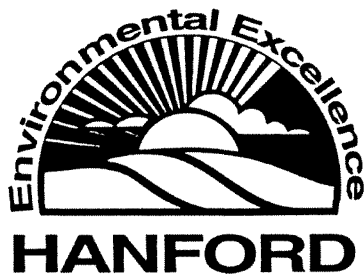


BHI-00395  
Rev. 0

# **Design, Operations, and Maintenance of the Soil Vapor Extraction Systems for the 200 West Area Carbon Tetrachloride Expedited Response Action**



Prepared for the U.S. Department of Energy  
Office of Environmental Restoration and  
Waste Management

**Bechtel Hanford, Inc.**  
Richland, Washington

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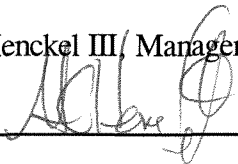
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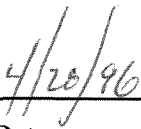
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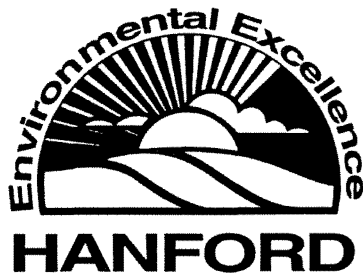
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Author  
R. K. Tranbarger

Date Published  
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## ACRONYMS

|         |  |
|---------|--|
| ARAR    | applicable or relevant and appropriate requirement                           |
| ASIL    | acceptable source impact level   |
| CAA     | committed administrative action  |
| CAM     | continuous air monitor   |
| CERCLA  | <i>Comprehensive Environmental Response, Compensation, and Liability Act</i> |
| DOE     | U.S. Department of Energy  |
| EA      | environmental assessment   |
| Ecology | Washington State Department of Ecology                                       |
| EE/CA   | engineering evaluation/cost analysis   |
| EPA     | U.S. Environmental Protection Agency   |
| ERA     | expedited response action  |
| GAC     | granular activated carbon  |
| HEPA    | high-efficiency particulate air  |
| OSHA    | Occupational Safety and Health Administration                                |
| ppmv    | parts per million by volume  |
| PSVE    | passive soil vapor extraction  |
| SVE     | soil vapor extraction  |
| VOC     | volatile organic compound  |

## 1.0 INTRODUCTION

This document supersedes document WHC-SD-EN-TI-010, *Design, Operations, and Maintenance of the 200 West Area Carbon Tetrachloride Vapor Extraction Systems*, in its entirety.

### 1.1 200 WEST AREA CARBON TETRACHLORIDE ERA BACKGROUND

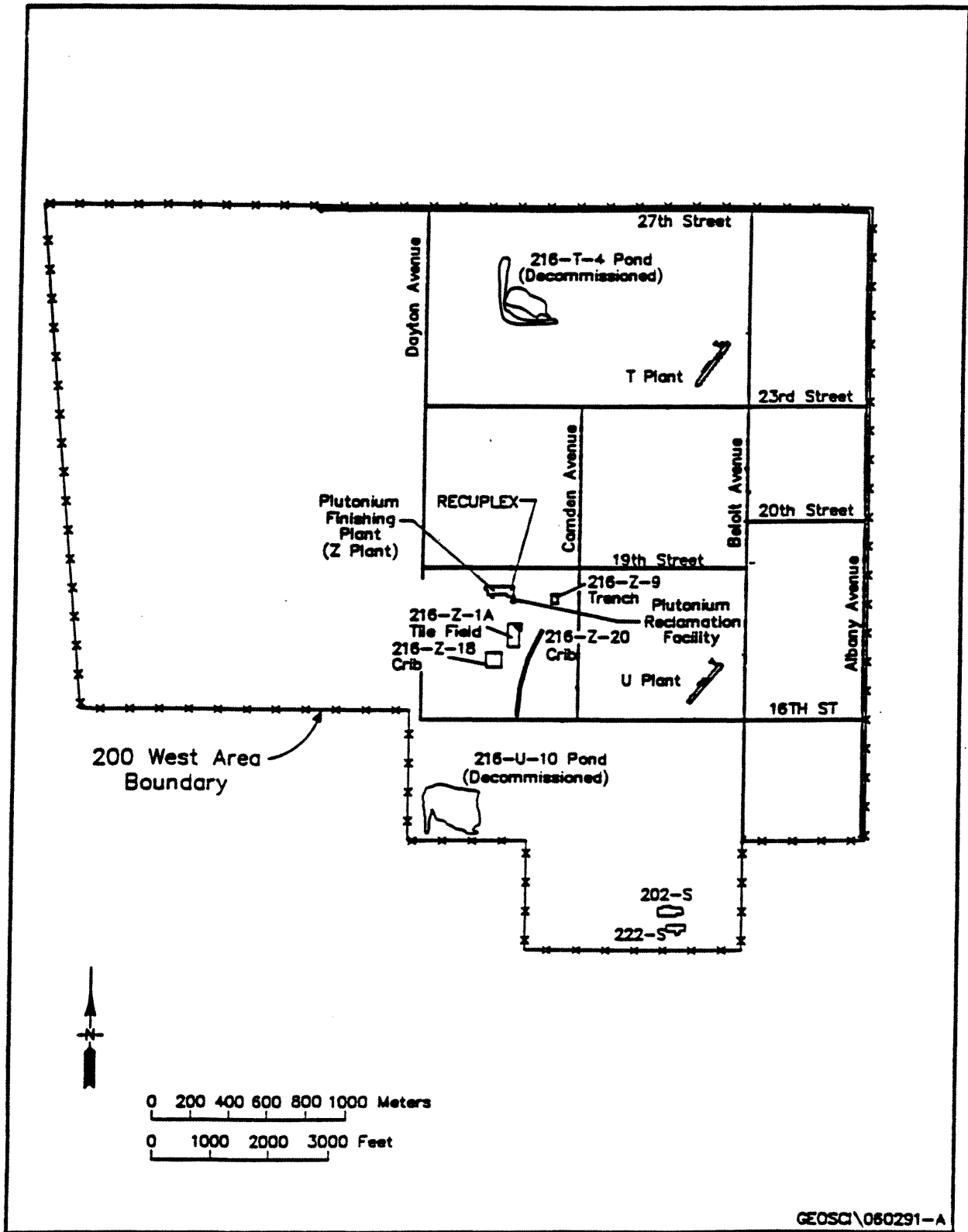
The 200 West Area Carbon Tetrachloride Expedited Response Action (ERA) is being conducted by the U.S. Department of Energy (DOE) at the direction of the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) as a provision included in the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The EPA is the lead regulatory agency with support provided by Ecology as needed.

An ERA allows expedited responses to be taken at waste sites where early remediation will abate imminent hazards or prevent significantly increased degradation that might occur if action were delayed until completion of a remedial investigation/feasibility study and record of decision. This ERA investigation was requested by the EPA and Ecology in 1990 based on the concern that carbon tetrachloride in the soils within the 200 West Area, specifically the 200-ZP-2 Operable Unit, was a source of contamination to the groundwater. The result of the investigation was to initiate remediation of the carbon tetrachloride-contaminated soils in 1992. Thus, the purpose of the ERA was, and is today, to reduce carbon tetrachloride migration toward the groundwater by implementing recommendations resulting from an engineering evaluation/cost analysis (EE/CA).

Based on results of a soil vapor extraction (SVE) system pilot test conducted in the spring of 1991 and the EE/CA (DOE-RL 1991), the EPA issued an action memorandum in January 1992 authorizing the initiation of the first phase of SVE in the 200 West Area at the 200-ZP-2 Operable Unit. Phase I encompassed upgrading the pilot unit (initial SVE system) and operating at the 216-Z-1A Tile Field and the 216-Z-18 Crib, and implementing a second SVE system to operate at the 216-Z-9 Trench. Phase II, the current phase of the ERA, calls for production-mode operation of two to three SVE systems to quantitatively remove the carbon tetrachloride from the contaminated vadose zone beneath the three primary inactive waste disposal sites, the 216-Z-1A Tile Field, 216-Z-18 Crib, and 216-Z-9 Trench (Figure 1). Phase II also allows for the relocation of SVE systems to other carbon tetrachloride-contaminated sites, which to date, includes only the 216-Z-12 Crib.

The proposed action for removing the carbon tetrachloride includes (mechanically induced) SVE using a network of extraction wells. Collection of the carbon tetrachloride (and other trace organics) uses granular activated carbon (GAC) adsorption. Passive soil vapor extraction (PSVE) uses barometric fluctuations to move soil vapor to the surface for treatment and is being implemented as part of wellfield optimization for the 200 West Area Carbon Tetrachloride ERA.

Figure 1. Site Map of 200 West Area.



## 1.2 PURPOSE AND SCOPE

This report documents the design, operating, and maintenance guidelines for the SVE systems implemented as part of the 200 West Area Carbon Tetrachloride ERA. Additionally, this document provides general information regarding the ERA, the SVE system design, and the general approach towards soil vapor extraction.

The remaining content of this document includes the following:

- Regulatory compliance (Section 1.3)
- Summary of vadose zone physical and contaminant characteristics (Section 1.4)
- Past and present SVE system designs and potential design upgrades (Section 2.1)
- General design and monitoring considerations for the SVE systems (Section 2.2)
- Descriptions of the SVE system components and their respective functions (Section 2.3)
- Safety requirements (Section 2.4)
- Operation of the SVE systems including startup, surveillances, shutdown, GAC canister changeouts, and wellfield characterization (Section 3.1)
- Monitoring requirements (Section 3.2)
- SVE optimization (Sections 3.3)
- Instrument calibrations, preventive maintenance, and spare parts and site inventory requirements (Section 4.0)

Passive soil vapor extraction is ongoing as part of wellfield optimization for the ERA; however, the design, operation, and maintenance of the PSVE system(s) are not included within the scope of this document and are being documented separately.

## 1.3 REGULATORY COMPLIANCE

Per the "Action Memorandum For 200 West Area Carbon Tetrachloride Plume" (EPA 1992), the ERA is being conducted prior to the final cleanup actions for the 200-ZP-2 Operable Unit and, therefore, it is not required to meet final cleanup standards or ARARs, although this action is required to be consistent with the anticipated final remedy for the affected operable unit. Therefore, operations at the 200 West Area Carbon Tetrachloride ERA will be guided by applicable, relevant and appropriate regulations, and state laws and regulations. These regulations are identified in Table 1.

Table 1. Applicable or Relevant and Appropriate, and To-Be-Considered Requirements. (sheet 1 of 2)

| Regulation  | ARAR/TBC    | Comments  |
|---|-------------|---|
| 10 CFR 835<br>Occupational Radiation Protection   | Applicable  | This will only be applicable if radiation is detected during the ERA.   |
| 40 CFR 61<br>National Emission Standards for Hazardous Air Pollutants                   | Applicable  | There is little chance for the potential to emit radionuclides. This regulation will only become applicable if extracted radionuclides result in a dose of 0.1 mrem or greater.   |
| 40 CFR 302<br>Designation, Reportable Quantities, and Notification - CERCLA             | Applicable  | Reportable quantities are over 4.5 kg CCl <sub>4</sub> /day/disposal site and 2.270 kg HCl/day/disposal site.   |
| 40 CFR 1500<br>Council on Environmental Quality (National Environmental Protection Act) | Applicable. | Environmental assessment performed with a finding of no significant impact issued by DOE Headquarters.  |
| WAC 173-303<br>Dangerous Waste Regulations  | Applicable  | Hazardous waste is potentially being produced that must either be managed as waste or recycled (e.g., GAC canisters with CCl <sub>4</sub> ). Also, water knockout tank has CCl <sub>4</sub> in it.  |
| WAC 173-400<br>General Regulations for Air Pollution Sources                            | Applicable  | Ecology has the authority to review all proposed new source or modifications for emissions of hazardous air pollutants.   |
| WAC 173-460<br>Controls for New Sources of Toxic Air Pollutants                         | Applicable  | For passive soil vapor extraction, SQE limit for CCl <sub>4</sub> is 20 lb/yr per emission point. ASIL for CCl <sub>4</sub> is 0.067 µg/m <sup>3</sup> (annual average). SQE for HCl is 500 lb/yr. ASIL for HCl is 7.0 µg/m <sup>3</sup> - 24-h average. Best Available Control Technology for Toxics evaluation must be completed. |
| WAC 246-247<br>Radiation Protection - Air Emissions                                     | Applicable  | Only if radionuclides are emitted. However, the process area of the SVE system was established as a radiologically controlled zone as a precaution.   |
| DOE Order 5400.1<br>Guide to Environmental Protection Program                           | TBC         | TBC until crosswalk is received for new DOE Order 451.1   |

Table 1. Applicable or Relevant and Appropriate, and To-Be-Considered Requirements. (sheet 2 of 2)

| Regulation   | ARAR/TBC | Comments  |
|--|----------|---|
| DOE Order 5400.5<br>Radiation Protection of the Public and the Environment   | TBC      | Only if radionuclides are emitted.<br>TBC until crosswalk is received for new DOE Order |
| DOE Order 5480.4<br>Environmental Protection, Safety and Health Protection Standards   | TBC      | TBC until crosswalk is received for new DOE Order                                       |
| DOE Order 5480.10<br>Contractor Industrial Hygiene Program   | TBC      | TBC until crosswalk is received for new DOE Order                                       |
| DOE 5480.11<br>Radiation Protection for Occupational Workers   | TBC      | Only if radionuclides are emitted. Also see 40 CFR 835 above.                           |
| DOE Order 5484.1<br>Environmental Protection, Safety, and Health Protection Information Reporting Requirements   | TBC      | TBC until crosswalk is received for new DOE Orders 225.1 and 221.1                      |
| DOE Order 5820.2A<br>Radioactive Waste Management  | TBC      | Only is radioactive waste is generated.   |
| <p>ARAR = applicable or relevant and appropriate requirement<br/> ASIL = acceptable source impact level<br/> CCl<sub>4</sub> = carbon tetrachloride<br/> ERA = expedited response action<br/> GAC = granular activated carbon<br/> HCl = hydrochloric acid<br/> SQE = small quantity emissions<br/> TBC = to be considered</p> |          |   |

Before implementation of the ERA, an environmental assessment (EA) was written to comply with the *National Environmental Protection Act*. A finding of no significant impact was issued by DOE Headquarters for the ERA based on the information gathered during the EA. The EA was included in the *Expedited Response Action Proposal (EE/CA) for the 200 West Area Carbon Tetrachloride Plume* (DOE-RL 1991).

#### 1.4 SUMMARY OF SOIL PHYSICAL AND CONTAMINANT CHARACTERISTICS

The upper geologic unit of the Hanford formation in the 200 West Area consist of two facies: (1) coarse-grained sand and granule-to-boulder gravel and (2) fine- to coarse-grained sand and silt. In the 200 West Area, the Hanford formation ranges in thickness from 6 m to more than 60 m. It is underlain by 1.5 to 18 m of silts and fine sands, which are underlain by another gravel unit.

Carbon tetrachloride vapor concentrations observed throughout the 200 West Area since 1991 ranged from less than detectable to tens of thousands parts per million by volume (ppmv) in the vadose zone. Observed concentrations are highest in the vicinity of the three primary units (216-Z-1A Tile Field, 216-Z-18 Crib, and 216-Z-9 Trench) where carbon tetrachloride is known to have been discharged to the soil column (Figure 1). Measured concentrations at the 216-Z-1A and 216-Z-18 units initially ranged from 300 to 1,500 ppmv, whereas concentrations at the 216-Z-9 unit measured as high as 30,000 ppmv. As of March 1996, all measured carbon tetrachloride concentrations in vapors exiting extraction wells were less than 200 ppmv. However, these lower concentrations should not be misinterpreted as approaching closure of the ERA because closure requirements have not yet been agreed upon by the DOE and regulators. Also, note that trace concentrations of other volatile organic compounds (VOCs) have been identified including chloroform, methylene chloride, and methyl ethyl ketone.

Many of the liquid waste streams discharged to the soil column in the 200 West Area since 1944 contained radionuclides. Plutonium and americium are the major radionuclide components of the aqueous and organic liquids discharged to the three primary carbon tetrachloride disposal units. The plutonium contamination extends approximately 30 m beneath the 216-Z-1A Tile Field; the lateral spread is limited within a 9-m-wide zone around the perimeter of the tile field. In 1978, the top 30 cm of contaminated soil in the 216-Z-9 Trench was removed, successfully removing 58 kg of plutonium. Based on the 58 kg of plutonium, it is estimated that a maximum of 48 kg of plutonium may remain in the 216-Z-9 Trench soils (Ludowise 1978). The americium-241 inventory for the 216-Z-9 Trench is estimated to be 2.5 kg. Other radionuclides, such as radioactive isotopes of cesium, cobalt, hydrogen, iodine, strontium, and technetium, have also been discharged to the soil column beneath the 200 West Area. In addition, radon gas occurs naturally in Hanford soils.

Additional detail regarding waste site description and waste inventories for the 216-Z-1A Tile Field, 216-Z-18 Crib, and 216-Z-9 Trench is provided in DOE-RL (1991).

## 2.0 SOIL VAPOR EXTRACTION SYSTEM DESIGN

Active SVE uses a mechanical device (motorized blower) to induce a pressure gradient (vacuum) within the vadose zone that provides the convective force needed to transport carbon tetrachloride-laden soil vapor through the extraction well(s) and the SVE system. A typical system consists of a network of extraction wells fitted with hoses that are joined together by a common header pipe prior to entry into the SVE system. The soil vapor then travels through a water separator (also known as a water knockout tank) to remove a portion of the water vapor, then through a high-efficiency particulate air (HEPA) filter housing to remove potential radioactive particulates, then through the (vacuum) blower, and finally through the GAC canisters for treatment. The GAC-filled canisters effectively remove the carbon tetrachloride (and other VOCs) from the contaminated vapor stream. Other vapor stream treatment technologies may be used, if feasible.

Passive soil vapor extraction may also be implemented on extraction wells by using the natural pumping power created by barometric pressure fluctuations to move contaminated soil vapor to the surface for treatment. In the simplest case, the extraction well is simply left open and allowed to passively vent to the atmosphere. However, the PSVE systems used as part of the ERA are typically fitted with an appropriately sized (dependent on carbon tetrachloride concentration and PSVE system design) GAC-filled canister to treat the venting vapor.

Note that the following sections are specific to the active SVE system design, operation, and maintenance. The PSVE systems are beyond the scope of this document.

### 2.1 SOIL VAPOR EXTRACTION SYSTEM BACKGROUND

In the spring of 1991, a soil vapor characterization test was conducted using a SVE system located at the 216-Z-1A Tile Field. The system was trailer mounted for mobility. The major components of the system included the intake manifold, water separator, prefilter, blower, HEPA filters, GAC canisters, exhaust stack, piping, and instrumentation. The well field design used four wells for extraction and observation. The four wells were W18-87, W18-150, W18-167, and W18-171, and each had perforated intervals at various depths within the vadose zone.

The SVE system design for the characterization test went beyond typical system designs because of the potential for radionuclide particulates in the extracted vapor stream. Thus, as a safety and health precaution, HEPA filters and alpha and beta continuous air monitors (CAMs) were added to the system. The process area of the SVE system was cordoned off as a radiologically controlled zone.

Test results indicated that no transuranic radionuclides were transported from the vadose zone through the SVE system. However, naturally occurring radon and associated decay products were detected in the system. More information on the test results is provided in DOE-RL (1991).

The SVE system used for characterization functioned well during the test, thus leading to full-scale operation of three SVE systems within the 200-ZP-2 Operable Unit -- a 14-m<sup>3</sup>/min (500-ft<sup>3</sup>/min) system at the 216-Z-18 and 216-Z-12 Cribs, a 28-m<sup>3</sup>/min (1,000-ft<sup>3</sup>/min) system at the 216-Z-1A Tile Field, and a 42-m<sup>3</sup>/min (1,500-ft<sup>3</sup>/min) system at the 216-Z-9 Trench.

During the 5 years of operation experienced to date, the following design improvements to the systems have been made.

- HEPA filters were located further upstream, ahead of most of the equipment and instruments, to reduce the amount of equipment and instruments potentially exposed to radioactive contamination.
- Instrumentation was better matched to the system (i.e., instrument detectors).
- Vapor sampling ports were made more accessible.
- Lighting was provided for nighttime activities.
- The SVE systems were automated.
- The data acquisition system was given greater information capacity and flexibility.
- A 3,874-L (1,000-gal) tank was installed and insulated at the 42-m<sup>3</sup>/min (1,500-ft<sup>3</sup>/min) system to collect condensed water vapor from the heat exchanger.
- Secondary containment was provided for the water separator tanks at all three systems to comply with *Resource Conservation and Recovery Act* regulations.
- The water separator tanks at the 14- and 28-m<sup>3</sup>/min (500- and 1,000-ft<sup>3</sup>/min) systems were insulated.

Additional design improvements recommended for the systems include the following:

- On the 14- and 28-m<sup>3</sup>/min (500- and 1,000-ft<sup>3</sup>/min) systems, install a condenser and preheater downstream from the blower to reduce moisture in the soil vapor, thus improving GAC efficiency.
- To alleviate condensate accumulation in the extraction hoses during cold weather, slope the hoses to a low point fitted with a drain and collection tank.
- On the 14- and 28-m<sup>3</sup>/min (500- and 1,000-ft<sup>3</sup>/min) system water knockout tanks, install high-level switches with shutdown interlocks.
- Heat trace and insulate the water knockout tank pumps on all three SVE systems.

- Insulate pipe to the effluent stack on the 14-m<sup>3</sup>/min (500-ft<sup>3</sup>/min) system to alleviate condensate accumulation during cold weather. (Condensate on the effluent flowmeter can prompt an unwarranted system shutdown.)
- Insulate the HEPA filter housing on the 28-m<sup>3</sup>/min (1,000-ft<sup>3</sup>/min) system to alleviate condensate accumulation.
- Design a HEPA filter housing with a HEPA filter for installation at extraction wells that contain radioactive particulates.

## 2.2 GENERAL DESIGN REQUIREMENTS

The general design and monitoring requirements for all active SVE systems designed, purchased, leased, and/or upgraded in support of the ERA are as follows. These general design and monitoring requirements incorporate limits established by the *Safety Analysis for the 200 West Area Expedited Response Action for Remediation of Carbon Tetrachloride* (Lehrschall 1995).

- Be capable of extracting and collecting carbon tetrachloride and associated organic vapors from three or more wells at one time, depending on site characteristics.
- Equipment should be mounted on mobile trailers.
- Be capable of continuous 24-h/day, 7-days/week operation.
- Be able to operate in ambient temperature conditions ranging from 12°C to 43°C (10°F to 110°F) and wind speeds up to 161 km/h (100 mi/h).
- Be capable of sampling and monitoring the extracted soil vapor to ensure that operations meet all environmental, regulatory, health, and safety requirements and controls.
- Prevent or minimize contamination of the SVE system by transuranic radionuclides.
- Provide a minimum of 14 m<sup>3</sup>/min (500 ft<sup>3</sup>/min) of SVE and vacuum up to 10 in. of mercury (135.8 in. of water per blower).
- Use a stack with a minimum height of 6 m (20 ft) above ground as the final effluent release point.

### 2.2.1 Safety Analysis Requirements

The SVE system design must adhere to the safety functions required by committed administrative actions (CAAs) listed in the safety analysis document (Lehrschall 1995). The CAA requirements are provided in the following sections.

**2.2.1.1 Committed Administrative Action for Fuel Sources.** The objective of this CAA is to ensure that whenever large propane storage tanks [3,785 L (1,000 gal)] are used at the site, a common-mode fire affecting the propane tank, fuel truck, or generator would not affect the GAC canisters and result in regeneration of carbon tetrachloride and cause unacceptable consequences to the site worker and the nearest uninvolved individual.

Requirements:

1. The propane fuel tank or a fuel truck for refueling the propane tank shall be located a minimum of 15 m (50 ft) from GAC canisters containing carbon tetrachloride, whether the canisters are in storage or are being used in the process.
2. The generator shall be located a minimum of 8 m (25 ft) from the GAC canisters.

**2.2.1.2 Committed Administrative Action for Limiting Carbon Tetrachloride Exposure.**

The objective of this CAA is to ensure that the concentrations of carbon tetrachloride from SVE system operations do not exceed the Occupational Safety and Health Administration (OSHA) or American Conference of Governmental Industrial Hygienists exposure limits, whichever is more restrictive, causing unacceptable consequences to the site worker and the nearest uninvolved individual.

Requirements:

Automatic Operation Mode (automated sampling for contaminants)

1. A carbon tetrachloride detector shall be located downstream of the final GAC (stack monitor) and interlocked to shut down the blower if the carbon tetrachloride concentration exceeds 25 ppmv for a 14-m<sup>3</sup>/min (500-ft<sup>3</sup>/min) effluent stream or 10 ppmv for a 42-m<sup>3</sup>/min (1,500-ft<sup>3</sup>/min) effluent stream.
2. A minimum of two GAC-filled canisters [minimum 680 kg (1,500 lb) GAC per canister] per 14 m<sup>3</sup>/min (500 ft<sup>3</sup>/min) shall be in series to ensure carbon tetrachloride breakthrough in the first GAC canister is adsorbed in the second canister. The secondary GAC canister shall have full adsorptive capacity whenever installed in the system.
3. Flowmeters shall be located upstream of the primary GAC canister and downstream of the final GAC canister. A logic system shall be in place to initiate a system shutdown within 1 minute when flowrate variance is greater than 50% above the combined accuracy of the flowmeters.

Manual Operation Mode (manual sampling for contaminants)

1. To ensure that stack concentrations of carbon tetrachloride do not exceed 25 ppmv for a 14-m<sup>3</sup>/min (500-ft<sup>3</sup>/min) effluent stream or 10 ppmv for a 42-m<sup>3</sup>/min (1,500-ft<sup>3</sup>/min) effluent stream, the sampling frequency shall be a minimum of every 2 h at the point of discharge (stack sample port).
2. A minimum of two GAC-filled canisters [minimum 680 kg (1,500 lb) GAC per canister] per 14 m<sup>3</sup>/min (500 ft<sup>3</sup>/min) shall be in series to ensure carbon tetrachloride breakthrough in the first GAC canister is adsorbed in the second canister. The secondary GAC canister shall have full adsorptive capacity whenever installed in the system.
3. Personnel who operate an SVE system shall be trained to monitor the system, sample for carbon tetrachloride concentrations, and shut down the blower in the event the concentrations of carbon tetrachloride detected at the stack sample port exceed 25 ppmv for a 14-m<sup>3</sup>/min (500-ft<sup>3</sup>/min) effluent stream or 10 ppmv for a 42-m<sup>3</sup>/min (1,500-ft<sup>3</sup>/min) effluent stream.
4. Hose installations between an SVE system and GAC canisters shall be verified by operating personnel prior to startup.
5. If interlocks are not operable to detect a flow variance of greater than 50% (exceeding 50% variance for more than 1 minute will require shutdown of the SVE system), monitoring of flowmeters will be required by operations personnel as prescribed in the work procedures. If flowmeters and interlocks are not operable, constant monitoring for carbon tetrachloride at 2-h intervals is required around the portion of the SVE system(s) under positive pressure.

**2.2.1.3 Committed Administrative Action for Reducing the Potential for GAC Canister Overheating.** The objective of this CAA is to prevent a GAC-filled canister overheating event that could possibly result in the production and release of hydrochloric acid, causing unacceptable consequences to the site worker and the nearest uninvolved individual.

Requirement:

The air stream concentration of carbon tetrachloride at the primary GAC canister inlet shall be determined by sampling at startup of operations and at 2-h intervals. If two consecutive samples contain greater than 10,000 ppm carbon tetrachloride, 1,000 ppm methyl ethyl ketone, or 500 ppm chloroform, shutdown of operations is required.

### 2.2.2 ARARs

Based on ARARs, the design and monitoring requirements for the SVE systems shall be such that emissions do not cause the following limits to be exceeded:

- Carbon tetrachloride levels at the fenceline (Hanford Site boundary) - acceptable source impact level of 0.067 mg/m<sup>3</sup> (0.01 ppmv)
- Carbon tetrachloride emissions at each individual SVE stack - reportable quantity of 4.5 kg/day (10 lb/day).

## 2.3 SOIL VAPOR EXTRACTION SYSTEM DESIGN

Included below are design requirements. Existing equipment meets these requirements and shall be maintained to meet these requirements.

### 2.3.1 Soil Vapor Extraction Sites

The SVE sites within the 200-ZP-2 Operable Unit include the area encompassing the well fields, process equipment, process trailers, office trailers, sea/land shipping containers, and designated equipment laydown areas. To maintain effective management of the SVE site and systems, the supporting facilities and areas should be situated near the well field(s). The SVE system process equipment is placed as close together as practicable and is interconnected with hoses, electrical cables, and instrumentation cables. A control zone is maintained around the area where this equipment is located to prevent inadvertent access by uninvolved individuals. Operations support trailers are maintained outside the control zone and may be connected to the SVE system process equipment via electrical and instrumentation cables.

The GAC canisters used for removal of the carbon tetrachloride from the soil vapor are placed adjacent to the SVE system and are connected by flexible hoses. Separate staging areas are maintained for storage of unused GAC canisters and saturated GAC canisters ready for regeneration.

### 2.3.2 Soil Vapor Extraction Well Field

Soil vapor extraction wells provide access to the soil vapor in the vadose zone to maximize extraction of carbon tetrachloride and associated organics. Note that only a portion of the extraction wells are connected (on-line) to the SVE system(s) at the same time. Perforations in well casings or well screens should provide at least a 3% open area in the perforated/screened intervals. Access to individual perforated/screened intervals is provided by packers or piping. Alterations to a well must not preclude future ability for closure to *Washington Administrative Code* standards and should not facilitate extraction of radionuclide particulates if possible.

The extraction wells in the 200-ZP-2 Operable Unit are located in the vicinity of the 216-Z-1A Tile Field, 216-Z-9 Trench, 216-Z-18 Crib, and 216-Z-12 Crib as shown in Figure 2. Online extraction wells should be connected to the SVE system(s) in a manner that will yield the most efficient removal of carbon tetrachloride.

**2.3.2.1 Extraction Well Field Configuration.** The lead engineer/scientist for the ERA will be responsible for determining which extraction wells will be on line. Available extraction wells are depicted in Figure 2.

**2.3.2.2 Extraction Well Perforations.** Some wells are perforated at selected intervals to provide a means of monitoring and extracting soil vapor from a specific soil depth in the subsurface. The intervals are determined using known geological data and permeability tests. Additional information regarding perforating can be found in Fancher (1995).

**2.3.2.3 Wellhead Design.** There are three types of wellhead configurations, and each consists of a slip flange and a cam-loc fitting for connection to the extraction hose. The wellhead designs are provided on drawing 200W-DD-MO203. The single-interval wells typically have a single cam-loc fitting for connecting the extraction hose, whereas multiple interval wells have a wellhead packer assembly that is connected to a wellhead manifold.

**2.3.2.4 Wellhead Manifold.** Wellhead manifolds are typically used on extraction wells with multiple perforated/screened intervals. The wellhead manifold contains valves that permit SVE from one or more of the perforated/screened intervals. Typical wellhead manifolds are provided on drawing 200W-DD-MO202.

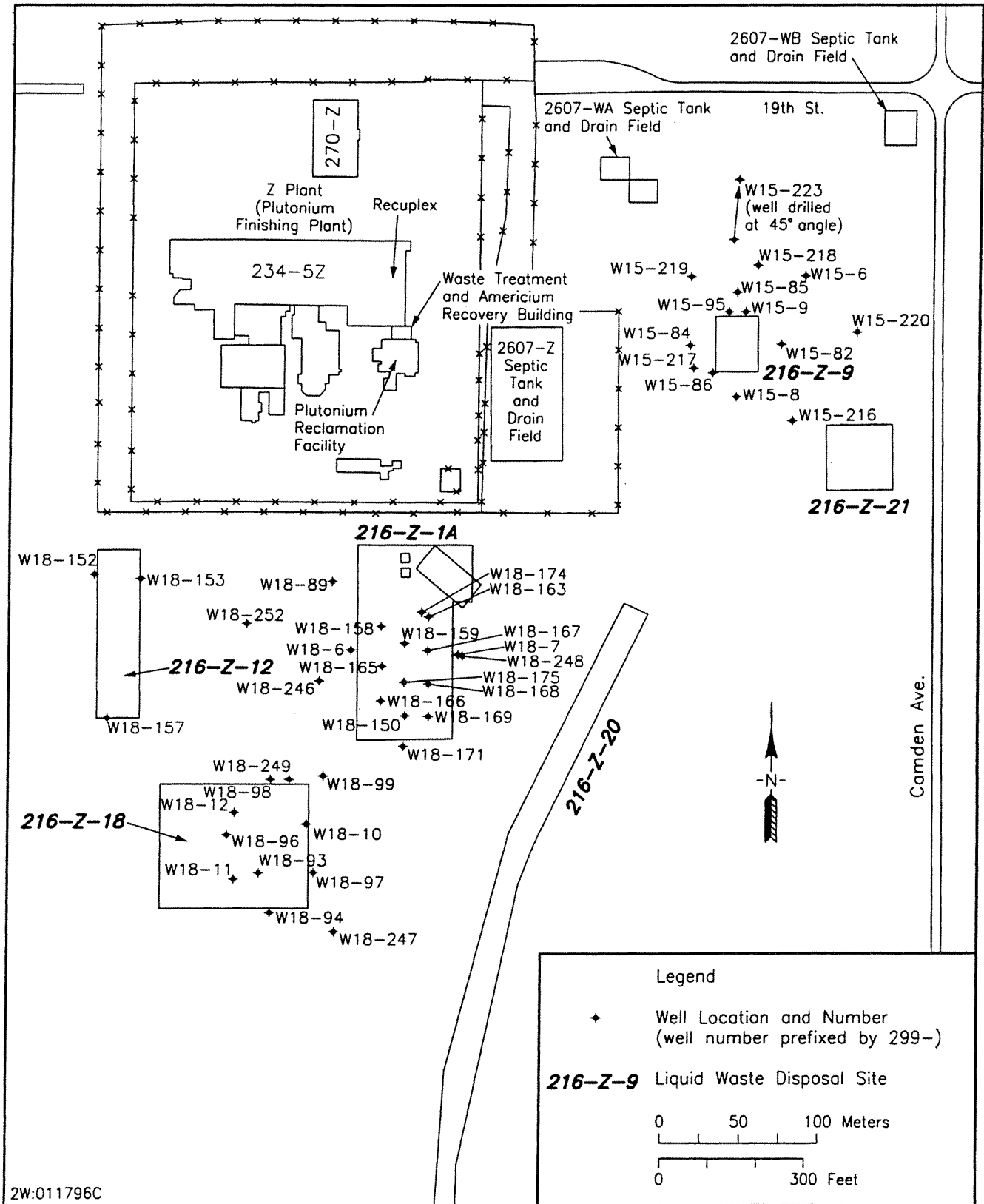
**2.3.2.5 Soil Vapor Extraction Hose.** Soil vapor extraction hoses are typically 10-cm- (4-in.-) diameter, flexible polymer-reinforced hoses that lie on the ground and have positive seal-quick (cam-loc) disconnect fittings to provide ease of disconnection and movement when necessary.

### **2.3.3 Soil Vapor Extraction Systems**

The general function of the SVE equipment is to create a pressure gradient (vacuum) in the vadose zone and provide a conduit (extraction hoses) to transport the extracted soil vapor to the HEPA filter and blower trailers. The contaminated soil vapor is treated to remove moisture, to filter radionuclide particulates, to cool and/or heat the vapor (maintain relative humidity at about 40%), to remove the carbon tetrachloride, and finally to discharge the treated vapor stream to the atmosphere. An index of as-built drawings for the 14-, 28-, and 42-m<sup>3</sup>/min (500-, 1,000-, and 1,500-ft<sup>3</sup>/min) SVE systems is provided on drawing 0200W-DD-G0021. The major components of the SVE system(s) and their respective functions are described in the following sections.

**2.3.3.1 HEPA Filter Trailer.** The HEPA filter trailer provides a platform for mounting the inlet manifold, prefilter, HEPA filter, gas sampling cabinet(s), the electrical power distribution system, and other appurtenant equipment. The major function of the HEPA filter trailer equipment is to remove potentially radioactive particulates from the vapor stream.

Figure 2. Available Existing Wells Around the Four Disposal Sites - Modified Configuration.



**2.3.3.2 Blower Trailer.** The equipment on the blower trailer serves two major purposes. The most important purpose is to provide the mechanical force (blower motor) required to induce an effective pressure gradient in the vadose zone, thus the means for extraction and distribution of the soil vapor through the SVE system. Secondly, the same mechanical force is used to transport the soil vapor through the treatment train (GAC canisters) and effluent stack.

**2.3.3.3 Piping and Transfer Hose.** Piping on the HEPA and blower trailers is anchored so that no damage occurs during transportation and to minimize line vibration during SVE operations. Piping and hoses are used to interconnect the various components of the SVE system(s). Hoses are typically used from the extraction wells to the intake manifold. Piping and/or hoses may be used from the intake manifold to the water separator, from the water separator to HEPA filtration unit, from the HEPA filtration unit to the blower, from the blower to the primary GAC canister, between GAC canisters, and finally to the exhaust stack.

**2.3.3.4 Well Field Intake Manifold.** The well field intake manifold receives and combines all the soil vapor from the extraction wells connected to the system. The connections of the hoses to the manifold are made with seal-tight, quick-disconnect fittings. Valves on the manifold provide control of the flow from each well.

The manifold is also fitted with several instruments. Flowmeters and vacuum transmitters are placed in each manifold inlet segment, and pressure gages are installed to allow local indication of the pressure in each leg of the manifold. A relative humidity transmitter and temperature transmitter are located in the header portion of the manifold.

From the intake manifold, the soil vapor flows to the water separator (knockout tank).

**2.3.3.5 Water Separator (Knockout Tank).** Moisture may wet HEPA filter media and subsequently allow the migration of radionuclides, reducing if not eliminating the effectiveness of the HEPA filters. Likewise, moisture may occupy interstitial pore spaces of the GAC, thus reducing GAC efficiency. Thus, the primary function of the water knockout tank is to provide preliminary removal of moisture from the vapor stream, thus supporting increased HEPA filtration and GAC efficiency. However, it should be noted that the knockout tanks do not remove the mass of water vapor needed to provide optimal GAC efficiency. The removal of this additional mass of water vapor requires the implementation of condensers, which are not currently in use on the SVE systems.

The increased residence time of the vapor in the knockout tank (as compared to extraction hoses) and the cold metal surface on the tank facilitates the condensing of the water vapor. At the discretion of the cognizant engineer/scientist, the water separator may be used optionally based on the mass of water moisture present in the vapor. If a water separator is used, it must be capable of holding a minimum of 114 L (30 gal) of condensate. The water knockout tank will be equipped with a level indicator (e.g., site glass) and drain valve, or a high-level switch with a system shutdown interlock may be substituted for the level indicator.

From the water separator (knockout tank), the soil vapor flows to the preheater.

**2.3.3.6 Vapor Preheater.** An air preheater may be used prior to the HEPA filtration system to increase the temperature of the vapor stream (decreasing the relative humidity) so that moisture will not condense on the HEPA filter media. Based on the safety analysis document (Lehrschall 1995), a concern exists that the preheater might produce phosgene gas when heating the carbon tetrachloride vapor at temperatures exceeding 204°C (400°F). Therefore, the heater, if used, will be set to provide an alarmed shutdown if the airstream temperature exceeds 93.3°C (200°F).

**2.3.3.7 HEPA Filtration Unit.** The prefilter removes larger particulate from the vapor stream. The HEPA filter removes particulates from the soil vapor stream including potentially radiologically particulates. The HEPA filters are rated 99.97% efficient for particles 0.3 microns ( $\mu$ ) or larger.

The HEPA filtration unit housing instrumentation includes differential pressure gages across each of the filter banks and may have alpha and beta CAMs to monitor for the presence of radionuclide contamination at the HEPA filters. The CAMs have individual audiovisual alarms. The CAMs may also have alarm interlocks connected to the process control system to shut down the SVE system in an alarm condition.

**2.3.3.8 Blower.** The blower motor is located on the blower trailer and creates the vacuum (downstream) and pressure (upstream) for the SVE system and thus the entire force for soil vapor flow through the system. Blowers shall provide a nominal 14-m<sup>3</sup>/min (500-ft<sup>3</sup>/min) vapor flow and shall be capable of developing 10 in. mercury (34 kPa).

**2.3.3.9 Heat Exchangers.** Heat exchangers will be used, as needed, to lower the temperature of the soil vapor stream as it exits the blower. Typically, the blower can increase the vapor stream temperature by as much as 93°C (200°F) above the ambient temperature. The heat exchangers are required to reduce the vapor stream temperature from the blower to below 66°C (150°F) in support of maintaining the maximum adsorption of carbon tetrachloride on the GAC.

**2.3.3.10 Soil Vapor Sampling System.** The carbon tetrachloride (and other VOC) concentrations in the soil vapor are measured from three locations on the SVE system(s). Sample lines deliver the vapor to a temperature-controlled sample cabinet that houses a photoacoustic infrared spectrometer (Brüel & Kjaer) that analyses the sample. Each sample location is automatically valved into the Brüel & Kjaer, and the sample results are logged in the process controller. The three sampling locations are (1) primary GAC canister inlet (combined extraction hose concentrations), (2) primary GAC outlet, and (3) stack effluent.

**2.3.3.11 Exhaust Stack.** The base inlet of the exhaust stack should be from 10 to 25 cm (4 to 10 in.) in diameter depending on the amount of flow to be exhausted. The vertical portion of the stack is to be a minimum of 6 m (20 ft) tall as measured from the ground and should be constructed of steel. Carbon tetrachloride concentrations and volumetric flow are monitored at this point.

**2.3.3.12 Electrical Service.** All wiring and equipment is to comply with the National Electric Code for NEMA 3R. All circuits should be clearly labeled in the panel box(es). All cables

should be UL listed as type TC, sunlight resistant, and approved for direct burial. All connectors should be Appleton-style two-to-five wire, three-to-five pole, 600 VAC.

Typical electrical one-line diagrams for the electric power supplied by either a portable generator or line power are provided on drawings 200W-DD-E0122, -E0119, and -E0158.

**2.3.3.13 Instrumentation.** SVE system instrumentation includes pressure gages, vapor relative humidity sensors, temperature gages, thermocouples, flowmeters, carbon tetrachloride detectors, CAMs, and radon detectors. The relative humidity sensors are currently used for indication only and are not a design requirement. An air sampler is used to provide a record sample of the radioactive particulates pulled from the soil. Sample ports provide a means of sampling the soil gas. All instrument transmitters connect to the process control system. All instruments, including transmitters, are to be individually labeled. Calibration, or indication only, stickers are attached as required for the location.

**2.3.3.14 Lighting.** Each SVE system has pole-mounted lights for nighttime use. Two photo-cell-controlled extension floodlight towers are to provide lighting. Each tower will consist of two adjustable 3,200-lm lights. Low-pressure sodium or incandescent lights are to be used. The light tower is to extend a minimum of 3 m (10 ft) in height.

## **2.3.4 Soil Vapor Treatment System**

The soil vapor treatment system uses GAC to remove the volatile organics, mainly carbon tetrachloride, from the extracted soil vapor stream. A minimum of two GAC-filled canisters shall be on line during extraction operations. The first canister functions as the primary treatment and the others function as the polishing treatment. When the primary canister reaches its adsorptive capacity, as indicated by monitoring for carbon tetrachloride breakthrough, it is taken off line for regeneration. It is replaced immediately by the secondary canister. Additional GAC canisters may be placed in series provided that the system pressure is limited to 10 in. mercury (34 kPa) measured just downstream of the vacuum blower.

The canisters are labeled as 2,000-lb GAC canisters but actually contain approximately 798 kg (1,760 lb) of GAC. The canisters are normally operated at a flow of 14 m<sup>3</sup>/min (500 ft<sup>3</sup>/min) and pressure of less than 10 in. mercury (34 kPa). The canisters, however, are designed for a maximum flow of 18 m<sup>3</sup>/min (650 ft<sup>3</sup>/min) and a maximum pressure of 60 in. mercury (207 kPa). The canisters are equipped with 15-cm (6-in.) threaded fittings to which quick-disconnect fittings are attached. The inlet and outlet of each canister is equipped with valves for sealing the canister during non-use. The canisters are approved for shipping by the U.S. Department of Transportation. The carbon will be regenerated offsite unless an onsite carbon tetrachloride treatment and/or destruction system is implemented.

### 2.3.5 Process Control System

The process control system supporting monitoring and data collection for SVE operations is computer based and includes analytical and process instrumentation, process sensors and transmitters, alarm interlocks, and associated equipment. The control system provides mostly a monitoring function, with some control capabilities. Input to the process control system is provided by electronic transmitters and process or analytical instrumentation. Transmitters send electronic signals to the programmable logic controller. This provides the process computer with inputs for system operational control, recording of unplanned events (alarms), and system performance analysis.

The computer may be located in the office trailer or on the SVE system. The computer allows site personnel to access information from the transmitting instruments and make control changes. Modems can also be used with home and office computers to attain these capabilities. Essential operational safety controls and interlocks are provided in Table 2.

**2.3.5.1 Radiation Inputs.** Radioactive particulates in the soil vapor stream will be measured using a vacuum sample pump and filter paper located after each HEPA filtration unit. To assess the effectiveness of the HEPA filtration unit, the sample filter paper will be changed and analyzed for radionuclide particulates as discussed in Section 3.2.2.4. Additionally, CAMs may be used to measure specific radionuclides that may be mobilized during remediation activities. Each CAM has individual local audiovisual indication and is capable of transmitting alarms to the process control system to provide an interlocked shutdown of the SVE system if the radiation level set point is exceeded.

**2.3.5.2 Carbon Tetrachloride Input.** Carbon tetrachloride (and other VOCs) in the soil vapor are to be measured at the primary GAC inlet, at the primary GAC outlet, and at the effluent stack. The process control system will be used to monitor and record these measurements for compliance monitoring and system trend analysis. When the carbon tetrachloride monitor is connected to the process control system, an interlock will automatically shut down the SVE system when programmed limits are exceeded (see Section 3.2.2).

**2.3.5.3 Temperature Inputs.** Heater temperatures, process equipment temperatures, and soil-gas temperatures are monitored for operational control and safety compliance. Both thermometers and temperature sensors (thermocouples) are used to measure temperatures.

**2.3.5.4 Pressure Inputs.** Process vacuums are measured before (after the HEPA filtration unit) and after the blower. The blower inlet vacuum is measured to protect the HEPA filter housing, and the exhaust pressure is measured to protect the GAC canisters. Both measuring devices are interlocked to shut down the SVE system at a set point of 10 in. mercury (34 kPa).

Table 2. Soil Vapor Extraction System(s) Safety Equipment List and Interlocks.

| Equipment   | Interlocks  | Location                    |
|---|---|-----------------------------|
| Carbon tetrachloride analyzer   | Carbon tetrachloride concentration >10,000 ppmv = system shutdown | Primary GAC inlet and stack |
| Differential flowmeters   | Vapor flow differential >50% = system shutdown                    | Blower outlet and stack     |
| Relative humidity transmitter   | None - Indication only  | HEPA filter inlet           |
| Thermocouple  | Soil vapor temperature >275°F = system shutdown                   | Blower outlet               |
| Vacuum transducer   | System vacuum >10 in. Hg = system shutdown                        | Blower inlet                |
| Pressure transmitter  | System pressure >10 in. Hg = system shutdown                      | Blower outlet               |
| Radioactive particulate sampler   | None - Indication only  | Blower outlet               |
| HEPA filter differential pressure gages   | None - Indication only  | HEPA filter housing         |
| Shutdown relays   | None  | Blower                      |
| Process control system  | None  | Office trailer              |
| Piping and hoses  | Flow differential >10 in. Hg = system shutdown                    | Downstream of blower        |
| HEPA filters  | None  | HEPA trailer                |
| GAC canisters   | None  | SVE system(s)               |
| <p>GAC = granular activated carbon<br/> HEPA = high-efficiency particulate air<br/> Hg = mercury<br/> SVE = soil vapor extraction</p> |   |                             |

**2.3.5.5 Flow Input.** Soil vapor flow is measured at two separate locations within the system. The first location is at the outlet of the blower and provides a measurement of the total flow from all the wells under extraction. The second location is prior to the exhaust stack, which also yields the total flow from all the wells under extraction. The flowmeters transmit the flow data to the process control system where the information is stored for future evaluation.

The two flow rates are automatically compared by the process control system to monitor for effluent leakage from the portion of the unit under positive pressure. If a variance is experienced that is greater than 50% above the combined accuracy of the flowmeters, an interlock within the process control system will automatically shut down the SVE system.

**2.3.5.6 Relative Humidity Input.** The relative humidity is measured upstream of the HEPA filter housing and is used to evaluate the potential accumulation of water vapor on the HEPA filters. The relative humidity measuring instruments are used for indication only as the HEPA filters are tested annually.

**2.3.5.7 Interlocks.** Interlocks are designed in the SVE systems to maintain established parameters, thus allowing unattended operation of the systems. The interlocks include set points, response logic, and annunciation and/or shutdown responses. An SVE system shutdown consists of shutting the blower(s) off. A summary of the interlocks and their responses is provided below.

- During an automated mode of sampling, if the inlet vapor stream contaminant concentrations exceed 10,000 ppmv carbon tetrachloride, 1,000 ppmv methyl ethyl ketone, or 500 ppmv chloroform, the system shuts down and a high inlet contaminant concentration alarm annunciates (Lehrschall 1995, Section 4.0).
- During an automated mode of sampling, if the carbon tetrachloride concentrations at the stack exceed 25 ppmv for a 14-m<sup>3</sup>/min (500-ft<sup>3</sup>/min) effluent stream or 10 ppmv for a 42-m<sup>3</sup>/min (1,500-ft<sup>3</sup>/min) effluent stream, the system shuts down and a high stack carbon tetrachloride alarm annunciates. The 25 ppmv limit is to ensure worker safety (Lehrschall 1995), and the 10 ppmv limit is to ensure compliance with Title 40, *Code of Federal Regulations* (CFR), Part 302 (see Table 1) .
- If the vapor flow into the primary GAC canister and out of the final GAC canister has a differential flow of greater than 50%, beyond the range of accuracy of each instrument, the system shuts down and a high flow differential alarm annunciates (Lehrschall 1995, Section 4.0).
- If the blower exhaust temperature is greater than 135°C (275°F), the system shuts down and a high blower outlet temperature alarm annunciates. [The blower manufacturer recommends 177°C (350°F).]
- If the vacuum is greater than 10 in. of mercury (135 in. water or 34 kPa) upstream from the blower, the system shuts down and a high system vacuum alarm annunciates.

- If the blower exhaust pressure is greater than 10 in. mercury (34 kPa), the system shuts down and a high blower outlet pressure alarm annunciates.

### **2.3.6 Office Trailer**

The office trailer provides working space for the project support personnel at the site and also houses the current and/or original (should be less than 1 week old) site quality assurance records. The office trailer is a standard single-wide trailer with heating and air conditioning. The trailer is blocked and tied down.

## **2.4 HEALTH AND SAFETY REQUIREMENTS**

Special precautions are undertaken during SVE system installation and operation to protect the health and safety of all involved personnel. Standard radiation protection procedures are followed, and personnel will be protected to keep radiation and chemical exposure to as low as reasonably achievable. The project support area is accessible only to authorized personnel and emergency vehicles. Emergency evacuation routes will not be obstructed. A zone around the process equipment will be maintained by rope to prevent inadvertent access by uninvolved individuals.

A site-specific health and safety plan (BHI 1995) has been written and is readily available at the SVE system office trailers.

The SVE system operations, characterization activities, and treatability demonstrations are classified as a nonnuclear activity compliant with the requirements in DOE (1994a) and are low-hazard activities compliant with the requirements in DOE (1988) and Hanson et al. (1993). The activities associated with the SVE system(s) remedial operations are not defined as radiological because the radiological material inventories are below the reportable quantity values as specified in 40 CFR 302. The SVE system workers shall comply with the controls implemented for working in the ERA waste site radiation zones. The other radiological controls implemented for the facilities in the vicinity should be considered by the individuals performing SVE system operations (Lehrschall 1995).

The SVE system operations were evaluated against the standards for preparation of auditable safety analysis reports (DOE 1993a); guidance for safety class of safety significant structures, systems, or components (DOE 1994b); and occurrence reporting requirements (DOE 1993b). The potential worst-case consequences are below the numerical accident acceptance guidelines for public and onsite radiological and toxicological exposure. Therefore, safety class or safety significant structures, systems, or components and technical safety requirements are not required (Lehrschall 1995).

This project is designed to meet requirements of the National Electric Code, OSHA, applicable environmental regulations, and the *Safety Analysis for the 200 West Area Expedited Response Action for Remediation of Carbon Tetrachloride* (Lehrschall 1995).

The safety equipment list (see Table 2) provides a list of safety systems and equipment requiring particular care, use, and maintenance to ensure safe carbon tetrachloride remediation operations.

### 3.0 OPERATIONS

#### 3.1 SOIL VAPOR EXTRACTION SYSTEM OPERATION

The SVE systems extract soil vapors from the vadose zone, filter potential radionuclide particulates, remove carbon tetrachloride and associated VOCs from the soil vapor, and vent the treated effluent to the atmosphere. Additionally, operation of the SVE system(s) includes sampling and monitoring of the soil vapor at various stages in the process.

Operation of the 14-, 28-, and 42-m<sup>3</sup>/min (500-, 1,000-, and 1,5000-ft<sup>3</sup>/min) SVE systems will be conducted per operating procedures BHI-OP-00059, BHI-OP-00060, and BHI-OP-00061 (BHI 1996a, 1996b, 1996c), respectively.

The discussion below includes requirements that are routinely observed in current operations.

##### 3.1.1 Operation Control

Operation control is accomplished through both administrative and engineered controls. The administrative controls are implemented via the operating procedures, a site-specific safety and health plan, and radiation work permits. Engineered controls are accomplished via the process control system, which primarily provides a system monitoring function with some control capabilities. The control functions are implemented via system set points and interlocks and can provide system shutdowns and annunciations.

Manual gages on the SVE systems provide local indication of flow, pressure (or vacuum), and temperature during initial startup of systems. However, interlocks are actuated via the process control system, and therefore the flow, pressure, and temperature measurements should be obtained from the process control system during system startup.

The SVE system interlocks, shutdown parameters, and responses for the process control system are energized and implemented during operation and are controlled directly by the process control system. An interlock shutdown of an SVE system consists of shutting the blower(s) off.

### 3.1.2 System Startup

System startup is performed in accordance with operation procedures BHI-OP-00059, BHI-OP-00060, and BHI-OP-00061 (BHI 1996a, 1996b, 1996c) for the 14-, 28-, and 42-m<sup>3</sup>/min (500-, 1,000-, and 1,500-ft<sup>3</sup>/min) systems, respectively. A brief description of system startup follows.

A safety walkthrough and prestart checks will be performed before routine startups after a planned shutdown. The safety walkthrough requires operating personnel to look for loose hose connections, weeds or other combustible materials, and damaged electrical cords that lie on the ground. Prestart checks include verifying valve positions to achieve the correct flowpath for the system and checking the oil level in the blowers. Performance of a system startup shall be documented in the appropriate operations procedure checklists.

### 3.1.3 Normal Operation and System Surveillances

Normal operation of the SVE system(s) is performed in accordance with operating procedures BHI-OP-00059, BHI-OP-00060, and BHI-OP-00061 (BHI 1996a, 1996b, 1996c) for the 14-, 28-, and 42-m<sup>3</sup>/min (500-, 1,000-, and 1,500-ft<sup>3</sup>/min) systems, respectively. A brief description of normal operation follows.

Normal operation of the SVE system(s) is controlled by the process control system and does not require full-time support by operations personnel because the systems are automated. After a shutdown, the system must be manually restarted after evaluating the cause of the shutdown. Daily, weekly, and monthly system surveillances are performed by operating personnel during normal working days.

**3.1.3.1 Daily System Surveillances.** Daily system surveillances performed on the SVE system(s) include routine vapor stream contaminant monitoring, a safety walkthrough of the equipment, water separator level checks, and a surveillance of the process control system. If the system is shut down when operating personnel visit the site, the operating personnel will determine the nature of the problem via the system computer and take appropriate action as described in the operating procedure for the respective system. Performance of the daily system surveillance shall be documented in the appropriate operating procedure checklists.

**3.1.3.2 Weekly System Surveillances.** Weekly system surveillances performed on the SVE system(s) include weekly particulate radiation sample filter changes, a survey of the SVE system(s) piping and hoses for leaks, and weekly operability checks of the organic monitor and safety function flowmeters. Weekly surveillances also require the weekly review of contaminant sampling data and daily surveillances recorded during the previous week.

**3.1.3.3 Monthly System Surveillances.** Monthly surveillances performed on the SVE system(s) include monthly functional checks of the organic analyzer and safety function flowmeters and an inspection of the SVE system(s) equipment for signs of wear, leaks, and

corrosion. Monthly surveillances also include a review of weekly surveillances completed during the previous month.

### **3.1.4 GAC Changeouts**

GAC changeouts are performed in accordance with operating procedures BHI-OP-00059, BHI-OP-00060, and BHI-OP-00061 (BHI 1996a, 1996b, 1996c) for the 14-, 28-, and 42-m<sup>3</sup>/min (500-, 1,000-, and 1,500-ft<sup>3</sup>/min) systems, respectively. A brief description of the GAC changeouts follows.

The GAC canisters are stored at the site in three separate locations. These locations allow the proper handling, usage, and storage of the canisters.

- Area 1--This storage area is for GAC canisters that have been received but have not been used since receipt.
- Area 2--This area is the process treatment area where the GAC canisters are in actual use. GAC canisters brought into this area are placed in the secondary or tertiary position in the treatment train where they function as a polishing step. These canisters will sequentially be moved up to the primary position in the treatment train where they will function as the primary adsorber of carbon tetrachloride from the vapor stream.
- Area 3--This storage area is for GAC canisters that have been used and are awaiting shipment to the offsite regeneration facility.

The GAC canisters require changeout for many reasons, including the following.

- Primary GAC canister has reached its adsorptive capacity of carbon tetrachloride.
- Breakthrough of carbon tetrachloride in a concentration exceeding the established limit is noted by instrumentation between primary and secondary GAC canisters or downstream of secondary GAC canister.
- Primary or secondary GAC canister has a physical defect that has become apparent.

On receipt, each of the GAC canisters shall be labeled with a serial number. The use of a GAC canister shall be recorded in the appropriate operating procedure checklists and shall include the assigned serial number and positioning of the GAC canister in the treatment train.

### **3.1.5 System Shutdown**

System shutdowns are performed in accordance with operating procedures BHI-OP-00059, BHI-OP-00060, and BHI-OP-00061 (BHI 1996a, 1996b, 1996c) for the 14-, 28-, and 42-m<sup>3</sup>/min

(500-, 1,000-, and 1,500-ft<sup>3</sup>/min) systems, respectively. A brief description of system shutdown follows.

System shutdown shall be performed as needed for maintenance, GAC canister changeouts, or at the end of the working day if the system is not scheduled for 24-h/day operations. System shutdown consists of purging the system for a few minutes on ambient air to remove any residual carbon tetrachloride trapped in the lines. Performance of a system shutdown shall be documented on the appropriate operating procedure checklists.

### **3.1.6 Characterization Operations**

Initial operations at a new extraction site or a newly developed extraction well will include SVE characterization tests to determine the anticipated concentration of organics and the vapor flow potential that can be expected from the well during operations. Thus, the characterization process requires a vacuum to be applied to the well to extract a soil-vapor sample from the perforated/screened interval within the well and measure soil-vapor flow characteristics. The pressure (vacuum), vapor flow, and carbon tetrachloride concentrations are monitored by instrumentation and recorded. Initial tests provide a baseline for monitoring the influence of SVE operations on the well field.

During characterization operations, vapor samples may be taken for laboratory analysis if required by the project engineer/scientist. Particular attention will be given to analyzing for carbon tetrachloride and ketones because at high concentrations these contaminants may cause a GAC bed to overheat.

Over time, the concentration of known contaminants will change and new contaminants may be drawn into the well field as a result of SVE operations. To monitor these effects and collect data to evaluate extraction wells that will provide optimal production, characterization analyses should be performed monthly on online extraction wells and quarterly on both online and offline wells. Additionally, to provide data regarding the zone of influence of the SVE operations, pressures in offline extraction wells should be measured monthly.

## **3.2 SOIL VAPOR EXTRACTION SYSTEM MONITORING**

Soil vapor extraction system monitoring will consist of a combination of continuous electronic monitoring/manual sampling to measure essential operating parameters at various locations throughout the system. Electronic monitoring will use instrumentation and interlocks connected to a process control system that will monitor system parameters and provide system shutdown capability when alarm conditions exist. Automatic control of the SVE system will be accomplished via the process control system where feasible. When the process control system cannot be interlocked to monitor system parameters, manual monitoring will be required by operations personnel during SVE system operation. The following sections describe the instrumentation used and the essential parameters that are monitored.

### 3.2.1 Instrumentation

Monitoring instrumentation includes devices to measure contaminants in the vapor stream as well as various SVE system physical parameters (vacuum, vapor flow, temperature, relative humidity, radioactivity). Types of instrumentation that may be used include carbon tetrachloride monitoring instruments, radon detectors (currently not used), alpha and beta radiation CAMS (currently not used), mass flowmeters, pressure transducers, relative humidity meters, and thermocouples.

### 3.2.2 Vapor Stream Contaminant Monitoring

Soil vapor removed from the vadose zone by the SVE systems will be sampled for contaminants (volatile organics) at various locations within the SVE systems equipment and piping. Samples will be taken using contaminant-resistant sample tubing connected to piping sample ports. Contaminant sampling will be accomplished automatically; however, manual samples may be taken if needed (e.g., process control system not functioning properly). The preferred instrument for analyzing samples uses a photoacoustic infrared spectrometer. Other instruments or analytical methods for monitoring carbon tetrachloride will be evaluated for use as they become available. Automated monitoring instruments will be connected to insulated sample tubing runs and will be housed in climate-controlled cabinets.

**3.2.2.1 Carbon Tetrachloride.** The incoming vapor stream from the extraction wells to the SVE systems will be monitored for carbon tetrachloride, chloroform, methylene chloride, and methyl ethyl ketone concentrations to determine the total amount removed from the subsurface and to maintain safe operating limits.

Monitoring carbon tetrachloride concentrations is required to calculate the amount of the contaminant removed from the subsurface over time. Weekly reporting of the amount removed is required from the SVE system operations engineer to the project engineer/scientist. The following formula is used to calculate the amount of carbon tetrachloride extracted in pounds per day.

$$\text{CCl}_4 \text{ extracted (lb/day)} = (\text{daily operating time (min/day)}) \times (\text{daily average flow (ft}^3\text{/min)}) \times (\text{daily average CCl}_4 \text{ concentration (ppmv)} \times 10^{-6}) \times (0.393)$$

where:  $0.393 = (1.16 \text{ mole/ft}^3)(153.823 \text{ g CCl}_4\text{/mole})(\text{lb}/454 \text{ g})$ , and  $1.16 \text{ mole/ft}^3$  is calculated from the ideal gas law @ 25 °C and 1 atmosphere.

Weekly quantities of extracted carbon tetrachloride are calculated by simply adding the daily quantities of carbon tetrachloride.

Monitoring carbon tetrachloride concentrations is also required to determine GAC canister loading and to comply with CAAs documented in the safety analysis document (Lehrschall

1995). One CAA limits carbon tetrachloride concentrations exiting an SVE system stack to control chemical exposures to site workers and the nearest uninvolved individual to below the OSHA permissible exposure limit. Another CAA limits the amount of carbon tetrachloride, methyl ethyl ketone, and chloroform at the inlet to the SVE system(s), and thus sent to the GAC treatment system, to prevent possible overheating of the GAC material.

**3.2.2.1.1 Inlet to the Soil Vapor Extraction System(s).** Inlet vapor stream concentrations of carbon tetrachloride, methyl ethyl ketone, and chloroform shall be maintained below 10,000 ppmv, 1,000 ppmv, and 500 ppmv, respectively. Concentrations of these contaminants will be determined by sampling at 2-h scheduled intervals. If contaminant concentrations are found to exceed these limits, the system will automatically shut down.

**3.2.2.1.2 Between GAC Canisters.** Measurements of carbon tetrachloride concentrations between the primary and secondary GAC canisters will be taken at 2-h scheduled intervals and will be used to trend the loading of the primary GAC canister. This trending will be used to predict when a canister will experience breakthrough and thereafter saturation. Saturation of a GAC canister occurs when the inlet contaminant concentrations approximately equal the outlet concentrations, indicating that the GAC has exhausted its adsorptive capacity. Once the primary GAC canister becomes saturated, it is removed from service and replaced with a fresh (new or regenerated) GAC canister.

**3.2.2.1.3 Stack.** Effluent concentrations of carbon tetrachloride exiting an SVE system stack shall be maintained below 25 ppmv for a 14-m<sup>3</sup>/min (500-ft<sup>3</sup>/min) effluent stream or 10 ppmv for a 42-m<sup>3</sup>/min (1,500-ft<sup>3</sup>/min) effluent stream. Sampling at the stack will be required at 2-h scheduled intervals to ensure that the limits are not exceeded. During an automated sampling mode, a reliable instrument for measuring carbon tetrachloride concentrations will be placed at the SVE system(s) stack and will be interlocked to shut down the SVE system(s) in the event that maximum allowable concentrations are exceeded. The stack sampling frequency was determined based on the requirement that a minimum of two GAC canisters [containing at least 680 kg (1,500 lb) of GAC each] be in place per treatment train.

**3.2.2.2 Other Chemical Constituents.** The principal contaminants of concern found within the subsurface consist of VOCs (principally carbon tetrachloride, chloroform, and methylene chloride), butyl alcohol (a degradation product of tributyl phosphate and dibutyl-butyl phosphonate, ketones (such as methyl ethyl ketone), and methane. Characterization analyses are performed for these contaminants prior to starting full-scale vapor extraction from a different well field or newly developed wells within the existing well field. Vapor samples may be taken from wells and analyzed for these contaminants at the discretion of the project engineer/scientist.

**3.2.2.3 Radon.** Radon is a naturally occurring gas present in varying quantities in all soils. Since GAC adsorbs radon and thus concentrates it, the radiation dose to site workers may be of concern. For this reason, gamma radiation monitoring of the GAC canisters will be conducted. Additionally, the cognizant engineer/scientist may request monitoring of radon loading within the GAC treatment canisters for research purposes.

**3.2.2.4 Radioactive Particulates.** Radioactive particulates including plutonium and americium could be transported on soil particles, but are not expected to be transported into the vapor stream during SVE system(s) operations. However, precautions shall be taken to monitor the system for radiological contamination. A continuous sample of the vapor stream will be drawn through sample filter paper and analyzed by radiological control technicians on a weekly basis for the presence of particulate radionuclides.

### **3.2.3 Differential Flow**

Flowmeters located upstream of the primary canister and downstream of the final GAC canister are used to monitor for leaks in the system piping and hoses that are under positive pressure (downstream from the blower). The flowmeters shall be interlocked to shut down the blower if there is a flow difference detected greater than 50% of the combined accuracy of the flowmeters. If the flowmeters and interlocks are not operable, the affected systems shall be shut down.

### **3.2.4 Water Separator (Knockout) Tank Liquid Level**

The water separator, or water knockout tanks, are used because of high water moisture concentrations in the soil vapor. The knockout tank will be equipped with level indication devices and, in some cases, may be directly interlocked to the system to initiate a shutdown of the system upon high water level within the tank. Periodic surveillance of the tank water level will be made, and the tank will be drained if the tank is greater than half full. Liquid drained from the water separator will be transferred to the 200-ZP-1 "Pump and Treat" system or other approved site for treatment.

## **3.3 SOIL VAPOR EXTRACTION OPTIMIZATION**

Soil vapor extraction characterization data from each well will be used to optimize extraction of carbon tetrachloride from the vadose zone. Specific objectives include the following:

- Measure the existing concentrations of carbon tetrachloride and other contaminants in the subsurface
- Investigate and trend how the existing concentrations of carbon tetrachloride and other contaminants vary with time
- Evaluate the impact of vapor extraction on the distribution and concentrations of carbon tetrachloride and other contaminants in the subsurface
- Use a numerical vapor flow model to indicate flow paths through the vadose zone and assess the zone of influence for the SVE system

- Evaluate the correlation between carbon tetrachloride concentration in the soil to that in the vapor.

Initial SVE characterization tests will be used primarily for determining baseline contaminant levels. This information will be used to determine initial parameters of operation such as the estimated volume of vapor required to achieve the intended removal rates and the amount of GAC required for contaminant treatment. Further data collection during full-scale SVE operations will be used to study the effect of varying vacuums, flow rates, well locations, and depths in the extraction wells on vacuum pressures, contaminant travel, and carbon tetrachloride concentrations observed in the well field. Trending analyses of the data will be used to determine if carbon tetrachloride concentrations are increasing or decreasing with the varying parameters. This will determine the configuration of SVE operations required to optimize contaminant extraction.

#### **4.0 ROUTINE MAINTENANCE**

System instrument calibration and equipment maintenance will be performed on a routine and as-needed basis. Maintenance activities shall be scheduled to allow minimal system downtime and shall be performed according to manufacturers' recommended instructions. The SVE system and component designs allow easy access for maintenance. This includes provisions for accessing the equipment, removing equipment and material, lubricating the equipment, and performing diagnostic tests. Table 3 lists equipment requiring routine maintenance and the suggested frequency of maintenance required.

Table 3. Routine Maintenance Equipment.

| Component   | Frequency                           | Required Maintenance                |
|---|-------------------------------------|-------------------------------------|
| Motor   | Quarterly                           | Visually inspect                    |
| Blower (28- and 14-m <sup>3</sup> /min units)                     | 500 h (3-wk continuous operation)   | Change lubricant and clean breather |
| Blower (42-m <sup>3</sup> /min unit)                              | 4000 h (24-wk continuous operation) | Change lubricant and clean breather |
| Belts   | Quarterly                           | Visually inspect                    |
| Water separator (knockout) tank liquid level sensor and interlock | As needed                           | Drain accumulated water             |
| Heat exchangers (air-to-air) 14 m <sup>3</sup> /min only          | Annual                              | Oil motors                          |
| HEPA filters  | Monthly                             | Check differential pressure gages   |
| HEPA filters  | Annual                              | Aerosol test                        |
| HEPA = high-efficiency particulate air                            |                                     |                                     |

#### 4.1 INSTRUMENT CALIBRATIONS

Instrument calibrations are performed on a routine and as-needed basis and are performed according to manufacturers' instructions. Instruments that require routine calibration and the required frequency are as follows:

- Alpha CAM - Semiannually (if used)
- Beta CAM - Semiannually (if used)
- Radon monitor - Annually (if used)
- Carbon tetrachloride and other VOC sampler/analyzer - Annually
- Volumetric flowmeters - Annually.

Other instruments that require calibration on an as-needed basis are the following:

- Pressure gages and transducers
- Vacuum gages and transducers
- Well manifold flowmeters
- Humidity sensors

- Thermocouples
- Temperature gages.

As part of the calibration maintenance, weekly operability checks and monthly interlock response checks are required. Test data shall be properly recorded and documented according to operating procedures. The equipment to be tested is as follows.

- Carbon tetrachloride sampler/analyzer
- Flowmeters located upstream (after blower motor) of the primary GAC canister and downstream of the final GAC canister.

#### **4.2 PREVENTIVE MAINTENANCE**

Preventive maintenance includes periodic inspection, testing, and system overhaul on a regular basis, following manufacturers' instructions. This reduces in-service failures and retards system deterioration. Equipment listed in Table 3 should be visually inspected (if feasible) at least monthly for signs of wear, leaks, corrosion, or any other indication that may be applicable.

#### **4.3 SPARE PARTS LIST AND SITE INVENTORY REQUIREMENTS**

Consumable spare parts (e.g., drive belts, fuses, filter elements) may be kept on hand at the SVE site either in the office trailer or in storage boxes. Spare carbon tetrachloride samplers/analyzers will be maintained by the system engineer. Some of the larger, more critical equipment items such as the blower motor, blower, alpha and beta CAMs, and pressure and flow instrumentation will also be maintained as spares.

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