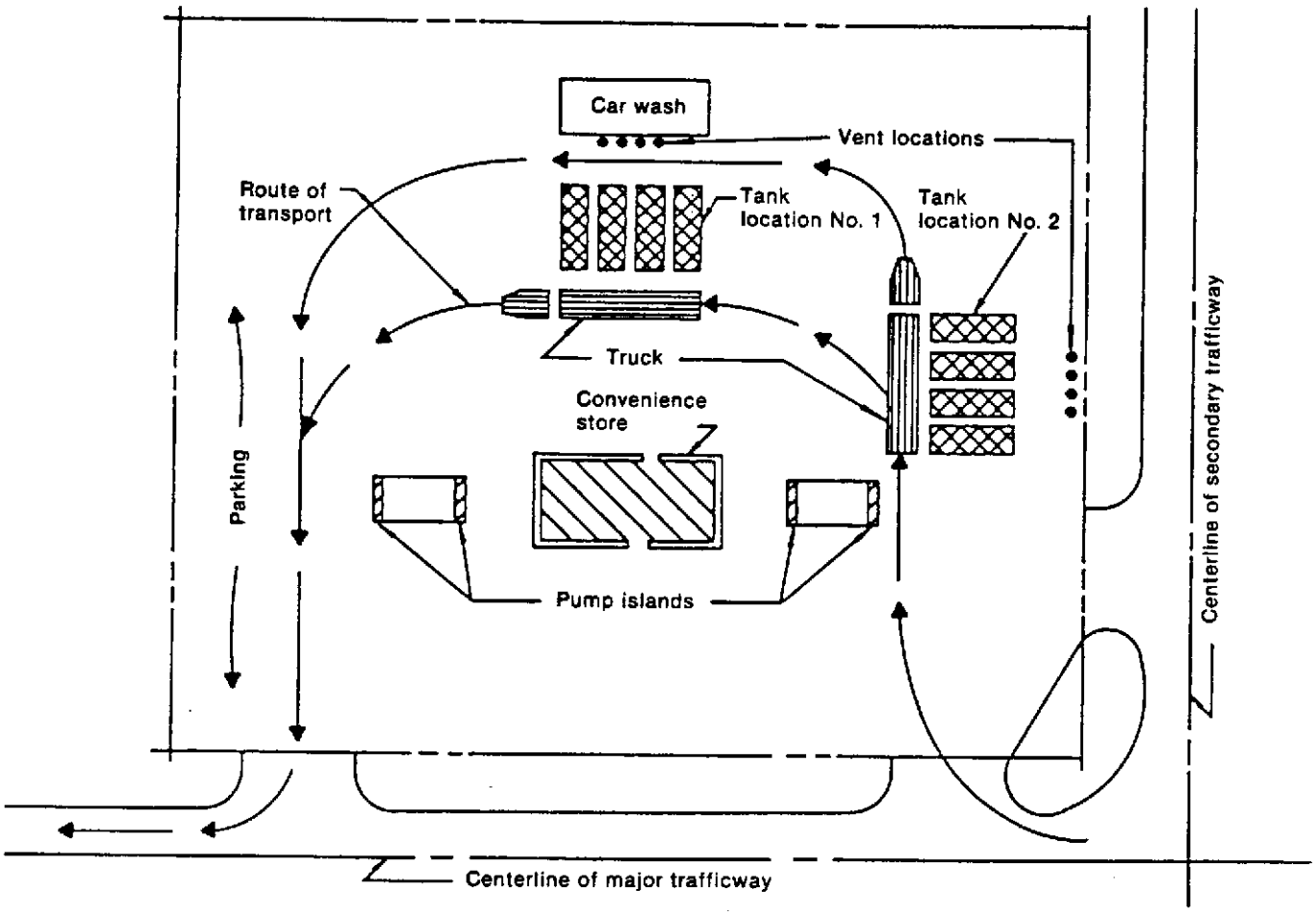
5.2.2 Tanks should be located so that the tank truck making the product delivery will not be on a public right-of-way, block motorists' views of roadways, or impede the flow of vehicles or pedestrians.

5.2.3 Local regulations usually specify permissible distances from underground storage tanks to property lines or buildings. If a tank is to be placed near a building foundation, care should be taken to prevent damage to the building or the tank. If soil instability creates concern about damage, the tank should be positioned so that the angle from the bottom of the building foundation to the nearest edge of the bottom of the tank excavation does not exceed 45 degrees. Tanks should not be located less than 3 feet from the property line of any adjacent property on which a structure can be built.

5.3 Excavation Dimensions

5.3.1 Excavations for steel tanks should be large enough to provide a minimum clearance of 12 inches between the ends and sides of tanks and the sides of the excavation. Excavations for FRP tanks should be large enough to provide a minimum clearance of 18 inches. Steel tanks should be at least 12 inches apart, and FRP tanks should be at least 18 inches apart. Other distances may be required by the manufacturer.

5.3.2 For both steel and FRP tanks, the excavation should be deep enough to provide for a backfill depth of at least 12 inches below the bottom of the tank, with or without a hold-down pad. The burial depth of the tank depends on local regulations, the type of finished surface to be applied, soil conditions, topography, the vertical distance needed to provide the required slope for vapor and product lines, suction lift requirements, the need for a piping cover, the bedding thickness, the hold-down pad (if required), and the manufacturer's recommendations. The cover over the tanks (backfill and/or paving) will vary depending on whether there will be traffic over the tanks. In areas that are not subject to traffic, the cover should consist of a minimum of 24 inches of backfill, or a minimum of 12 inches of backfill plus at least 4 inches of reinforced concrete. In areas that are subject or are likely to be subject to traffic, the cover should consist of a minimum of 36 inches of well-tamped backfill, or a minimum of 18 inches of well-tamped backfill plus at least 6 inches of reinforced concrete or 8 inches of asphaltic concrete.



Notes:
1. The optimum turning radius for a transport truck is 50 feet.
2. The transport truck should not be required to back up.
3. With both suction and remote pumping systems, product lines should be of a practical length.

Figure 1—Typical Plot Plan Showing Possible Tank Locations: Convenience Store and Car Wash

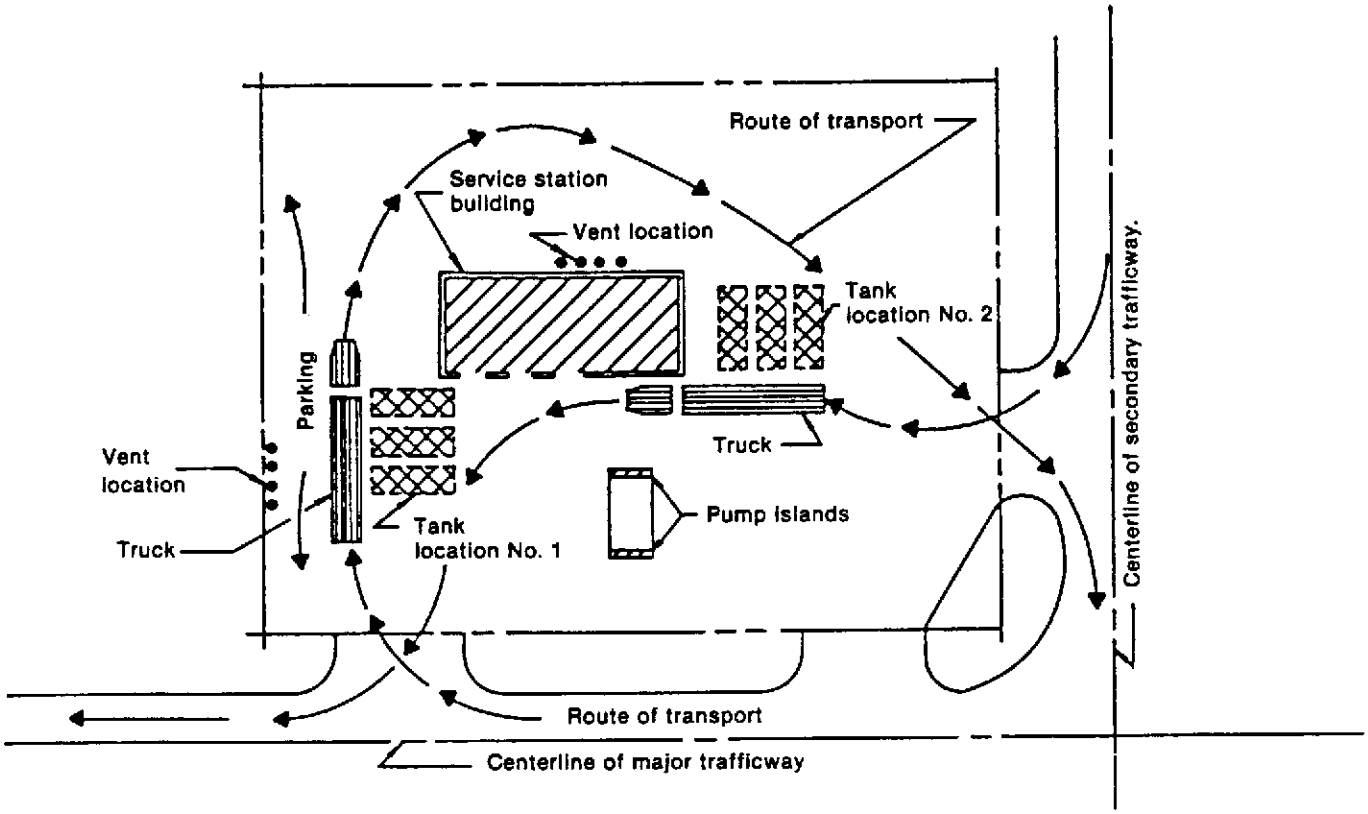
SECTION 6—EQUIPMENT PLACEMENT, ANCHORAGE, SECONDARY CONTAINMENT, AND BALLASTING

6.1 Placement

6.1.1 Steel and FRP tanks should be placed on a bed of suitable backfill (see Section 10) that has been graded, leveled, and compacted to the depth specified in 5.3.2. If a concrete hold-down pad is required, as described in 6.2.3, at least 12 inches of compacted backfill should cover the pad. An underground tank should never be installed directly on a hold-down pad. Care should be taken to prevent impact between the tank and the hold-down pad or other anchorage when the tank is lowered onto the pad or moved into the excavation. The use of handlines for manual control will facilitate this procedure.

6.1.2 Suitable backfill should be placed carefully along the bottom quadrant of the tank to prevent movement and ensure proper support.

6.1.3 It is occasionally necessary or advisable to install more than one storage tank for a given product. Such tanks may be interconnected by means of a siphon connection, which permits the equalization of the product level in the connected tanks (see 9.2.4). Interconnected



Notes:
1. The optimum turning radius for a transport truck is 50 feet.
2. The transport truck should not be required to back up.
3. With both suction and remote pumping systems, product lines should be of a practical length.

Figure 2—Typical Plot Plan Showing Possible Tank Locations: Service Station

tanks should have the same diameter and should be installed with their bottoms at the same depth (see Figures 3 and 4).

6.2 Anchorage

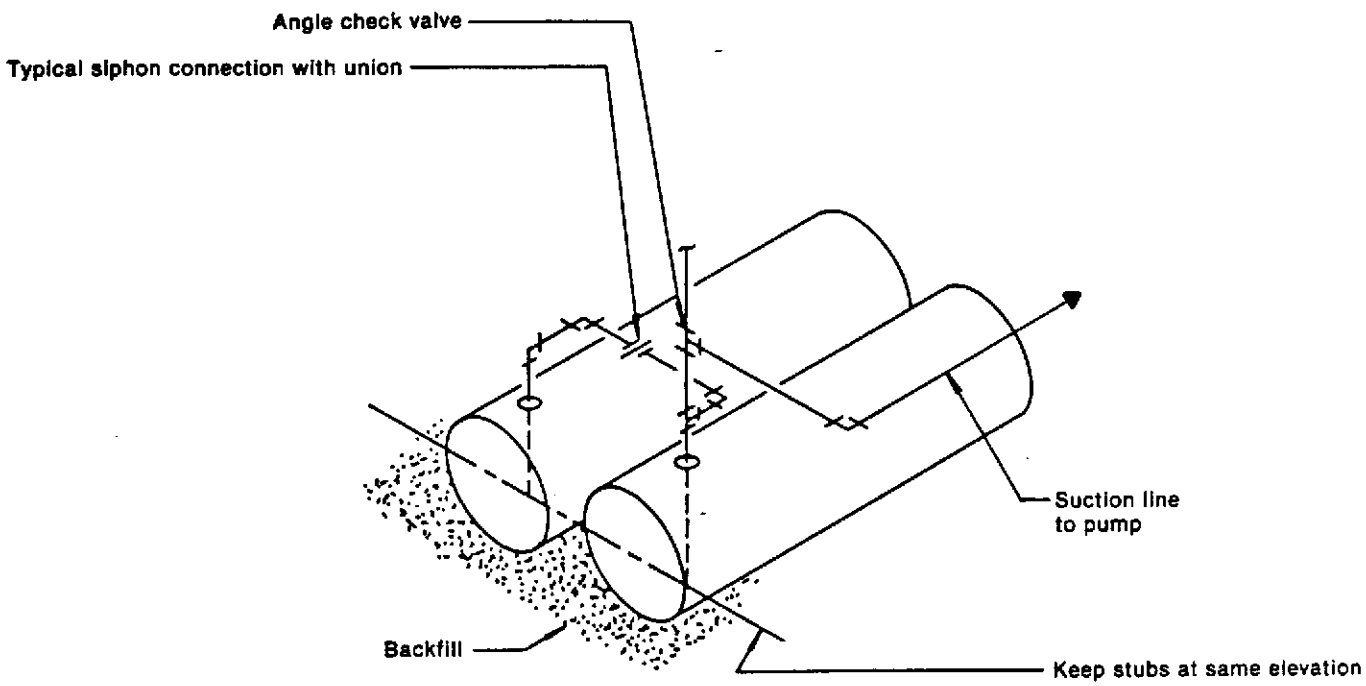
6.2.1 An underground tank can float if it is submerged in a high water table or as a result of flooding, even if the tank is partly or completely full of product. Product weight, tank weight, the type of tank cover (backfill and paving), and the height of water around the tank all have an effect on whether a tank will float.

6.2.2 All of the factors given in 6.2.1 should be considered in determining whether anchorage is required. If a high water table exists or if flooding can be expected, tanks should be anchored. The presence of these conditions should have been identified during the preinstallation site analysis (see Section 2).

6.2.3 Tanks can be secured against flotation in many ways. The following methods are the most common:

a. Placing a concrete slab under the tanks, with a 12-inch cushion of proper backfill between the bottom of the tank and the slab.
b. Burying concrete deadmen on either side of the tank.

Each of the anchorage methods above requires that anchor straps be installed over the tank and secured to the anchorage (see Figure 5). The straps should be installed in accordance with the manufacturer's instructions, should not damage the tanks or their coatings, and if the tank is steel should be electrically isolated from the tank (see 7.4.2). It is particularly important to follow the manufacturer's instructions when anchor straps are installed over fiberglass tanks, since special straps, which must be used at specific locations on the tank, are required.



Notes:
1. If Stage I or Stage II vapor recovery is required, it should be installed as shown in Figure 16.
2. Other tank piping details should be as shown in Figure 16.

Figure 3—Typical Suction Pump System: Manifolded Tanks

6.2.4 The following two methods of securing tanks against flotation are sometimes used:

a. Increasing the tank's burial depth to increase the hold-down weight.
b. Increasing the thickness and/or extent of a concrete paving slab over the tank.

6.2.5 In considering any of the options described in 6.2.3 and 6.2.4, the requirements for burial depth given in 5.3.2 should be taken into account.

6.2.6 When it has been determined that anchorage is necessary, professional assistance should be obtained to determine which of the options described in 6.2.3 and 6.2.4 should be used and to help in designing the installation. This assistance may be available from the tank manufacturer, professional engineers, or professional tank installers.

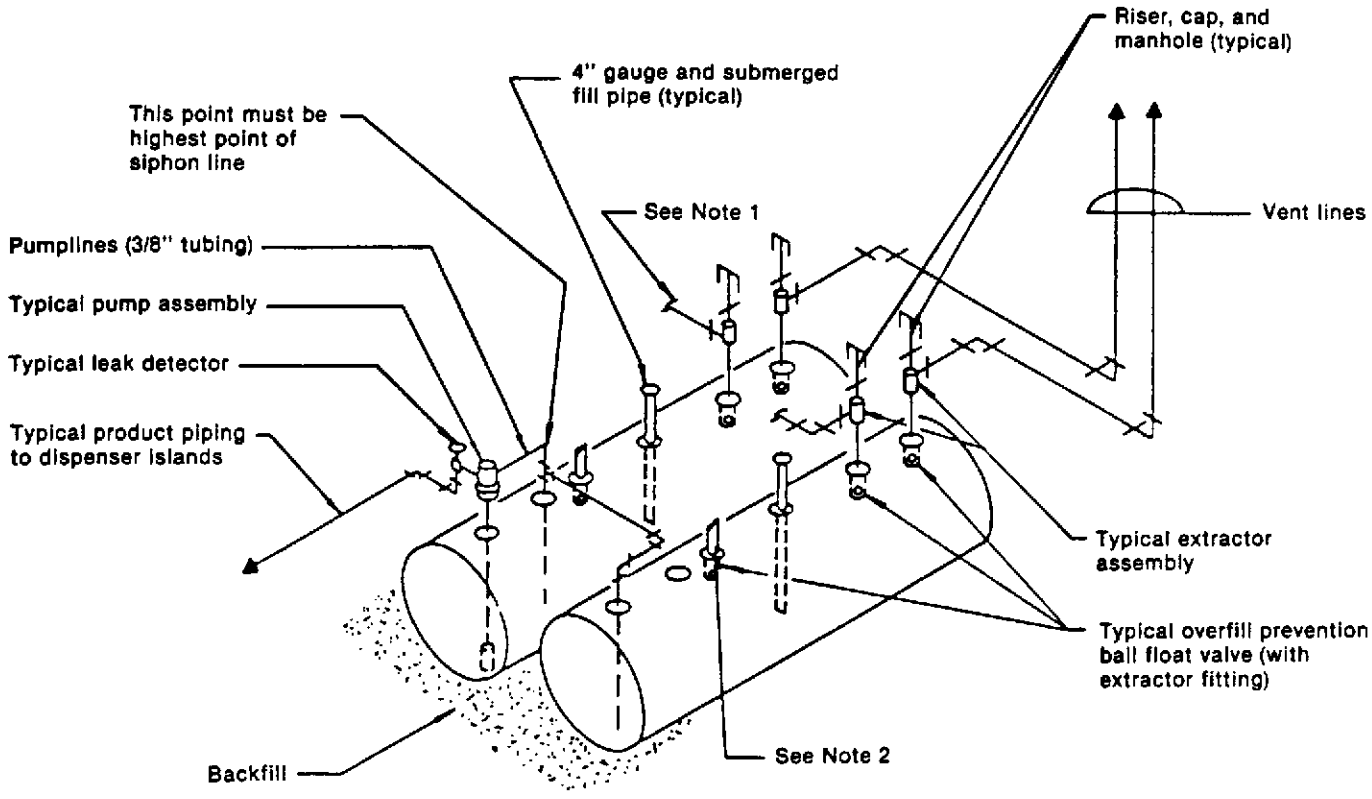
6.3. Secondary Containment

6.3.1 If secondary containment is deemed necessary or is required based on the criteria given in 2.2.2, it must be included as part of the equipment installation. The following components of the installation may require secondary containment:

a. Tanks.
b. Piping.
c. Dispensers.
d. Submerged pumps (which may be inside the tanks' secondary containment).
e. Tank fill pipes (which may be inside the tanks' secondary containment).

6.3.2 Secondary containment can be provided by the following means:

a. Impervious liners for tanks.
b. Impervious liners under lines (which should be drained to a sump in the tank pit).
c. Containment under dispensers.
d. Containment around submerged pumps.
e. Containment around fill manholes.
f. Double-wall tanks (with a tank excavation sump for line and dispenser containment and with containment around submerged pumps and around fill manholes).
g. Double-wall pipe (which should be drained to a sump in the tank pit).



Notes:
1. If required, a Stage II vapor recovery line should run to the vapor collection manifold and then to the dispenser islands. If the vapor recovery system is not manifolded, each line should go to the dispenser islands. A float valve, extractor, riser, cap, and manhole should be included for each tank. (The arrangement shown is typical.)
2. If required, a Stage I vapor recovery riser should run to the vapor collection manifold, with one surface pickup point. If the vapor recovery system is not manifolded, each riser should go to a separate surface pickup point. Each riser pipe should be connected to a ball float valve. (The arrangement shown is typical.)
3. Tank bottoms should all be at the same elevation.
4. The bottom of all siphon stubs should be at the same elevation.
5. See Figure 12 for details of tank piping.

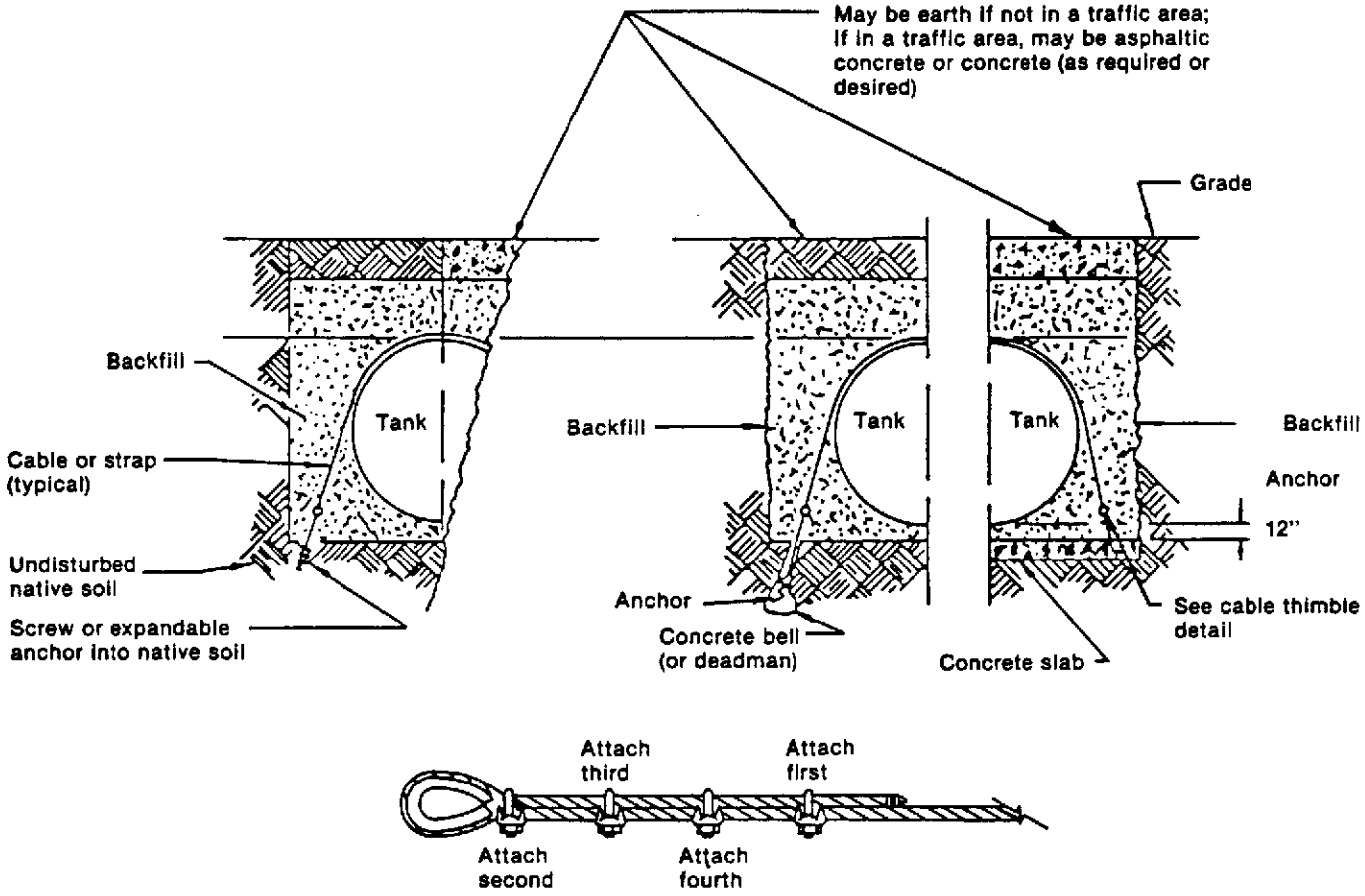
Figure 4—Typical Remote-Pumping Manifolded Tank Siphon System (Shown With Stage I and Stage II Vapor Recovery)

6.3.3 Secondary containment for tanks can be provided by the use of double-wall tanks (see 1.3.6) or impervious liners (see 1.3.11) for the tank excavation. Another form of secondary containment can be provided by impervious soil treatment (see 1.3.12), which decreases the permeability of the soil beneath the tanks. The type of secondary containment used depends on site conditions and economic factors.

6.3.4 Secondary containment for piping can be provided by the use of double-wall pipe (see 1.3.5) or impervious liners (see 1.3.11) for the pipe trench. If double-wall pipe is used, it must be installed in accordance with the manufacturer's instructions.

6.3.5 Concrete vaulting (see 1.3.41) should not be used to provide secondary containment for tanks or lines, because of the vaulting's propensity for cracking and structural degradation as a result of freeze-thaw cycles, aggressive soil conditions, and geologic shifts. The coatings used on vaulting can also degrade over time.

6.3.6 Various combinations of secondary containment can be used (see Figure 6). If double-wall tanks are used, containment should be provided for the fill manholes.



CABLE THIMBLE DETAIL

Notes:
1. The tank manufacturer should be consulted for recommendations for anchorage and installation.
2. This figure shows a tank installation where subsurface water is present.

Figure 5—Typical Anchorage for Underground Tank

In addition, a sump is usually provided for the dispenser, line containment systems, and submerged pumps. Otherwise, a small spill at the fill pipe or a leak at the submerged pump could appear to be a tank or line leak requiring extensive and costly investigation. For secondary containment to be effective and to eliminate unnecessary and costly investigation, the source of any free product must be easily identifiable.

6.4 Ballasting

6.4.1 Underground tanks should be ballasted with product as soon as possible after the tanks are installed and backfill has been placed around the tank (see Section 10). At no time during the backfilling process should the height of the ballast in the tank exceed the level of backfill around the tank.

6.4.2 Water may be used as an alternative ballast, but the installation of submerged pumping units in the tank must be deferred until after the water ballast is removed. If ballasting is necessary to prevent flotation of the tank (as a result of a high water table or flooding), water ballast should be the first choice.

6.4.3 When gasoline is used as ballast, the tanks should be vented to the atmosphere in accordance with NFPA 30.

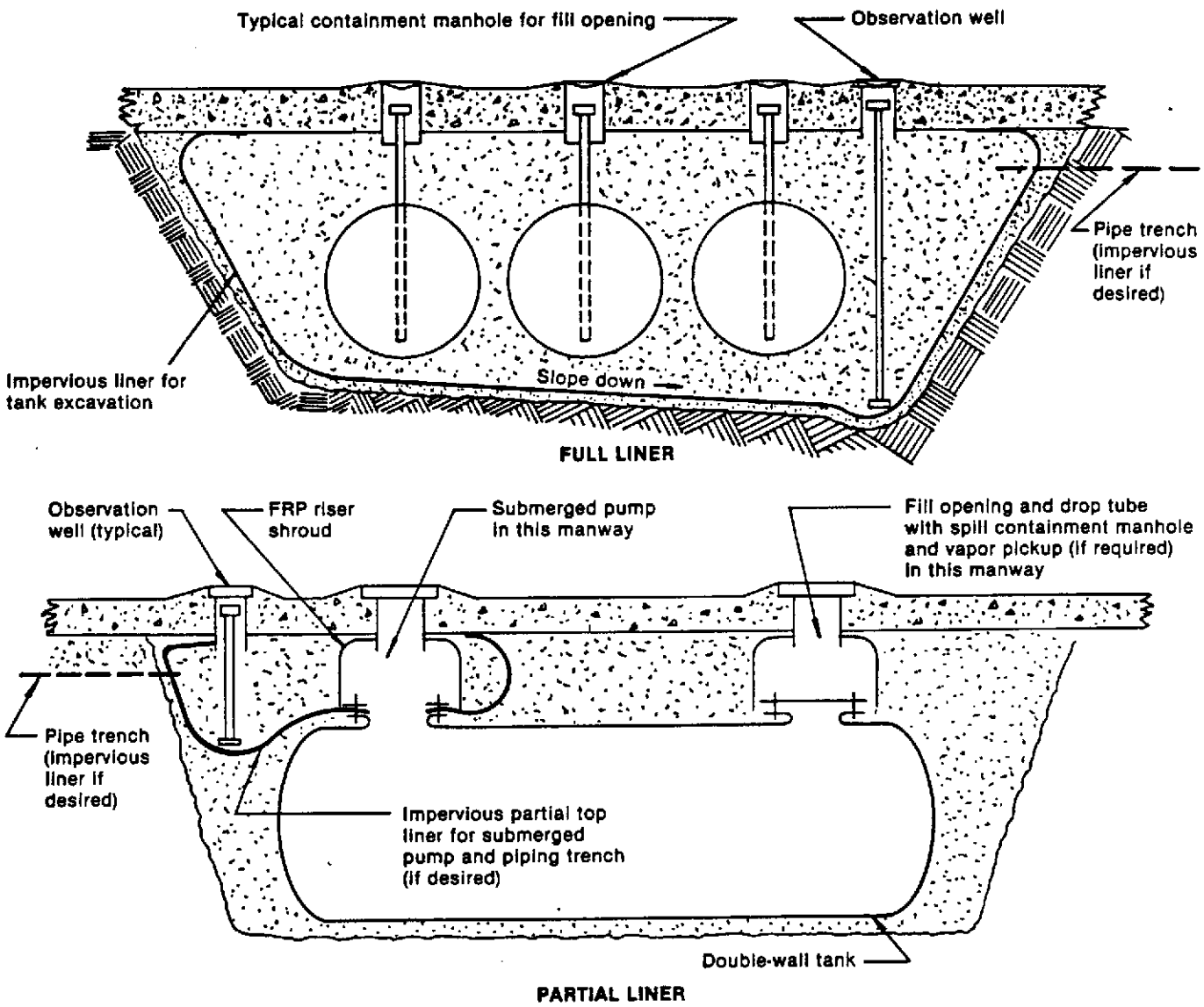


Figure 6—Typical Impervious Liners

6.4.4 If tanks are to be ballasted before the backfilling process is completed, the manufacturer's special instructions must be followed.

6.4.5 When product is used as ballast, care is required in handling, controlling inventories, and safeguarding against fires, accidents, and thefts. All fill caps and pumps should be kept locked when the system is unattended.

SECTION 7—CATHODIC PROTECTION

7.1 General

7.1.1 EPA 530-SW-85-023 contains the following requirements for each new tank and its piping:

a. They must be compatible with the substance to be stored.

b. They must be cathodically protected or constructed of noncorrosive material or of steel clad with noncorrosive material.

c. They must be designed to prevent the release or threatened release of any stored substance for the operational life of the system.

EPA 530-SW-85-023 does allow an exemption from corrosion control: If the soil at a site has a resistivity (electrical resistance determined across a 1-centimeter cube of soil) greater than or equal to 12,000 ohm-centimeters, measured as specified in ASTM G 57, cathodic protection may be eliminated. (For additional information and details about cathodic protection, see API Recommended Practice 1632 and NACE RP-02-85.)

7.1.2 There are two systems of cathodic protection: the *impressed-current system* and the *sacrificial-anode system,* which are discussed in 7.2 and 7.3, respectively. Both systems operate more efficiently with properly coated steel tanks and piping.

7.2 Impressed-Current Protection

An impressed-current system can be designed to protect steel tanks, steel underground piping, and other steel underground equipment at the site. Impressed-current systems use alternating current supplied by the electrical system at the site. The alternating current is converted to direct current by a rectifier, which is electrically connected to impressed-current anodes. The direct current flows from the rectifier to the anodes, through the soil to the steel equipment, and back to the rectifier. Corrosion is controlled by managing the flow and direction of the current. Changes or additions of USTS equipment may require alterations in existing impressed-current systems.

7.3 Sacrificial-Anode Protection

7.3.1 A sacrificial-anode system protects steel structures by managing the flow of electrical currents from the structures. Sacrificial anodes are electrically connected to the structure to be protected. Underground electrical currents exit to the surrounding soil through an anode that corrodes, rather than the structure corroding.

7.3.2 Sacrificial-anode protection can be provided by purchasing preengineered cathodically protected steel tanks. These tanks are delivered to the site properly coated, with sacrificial anodes attached and electrically connected to the tanks, ready for installation.

7.3.3 If steel tanks are installed without attached preengineered anodes, separate field-installed sacrificial anodes or an impressed-current system should be employed to protect the tanks.

7.3.4 When a sacrificial-anode system is used, piping must be electrically isolated from the tank and protected separately by field-installed sacrificial anodes (see 7.4.1).

7.3.5 The steel tanks and steel piping discussed in 7.3.2 through 7.3.4 must be coated to reduce their current requirements to levels that can be supplied over a long period of time by sacrificial anodes. Coal-tar enamel or asphalt coatings should not be considered adequate for purposes of cathodic protection. Coatings with high dielectric resistance should be used for underground storage tanks and piping. Other important properties of coatings are described in NACE RP-01-69.

7.4 Insulation of Exposed Surfaces

7.4.1 After all piping has been tested and found to be tight (see 10.2), all exposed threads of steel pipe should be coated with an appropriate dielectric material (see 7.3.5). This prevents an electrolytic cell from forming between the galvanized fitting and the threaded area, where the protective coating has been removed. Electrolytic cells can cause corrosion and premature pipe failure. Where a sacrificial-anode system has been installed, nonmetallic (for example, nylon) tank bushings should be installed in tank openings at all points at which product and vent piping are connected to the tank. Separate cathodic protection should be provided for steel piping.

7.4.2 When tank anchorage is installed (see 6.2.3), anchor straps should be installed so that they do not damage tanks or their coatings and so that the tank is electrically isolated from the straps. Electrical isolation can be accomplished by placing 90-pound roofer's felt or a section of rubber tire between the tank and the anchor straps. Anchor straps should be constructed of a noncorrosive material or of coated steel (galvanized or having a dielectric coating).

7.5 Electrical Connections

To ensure electrical continuity between all components of a cathodic protection system, all electrical connections in the system must be secure. For new installations where product is not present, and where safety considerations permit, these connections should be powder-weld connections. If necessary, pressure-type grounding clamps or other clamps designed for this purpose can be used. Electrical work must conform to federal, state, and local codes.

CAUTION: If tanks or lines contain or have contained flammable or combustible liquids, powder welds should not be used.

7.6 Testing

7.6.1 Before installation, all equipment should be inspected to ensure that it is undamaged, that electrical continuity has been maintained, and that the equipment is operating properly. After installation but before the system is placed in operation, all equipment should again be inspected and tested for proper operation.

7.6.2 The rectifiers in impressed-current systems should be checked monthly for proper operation. Annual surveys of structure potentials (see 1.3.32 and 1.3.33), conducted under the supervision of a qualified person, are necessary to ensure continued satisfactory operation. The results of the annual surveys should be kept with the permanent cathodic protection records for the location.

7.6.3 Sacrificial-anode systems should be checked for proper operation by a qualified person 6–12 weeks after installation and again 1 year later. If these tests confirm proper operation, subsequent inspection intervals can be extended to 5 years. However, if underground work is performed at a protected site, the sacrificial-anode system should be reinspected 6–12 weeks after the work is completed and again 1 year later before the 5-year inspection intervals are resumed. The inspection procedures used and the data obtained should be clearly recorded and kept with the permanent cathodic protection records for the location.

SECTION 8—DETECTION OF RELEASES

8.1 General

8.1.1 The prevention of product leaks and spills from storage and dispensing systems is necessary to provide a safe environment and to prevent pollution and should be given the highest priority. This can best be accomplished by properly installing and maintaining tight storage and dispensing systems that are specifically designed and protected for their particular environment.

8.1.2 If a leak develops, it must be detected promptly to avoid fire, safety, and environmental problems. Early detection also eliminates or reduces product migration and minimizes the costs of corrective action. To assist in the early detection of a release, the following means are available:

a. Inventory control.
b. Line leak detectors.
c. Automatic tank gauging systems.
d. Observation wells.
e. Monitoring wells.
f. Interstitial monitoring.

For further information about release detection, see API Recommended Practices 1621 and 1635.

8.2 Inventory Control

8.2.1 Gauging for inventory control can be accomplished manually or by means of an automatic tank gauging system (see 8.2.3 and 8.4).

8.2.2 Manual gauging is accomplished by using a gauge stick to measure the product depth in each tank at the open and close of each business day. The stick can also be used to gauge water bottoms. No special equipment installation is necessary for inventory control by manual gauging.

8.2.3 Automatic tank gauging systems include both mechanical (float) and electronic (sensor) gauging devices, as described in 8.2.3.1 and 8.2.3.2, respectively.

8.2.3.1 Mechanical gauging equipment is available for installation in underground tanks. This equipment is float operated and should be installed, operated, and maintained in accordance with the manufacturer's instructions. When mechanical gauging equipment is used, water bottoms in tanks may be measured manually with a gauge stick.

8.2.3.2 Electronic gauging equipment can provide extremely precise tank level measurements. Many different degrees of sophistication are available. The information can be provided on remote readouts and printouts and can include time and date, product temperature, water level, product level, water volume, product volume, tank leak testing mode (see 8.4), and data from observation and monitoring wells (see 8.5 and 8.6). The use of electronic gauging equipment requires the installation of probes and sensors in the underground tanks, with electrical connections to a remote readout location. Since this equipment is complex, it must be installed, operated, and maintained in exact accordance with the manufacturer's instructions.

8.3 Line Leak Detectors

8.3.1 A variety of leak detectors are available for underground product lines. One type of line leak detector utilizes a pressure-sensing valve, which is usually

installed at the discharge end of a submerged pump. This device senses pressure losses in the line and, when triggered, reduces product flow.

8.3.2 More sophisticated line leak detectors are available that respond very quickly to a small pressure drop to shut off the electric power to a submerged pump. The use of these systems necessitates installation of pressure sensors in the discharge line immediately after the submerged pump, along with the necessary electrical connections.

8.4 Automatic Tank Gauging Systems

Some types of automatic tank gauging systems have a leak testing mode. When the gauging system is set in this mode during a time when the USTS is not in operation, a tank leak test can be conducted. The accuracy of the test is usually related to the period of time the equipment is maintained in the leak testing mode. A test typically takes 4–6 hours; however, this may vary depending on the type of equipment used. The test date, time, and gauging data are usually recorded on a remote printout and can be kept as part of the permanent records for the site.

8.5 Observation Wells

8.5.1 Observation wells can be used to observe secondary containment areas in lined excavations or, where the water table is normally within the excavation or where an impermeable barrier has been installed in the floor of an excavation, to monitor the backfill area around underground tanks. For new installations, an impermeable barrier (see 1.3.10) can be installed in the bottom of the tank excavation if the soil permeability is too high. Observation wells have a casing at least 2 inches in diameter with 0.020-inch slots or an equivalent perforation design. If surface drainage is expected to enter the manhole, the slots should not extend to within 12 inches of grade (see Figure 7).

8.5.2 When only one tank is to be installed, an observation well should be installed near each end of the tank, inside the tank excavation. When two, three, or four tanks are to be installed in a single excavation, observation wells should be installed at two diagonal corners inside the excavation. When more than four tanks are to be installed in a single excavation, a site-specific hydrogeologic analysis should be performed to determine the correct number and location of observation wells.

8.5.3 Observation wells should extend to a depth of 24 inches below the bottom of the tank or to the top of the concrete hold-down pad, if one is used for anchoring.

8.5.4 When an impervious liner is used to provide secondary containment, only one observation well is required. This well should extend to within 6 inches of the bottom of a sump at the lowest point of the containment. If impervious liners are used for underground lines and submerged pumps, one observation well should be installed in the collection sump.

8.5.5 Observation wells can be equipped with electronic product-monitoring devices. Sensors may be required in each well and must be electrically connected to the readout point. Sensors are available that detect both vapors and liquid. When vapor sensors are used, care should be taken to avoid false alarms resulting from extraneous vapor sources.

8.5.6 Manual monitoring requires securing a water sample from the well and observing the sample for evidence of petroleum product. The sample can be obtained by using a portable bailer or another device. If no water is present in the well, the vapors in the well can be checked for hydrocarbons by using a portable or stationary monitoring/detection device.

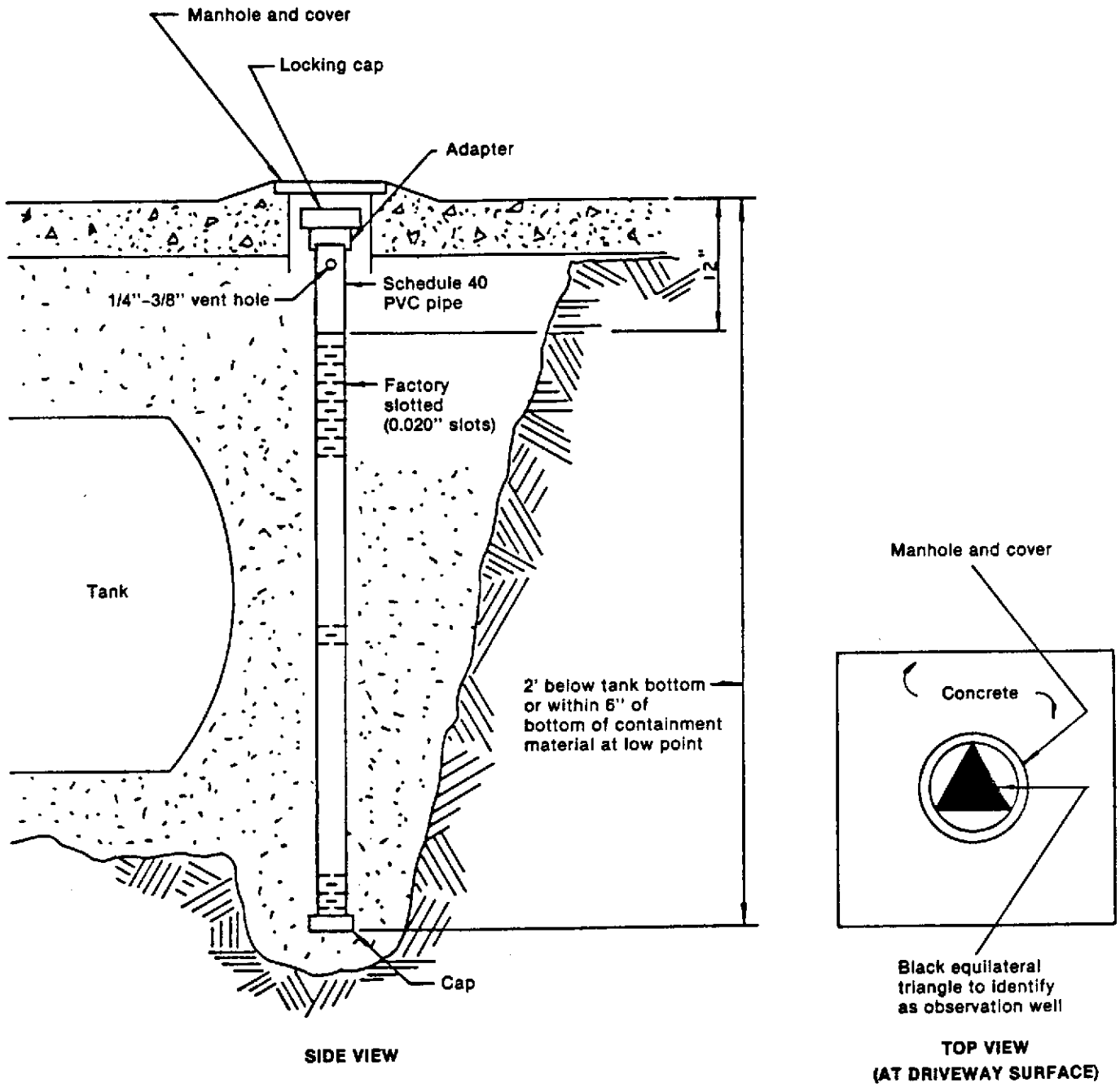
8.5.7 Observation wells should be identified, sealed, and secured to prevent the accidental or deliberate introduction of product, precipitation, or other materials. The identifying symbol should be a black equilateral triangle on a white background (see Figure 7). One or more of the following actions should be taken to identify new and existing observation wells:

a. Painting a black equilateral triangle on a white background on the cover and/or cap of the well.
b. Permanently affixing, to the cover and/or cap of the well, a decal or tag that shows a black equilateral triangle on a white circular background.
c. Attaching to or casting into the cover and/or cap of the well a raised black equilateral triangular plate on a white circular background.
d. Installing a triangular well manhole and cover. The cover should be painted black, with its rim or edge painted white.

8.5.8 In addition to the requirements in 8.5.7, at least one fixed internal component of the well manhole (for example, the cap lock, cap, well casing, or internal manhole surface) should have affixed to it a label (preferably metal or plastic) with the following warning (or a similar one) permanently printed, embossed, or engraved on it:

OBSERVATION WELL

WARNING: Do not place gasoline, petroleum products or other substances in this well. Violators may be subject to civil or criminal penalties.



Note: PVC = polyvinyl chloride.

Figure 7—Typical Observation Well

8.5.9 New and existing observation wells should be secured by taking one or more of the following actions:

a. Installing a locking cap on the well casing and/or manhole.
b. Installing a limited-access manhole (see 1.3.14).
c. Installing a device that renders the well casing incompatible with product fill hoses and nozzles that are likely to be used at the facility.

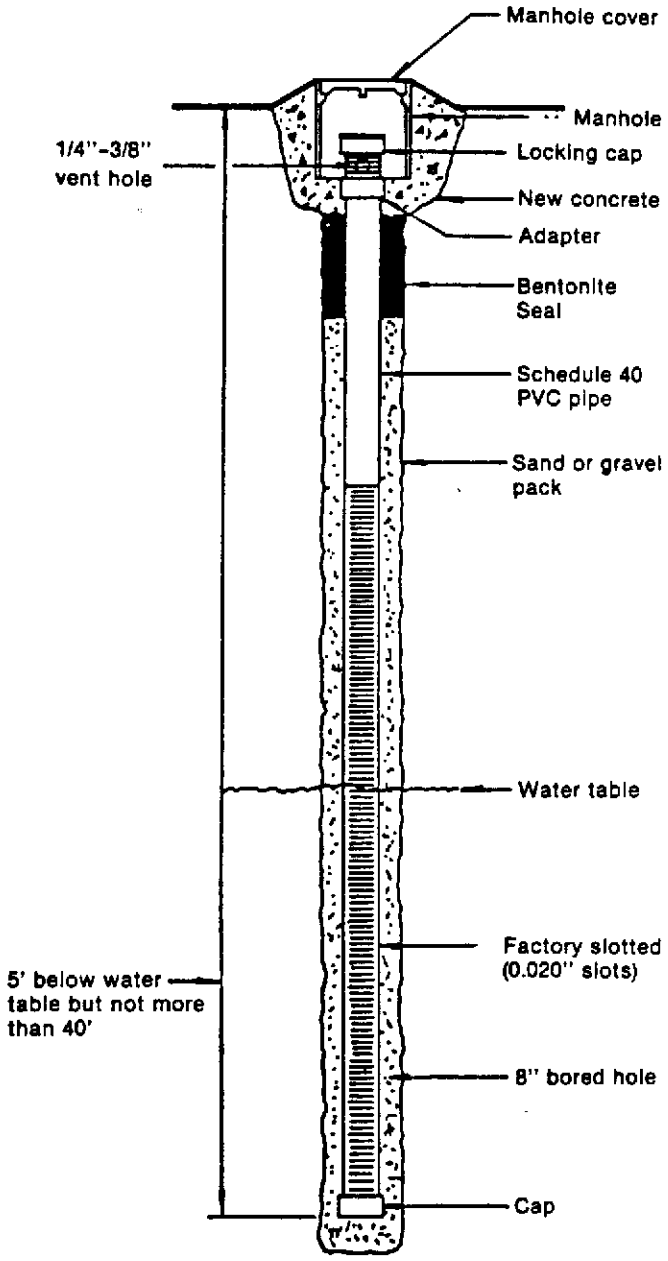
The keys, tools, or codes used to access these security devices should be incompatible with those used to access product fill pipes at the same facility.

8.6 Monitoring Wells

Monitoring wells are used to monitor the water table in the area of a USTS. They provide leak detection capabilities equivalent to those of observation wells but should only be used when soil permeability is high and when the normal water table is below the tank excavation but within 40 feet of the ground surface. Monitoring wells should be installed so that the bottom of the well is at least 5 feet below the lowest anticipated water table. Well casings should be at least 2 inches in diameter with 0.020-inch slots (see Figure 8). Monitoring wells are used to detect the presence of petroleum products on the groundwater surface and can be monitored using electronic or manual devices, as described in 8.5.5 and 8.5.6, respectively. The placement of monitoring wells depends on site-specific conditions.

8.7 Interstitial Monitoring

The interstice of double-wall tanks and piping can be monitored for product releases either manually or with an automated device. This monitoring can be periodic or continuous, depending on the device used. The manufacturer should be consulted regarding the specific installation requirements of interstitial monitoring devices.



Note: PVC = polyvinyl chloride.

Figure 8—Typical Monitoring Well

SECTION 9—PIPING

9.1 General

Proper installation and testing of the piping system is one of the most important aspects of any USTS installation. Many of the most severe product releases, especially in pressurized pumping systems, have occurred because of improperly installed piping and pipe joints or because of damage to piping during construction. This applies to both FRP and steel pipe. The authority having jurisdiction should be consulted regarding specifications for installation, testing, and operation of piping systems.

9.2 Layout and Design

9.2.1 A carefully planned, clearly detailed layout should be prepared for each installation. If the layout is properly planned, the length of pipe runs will be minimized, operation will be more efficient, and maintenance will be easier. Piping should be installed in a single trench between the tank area and the island area. Vent lines between the tank area and the building or other structure to which the aboveground vent lines are attached should also be installed in a single trench. Piping across tanks should be minimized, and pipe trenches should run in straight lines with 45- or 90-degree bends. If the location of pipe runs is changed from that shown on the installation drawings, the actual location should be noted on as-built drawings. Photographs of the underground installation should be taken and retained as a part of the permanent records for that location.

9.2.2 Underground piping from tanks to dispensers should be sized according to the pump manufacturer's recommendations. In determining size, consideration must be given to the length of runs, flow rates, the number and size of pumps, and the number of dispensers to be served. In any case, piping should not have an inside diameter of less than 2 inches.

9.2.3 Underground product lines and vapor return lines (if required) should have a uniform slope of not less than 1/8 inch per foot toward the tank. The historical depth of frost (if any) should be taken into account when the burial depth of the piping is determined. Product lines should be at least 12 inches below the finished surface (see 10.3.1). The pipe manufacturer's instructions should be followed if burial at a greater depth is required. Traps or sags should be avoided in all piping.

9.2.4 It is occasionally necessary or advisable to install more than one storage tank for a given product. Such tanks may be interconnected by means of a siphon connection. A siphon will provide reliable service only if care is taken to ensure that all joints in the siphon manifold are tight. Although not recommended, if it is necessary to connect tanks of different diameters at a new installation by means of siphons, both the bottoms of all the tanks and the ends of the suction stub piping in each tank should be at the same elevation (see Figures 3 and 4). In addition, care should be taken to ensure that the vent line leaving the smaller diameter tank rises vertically to a point higher than the top of the larger tank before the horizontal section of vent piping is installed. Remote pumps are available with a siphoning attachment that can be connected to a siphon manifold. This permits one pump to draw the contents from two or more interconnected tanks (see Figure 4). The manufacturer's installation instructions should be followed. Siphon piping should be of the same diameter as the suction and/or delivery lines to the dispensers.

9.2.5 The vent piping for all tanks should be adequately sized. This is necessary to prevent excessive pressure from building up while the tank is being filled and to prevent vapor or liquid from blowing back at the fill opening when the unloading hose is disconnected. The maximum fill rate can be limited by the diameter of the vent line. Vents that are 2 inches in diameter (for up to 150 feet in length) should be adequate for flow rates incurred using 4-inch delivery equipment (see NFPA 30).

9.2.6 Vent piping should be at least 12 inches below the finished surface (or at least 4 inches in no-load areas), measured from the point where the piping rises vertically, and should slope uniformly toward the tank. The pipe manufacturer's instructions should be followed if a greater burial depth is recommended. The piping should slope no less than 1/8 inch per foot, and the piping should be laid to avoid sags or traps in the line, in which liquid could collect.

9.2.7 Aboveground vent piping should be Schedule 40 galvanized steel and should be located, or protected and anchored, to prevent damage from traffic and other sources. FRP piping should not be used aboveground. Vents may be either freestanding with a vertical support or attached to a building (see Figure 9). Vent outlets should be located to prevent flammable vapors from entering confined areas and building air-conditioning and/or ventilation intakes or from reaching potential ignition sources. Vent outlets must discharge upward, and the discharge point must be no less than 12 feet above the adjacent ground or, if the vent is attached to a building, no less than 2 feet above the roof at the point of attachment. Where required by local ordinances or special conditions, vent caps should be installed.

9.3 Steel Piping

9.3.1 Underground steel piping should be Schedule 40 galvanized steel. As a minimum, couplings and fittings should be 150-pound malleable iron. A thread sealant certified for petroleum service should be used for all fittings.

9.3.2 Breakage of underground piping and vent lines, as well as loosening of pipe fittings, which can result in product leaks, can be minimized by the use of flexible joints (see 1.3.8). Flexible joints should be installed in lines at points where the piping connects with the under-

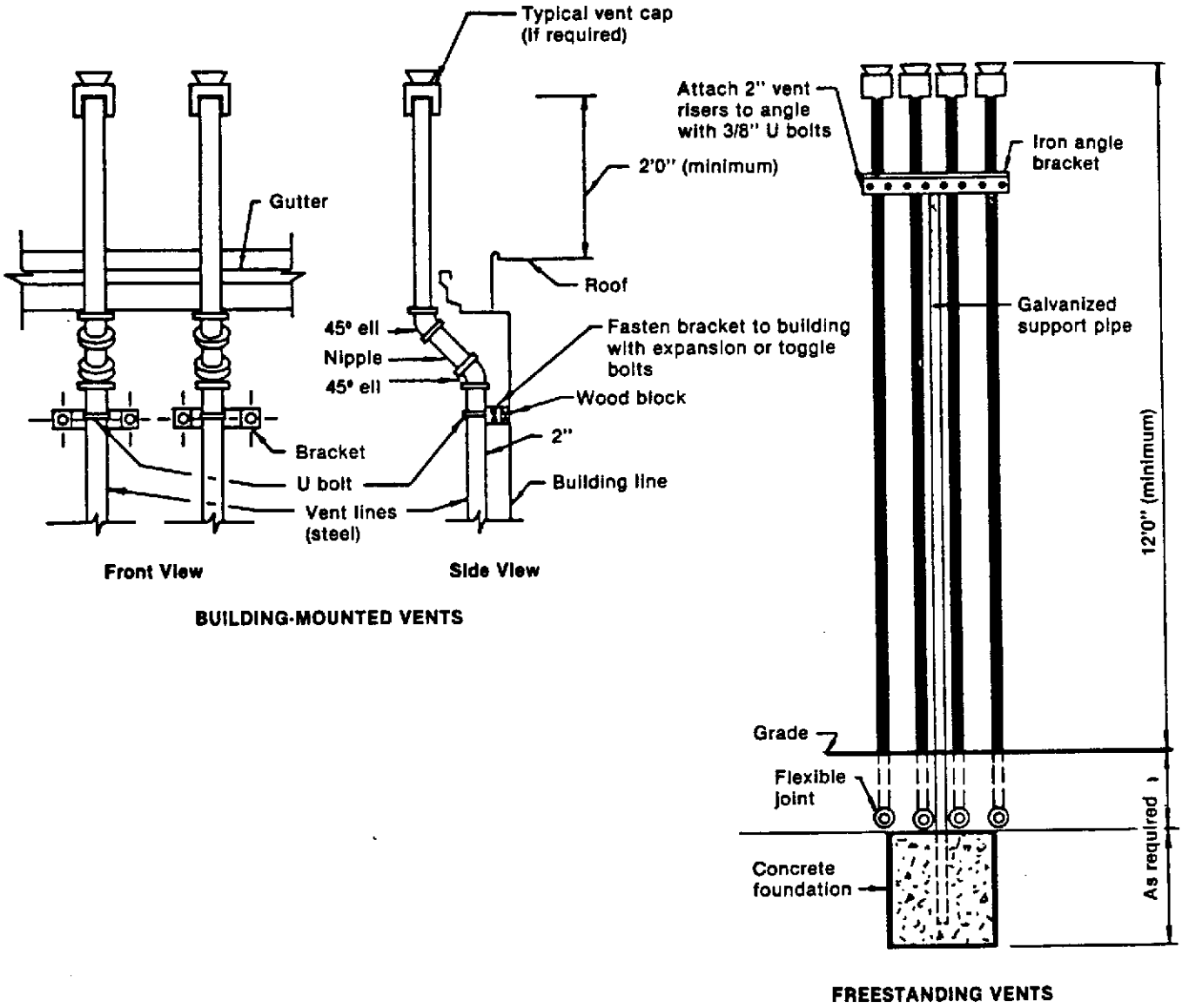


Figure 9—Typical Vent Details

ground tanks and where the piping ends at the pump islands and vent risers (see Figures 10 and 11).

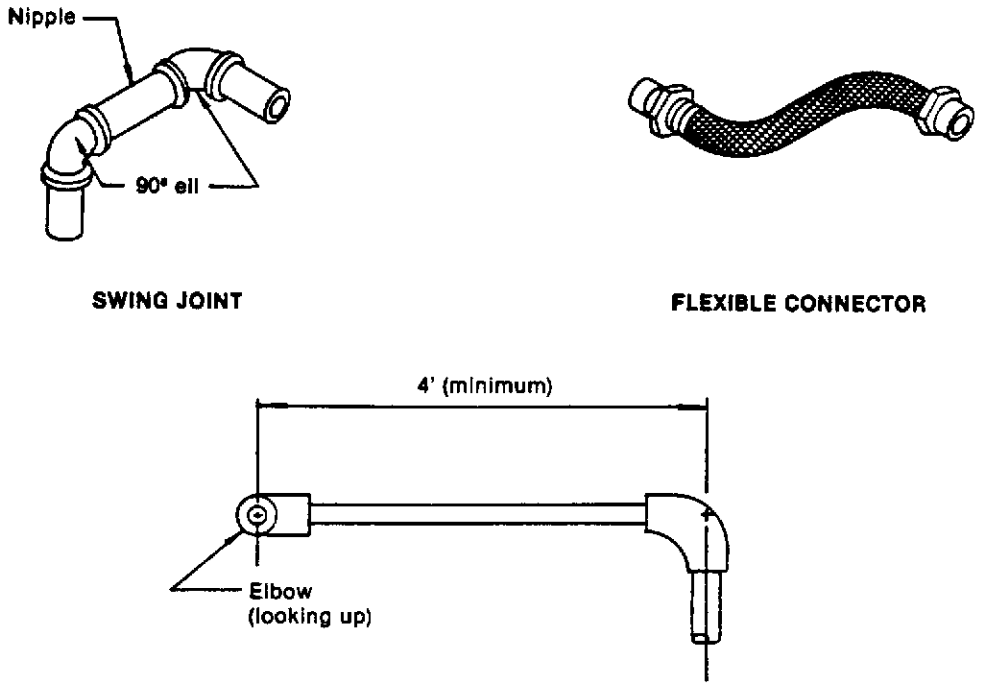
9.4 Fiberglass-Reinforced Plastic Piping

9.4.1 Any FRP pipe used in an underground petroleum installation should be UL approved.

CAUTION: When FRP pipe is used, it is extremely important that it be installed in exact accordance with the manufacturer's instructions.

9.4.2 FRP piping, which is inherently flexible, can be used to create its own flexible joint if at least 4 feet of straight run is provided between any directional changes of more than 30 degrees (see Figure 10). Commercially available flexible joints that are certified for petroleum service, as described in 9.3.2, may be used under dispensers and suction pumps and at submerged pumps and tanks in lieu of the 4-foot straight run mentioned above.

9.4.3 Pipe joints must be straight, not cocked, and must be fully seated, not backed out. The joint adhesive used must conform to the manufacturer's recommendations for underground petroleum service and must not



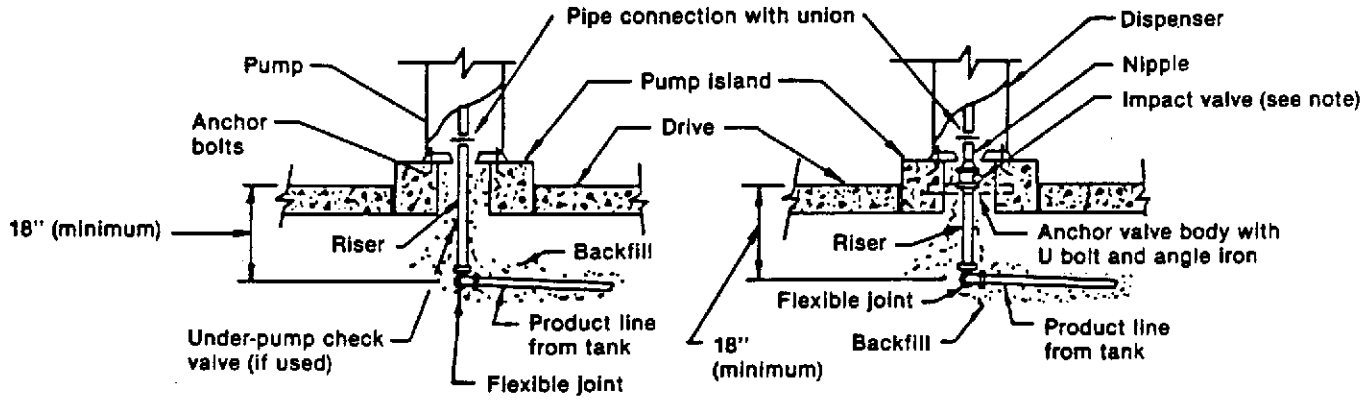
SWING JOINT

FLEXIBLE CONNECTOR

FLEXIBLE FRP PIPE JOINT

Note: There must be a minimum of 4 feet of straight pipe between any directional changes of more than 30 degrees.

Figure 10—Typical Flexible Joints for Piping



SUCTION PUMP PIPING

SUBMERGED PUMP PIPING

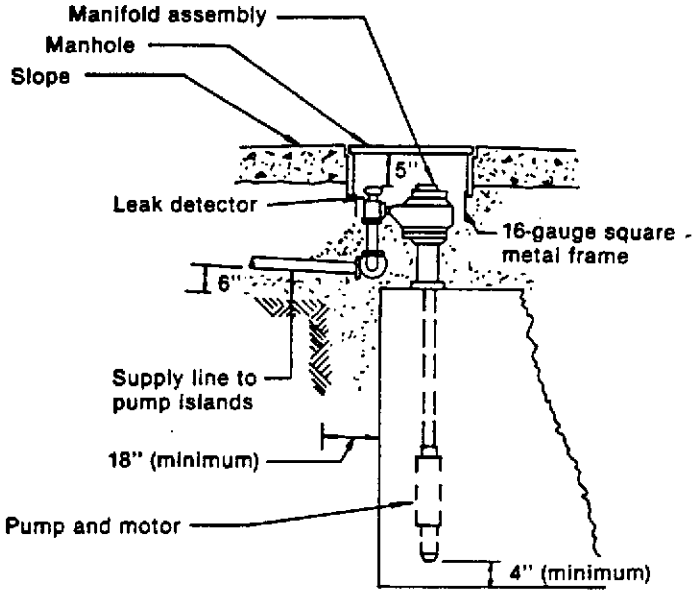
Note: For the impact valve to function properly, it must be installed so that the shear section is level with the top of the island pedestal.

Figure 11—Typical Island Piping: Dispenser/Suction System Without Vapor Recovery

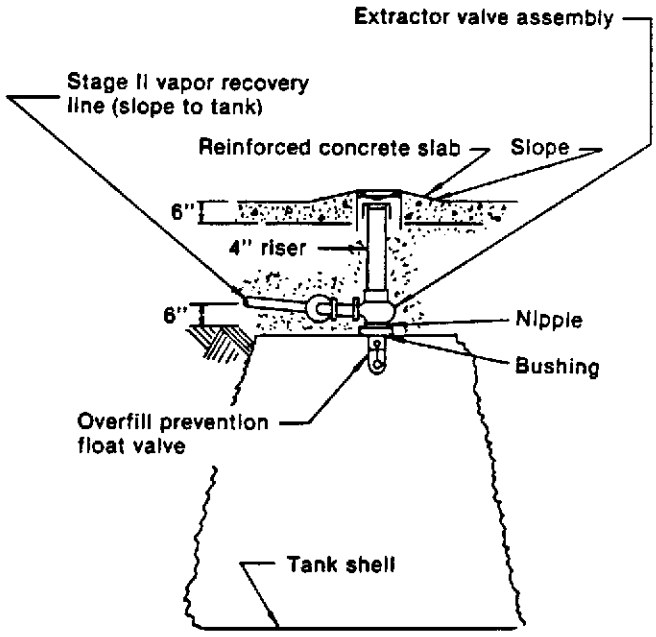
be used at temperatures below the recommended minimums. If the temperature is below the recommended minimum, the manufacturer's instructions should be followed for providing heat to the joint to ensure a complete cure.

9.5 Overfill Protection and Containment of Fill-Pipe Spills

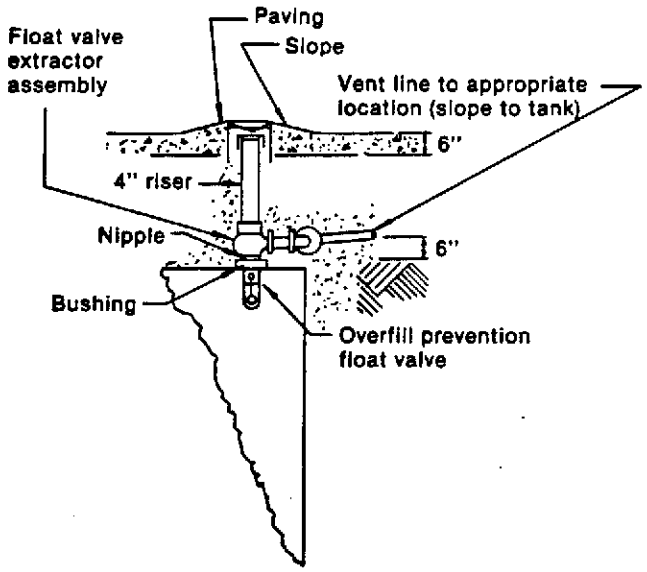
9.5.1 Spills, drips, and overfills that occur during transfer operations from the delivery truck to the under-



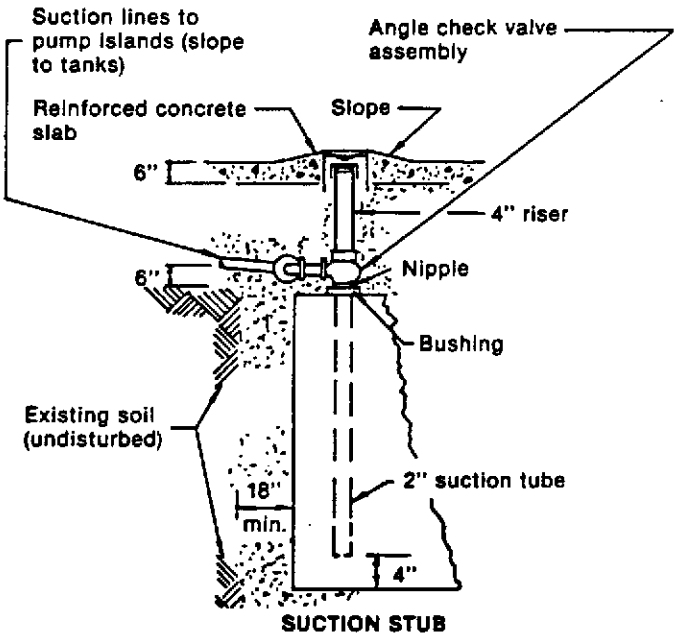
SUBMERGED PUMP



VAPOR RECOVERY LINE TO MANIFOLD OR ISLAND (WITH OVERFILL PREVENTION)



VENT LINE (WITH SWING JOINT AND OVERFILL PROTECTION)



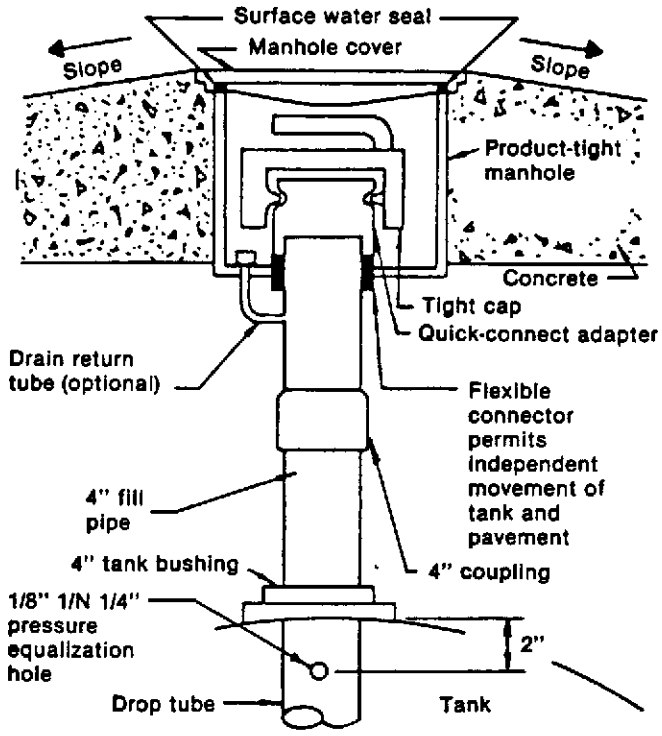
SUCTION STUB (WITH ANGLE CHECK VALVE)

Figure 12—Typical Tank Piping Details

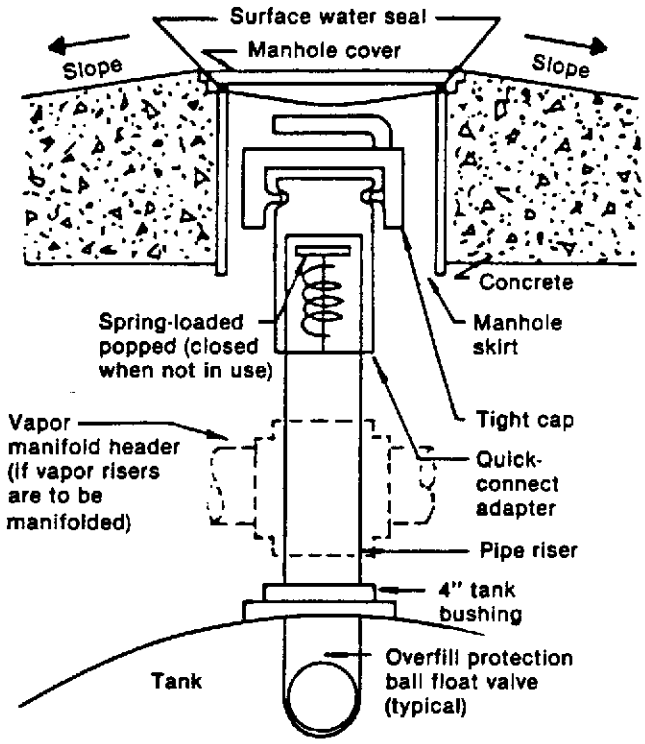
ground tank should be prevented or contained. Overfill problems can be reduced by installing ball check valves or float valves in the vent line and Stage I and Stage II vapor recovery lines where the vent lines leave the underground tank (see Figure 12).

9.5.2 To contain small overfills that may still occur, a spill containment manhole should be installed on the fill pipe of the underground tank (see Figure 13). Containment manholes can be purchased with a drain that routes any spilled product back into the underground tank.

9.5.3 The overfill protection described in 9.5.1 and 9.5.2 is necessary even if partial or full secondary containment is installed. Without this protection, spilled product may get into the backfill and may reach the observation well of the secondary containment and be interpreted as a suspect leak. Secondary containment is discussed in 6.3 and is illustrated in Figure 6.



FILL-PIPE SPILL CONTAINMENT MANHOLE



TRANSPORT VAPOR PICKUP POINT

Figure 13—Typical Piping Details: Fill-Pipe Spill Containment Manhole and Transport Vapor-Pickup Point

SECTION 10—BACKFILLING

10.1 General

Backfilling operations are an important aspect of USTS installation and should be continuously supervised by a qualified person to ensure that only specified materials and installation methods are used by the contractor. Excavated material is not generally suitable as backfill for underground tanks and lines. Unless the excavated material is specifically examined and approved for use by the authority having jurisdiction, it should be removed from the site.

10.2 Pipe Tightness Test

Before backfilling, piping should be isolated from the tanks and subjected to a pipe tightness test (see 1.3.22). Other testing methods may be substituted if approved by the authority having jurisdiction.

10.3 Placement of Materials and Compaction of Backfill

10.3.1 UNDERGROUND LINES

Before any underground lines are installed, the trench for such piping should receive a bed of well-compacted backfill at least 6 inches deep, as recommended by the piping manufacturer. The bed must be free from ice, snow, debris, and organic material. All trenches should be wide enough to permit at least one pipe diameter between steel lines, two pipe diameters between FRP lines, and 6 inches of backfill between all underground lines (whether steel or FRP) and the sides and floor of the trench. A cover of at least 6 inches of well-compacted backfill is recommended.

10.3.2 UNDERGROUND TANKS

10.3.2.1 Steel and Fiberglass-Clad Steel Tanks

Backfill for steel and fiberglass-clad steel tanks should be well compacted, as recommended by the manufacturer, and must be free from ice, snow, debris, and organic material, which adversely affect compaction and may damage the tank or its coating. The backfill bed for steel tanks should be 12 inches deep, with or without a hold-down pad. A minimum of 12 inches of backfill (or the amount required by the manufacturer) should be placed between all tanks and at the ends and sides of all tanks. All bedding material, backfill around the tanks, and covering over the tanks (see 5.3.2) should be of the same material.

10.3.2.2 Fiberglass-Reinforced Plastic Tanks

Backfill for FRP tanks must be free from ice, snow, debris, and organic material, which adversely affect compaction and may damage the tank. All backfill material should be in strict accordance with the manufacturer's specifications. Such backfill is generally pea gravel or crushed stone that meets the requirements of ASTM C 33. The backfill bed for FRP tanks should be 12 inches deep on top of the hold-down pad or the bottom of the excavation. If no hold-down pad is used, 18 inches of backfill should be placed between all tanks. All bedding material, backfill around the tanks, and covering over the tanks (see 5.3.2) should be of the same material.

10.3.2.3 Compaction of Backfill for All Tanks

It is especially important that the bottom quadrant of all tanks (both FRP and steel) be evenly and completely supported. The backfill material should be carefully placed along the bottom and under the sides and end caps or heads of the tanks by manual shoveling and tamping. The backfilling may then be completed in 12-inch lifts, uniformly placed around the tanks. Care must be taken to avoid damage to the tanks or their coating.

10.4 Grading and Paving

CAUTION: Extreme care should be taken during final grading operations to avoid damage to piping and equipment by heavy tractor blades and cleats. Equal care should be taken when stakes are driven for grading or paving, to avoid damage to piping by a stake being driven into or against the piping. *Puncturing an installed system can lead to the migration of flammable liquids or vapors to an ignition source, resulting in an explosion on the site or in an adjacent area.* Mistakes made during grading and paving are among the most common causes of installation-related failure of USTSs.

10.5 Post-Backfill Inspection of Fiberglass-Reinforced Plastic Tanks

After backfilling has been completed but before concrete or asphalt paving has been installed, the inside diameter of FRP tanks should be measured and compared with the inside diameter measured as recommended in 3.5.1.3, to ensure that tank deformation resulting from backfilling does not exceed the manufacturer's specifications. The diameter measurements should be retained permanently for future reference.

CAUTION: Tanks should not be entered for any purpose unless the proper safety precautions, as outlined in API Publication 2217, are taken.

10.6 Final Testing

a. Conduct precision test (see 1.3.23) of all tanks and piping after all paving over the tanks and piping has been completed and before the system is placed in operation.

b. Operationally test all other equipment, including impact (shear) valves, and leak detector alarms.

SECTION 11—OTHER EQUIPMENT

11.1 Pumping Systems

11.1.1 GENERAL

Although this recommended practice is intended primarily as a guide for installing underground tanks and piping, consideration should be also be given to the type of pumping system to be used. Such consideration will in turn determine aspects of piping design and leak detection.

11.1.2 SUCTION PUMPING SYSTEMS

11.1.2.1 A suction pumping system (see 1.3.34) usually consists of a pump in each dispenser, with individual product suction lines running from each pump to the underground storage tank.

11.1.2.2 When a suction pumping system is used, the height to which the pumps can lift the product is a critical factor. The tank diameter and the length of product piping between the tank and the pump should therefore be kept to a minimum. This is especially important in warmer climates and at higher altitudes. The pump manufacturer can provide assistance with these design requirements.

11.1.3 REMOTE PUMPING SYSTEMS

11.1.3.1 A remote or submerged pumping system (see 1.3.28) is located in or above the underground storage tank (see Figure 14). This permits the use of a single product line from each product pump to the dispensers on the pump islands. This type of system permits the use of more dispensers for each product and a reduction in the quantity of buried piping. An impact valve, level with the top of the island, must be installed at each dispenser (see Figures 11 and 15; see also NFPA 30A).

11.1.3.2 With remote pumping systems, the delivery of product does not depend on the depth of the tank or (within certain limits) on the length of the product piping.

11.1.4 OTHER FACTORS

11.1.4.1 Other factors to be considered in the selection and installation of pumps are described in 11.1.4.2 through 11.1.4.7.

11.1.4.2 Pump seals and materials of construction should be designed for and compatible with the liquids to be handled. The authority having jurisdiction and the manufacturer should be consulted for additional requirements.

11.1.4.3 Suction stubs in underground tanks for suction pumping systems should have the same diameter as do the product lines they serve. Suction stubs and remote pumps should extend to within 4 inches of the bottom of the tank or to the level specified by the manufacturer.

11.1.4.4 Where suction pumps are used, a double poppet valve should be installed under each pump, or an angle check valve should be installed at the tank for each product line (see Figure 16). If the fitting is to be installed under concrete, an extractor angle-valve manhole or concrete breakout can be used.

11.1.4.5 For remote pumping systems, a line leak detector should be installed that has the capability of detecting a leak and restricting product flow (so it is evident that a potential problem exists) or shutting down the pumping system (see 8.3).

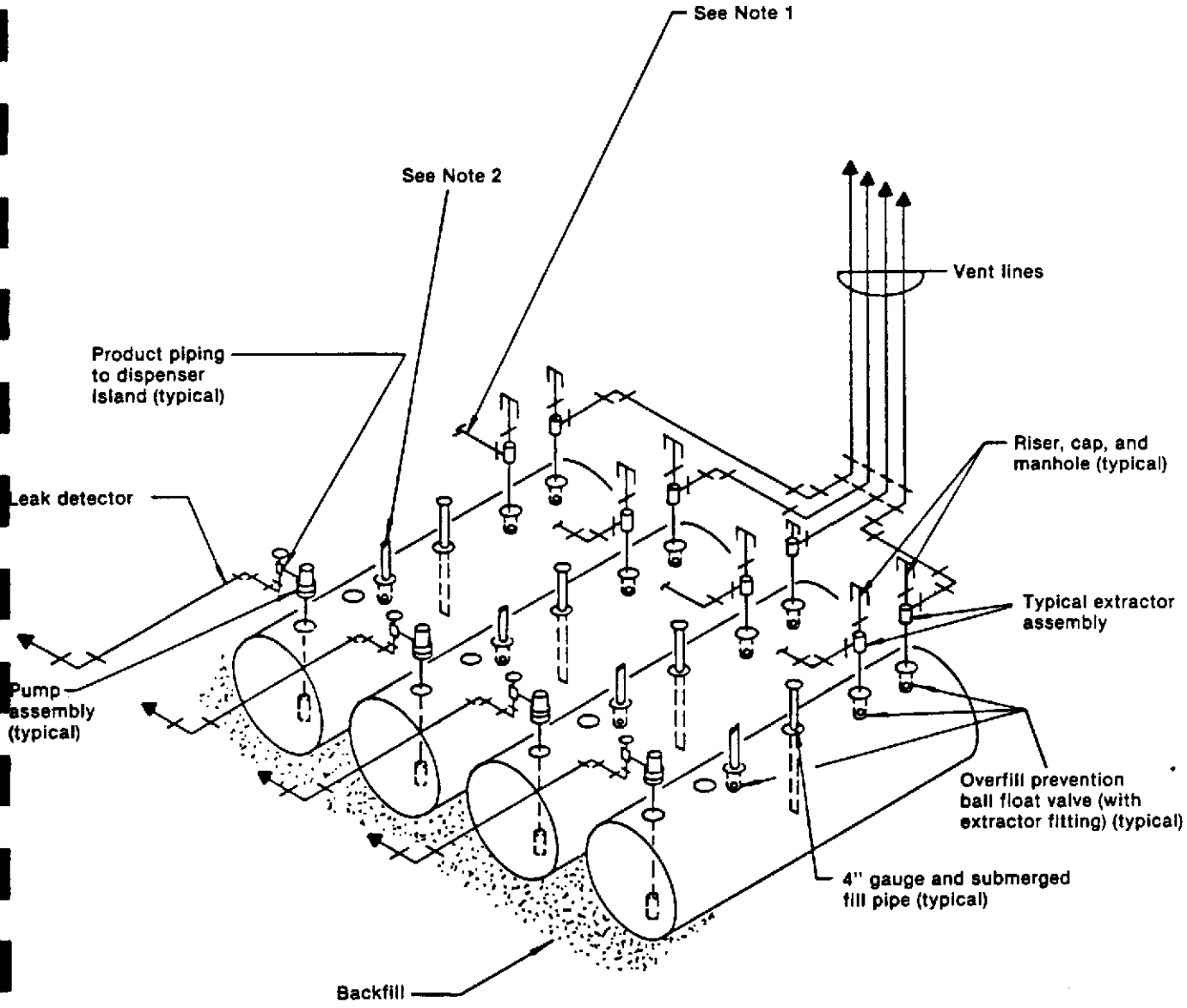
11.1.4.6 Pumping systems should be equipped with clearly identified and easily accessible electrical switches or circuit breakers. The switches or breakers should be located away from dispensers and pumps and should permit the immediate shutdown of all dispensing devices in the event of an emergency. The authority having jurisdiction should be consulted for any additional requirements.

11.1.4.7 Dispensers should meet the requirements of UL 87 and should bear the UL label.

11.2 Tank Fittings

11.2.1 Tanks should be equipped with the desired number and size of tank openings. The tank manufacturer's specifications and drawings must be checked to determine the types (steel or FRP), sizes, and capacities that are available.

11.2.2 Tank openings should be 4 inches in diameter, and most tank openings are of this size. Fill pipes, fill caps, and fill tubes are also normally 4 inches in diameter. Submersible pumps designed with the capacity to meet the normal layout and operation requirements of service stations are built to fit 4-inch tank openings. If greater capacity is needed, larger pumps and tank openings may be required.



Notes:
1. If required, a Stage II vapor recovery line should run to the vapor collection manifold and then to the dispenser islands. If the vapor recovery system is not manifolded, each line should go to the dispenser islands. A float valve, extractor, riser, cap, and manhole should be included for each tank. (The arrangement shown is typical.)
2. If required, a Stage I vapor recovery riser should run to the vapor collection manifold, with one surface pickup point. If the vapor recovery system is not manifolded, each riser should go to a separate surface pickup point. Each riser pipe should be connected to a ball float valve. (The arrangement shown is typical.)
3. See Figure 12 for details of tank piping.

Figure 14—Typical Remote Pumping System (Shown With Stage I and Stage II Vapor Recovery)

11.2.3 Double-tapped bushings are used to reduce the size of the tank opening so that appropriate fittings can be attached and connecting pipes inside and outside of the tank can be installed.

11.2.4 Nonmetallic tanks are fitted with threaded openings to receive the double-tapped bushings described in 11.2.3, as well as plugs.

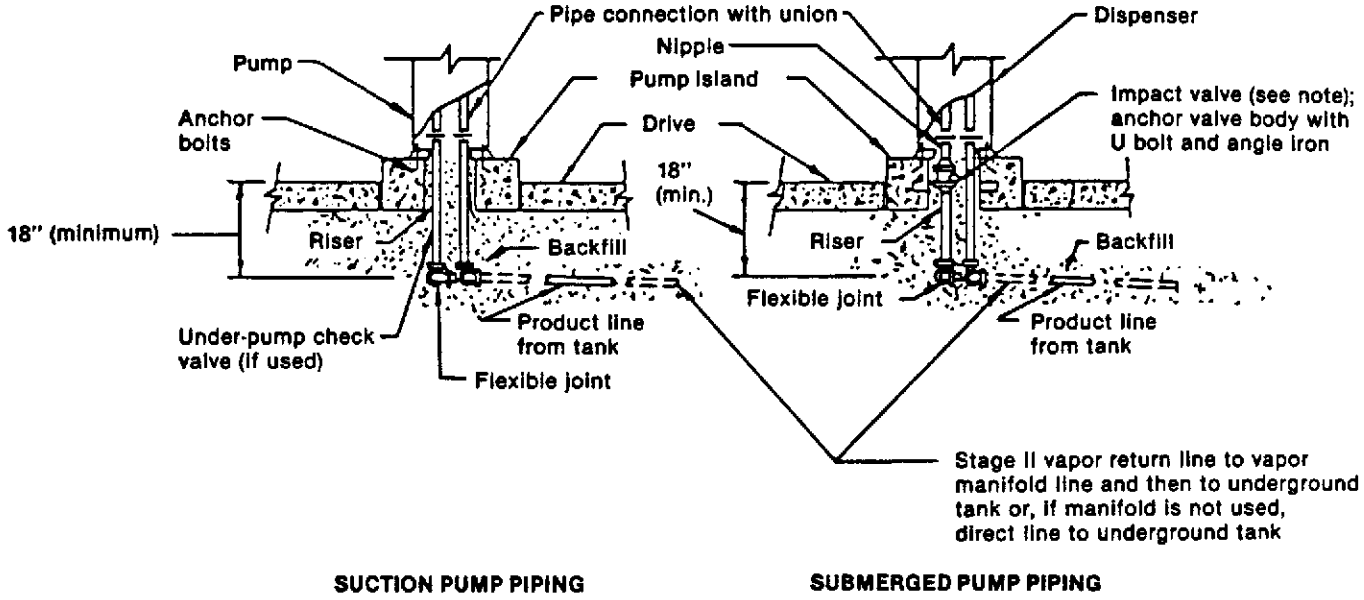


Figure 15—Typical Island Piping: Dispenser/Suction System With Stage II Vapor Recovery

11.2.5 Fill pipes may be located at any opening in the tank. Reinforced plates should be installed under fill and gauge openings in all tanks.

11.2.6 All fill connections should be of a tight-fill design. A fill tube should be inserted at the fill opening and should extend to within 6 inches of the tank bottom. The use of tight fill connections and fill tubes will increase the rate of product flow during filling and decrease turbulence and product vapor loss. If the fill connection is to be used for gauging, a 1/8-inch hole should be installed in the drop tube immediately inside the tank to allow for pressure equalization, which will permit accurate gauging.

11.2.7 A liquid-tight fill cap, equipped with a lock, should be installed and should be used in conjunction with a manhole ring and cover.

11.3 Identification of Driveway Manholes

The product being handled and the size of the tank should be marked on the fill assembly or manhole cover. The product can be identified by using a color code (see API Recommended Practice 1637) or by stamping or otherwise applying the product name to the fixed portion of the fill assembly or by both means.

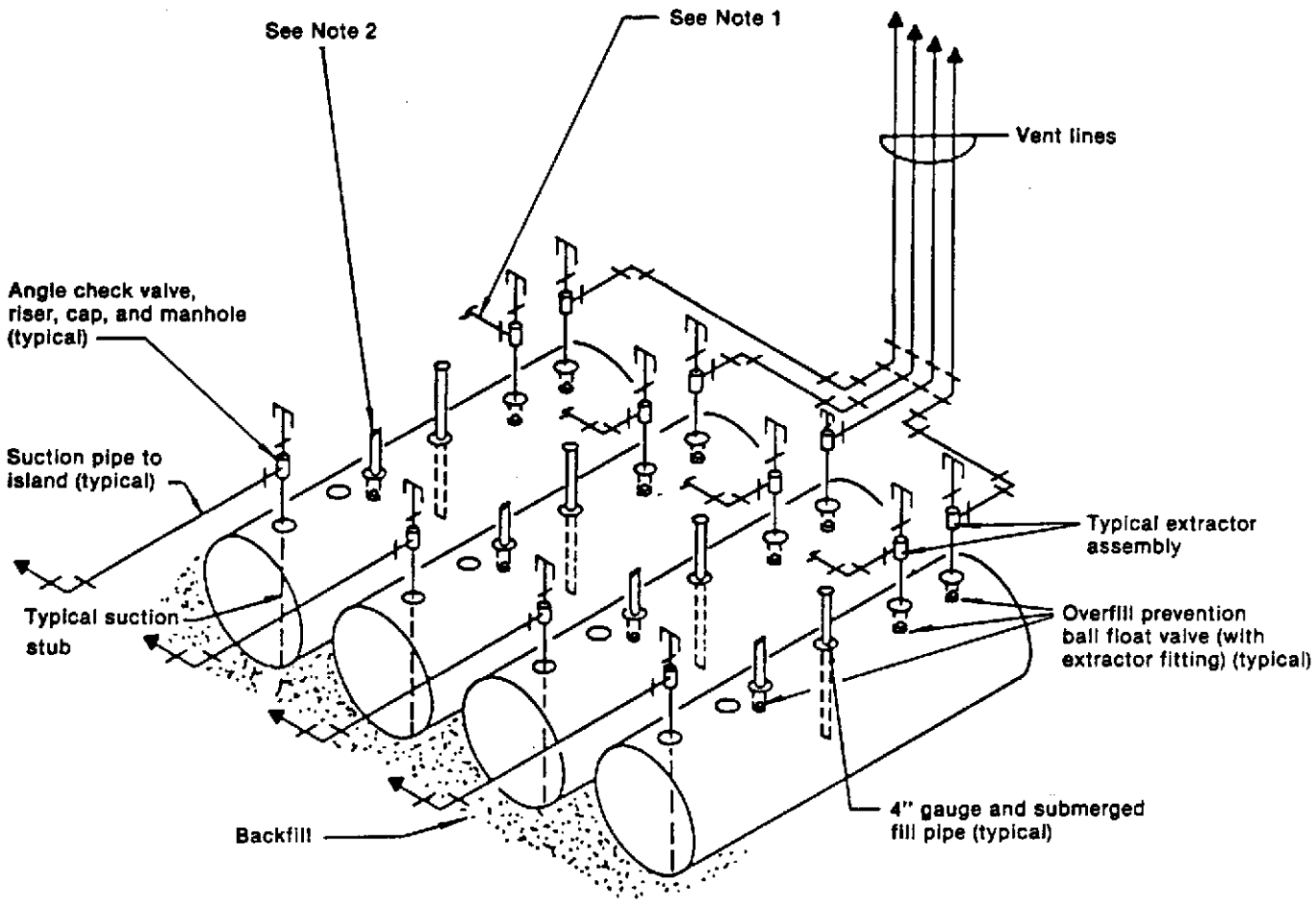
SECTION 12—VAPOR RECOVERY

12.1 General

12.1.1 The use of vapor recovery systems is required in some areas of the United States. The purpose of vapor recovery is to reduce vapor emissions to the atmosphere. The authority having jurisdiction should be consulted for specific requirements.

12.1.2 Vapor recovery is sometimes required during transfer operations, namely, the unloading of a transport truck cargo into underground storage tanks. This type of vapor recovery is referred to as Stage I vapor recovery (see Figures 4 and 16). Vapor recovery may also be required during the delivery of gasoline into the fuel tank of a motor vehicle. This type of vapor recovery is referred to as Stage II vapor recovery (see Figure 15). Different systems or variations of systems can be used to accomplish both Stage I and Stage II vapor recovery. The primary systems used are of the following types:

a. Balance systems.
b. Vapor processing systems.



Notes:
1. If required, a Stage II vapor recovery line should run to the vapor collection manifold and then to the dispenser islands. If the vapor recovery system is not manifolded, each line should go to the dispenser islands. A float valve, extractor, riser, cap, and manhole should be included for each tank. (The arrangement shown is typical.)
2. If required, a Stage I vapor recovery riser should run to the vapor collection manifold, with one surface pickup point. If the vapor recovery system is not manifolded, each riser should go to a separate surface pickup point. Each riser pipe should be connected to a ball float valve. (The arrangement shown is typical.)
3. See Figure 12 for details of tank piping.

Figure 16—Typical Suction-Pump Tank System (Shown With Stage I and Stage II Vapor Recovery)

12.2 Balance Systems

12.2.1 GENERAL

The most commonly used method of vapor recovery is the balance system. A balance system will meet the efficiency requirements of most regulations. A balance system simply provides for the gasoline vapors in the receiving tank to be returned via piping and/or hoses to the delivering tank. A balance system can be used for both Stage I and Stage II vapor recovery.

12.2.2 STAGE I VAPOR RECOVERY

12.2.2.1 General

Three of the most common designs for Stage I vapor recovery balance systems are as follows:

a. Two-point balance system.
b. Single-point manifold balance system.
c. Coaxial balance system.

12.2.2.2 Two-Point Balance System

12.2.2.2.1 The two-point balance system for vapor recovery during transport deliveries to underground tanks is provided by installing a vapor pickup point (a vapor return riser) in each underground tank that is required to have Stage I vapor recovery.

12.2.2.2.2 The vapor pickup uses one of the 4-inch openings in the underground tank (see Figure 13). For ease in hose handling, this is usually the opening immediately next to the fill-pipe opening. A riser pipe with an inside diameter of 3 or 4 inches, ending in a manhole similar to a fill manhole, is extended from the tank to the surface. A vapor pickup adapter is installed on top of the riser pipe, to provide a quick-disconnect connection for the transport's vapor pickup hose. The vapor pickup adapter must have a spring-loaded poppet valve that is closed when the vapor pickup hose is not connected.

12.2.2.2.3 As with the other Stage I balance systems described in 12.2.2.3 and 12.2.2.4, when the two-point system is in operation, vapors are automatically returned to the transport when the product is delivered to the underground tank. The small vacuum created in the transport and the ease of movement through a larger (3- or 4-inch) pipe cause the vent to be bypassed.

12.2.2.2.4 With both the two-point system and the coaxial system (see 12.2.2.4), if more than one tank is used to store a single product and the tanks are manifolded for product leveling, a vapor manifold should be provided for vapor transfer between the tanks.

12.2.2.2.5 A variation of the two-point system uses a special fill-and-drop-tube assembly, which combines a vapor return tube with the product drop tube in one riser. This special riser pipe has a Y fitting that routes the product and vapor conductors to separate hose connection points in the driveway surface.

Note: This vapor recovery configuration cannot utilize a float valve to prevent overfills.

12.2.2.3 Single-Point Manifold Balance System

The single-point manifold balance system is very similar to the two-point balance system. The primary difference is that in the single-point manifold system, the vapor pickup riser in each tank is manifolded into a vapor manifold header from which a single (3- or 4-inch) riser is brought to the surface, where the same adapter and poppet are installed within a manhole (see Figure 13).

12.2.2.4 Coaxial Balance System

The coaxial balance system uses one opening in each tank. This opening accommodates both a fill tube and a vapor return from the tank to the surface in concentric pipes. At the surface, a special adapter is installed within a manhole. A special tight-fill delivery nozzle with combination product and vapor conductors must be used with the adapter on the top of the riser. Both the transport-truck fill hose and the vapor return hose are connected to this special coaxial nozzle.

Note: This vapor recovery configuration cannot utilize a float valve to prevent overfills.

12.2.3 STAGE II VAPOR RECOVERY

12.2.3.1 Balance system vapor recovery can be provided during delivery from an underground tank to a vehicle fuel tank by installing a vapor return line from a special dispensing nozzle (which provides a seal at the fuel tank opening) to the underground tank. A separate vapor return line should be provided for each product, unless the tank vapor spaces are manifolded as described in 12.2.2.3. If the tank vapor spaces for all gasoline products are manifolded to a single vapor manifold header for Stage I vapor recovery, the vapor return line from each dispensing nozzle may also be manifolded to a single, larger diameter vapor return line from the islands to the manifolded tanks. This vapor return line from under the dispenser to the underground tanks can be of the same material as the underground lines that deliver product to the dispenser.

12.2.3.2 All aboveground piping must be steel. The minimum inside diameter for vapor return lines is 2 inches.

12.2.3.3 The vapor return line piping in the dispenser should be continued to the outside of the dispenser, where a hose connection can be made. A hose must then be connected from this vapor return pipe to the special vapor recovery dispensing nozzle.

12.2.3.4 The system design must provide a continuous slope from the dispenser or island to the underground tanks. Any sags will provide pockets in which condensed vapor or product may collect and block the vapor return line.

12.2.3.5 As with the Stage I systems, when a Stage II system is in operation, vapors are automatically returned to the underground tank when product is dispensed into the vehicle fuel tank.

12.3 Vapor Processing Systems

The term *vapor processing* covers other methods of vapor recovery, such as flaring or burning and condensation by refrigeration or compression. Information about vapor processing systems can be obtained from manufacturers of petroleum equipment.

12.4 Equipment

Petroleum equipment manufacturers and suppliers can furnish all of the special equipment required for Stage I and Stage II vapor recovery.

12.5 System Design

If regulations require the installation of either Stage I or Stage II vapor recovery, professional assistance should be obtained in designing the system.

American Petroleum Institute
1220 L Street, Northwest
Washington, D.C. 20005

APPENDIX D
DETAILED COST ESTIMATE

Tank and Unloading Dock Removal:

1. Dumpster mud and sludge disposal

Labor $40/hr x 20hr	$ 800.00
4.5 yd^3 x $300/$yd^3$	1,350.00

2. Tank removal and disposal

P.E. evaluation and shoring	25,000.00
Excavation	7,000.00
Disposal (2 tanks x $1,000/tank)	2,000.00

3. Off-site soil disposal

200yd^3 x $300/$yd^3$	60,000.00
SUBTOTAL	$96,150.00

Removal of Free Product:

Pump rental $685/week x 1 week	$ 685.00

Backfill of Tank Pit:

1. Backfill material

200yd^3 x $10/$yd^3$	2,000.00

2. Labor and equipment

Eng. $67/hr x 6hr	402.00
Truck & driver $46 x 6hr	276.00
Compactor & op. $75 x 6hr	450.00

3. Regrading

750ft^2 x $4.40/$ft^2$	3,300.00
SUBTOTAL	$ 6,428.00

Groundwater Recovery & Treatment System:

1.	Recovery well installation (materials and labor)	$13,500.00
2.	Treatment equipment	33,000.00
3.	Installation services (recovery compound, electrical hookup, trenching, and piping)	26,000.00
	SUBTOTAL	$72,500.00

Soil-Vent System:

1.	Vapor point installation (materials and labor)	$20,000.00
2.	Treatment equipment	14,000.00
3.	Installation services	35,000.00
	SUBTOTAL	$69,000.00

Sampling and Analysis:

1.	Initial soil samples	
	20 samples x $225/sample	$ 4,500.00
2.	Groundwater monitoring and sampling	
	Labor $400/mo. x 24 mo	9,600.00
	10 samples/mo. x 24 mo. x $225/sample	54,000.00
3.	Air monitoring	
	Labor $100/mo. x 24 mo	2,400.00
	PID rental $95/day x 24 day	2,280.00
	2 samples/mo. x 24 mo. x $225/sample	10,800.00
4.	Confirmation sampling	
	Mobile lab $2750/day x 2 day	5,500.00
	10 soil samples x $225/sample	2,250.00
	SUBTOTAL	$91,330.00

Closure Report and Certification:

Eng II $67/hr x 40hr	$ 2,680.00
PE $93/hr x 20hr	1,860.00
Cart. $44/hr x 8hr	352.00
Admin I $31/hr x 8hr	248.00
Supplies	100.00
SUBTOTAL	$ 5,240.00
TOTAL	$341,333.00
HEALTH AND SAFETY (6%)	20,480.00
TOTAL COST ESTIMATE	**$361,813.00**

APPENDIX E
STANDARD OPERATING PROCEDURES

GROUNDWATER TECHNOLOGY
STANDARD OPERATING PROCEDURE
CONCERNING GROUNDWATER MONITORING
SOP 8

Groundwater monitoring of wells at the site shall be conducted using an ORS Interface Probe and Surface Sampler. The Interface Probe is a hand held, battery operated device for measuring depth to petroleum product and depth to water as measured from an established datum (i.e., top of the well casing which has been surveyed). Product thickness is then calculated by subtracting the depth to product from the depth to water. In addition, water elevations are adjusted for the presence of fuel with the following calculation:

(Product Thickness)(.8)+(Water Elevation)
= Corrected Water Elevation

Note: The factor of 0.8 accounts for the density difference between water and petroleum hydrocarbons.

The Interface Probe consists of a dual sensing probe utilizing an optical liquid sensor and electrical conductivity to distinguish between water and petroleum products. A coated steel measuring tape transmits the sensor's signals to the reel assembly, where an audible alarm sounds a continuous tone when the sensor is immersed in petroleum product and an oscillating tone when immersed in water. The Interface Probe is accurate to 1/16-inch.

A Surface Sampler shall be used for visual inspection of the groundwater to note sheens (difficult to detect with the Interface Probe), odors, microbial action, etc.

The Surface Sampler used consists of a 12-inch long cast acrylic tube with a Delrin ball which closes onto a conical surface creating a seal as the sampler is pulled up. The sampler is calibrated in inches and centimeters for visual inspection of product thickness.

To reduce the potential for cross contamination between wells the monitorings shall take place in order from the least to most contaminated wells. Wells containing free product should be monitored last. Between each monitoring the equipment shall be washed with laboratory grade detergent and double rinsed with distilled water.

GROUNDWATER TECHNOLOGY
STANDARD OPERATING PROCEDURE
CONCERNING WATER SAMPLING METHODOLOGY
SOP 9

Prior to water sampling, each well shall be purged by pumping a minimum of four well volumes or until the discharge water indicates stabilization of temperature, conductivity,and pH. If the well is evacuated before four well volumes are removed or stabilization is achieved, the sample should be taken when the water level in the well recovers to 80% of its initial level.

Retrieval of the water sample, sample handling and sample preservation shall be conducted in accordance with Groundwater Technology Laboratory Standard Operating Procedure (GTL SOP 10) concerning Sampling For Volatiles in Water". The sampling equipment used shall consist of a teflon and/or stainless steel samplers, which meets EPA regulations. Glass vials with teflon lids should be used to store the collected samples.

To insure sample integrity, each vial shall be filled with the sampled water such that the water stands above the lip of the vial. The cap should then be quickly placed on the vial and tightened securely. The vial should then be checked to ensure that air bubbles are not present prior to labeling of the sample. Label information should include a sample identification number, job identification, date, time, type of analysis requested and the sampler's name. Chain-of-Custody forms shall be completed as per Groundwater Technology Laboratory Standard Operating Procedure (SOP 11) concerning Chain of Custody.

The vials should be immediately placed in high quality coolers for shipment to the laboratory. The coolers should be packed with sufficient ice or freezer packs to ensure that the samples are kept below 4C. Samples which are received at the Groundwater Technology Laboratory above 10 C. will be considered substandard. To minimize sample degradation the prescribed analysis shall take place within seven days of sample collection unless specially prepared acidified vials are used.

To minimize the potential for cross contamination between wells, all the well development and water sampling equipment which contacts the groundwater shall be cleaned between each well sampling. As a second precautionary measure, the wells shall be sampled in order of increasing contaminant concentrations as established by previous analysis.

GT ENVIRONMENTAL LABORATORY (GTEL)
STANDARD OPERATING PROCEDURE
CONCERNING SAMPLING FOR VOLATILES IN WATER (DISSOLVED GASOLINE, SOLVENTS, ETC.).
SOP 10

1. Use only vials properly washed and baked, available from GTEL or I-Chem.

2. Use clean sampling equipment. Scrub with Alconox or equivalent laboratory detergent and water followed by a thorough water rinse. Complete with a distilled water rinse.

   Sampling equipment which has come into contact with liquid hydrocarbons (free product) should be regarded with suspicion. Such equipment should have tubing and cables replaced and all resilient parts washed with laboratory detergent solution, as above. Visible deposits may have to be removed with hexane. Solvent washing should be followed be detergent washing as above.

   This procedure is valid for volatile organics analysis only. For extractable organics (for example, pesticides, or base neutrals for EPA method 625) a final rinse with pesticide grade isopropyl alcohol, followed by overnight or oven drying, will be necessary.

3. Take duplicate samples for GTEL. Mark on forms as a single sample with two containers to avoid duplication of analysis.

4. Take a site blank using distilled water or known uncontaminated source. This sample will be run at the discretion of the project manager.

5. Fill out labels and forms as much as possible ahead of time. Use an indelible marker.

6. Preservatives are required for some types of samples. Use specially prepared vials from GTEL, marked as indicated below, or use the appropriate field procedure (SOP 12 for acidification). Make note on forms that samples were preserved. Always have extra vials in case of problems. Samples for volatile analysis should be acidified below pH 2 with hydocloric acid. Use vials with care and keep them upright. Eye protection, foot protection, and disposable vinyl gloves are required for handling. Samples designated for expedited service and analyzed within seven (7) days of sampling will be acceptable without preservation.

   Acid causes burns. Glasses or goggles (not contact lenses) are necessary for protection of the eyes. Flush eyes with water for 15 minutes if contact occurs and seek medical attention. Rinse off hands frequently with water during handling.

   For sampling chlorinated drinking water supplies for chlorinated volatiles, samples shall be preserved with sodium thiosulfate. Use vials labeled "CONTAINS THIOSULFATE". No particular cautions are necessary.

7. Fill vial to overflowing with water, avoiding turbulence and bubbling as much as possible. Water should stand above lip of vial.

8. Carefully but quickly slip cap onto vial. Avoid dropping the teflon septum from cap by not inverting cap until in contact with vial. Disc should have teflon face toward the water. Also avoid touching white teflon face with dirty fingers.

9. Tighten cap securely, invert vial and tap against hand to see that there are no bubbles inside.

10. Label vial using indelible ink as follows:

    a) Sample I.D. No.
    b) Job I.D. No.
    c) Date and Time.
    d) Type of analysis requested.
    e) Your name.

11. Unless the fabric type label is used, place scotch tape over the label to preserve its integrity.

12. For Chain of Custody reasons, sample vial should be wrapped end-for-end with scotch tape or evidence tape and signed with indelible ink where the end of the tape seals on itself. The septum needs to be covered.

13. Chill samples immediately. Samples to be stored should be kept at 4°C (39°F). Samples received at the laboratory above 10°C (as measured at glass surface by a thermocouple probe), after overnight shipping will be considered substandard, so use a high quality cooler with sufficient ice or freezer packs. (Coolers are available from GTEL).

14. Fill out Chain of Custody and Analysis Request form. (See Chain of Custody Procedures SOP 11).

GT ENVIRONMENTAL LABORATORY (GTEL)
STANDARD OPERATING PROCEDURE
CONCERNING CHAIN OF CUSTODY
SOP 11

1. Samples must be maintained under custody until shipped or delivered to the laboratory. The laboratory will then maintain custody. A sample is under custody if:

    a) It is in your possession
    b) It is in your view after being in your possession
    c) You locked it up after being in your possession
    d) It is in a designated secure area

2. Custody of samples may be transferred from one person to the next. Each transferee and recipient must date, sign and note the time on the chain-of-custody form.

3. In shipping, the container must be sealed with tape, bearing the sender's signature across the area of bonding at the ends of the tape in order to prevent undetected tampering. Each sampling jar should be taped and signed as well. Scotch tape works well.

4. Write "sealed by" and sign in the "Remarks" box at the bottom of the form before sealing up the box. Place form in a plastic bag and seal it inside the box.

5. The "REMARKS" section in the upper right part of the form is for documenting details such as:

    a) Correlation of sample numbers if samples are split between labs.
    b) QC numbers when lab is logging in the samples.
    c) Sample temperature and condition when received by lab.
    d) Preservation notation.
    e) pH of samples when opened for analysis (if acidified).
    f) Sampling observation or sampling problem

6. The chain-of-custody form should be included inside the shipping container. A copy should be sent to the project manager.

7. When the samples are received by the lab, the chain-of-custody form will be dated, signed, and a note of the time made by a laboratory representative. The form along with shipping bills and receipts will be retained in the laboratory files.

8. At the time of receipt of samples by the laboratory, the shipping container will be inspected and the sealing signature will be checked, the samples will be inspected for condition and bubbles and the temperature of a representative sample container will be measured externally by a thermocouple probe (held tightly between two samples) and recorded. The laboratory QC numbers will be placed on the labels, in the accession log, and on the chain-of-custody form. If samples are acidified their pH will be measured by narrow range pH paper at the time of opening for analysis. All comments concerning procedures requiring handling of the samples will be dated and initialed on the form by the laboratory person performing the procedure. A copy of the completed chain-of-custody form with the comments on sample integrity will be returned to the sampler.

GROUNDWATER TECHNOLOGY
STANDARD OPERATING PROCEDURE
CONCERNING MONITORING WELL INSTALLATION
SOP 13

The boreholes for the monitoring wells shall be drilled using a truck mounted hollow stem auger drill rig. The outside diameter (O.D.) of the auger should be a minimum of eight inches when installing 4-inch well screen. The hollow stem auger provides minimal interuption of drilling while permitting soil sampling at specific intervals. Soil samples can be taken at desired depths by hammering a conventional split barrel sampler containing precleaned 2 inch brass sample tubes.

The construction details of the monitoring wells to be drilled at the site are graphically depicted in the attached figure titled "Typical Detail of Monitoring Well Construction" (See Figure 1). The wells should be constructed of 4 inch PVC, .020 inch machine slotted screen and blank casing. The screened portion of the well will extend 5 feet above and 10 feet below the present water table. An appropriate sand pack as determined by grain size analysis shall be placed in the annular space between the casing and drilled hole to inhibit silt buildup around the well. An annular seal installed above the sand pack should consist of bentonite pellets overlain by neat cement or cement grout to the surface. The wellhead shall be protected below grade within a traffic rated street box. Each well shall have a permanently attached identification plate containing the following information (1) Well Number, (2) Wellhead Elevation, (3) Depth of Well, (4) Screened Interval.

Subsequent to installation the wells shall be developed to remove silts and improve well performance. The well development shall be conducted by air lifting the water within the well until groundwater pumped from the wells is silt free.

To assure that cross contamination does not occur between the drilling and development of successive wells all equipment contacting subsurface soils or ground water shall be steam cleaned. The steam cleaned equipment should include but not limited to the following (1) Drilling Augers, (2) Split Barrel Sampler, (3) Groundwater Monitoring and Sampling Equipment, (4) Well Development Piping and Sparging Equipment.

GROUNDWATER TECHNOLOGY, INC.
STANDARD OPERATING PROCEDURE
CONCERNING SOIL SAMPLING METHODOLOGY
SOP 14

Soil samples should be collected and preserved in accordance with Groundwater Technology Laboratory's Standard Operating Procedure (GTL SOP 15) concerning Soil Sample Collection and Handling when Sampling for Volatile Organics. A hollow-stem soil auger should be used to drill to the desired sampling depth. A standard 2-inch-diameter, split-spoon sampler, 18-inches in length shall be used to collect the samples. The samples are contained in 2-inch-diameter by 6-inch-long thin-walled, brass tube liners fitted into the split-spoon sampler (three per sampler).

The split-spoon sampler should be driven the full depth of the spoon into the soil using a 140-pound hammer. The spoon shall then be extracted from the borehole and the brass tube liners containing the soil sample removed from the sampler. The ends of the liner tubes should be immediately covered with aluminum foil, sealed with a Teflon^{R} or plastic cap, and then taped with duct tape. After being properly identified with sample data entered on a standard chain-of-custody form, the samples shall be placed on dry ice (maintained below 4°celsius) and transported to the laboratory within 24 hours.

One of the three soil samples retrieved at each sample depth shall be analyzed in the field using a photo-ionization detector and/or explosimeter. The purpose of the field analysis is to provide a means to choose samples to be laboratory analyzed for hydrocarbon concentrations and to enable comparisons between the field and laboratory analyses. The soil sample shall be sealed in a plastic bag and placed in the sun to accelerate the vaporization of volatile hydrocarbons from the soil. One of the two field vapor instruments shall be used to quantify the amount of hydrocarbons released into the air from the soils. The data, shall be recorded on the drill logs at the depth corresponding to the sample point.

GROUNDWATER TECHNOLOGY, INC.
STANDARD OPERATING PROCEDURE
CONCERNING SOIL SAMPLE COLLECTION AND
HANDLING WHEN SAMPLING FOR VOLATILE ORGANICS
SOP 15

1. Use a sampling means which maintains the physical integrity of the samples. The project sampling protocol will designate a preferred sampling tool. A split-spoon sampler with liners, or similar tube sampler which can be sealed, is best.

2. At the discretion of the project manager, the samples should be either.

   A. Sealed in liner with Teflon^{R} plugs (The "California Sampler") or

   B. Field-prepped for sample analysis.

   Projects using method "A" will incur a separate sample preparation charge of $10.00 per sample in the laboratory. For method "B", prepared and pre-weighed vials, and sample-coring syringes must be ordered at least two weeks ahead of time from the laboratory before sampling. (Vials are free if samples will be sent to Groundwater Technology Laboratory).

3. For sending whole-core samples (2A above):

   A. Seal ends of liner with Teflon^{R} tape or aluminum foil leaving no free air space inside.

   B. Tape with duct tape.

   C. Place in plastic bag labeled with indelible marker. Use well number, depth, date, and job number.

   D. Place inside a second bag and place a labelling tag inside outer bag.

   E. Enclose samples in a cooler with sufficient ice or dry ice to maintain samples at 4 celsius during shipment.

   F. Seal cooler with a lock or tape with samplers' signature so tampering can be detected.

G. Package cooler in a box with insulating material. Chain-of-custody forms can be placed in a plastic bag in this outer box.

H. If dry ice is used, a maximum of five pounds is allowed by Federal Express without special documents (documents are easy to obtain, but just not necessary for under five pounds). Write "ORM-A dry ice, UN-1845,_____ pounds, on the package. On the airbill under "Delivery and Special Handling" check item 6, (dry ice). Lastly, place the number of pounds of dry ice in the blank in item 6. UPS does not accept dry ice in air freight.

I. Make yourself a necessary supplies list before going into the field.

J. Soil cores kept at 4 degrees celsius are only viable for up to 7 days when aromatic hydrocarbons are involved. The lab will prepare them in methanol following procedures above once in the lab, but it is necessary to call ahead of time to schedule personnel.

4. For field-prepping (Step 2B above):

A. Obtain prepared sample containers from the laboratory. Order enough for number of samples intended and add 50 percent. This should be sufficient for Quality Assurance (QA) requirements (below), breakage, and additional samples taken by discretion of sampler.

B. Organize containers consecutively, they are all numbered and pre-weighed. Make a necessary supplies list before going into the field.

C. For a 6-inch liner section retrieved from the spoon sampler, spread a 12-inch square piece of broiler (heavy) aluminum foil and slice it lengthwise with a clean stainless-steel spatula.

D. Immediately sample with a coring syringe with plunger removed. Poke tube into mid-section of core (into undisturbed soil) to capture a 1/2-to 1-inch plug.

CAUTION: WORK ONLY IN WELL VENTILATED AREA. DO NOT BREATHE METHANOL VAPOR. IT IS TOXIC. SEE MSDS ATTACHED.

E. Immediately transfer plug to the sample vial with methanol by using plunger. Clean around lip of vial to remove soil with clean laboratory paper toweling and seal septum onto the vial with lid, Teflon^{R}-side (shiny) toward the sample. Shake sample enough to break it up so that whole sample is immersed in methanol. The rapid progression of steps indicated here is necessary to prevent loss of volatiles from the soil. Do not leave vials unopened for any extended period - the methanol evaporates quickly. Grit left on threads of vial can cause vial to break.

F. * If required (see 5 below). Take a duplicate sample from the other half directly across from the first sample, or wherever undisturbed, yet representative soil occurs.

G. Label vial with legible information as follows:

1. Job name or number.

2. Date.

3. Time.

4. Depth and well number.

5. Samplers initials.

H. Tape vial across septum with Scotch tape and around cap and sign on the tape with indelible ink to prevent tampering.

I. Wrap up a representative section of the core equivalent in volume to cube three centimeters on a side in the aluminum foil square, discarding the rest appropriately. Seal in Saran wrap. This section is for dry-weight determination. Close it in plastic bag with a tag or write on the bag with an indelible marker. These samples go into a separate cooler or box and not with the vials. The cooler for dry-weight samples need not be iced, but overnight delivery is requested.

J. Discard plastic-coring syringe, clean the spatula, and get clean equipment ready for next sample.

K. Ice the sample vials immediately and keep them iced through shipment.

L. Fill out chain-of-custody form. SOP 11 gives major details. Make sure sample requests is for proper analysis type.

M. Shipping of hazardous materials (methanol) requires special documents from Federal Express and UPS. Briefly you will need to add following to outside of package and on documents:

1. Flammable liquid label (some will come from lab with the vials).

2. "UN1230 methyl alcohol".

3. For UPS, a "Hazardous Material" label.

N. Ship overnight delivery to the lab. If dry ice is available, up to 5 pounds per package can be sent via Federal Express by simply writing "ORM-A dry ice, _____ pounds, for research" on outside of package and on shipping document. UPS does not accept dry-ice shipments.

5. Good sampling practice would include preparing one out of five samples to be prepared in duplicates for analysis. These four out of twenty samples will be for the following purposes:

A. One in every twenty samples should be analyzed as a field replicate to evaluate the precision of the sampling technique. A minimum of one sample per data set is suggested.

B. An additional one in twenty samples should be selected by sampler to be prepared in duplicate as alternative to Step (A). Choose a different soil type if available.

C. The lab does spiking with reference materials for internal Quality Control (QC) so additionally a minimum of two in twenty samples need to be prepared in duplicate.

6. Other QC procedures can be specified at the project manager's discretion. See Table 3-2 (reference 2) attached.

7. Decontamination of equipment in the field requires a detergent wash, a water rinse, and spectrographic quality acetone rinse followed by distilled water.

REFERENCES

1. Soil Sampling Quality Assurance Users Guide, USEPA Environmental Monitoring Systems Laboratory, Las Vegas, NV, EPA 600/4-84-043, May 1984.

2. Preparation of Soil Sampling Protocol. Techniques and Strategies, USEPA, Environmental Monitoring Systems Laboratory, Las Vegas, NV, EPA 600/4-83-020, August 1983 (PB83-206979).

3. Test Methods for Evaluating Solid Waste, USEPA, Office of Solid Waste and Emergency Response, Washington, D.C., SW 846, July 1982.