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Test Plan for the FY 1997 Rebound Study at the Carbon Tetrachloride Soil Vapor Extraction Site

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

Bechtel Hanford, Inc.
Richland, Washington

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Author(s): V. J. Rohay
R. K. Tranbarger

Approval: J. D. Isaacs, Groundwater Project Engineer

for JDI — 11/12/96

Signature — Date

G. C. Henckel III, Manager, Groundwater Project

11/12/96

Signature — Date

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Author
V. J. Rohay
R. K. Tranbarger

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1.0 INTRODUCTION

This test plan describes the strategy and field measurements designed to evaluate the potential rebound of carbon tetrachloride vapor concentrations following cessation of soil vapor extraction (SVE) operations at the 200-ZP-2 Operable Unit in the 200 West Area of the Hanford Site. Soil vapor extraction was initiated in February 1992 as the preferred remedial alternative of the Carbon Tetrachloride Expedited Response Action for removal of carbon tetrachloride from the unsaturated zone beneath the primary carbon tetrachloride disposal sites. The magnitude, extent, and rate of rebound in carbon tetrachloride vapor concentrations will help determine the availability of additional carbon tetrachloride for removal using SVE. At the conclusion of the field measurements, a report will be completed to evaluate the results of the rebound study.

1.1 PURPOSE AND SCOPE OF REBOUND STUDY

The SVE systems are being shut down during the 1996-1997 winter months to minimize the generation of water condensate. The rebound study is being conducted during this period to optimize future SVE system operations and performance goals.

The purpose of the rebound study is to evaluate the magnitude, extent, and rate of increase in carbon tetrachloride vapor concentrations in the unsaturated zone soils after the SVE systems are taken off-line. The rebound study will be conducted by periodically measuring carbon tetrachloride concentrations at selected subsurface monitoring points.

The scope of the rebound study includes all unsaturated zone soils within the volume of influence of the three SVE systems.

1.2 BACKGROUND

Carbon tetrachloride, discharged to the soil column from 1955 to 1973, was observed throughout the 66-m-thick unsaturated zone during site characterization from 1991 to 1993. Soil vapor extraction was initiated in February 1992 to remove carbon tetrachloride. Since then, carbon tetrachloride concentrations in extracted soil gas have decreased significantly.

1.2.1 Carbon Tetrachloride Waste Disposal

A total of 570,000 to 920,000 kg of carbon tetrachloride is estimated to have been discharged to the soil column between 1955 and 1973 in the 200 West Area (Table 1) (DOE-RL 1991). The three primary carbon tetrachloride disposal sites during this period were the 216-Z-9 Trench, the 216-Z-1A Tile Field, and the 216-Z-18 Crib (Figure 1). In addition, carbon tetrachloride was discharged in lesser amounts to the 216-Z-12 Crib.

Table 1. Carbon Tetrachloride Inventory in Primary Disposal Sites.

Site	Carbon Tetrachloride (kg)		
	Estimated Mass Discharged 1955 - 1973[a]	Estimated Mass Lost to Atmosphere 1955 - 1990[b]	Mass Removed Using Soil Vapor Extraction 1992 - 1996 (September 30)[c]
216-Z-1A	270,000	56,700	21,950[d]
216-Z-18	170,000	35,700	
216-Z-9	130,000 - 480,000	27,300 - 100,800	50,330

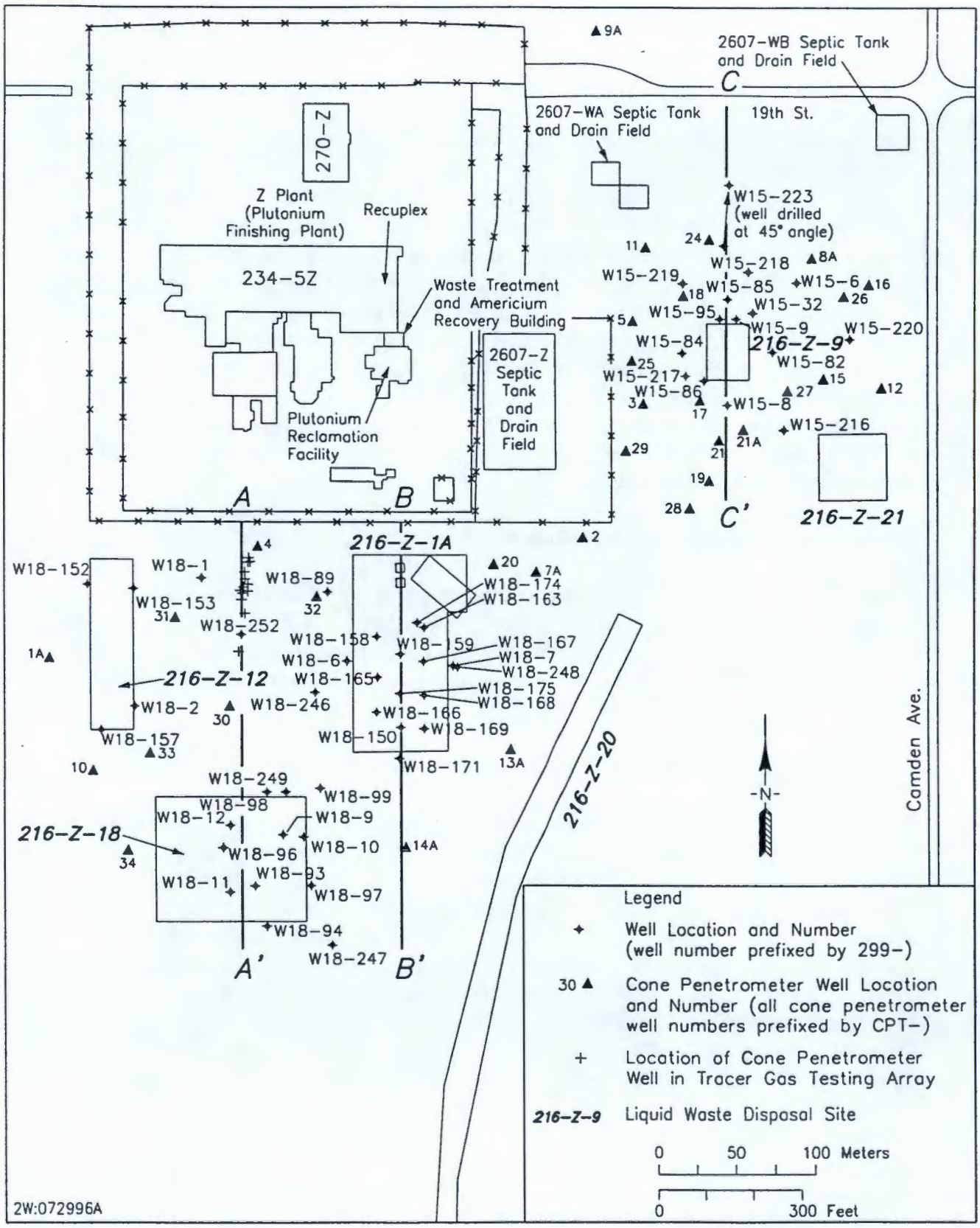
[a]Based on DOE-RL (1991).

[b]Based on WHC (1993).

[c]Based on 200-ZP-2 Project Weekly.

[d] Includes mass removed from 216-Z-12 site; reported as a combined value because the wellfields overlap.

Figure 1. Carbon Tetrachloride Vapor Extraction Site.



1.2.2 Characteristics of Unsaturated Zone

The unsaturated zone underlying the three principal carbon tetrachloride disposal sites currently averages 66 m thick and consists of gravel-, sand-, and silt-dominated sedimentary intervals. For discussion purposes, the unsaturated zone has been divided into seven informal hydrogeologic units. Although the thickness and configuration of these units vary laterally across the carbon tetrachloride vapor extraction site, average values are used to summarize the characteristics of the unsaturated zone (Table 2).

The presence of the less permeable Hanford lower fine and Plio-Pleistocene ("caliche") intervals within the sequence of more permeable sand and gravel layers affects both the distribution and remediation of carbon tetrachloride in the unsaturated zone. The lower permeability of these units probably slowed the vertical migration of organic and aqueous liquid and vapor phases and most likely temporarily diverted them laterally away from the waste disposal sites. Because this relatively low-permeability zone also has greater soil particle surface area, it potentially adsorbed more carbon tetrachloride. Finally, the less permeable Hanford lower fine and Plio-Pleistocene intervals effectively divide the SVE wellfield into two zones: an upper zone from the ground surface to the top of the Hanford lower fine layer and a lower zone from the bottom of the Plio-Pleistocene layer to the water table.

1.2.3 Carbon Tetrachloride Distribution

Carbon tetrachloride was found throughout the unsaturated zone underlying the three primary disposal sites during site characterization from 1991 through 1993. Laterally, the highest carbon tetrachloride concentrations in sediment samples were consistently observed at the 216-Z-9 site. Vertically, the highest concentrations at all three sites were associated with the fine-grained, less permeable Hanford lower fine and Plio-Pleistocene units (Rohay et al. 1994).

1.2.4 Vapor Extraction Wells and Monitoring Probes

There are currently 46 drilled wells available for on-line extraction and/or monitoring (Figure 1). Thirteen of these wells were drilled during 1992 and 1993 and completed as vapor extraction wells with stainless steel casing and screens; one well was drilled at a 45° incline. Thirty-three wells, drilled between 1954 and 1978 and completed with carbon steel casing, were adapted for vapor extraction by perforating the well casing using mechanical or jet perforators. Seventeen of the 46 available wells have two screened or perforated open intervals (designated U for upper and L for lower) isolated by downhole packers. Twenty-one well intervals are available at each of the three wellfields, 216-Z-18/12, 216-Z-1A, and 216-Z-9 (Figure 2). Well diameters range from 6.4 to 20 cm. Each of the three SVE systems extracts simultaneously from multiple wells open either above and/or below the Plio-Pleistocene layer.

There are 125 subsurface monitoring points at depths greater than 2 m: 11 cone penetrometer (CPT) wells, 104 soil gas probes, and 10 stainless steel tubes. A CPT was used to install 11 extraction and/or monitoring wells and 104 subsurface monitoring points emplaced at 33 locations at the carbon tetrachloride site in 1993 and 1994 (Figure 1). The 11 CPT wells are

Table 2. Characteristics of the Unsaturated Zone Underlying the Carbon Tetrachloride Disposal Sites.

Geologic Unit	Geologic Material	Depth (m below ground surface)	Thickness (m)	Permeability (m^2)[a]	Field Moisture Content[b] (vol %)
Hanford upper fine (H_{uf})	Gravelly sand and sand	0-6	6	1.6 E-11	5.5
Hanford upper coarse (H_{uc})	Gravel	6-16	10	4.1 E-10	4.6 - 5.7
Hanford fine (H_f)	Sand	16 - 30	14	1.6 E-11	1.5 - 19.7
Hanford lower coarse (H_{lc})[c]	Sandy gravel	30 - 34	4	3.3 E-10	5.1 - 5.3
Hanford lower fine (H_{lf})[c]	Interbedded silt and fine sand	34 - 38	4	1.6 E-12	6.1 - 11.8
Plio-Pleistocene (PP)	Fine sandy silt/ carbonate-cemented sandy gravel ("caliche")	38 - 45	7	8.2 E-13	8.1 - 38.5
Ringold Unit E (R_{ge})	Gravel	45-64	19	1.3 E-10	3.4 - 17.6

[a]Calibrated values based on numerical airflow model (Rohay and McMahon 1996).
[b]Source: Wright et al. (1994).
[c]Not present underlying 216-Z-9 Trench.

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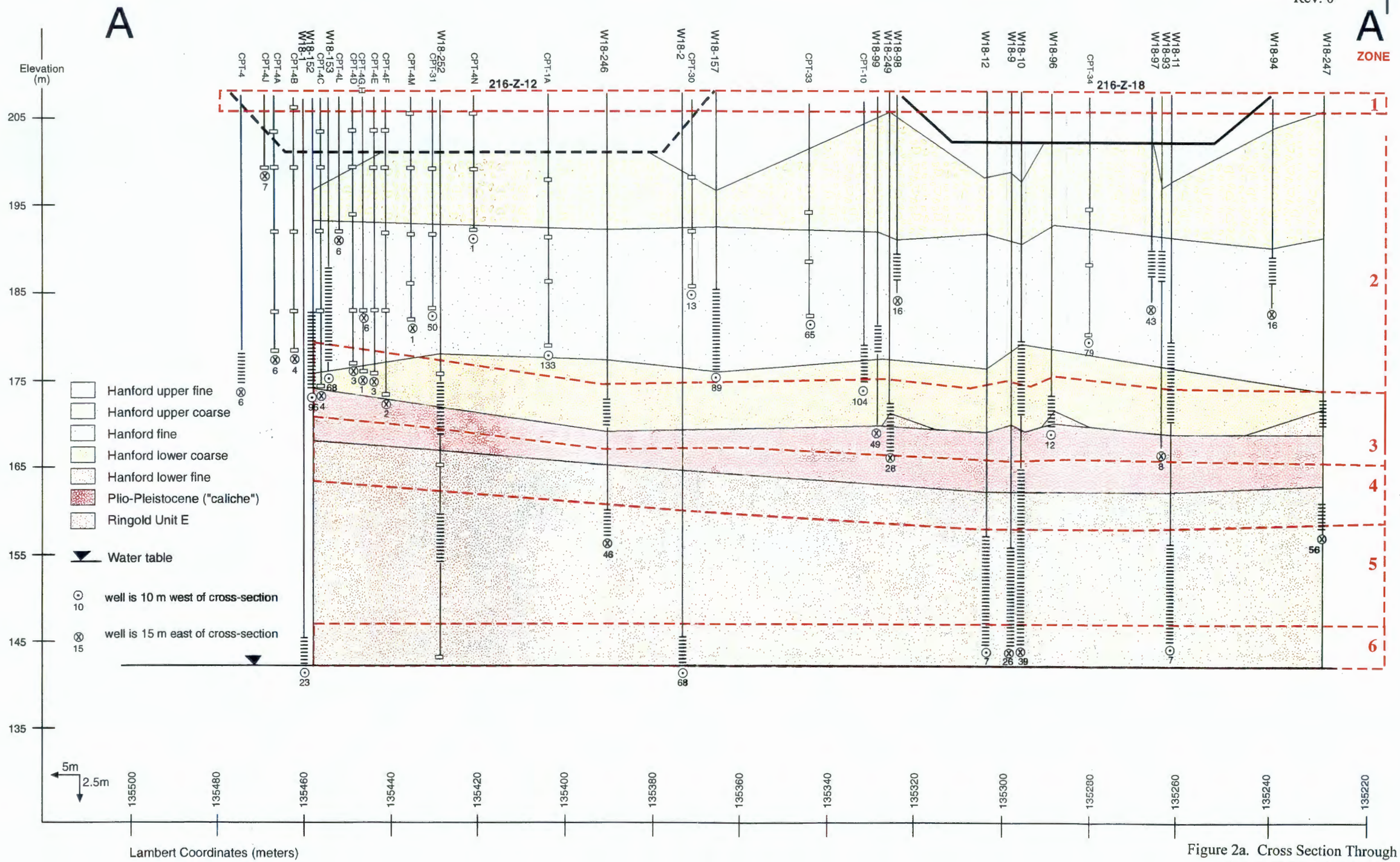


Figure 2a. Cross Section Through the 216-Z-18/Z-12 Wellfield. (Location shown in Figure 1).

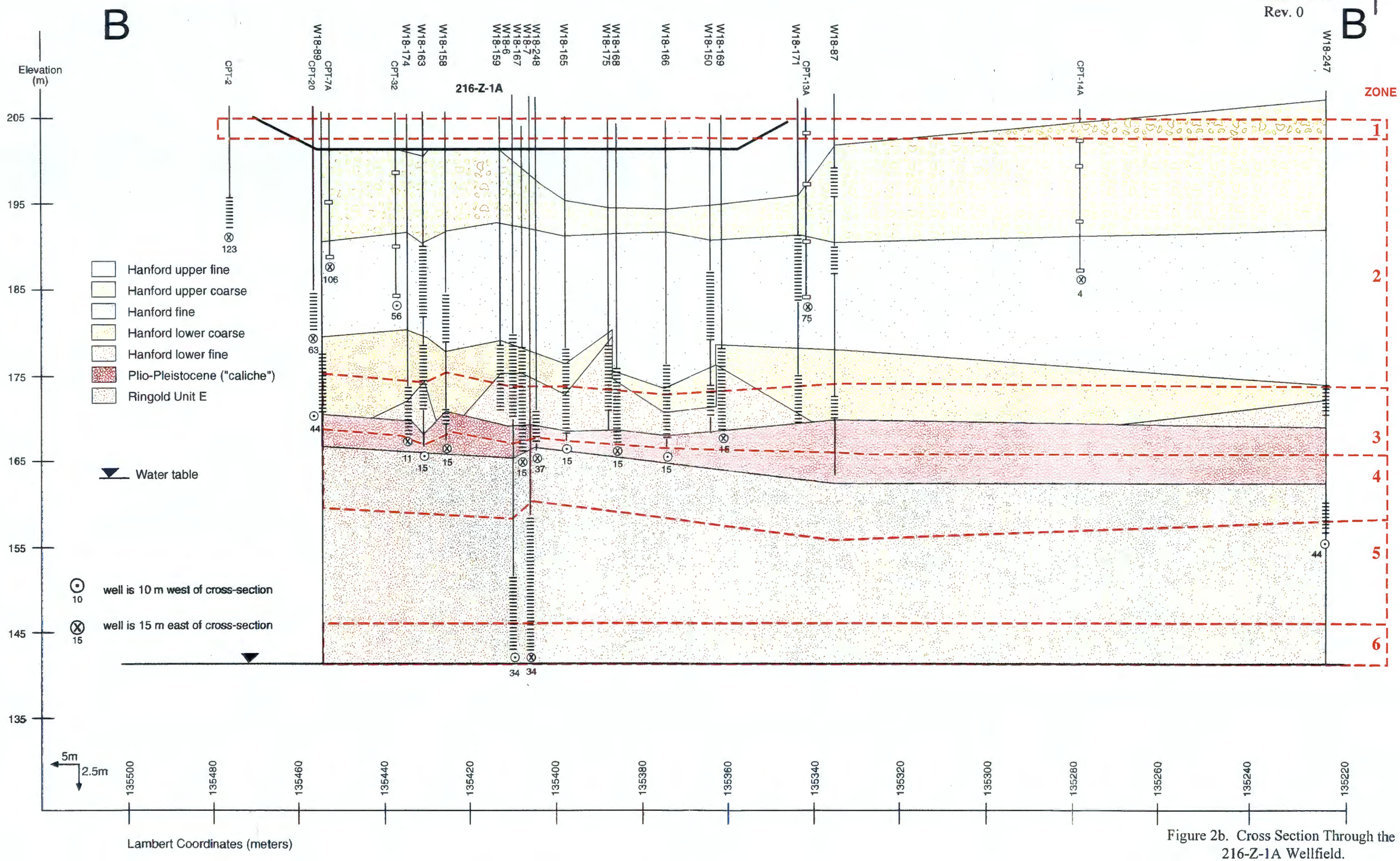


Figure 2b. Cross Section Through the 216-Z-1A Wellfield.
(Location shown in Figure 1)

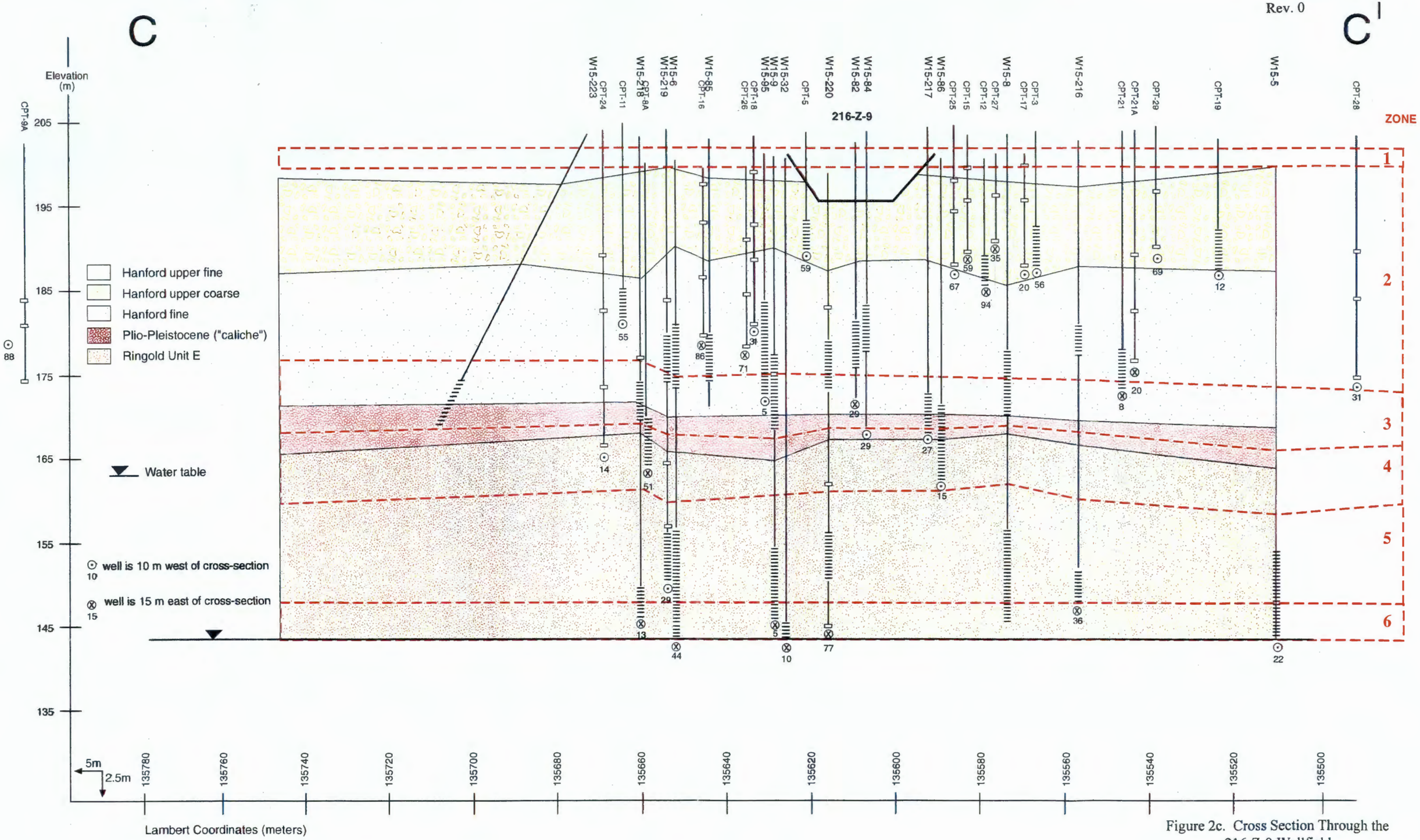


Figure 2c. Cross Section Through the 216-Z-9 Wellfield.
(Location shown in Figure 1)

constructed of 2.5-cm-diameter carbon steel rods. The open interval, located at the bottom of each well, consists of 4 m of rod machined with thirty-three 0.6-cm-diameter holes per each 1-m interval. Each of the 104 subsurface monitoring points consists of a sintered metal monitoring screen (12.7 cm long with an outside diameter of 1.3 cm) attached to a tube that runs to the surface. Each monitoring screen is surrounded by a column of up to 1.2 m of clean sand; bentonite is added to the column between sampling points to isolate them. Up to five monitoring screens were installed per location at various depths (Figure 2). Ten stainless steel tubes were strapped to the outside of the casing of four drilled wells during installation in 1993 to allow monitoring above and below the screened intervals (Figure 2).

There are 73 shallow soil gas probes at depths ranging from 1.2 to 1.8 m below ground surface (Figure 3). The network was installed between 1991 and 1995.

1.2.5 Carbon Tetrachloride Remediation Using Soil Vapor Extraction

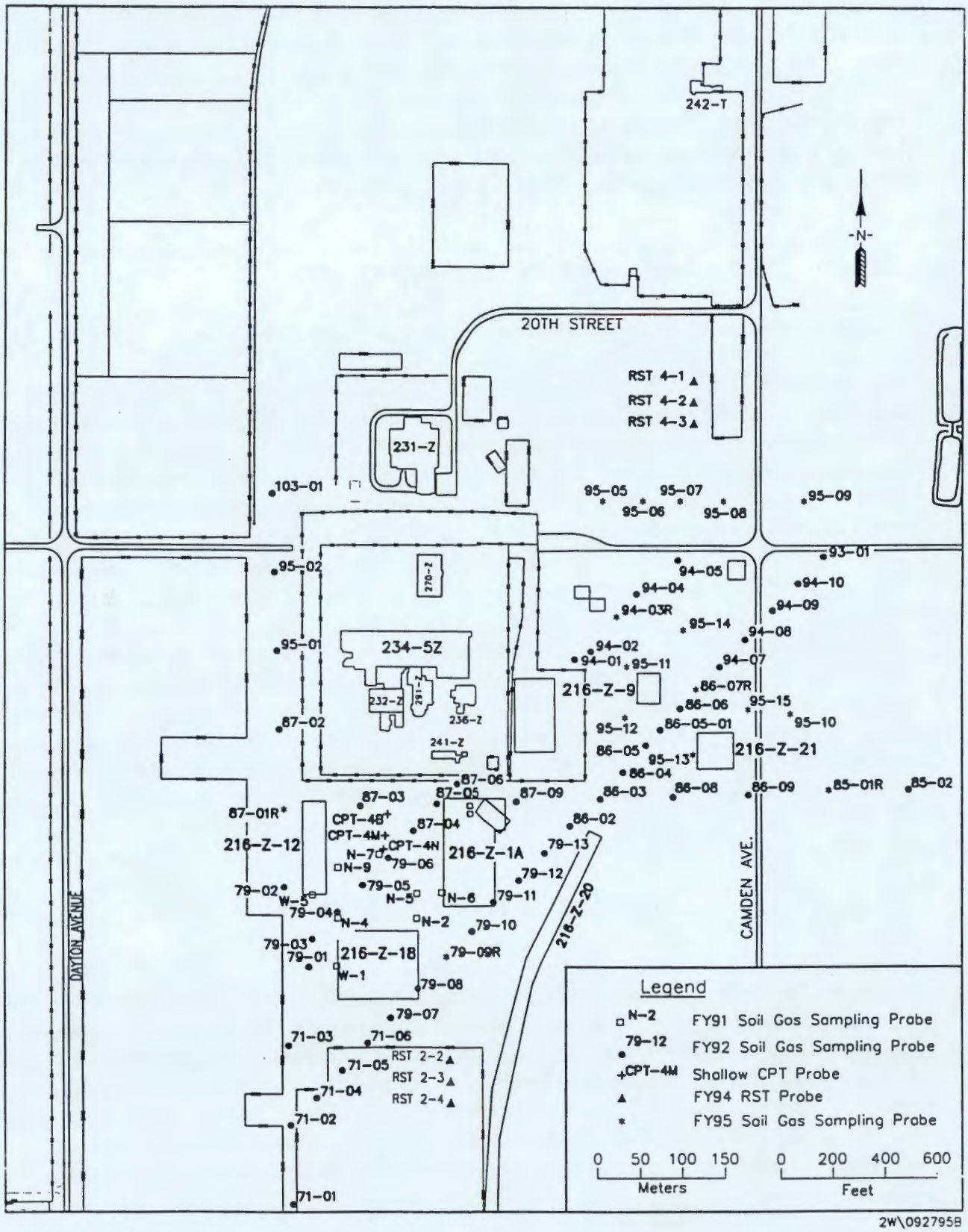
Soil vapor extraction was initiated in February 1992 to remove carbon tetrachloride from the unsaturated zone underlying the primary disposal sites. As of September 30, 1996, 72,280 kg of carbon tetrachloride had been removed from the subsurface (Table 1). The mass of carbon tetrachloride removed from the 216-Z-1A, 216-Z-18, and 216-Z-12 sites is reported as a combined value because wells from the 216-Z-1A and 216-Z-18 sites were undergoing extraction simultaneously using one SVE system in 1992 and 1993, and wells from the 216-Z-18 and 216-Z-12 sites have been undergoing extraction simultaneously using another SVE system since 1995. The wellfields at these sites overlap.

Carbon tetrachloride concentrations in extracted soil vapor have decreased significantly at all three wellfields during operation of the SVE systems. The most dramatic decrease has been at the 216-Z-9 wellfield, where carbon tetrachloride concentrations in extracted soil vapor have declined from approximately 30,000 ppmv in 1993 to 30 ppmv in 1996. In comparison, carbon tetrachloride concentrations in soil vapor extracted from the 216-Z-1A wellfield have declined from approximately 1,500 ppmv in 1992 to 20 ppmv in 1996.

2.0 REBOUND PROCESS DESCRIPTION

Rebound refers to the increase in soil vapor contaminant concentrations following cessation of vapor extraction operations. Vapor concentrations will rebound if diffusion and/or desorption is limiting the contaminant removal rate. The source of the additional carbon tetrachloride is either desorption and diffusion from the sediment particle micropores, desorption and diffusion from soil moisture or the exterior of sediment particles, or diffusion through a low-permeability zone. The magnitude of the concentration rebound becomes smaller as contaminant removal progresses, and the rate of the rebound becomes slower as diffusion distances lengthen.

Figure 3. Location of Shallow Soil Gas Probes at the Carbon Tetrachloride Site.



Increases in contaminant vapor concentrations may also be caused by diffusion of the contaminant from soils beyond the zone of influence of the SVE systems, from soils within the zone of influence but bypassed due to nonuniform induced airflow, and from groundwater.

The magnitude of the contaminant concentration rebound can be used to indicate the amount of potentially accessible contamination in the vapor phase. An order-of-magnitude increase in concentration would constitute significant rebound. The lateral and vertical extent of the rebound concentration can be used to indicate the distribution of the contaminant sources. The rate of concentration rebound at several monitoring points may help identify the location of the contaminant source.

The length of time required to achieve equilibrium may be very long (months to years) because of the slow process of diffusion out of the intraparticle micropores into the interparticle pore spaces. However, if the vapor concentrations increase rapidly and then approach equilibrium asymptotically, extrapolation to the equilibrium concentration may be possible.

Indications of the time required for rebound to occur when SVE inlet concentrations are less than 100 ppmv are provided by comparing soil gas concentrations before and after system shutdowns during fiscal year 1996. At the 216-Z-9 site, nine well intervals were on-line before and after an 11-day shutdown in December 1995. The combined concentration measured at the vapor extraction system inlet increased from 48 ppmv to 62 ppmv (Figure 4). Following the same 11-day shutdown, the combined concentrations from six on-line wells at the 216-Z-1A site increased from 37 ppmv to 49 ppmv (Figure 5). However, concentrations at the 216-Z-9 system only increased from 38 to 40 ppmv following an 8-day shutdown in July 1996 (Figure 6). In July 1996, the combination of on-line extraction wells was slightly different and the concentrations were slightly lower than in December 1995.

At both 216-Z-9 and 216-Z-1A, the initial concentrations after restart were less than the maximum concentration 1 or 2 days later, possibly suggesting that the source of the rebounding vapor concentration is at some distance from the wells. If the source of the contaminant is local (i.e., near the well), arrival of a peak concentration may be observed at the well; the time delay can be used to estimate the distance to the source and the dilution volume. If the source is distant, a peak concentration may not be observed at the well because of dilution resulting from mixing with uncontaminated air along the travel path.

Based on the tracer gas testing conducted by Washington State University (Barna 1995), the typical soil gas velocity ranged from 0.24 m/hr to 0.37 m/hr at flows ranging from 4.4 m^3/min to 6.7 m^3/min, respectively, at a well in the 216-Z-1A wellfield. At the average rate of 0.3 m/hr, a delay of 1 to 2 days corresponds to a distance of 7 to 15 m.

Tracer gas testing at the 216-Z-9 wellfield indicated a much higher subsurface velocity, 16.5 to 20.4 m/hr at a flow rate of 5.1 m^3/min (Barna 1995), which corresponds to a distance of approximately 440 m in 24 hours. The vacuum applied to the 216-Z-9 extraction well (19.9 kPa) was larger than the vacuum applied to the 216-Z-1A extraction well (13.0 kPa), and the induced vacuum at the 216-Z-9 tracer release site (3.2 kPa) was much larger than the induced vacuum at

Figure 4. Carbon Tetrachloride Concentration Rebound at the 216-Z-9 Soil Vapor Extraction System, December 1995 - January 1996.

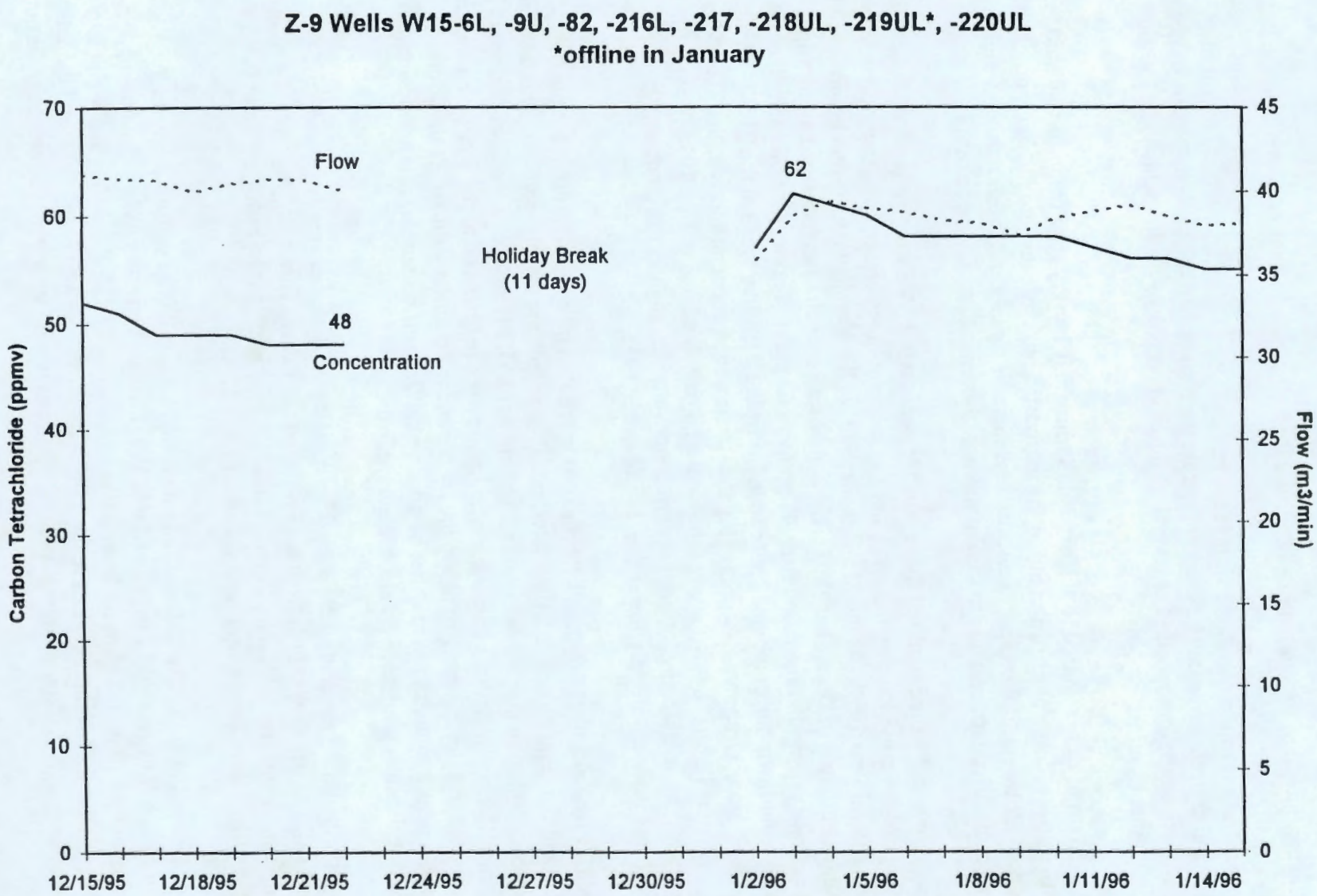
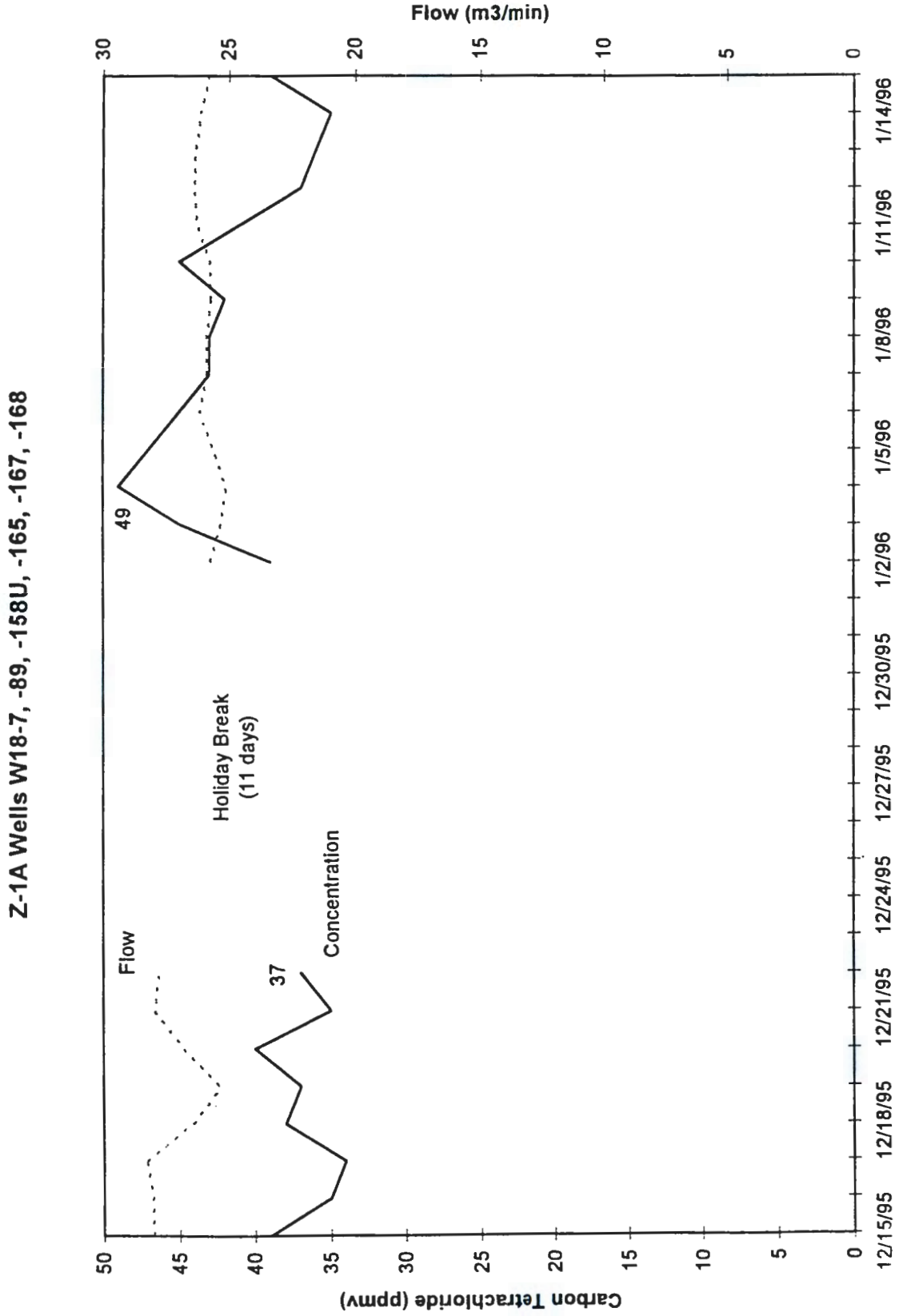


Figure 5. Carbon Tetrachloride Concentration Rebound at the 216-Z-1A Soil Vapor Extraction System, December 1995 - January 1996.



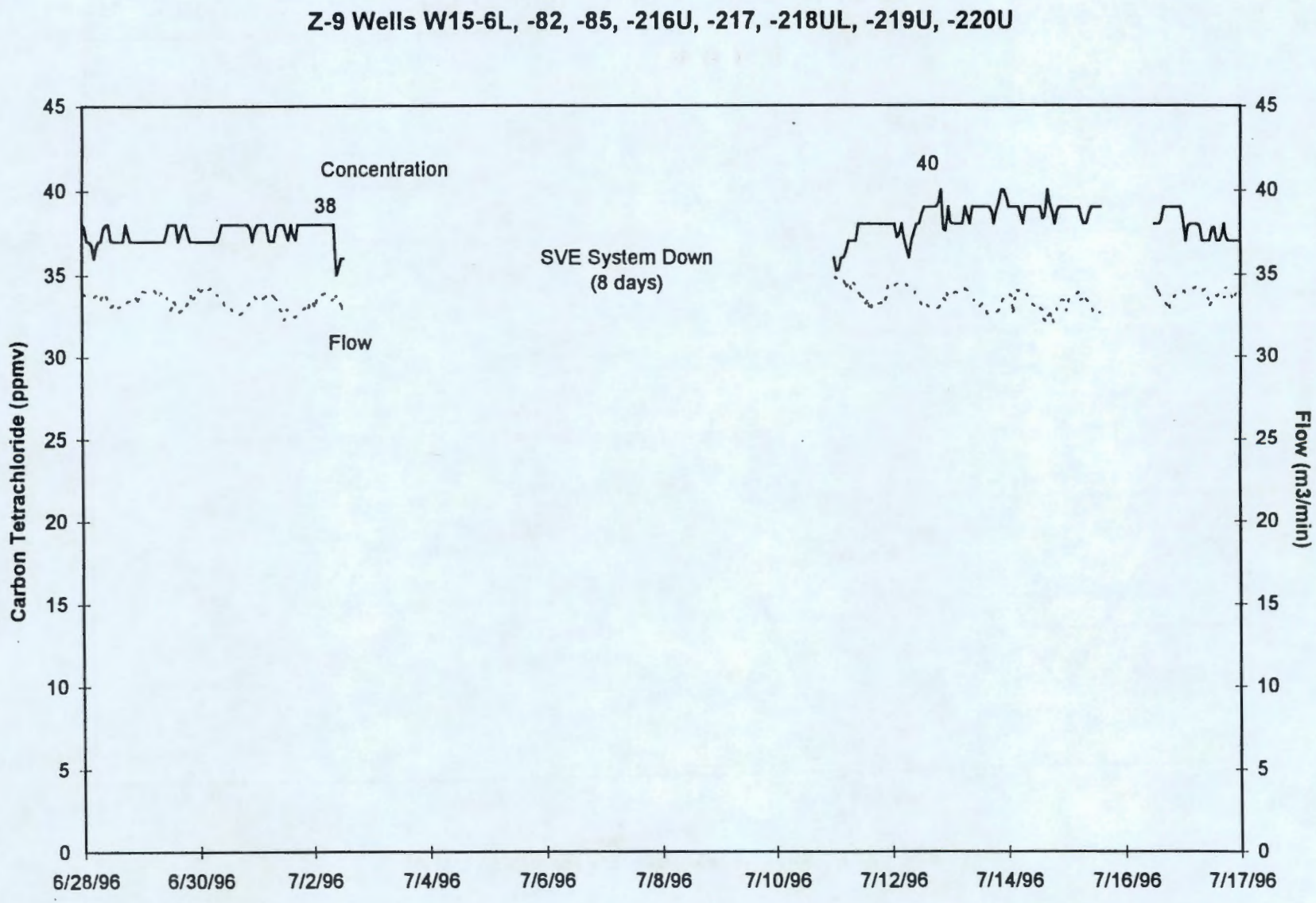


Figure 6. Carbon Tetrachloride Concentration Rebound at the 216-Z-9 Soil Vapor Extraction System, July 1996.

the 216-Z-1A tracer release site (0.3 kPa). Induced vacuums at monitoring wells close to the 216-Z-9 site are typically higher than those away from the disposal site (Rohay and McMahon 1996).

Concentration data observed at well W15-223 at the 216-Z-9 site also provide an example of rebound. Concentrations at this well decreased from 761 ppmv to 22 ppmv after continuous extraction from February 14 through June 27, 1995 (Figure 7). After being off-line for 85 days, concentrations at the well (sampled using the SVE system) had increased to 63 ppmv. After 7 days of extraction, concentrations had decreased to 18 ppmv, and the well was again taken off-line. After 216 days, the carbon tetrachloride concentration at this well was 64 ppmv; after 368 days, the concentration was 59 ppmv. This pattern suggests that 85 days was long enough for the vapor concentrations to rebound. The actual elapsed time to achieve the rebound concentration may have been significantly less. During the time that W15-223 was off-line, it was verified that this well was beyond the zone of influence of the SVE system during June 1996.

3.0 DATA OBJECTIVES AND PARAMETERS

A data quality objective (DQO) process was used by the 200-ZP-2 project team to establish the rebound study data needs. The resulting agreements on policy and technical issues are summarized in this test plan and will be documented in a separate memorandum. Data collected during the rebound study will be used to support decisions related to the following issues.

1. **Amount of additional carbon tetrachloride available for removal using SVE.** This issue will be addressed by monitoring both the magnitude and rate of changes in carbon tetrachloride concentration throughout the SVE area.

2. **Distribution of remaining carbon tetrachloride sources.** This issue will be addressed by monitoring carbon tetrachloride concentrations at selected depths within the unsaturated zone and at various distances from the source cribs.

3. **Evaluation of carbon tetrachloride transport between the unsaturated and saturated zones.** This issue will be addressed by evaluating carbon tetrachloride vapor concentrations collected near the water table as part of the 200-ZP-2 rebound study and by evaluating carbon tetrachloride groundwater concentrations collected by other projects (e.g., 200-ZP-1 pump-and-treat remediation). Data trends from the two independent sampling programs will be compared to detect possible correlations.

4. **Effectiveness of using SVE for plume control in the unsaturated zone.** This issue will be addressed by collecting carbon tetrachloride concentration data at the periphery and the core of the vapor extraction area to evaluate lateral transport of carbon tetrachloride vapor and at shallow soil gas probes to evaluate vertical transport of carbon tetrachloride through the soil surface to the atmosphere.

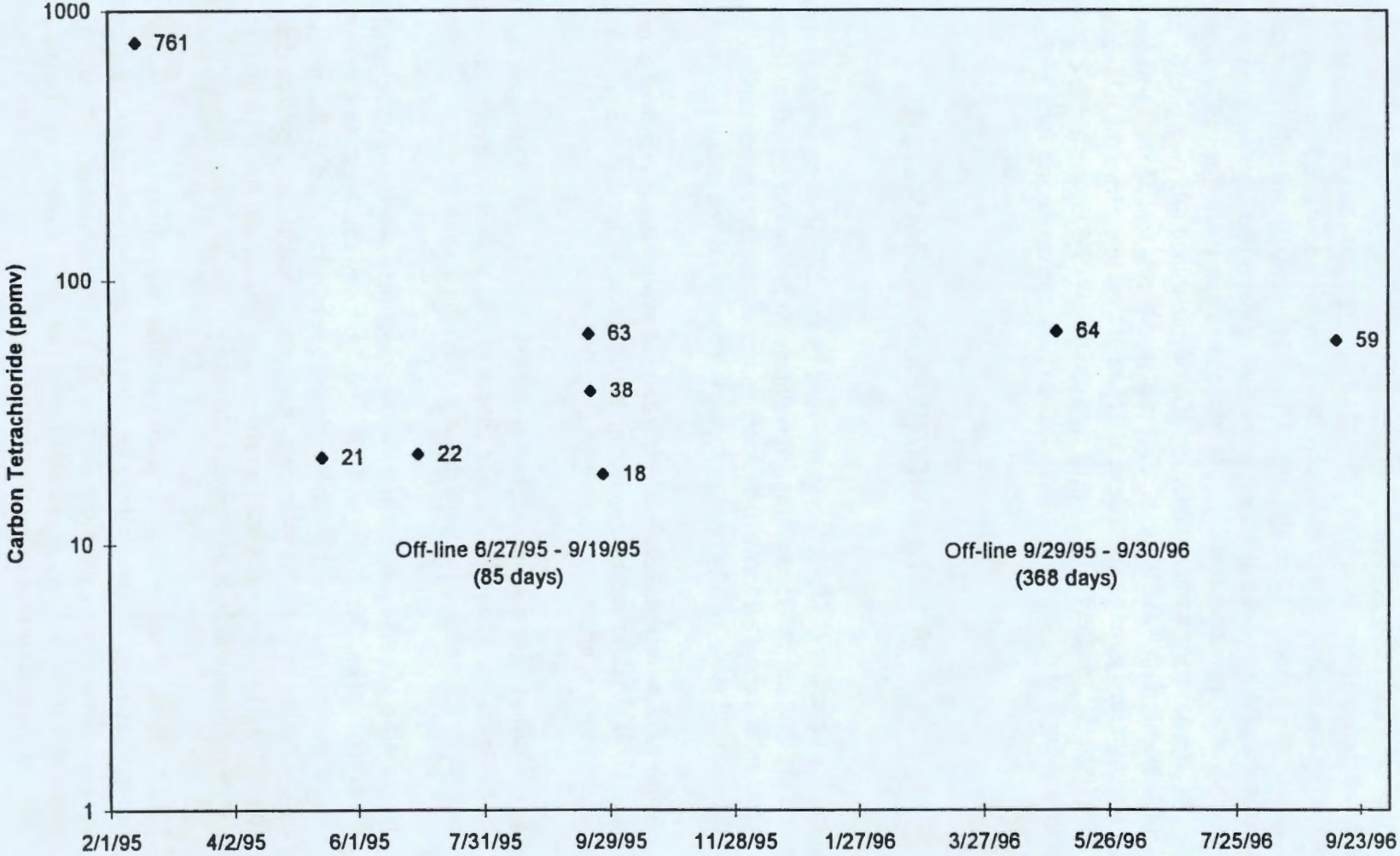


Figure 7. Carbon Tetrachloride Concentration Rebound at Well W15-223 at the 216-Z-9 Site, 1995 -1996.

5. **Optimization of current SVE system operations**. This issue will be addressed by monitoring the magnitude and rate of changes in carbon tetrachloride concentration within the SVE area during the rebound study and by comparing inlet SVE concentration data before and after the rebound study. The data will be used to compare carbon tetrachloride removal rates expected for continuous (constant), pulsed (fluctuating), or intermittent (periodically on and off) SVE operations. The rate of rebound will be used to suggest a reasonable frequency (e.g., weekly or monthly) for cyclic operations.

6. **Identification and achievement of cleanup goals**. The carbon tetrachloride rebound study data will be used to support discussions related to identifying target carbon tetrachloride cleanup levels.

7. **Selection of final remedy for carbon tetrachloride in the unsaturated zone**. The rebound in carbon tetrachloride concentration will provide information to assess the overall effectiveness of SVE for unsaturated zone remediation. Data gaps in the information needed to support selection and operation of the final cleanup technology will be identified.

To address these issues, the objectives of the rebound study are to obtain the following data:

- Baseline carbon tetrachloride concentrations in extraction wells when the SVE systems are taken off-line

- Magnitude of change in carbon tetrachloride concentrations while the SVE systems are off-line

  - Within the zone of influence of the SVE systems
  - At the perimeter or beyond the zone of influence of the SVE systems
  - Within geologic units of higher permeability
  - Within geologic units of lower permeability
  - Within soil near the ground surface
  - Within soil near the water table

- Rate of change in carbon tetrachloride concentrations while the SVE systems are off-line

  - Within the zone of influence of the SVE systems
  - At the perimeter or beyond the zone of influence of the SVE systems
  - Within geologic units of higher permeability
  - Within geologic units of lower permeability
  - Within soil near the ground surface
  - Within soil near the water table

- Rate of decrease in carbon tetrachloride concentrations in extraction wells when operation of the SVE systems resumes

- Sources of variability in carbon tetrachloride concentrations resulting from natural phenomena (e.g., barometric pressure fluctuations), sampling method, and/or analytical method

Specific parameters needed to assess the rebound include the following:

- Sample location
- Sample depth
- Sample date and time of day
- Carbon tetrachloride concentration
- Barometric pressure
- Subsurface-surface differential pressure.

The type of instruments used during the rebound study, and their factory-specified resolution and accuracy, will be recorded in the field logbook for this study. Calibrations for the concentration and pressure monitoring instruments will be current; calibration expiration dates will be recorded in the field logbook. Instruments will be selected to meet or exceed the desired resolutions listed below:

Measurement	Expected Range	Desired Resolution
Carbon tetrachloride concentration	0 - 200 ppmv	+/- 5 ppmv
Barometric pressure	80 - 110 kPa	+/- 0.3 kPa
Subsurface differential pressure	-2.5 - 2.5 kPa	+/- 0.02 kPa

3.1 AVAILABLE SOIL GAS SAMPLE LOCATIONS AND DEPTHS

Soil gas samples can be obtained from (1) vapor extraction wells, (2) deep soil gas probes and wells installed using the CPT, and (3) shallow soil gas probes (Figures 1 and 3). In addition, four of the vapor extraction wells have stainless steel tubes strapped to the outside of the casing. Total available sampling locations at the two wellfields are summarized in Table 3.

Table 3. Summary of Available Sampling Locations at Z-1A/18/12 and Z-9.

Sample Location	Well Intervals	CPT Probes/Wells >2 m Deep	Stainless Steel Tubes	Soil Gas Probes <2 m Deep
Z-1A/18/12	39	71	3	42
Z-9	20	44	7	31

Vapor extraction wells and stainless steel tubes have open intervals in five geologic layers: Hanford fine (Hf), Hanford lower coarse (Hlc), Hanford lower fine (Hlf), Plio-Pleistocene (PP), and Ringold Unit E (Rge) (Figure 2, Table 4). The deep CPT soil gas probes do not extend below the Plio-Pleistocene layer (Figure 2).

Radioactive contamination by alpha-emitting isotopes has been identified at 3 of the 46 extraction wells drilled or perforated at the vapor extraction sites (W15-8, W18-150, W18-175). The five open intervals in these wells were not considered for sampling during the rebound study to avoid potential contamination of personnel and equipment. To increase the number of wells available for sampling in the unsaturated zone near the water table, one additional well at the Z-9 site (W15-32) and two additional wells at the Z-1A site (W18-1, W18-2) have been included, although they have not been used for vapor extraction. Open intervals in two 216-Z-18 wells do not produce airflow in response to applied vacuums and are presumed to be effectively sealed (W18-10U, W18-247U).

The locations of the vapor extraction wells have been surveyed to the nearest 0.01 m. However, the locations of the CPT probes have only been estimated; locations of individual probes shown in Figure 1 may be off by as much as 10 m and will be surveyed as part of the rebound study. Shallow soil gas probe locations were measured from known points using a transit or compass and a tape and are probably accurate within 2 m.

3.2 SELECTED SOIL GAS SAMPLE LOCATIONS AND DEPTHS

Soil gas sampling locations and depths were selected to address the issues identified in the DQO process (Section 3.0). Soil gas samples will be collected both close to the source cribs and at the perimeter of the zone of influence of the SVE system. The depths selected for measuring carbon tetrachloride rebound are listed in Table 5. To support a systematic approach to data collection, the unsaturated zone has been divided into six sampling zones (Figure 2 and Table 5).

The target depths were selected to test different zones as potential sources of carbon tetrachloride (Table 6). Concentrations in samples collected near the water table (zone 6) will be compared to the equilibrium soil vapor concentrations expected if the source were the groundwater (using Henry's law and the groundwater plume map to estimate the equilibrium concentration). Samples from fine- and coarse-grained layers (zones 3 and 4 and zones 2 and 5, respectively) will be compared to determine if carbon tetrachloride is preferentially diffusing from the fine-grained layers.

Table 4. Sampling Depths Available in Extraction Wells and Deep Soil Gas Probes. (sheet 1 of 4)

Well No.	Top of Interval (m bgs)	Bottom of Interval (m bgs)	Length of Interval (m)	Interval in Layer Hf (m)	Interval in Layer Hlc (m)	Interval in Layer Hlf (m)	Interval in Layer PP (m)	Interval in Layer Rge (m)
Z-9								
W15-6U	21.0	28.7	7.6	7.6				
W15-6L	47.0	57.8	10.8					10.8
W15-8U	28.4	34.5	6.1	6.1				
W15-8L	50.3	59.5	9.1					9.1
W15-9U	26.8	34.5	7.6	5.8			1.8	
W15-9L	49.4	57.6	8.2					8.2
W15-32	59.1	60.6	1.5					1.5
W15-82	22.9	27.4	4.6	4.6				
W15-84	22.9	27.4	4.6	4.6				
W15-85	25.3	29.9	4.6	4.6				
W15-86	32.6	41.8	9.1	1.5			3.0	4.6
W15-95	22.3	29.9	7.6	7.6				
W15-216U	21.3	24.4	3.0	3.0				
W15-216L	53.2	56.3	3.0					3.0
W15-217	32.3	36.9	4.6	2.4			2.1	
W15-218U	30.0	34.6	4.6	2.4			2.1	
W15-218L	55.0	59.6	4.6					4.6
W15-219U	26.5	31.1	4.6	4.6				
W15-219L	50.9	55.5	4.6					4.6
W15-220U	24.4	29.0	4.6	4.6				
W15-220L	47.3	51.8	4.6					4.6
W15-223	31.3	35.6	4.3	2.1			2.1	
CPT-3EX	11.8	15.8	4.0					
CPT-5EX	10.6	14.6	4.0					
CPT-8AEX	30.4	34.4	4.0					
CPT-9A	18.3							
CPT-9A	21.3							
CPT-9A	27.7							
CPT-11EX	18.9	22.9	4.0					
CPT-12EX	10.3	14.3	4.0					
CPT-15	3.7							
CPT-15	7.9							
CPT-15	14.0							
CPT-16	3.0							
CPT-16	7.6							
CPT-16	13.7							
CPT-16	19.8							
CPT-17	3.0							
CPT-17	7.6							
CPT-17	15.2							
CPT-18	4.6							
CPT-18	10.7							
CPT-18	15.2							
CPT-18	22.9							
CPT-19EX	10.9	14.9	4.0					
CPT-21EX	25.3	29.3	4.0					
CPT-21A	13.7							

Table 4. Sampling Depths Available in Extraction Wells and Deep Soil Gas Probes. (sheet 2 of 4)

Well No.	Top of Interval (m bgs)	Bottom of Interval (m bgs)	Length of Interval (m)	Interval in Layer Hf (m)	Interval in Layer Hlc (m)	Interval in Layer Hlf (m)	Interval in Layer PP (m)	Interval in Layer Rge (m)
CPT-21A	19.8							
CPT-21A	26.2							
CPT-24	13.7							
CPT-24	21.3							
CPT-24	29.0							
CPT-24	36.0							
CPT-25	6.1							
CPT-25	9.8							
CPT-25	15.8							
CPT-26	8.5							
CPT-26	14.6							
CPT-26	20.7							
CPT-27	4.6							
CPT-27	10.1							
CPT-28	12.2							
CPT-28	18.3							
CPT-28	26.5							
CPT-29	7.0							
CPT-29	14.0							
SST-218	26.2							
SST-219	20.4							
SST-219	38.7							
SST-219	46.3							
SST-220	15.8							
SST-220	36.0							
SST-220	56.4							
Z-1A/18/12								
W18-1	59.4	65.9	6.5					6.5
W18-2	61.0	64.6	3.6					3.6
W18-6U	28.8	38.0	9.1		7.9		1.2	
W18-6L	57.9	63.4	5.5					5.5
W18-7	51.4	63.4	12.0					12.0
W18-10L	44.8	64.3	19.5				3.7	15.8
W18-11U	29.6	38.7	9.1	3.7	5.5			
W18-11L	54.9	64.9	10.1					10.1
W18-12	54.1	64.9	10.8					10.7
W18-89	32.0	38.7	6.7		6.7			
W18-93	18.3	22.6	4.3	4.3				
W18-94	19.8	22.9	3.0	3.0				
W18-96	37.2	40.2	3.0		1.8	0.9	0.3	
W18-97	18.3	22.0	3.7	3.7				
W18-98	19.2	22.6	3.4	3.4				
W18-99	27.4	30.5	3.0	3.0				
W18-150U	18.9	26.5	7.6	7.6				
W18-150L	33.5	35.1	1.5		0.6	0.9		
W18-152	26.2	35.4	9.1	7.3	1.8			
W18-153	22.9	32.0	9.1	9.1				

Table 4. Sampling Depths Available in Extraction Wells and Deep Soil Gas Probes. (sheet 3 of 4)

Well No.	Top of Interval (m bgs)	Bottom of Interval (m bgs)	Length of Interval (m)	Interval in Layer Hf (m)	Interval in Layer Hlc (m)	Interval in Layer Hlf (m)	Interval in Layer PP (m)	Interval in Layer Rge (m)
W18-157	23.8	32.9	9.1	9.1				
W18-158U	22.0	28.0	6.1	6.1				
W18-158L	35.7	37.2	1.5		0.3		1.2	
W18-159	27.1	36.3	9.1		4.3	4.9		
W18-163U	16.0	23.6	7.6	7.6				
W18-163L	27.3	35.5	8.2		4.6	3.7		
W18-165	28.7	37.8	9.1	0.9	4.3	3.7	0.3	
W18-166	29.3	38.4	9.1	3.0	3.0	2.4	0.6	
W18-167	26.2	38.6	12.3	0.9	3.0	5.2	0.9	
W18-168	28.7	37.8	9.1	1.5	0.3	5.8	1.5	
W18-169	28.4	37.5	9.1		3.0	6.1		
W18-171U	16.3	22.4	6.1	6.1				
W18-171L	34.1	38.7	4.6		4.3	0.3		
W18-174	32.5	38.6	6.1		1.8	2.1	2.1	
W18-175	26.5	35.7	9.1		0.3	8.8		
W18-246U	36.6	39.6	3.0		3.0			
W18-246L	50.3	53.4	3.0					3.0
W18-247L	49.4	52.4	3.0					3.0
W18-248	37.7	42.2	4.6			0.6	4.0	
W18-249	37.2	41.8	4.6		1.5	1.2	1.8	
W18-252U	34.5	40.5	6.1		3.7		2.4	
W18-252L	50.3	56.4	6.1					6.1
CPT-1A	10.7							
CPT-1A	16.8							
CPT-1A	20.7							
CPT-1A	27.7							
CPT-2EX	10.0	14.0	4.0					
CPT-4EX	27.4	31.4	4.0					
CPT-4A	3.0							
CPT-4A	7.6							
CPT-4A	15.2							
CPT-4A	22.9							
CPT-4A	27.7							
CPT-4B	7.6							
CPT-4B	15.2							
CPT-4B	22.9							
CPT-4B	27.4							
CPT-4C	3.0							
CPT-4C	7.6							
CPT-4C	15.2							
CPT-4C	22.9							
CPT-4C	32.6							
CPT-4D	3.0							
CPT-4D	7.6							
CPT-4D	12.2							
CPT-4D	22.9							
CPT-4D	30.2							
CPT-4E	3.0							

Table 4. Sampling Depths Available in Extraction Wells and Deep Soil Gas Probes. (sheet 4 of 4)

Well No.	Top of Interval (m bgs)	Bottom of Interval (m bgs)	Length of Interval (m)	Interval in Layer Hf (m)	Interval in Layer Hlc (m)	Interval in Layer Hlf (m)	Interval in Layer PP (m)	Interval in Layer Rge (m)
CPT-4E	7.6							
CPT-4E	22.9							
CPT-4E	31.4							
CPT-4F	3.0							
CPT-4F	7.6							
CPT-4F	15.2							
CPT-4F	22.9							
CPT-4F	33.2							
CPT-4G	30.5							
CPT-4H	22.9							
CPT-4J	7.6							
CPT-4L	15.2							
CPT-4M	7.6							
CPT-4M	14.9							
CPT-4M	20.1							
CPT-4M	24.4							
CPT-4N	7.6							
CPT-4N	14.3							
CPT-7A	9.8							
CPT-7A	15.8							
CPT-10EX	28.6	32.6	4.0					
CPT-13A	2.7							
CPT-13A	9.1							
CPT-13A	15.2							
CPT-13A	21.3							
CPT-14A	3.7							
CPT-14A	6.4							
CPT-14A	12.2							
CPT-14A	18.6							
CPT-20EX	20.7	24.7	4.0					
CPT-30	8.5							
CPT-30	14.6							
CPT-30	20.7							
CPT-31	7.6							
CPT-31	15.2							
CPT-31	23.2							
CPT-32	7.6							
CPT-32	15.2							
CPT-32	21.3							
CPT-33	12.2							
CPT-33	18.3							
CPT-33	24.4							
CPT-34	12.2							
CPT-34	18.3							
CPT-34	26.2							
SST-252	30.5							
SST-252	44.2							
SST-252	64.0							

Table 5. Selected Sampling Locations. (sheet 1 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Comment
Sample Pump	12 Wells	Z-9	6 Wells	W15-9L	56	Rge near gw	6	
	38 Probes		17 Probes	W15-217	35	top of PP	3	
				W15-6L	56	Rge near gw	6	alternate = W15-218L
				W15-82	25	Hf	2	historic high concentrations
				W15-86	37	bottom of PP	4	
				W15-218U	33	top of PP	3	
				W15-218SST/26	26	Hf	2	
				W15-219SST/23	23	Hf	2	
				W15-219SST/39	39	bottom of PP	4	
				W15-219SST/47	47	Rge	5	
				W15-220SST/16	16	Hf	2	
				W15-220SST/36	36	bottom of PP	4	
				W15-220SST/56	56	Rge near gw	6	
				CPT-8AEX	34	bottom of PP	4	
				CPT-9A/18	18	Hf	2	perimeter
				CPT-9A/28	28	Hf/top of PP	3	perimeter
				CPT-21A/14	14	Huc	2	
				CPT-21A/26	26	Hf	2	high in 1996 soil gas survey
				CPT-24/29	29	top of PP	3	high in 1996 soil gas survey
				CPT-24/36	36	bott of PP	4	high in 1996 soil gas survey
				CPT-27/10	10	Huc	2	near bottom of trench
				CPT-28/12	12	Huc	2	perimeter
				CPT-28/27	27	Hf/near PP	2	perimeter
		Z-1A	6 Wells	W18-7	62	Rge near gw	6	
			21 Probes	W18-174	37	top of PP	3	alternate = W18-165
				W18-248	40	top of PP	3	
				W18-167	38	PP	3	38 - 39 m = open hole
				W18-89	35	Hlc/top of PP	3	
				W18-252U	36	Hlc/top of PP	3	
				W18-252SST/31	31	Hlc/top of PP	3	
				W18-252SST/44	44	Rge near PP	4	
				W18-252SST/64	64	Rge near gw	6	
				CPT-4C/23	23	Hf	2	
				CPT-4C/33	33	Hlc/top of PP	3	
				CPT-4E/23	23	Hf	2	
				CPT-4E/31	31	Hlc/top of PP	3	
				CPT-4F/23	23	Hf	2	
				CPT-4F/33	33	Hlc/top of PP	3	
				CPT-1A/11	11	Huc	2	perimeter

Table 5. Selected Sampling Locations. (sheet 2 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Comment
				CPT-1A/28	28	Hf	2	perimeter
				CPT-2EX	12	Huc	2	perimeter
				CPT-7A/16	16	Hf	2	perimeter
				CPT-13A/9	9	Huc	2	perimeter
				CPT-13A/21	21	Hf	2	perimeter
				CPT-30/21	21	Hf	2	
				CPT-31/23	23	Hf	2	high in 1996 soil gas survey
				CPT-32/21	21	Hf	2	
				CPT-33/24	24	Hf	2	
				CPT-34/12	12	Huc	2	perimeter
				CPT-34/26	26	Hf	2	perimeter
Barometric Venting	Indicator	Z-1A	2 Wells	W18-9	60	Rge		below PP
	Wells			W18-99	29	Hf		above PP
	15 Wells	Z-9	5 Wells	W15-9U	31	Hf, PP	2-3	above PP
				W15-32	56	Rge near gw	6	below PP
				W15-216U	23	Hf	2	above PP
				W15-216L	55	Rge	5	below PP
				W15-223	33	top of PP	3	above PP; prior rebound record
		Z-1A	10 Wells	W18-96	39	Hlf, PP	3	above PP
				W18-168	33	Hlf, PP	2-3	above PP
				W18-169	33	Hlc, Hlf	2-3	above PP
				W18-249	40	Hlf, PP	3	above PP
				W18-152	31	Hlf	2-3	above PP; perimeter; prior rebound record
				W18-6L	61	Rge	5-6	below PP
				W18-1	63	Rge near gw	6	below PP
				W18-2	63	Rge near gw	6	below PP
				W18-252L	53	Rge	5	below PP
				W18-247L	51	Rge near PP	4	below PP; long baro pumping data record
Differential Pressure	2 Wells	Z-1A	2 Wells	W18-246U		top of PP	3	above PP
				W18-246L	53	Rge	5	below PP
Barometric Pressure	1 Well	Z-1A	1 Well	W18-246	N/A	N/A		alternate = Hanford Meteorological Station

Table 5. Selected Sampling Locations. (sheet 3 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Zone	Comment
Shallow Probe	25 Probes	Z-9	13	85-01R	1.5	1	perimeter
				86-03	1.5	1	between Z-9 and Z-1A
				86-04	1.5	1	perimeter
				86-06	1.5	1	close to Z-9
				94-02	1.5	1	historic high
				94-03R	1.5	1	historic high
				94-05	1.5	1	historic high
				94-09	1.5	1	perimeter
				95-07	1.5	1	perimeter
				95-09	1.5	1	perimeter
				95-11	1.5	1	close to Z-9
				95-12	1.5	1	close to Z-9
				RST4-1	1.5	1	perimeter
		Z-1A	12	71-04	1.5	1	perimeter
				79-02	1.5	1	perimeter
				79-03	1.5	1	perimeter
				79-11	1.5	1	close to Z-1A
				79-13	1.5	1	perimeter
				87-01R	1.5	1	perimeter
				87-03	1.5	1	between Z-1A and Z-12
				87-04	1.5	1	close to Z-1A
				95-01	1.5	1	perimeter
				C-1	1.5	1	center of Z-18
				N-5	1.5	1	close to Z-1A
				N-9	1.5	1	historic high

Table 6. Rationale for Selection of Soil Gas Sampling Depths.

Sampling Zone	Interval	Rationale
1	0 to 2 m below ground surface	Evaluate carbon tetrachloride rebound in near-surface soils available to vent to atmosphere through soil surface
2	Between zones 1 and 3	Evaluate rebound in relatively permeable soils through which significant airflow has been induced by SVE systems
3	4 m above Plio-Pleistocene to midline of Plio-Pleistocene	Evaluate distribution of carbon tetrachloride remaining in low-permeability Plio-Pleistocene layer and potential long-term effect on zone 2 rebound
4	Midline of Plio-Pleistocene to 4 m below Plio-Pleistocene	Evaluate distribution of carbon tetrachloride remaining in low-permeability Plio-Pleistocene layer and potential long-term effect on zone 5 rebound
5	Between zones 4 and 6	Evaluate rebound in relatively permeable soils through which significant airflow has been induced by SVE systems
6	3 m above water table to water table	Evaluate potential exchange of carbon tetrachloride between unsaturated and saturated zones

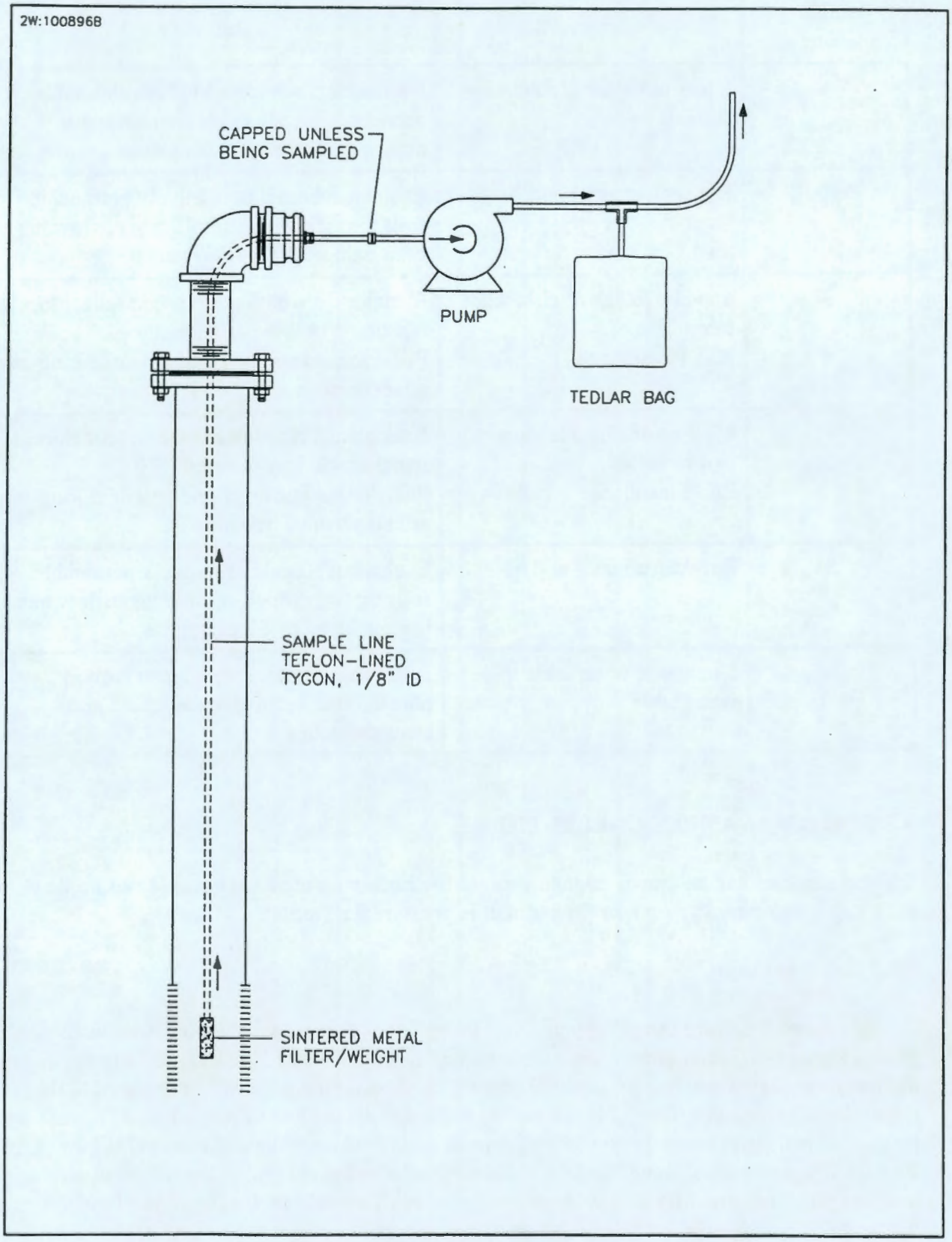
3.3 SOIL GAS SAMPLE COLLECTION

Soil gas samples can be drawn through wells to the surface for analysis using (1) a sample pump, (2) a vapor extraction system, or (3) barometric pressure fluctuations.

3.3.1 Sample Pump

A low-flow (0.8-L/min) sampling pump will be used to draw soil gas samples from wells and probes into a 1-L Tedlar (a registered trademark of E. I. du Pont de Nemours & Company, Wilmington, Delaware) bag for analysis (Figure 8). A sampling tube will be lowered to the target depth at the open interval in the well to minimize the volume of purged air. The tube will be 0.3-cm-inside-diameter Teflon-lined Tygon (a registered trademark of Norton Performance Plastics Corporation, Akron, Ohio). A metal filter attached to the end of the tube will also serve as a weight. The sampling tube will remain in the well for reuse for the duration of the rebound test and will be removed at the conclusion of the study.

Figure 8. Schematic Drawing of Soil Gas Sampling at an Extraction Well.



The subsurface sampling tubes attached to the deep CPT probes installed in 1993 are made of Teflon; two probes (CPT-4M, CPT-4N) installed in 1994 are polyethylene plastic (Figure 9). The sampling tubes are typically 0.3-cm inside diameter (0.6-cm outside diameter).

Two tube purge volumes will be drawn before the sample is collected from the well or deep CPT probe. The time needed to purge two tube volumes will be based on the purge flow rate adjusted for the estimated pressure drop through the sample tube.

Previous monitoring at wells and soil gas probes has indicated that barometric pressure fluctuations can affect the soil gas concentration available for sampling at a given depth. To evaluate this variability, the subsurface-surface differential pressure will be measured at each sampling depth at the time of soil gas sample collection.

Duplicate samples will be collected at a maximum of every 20th sample to evaluate the repeatability of the sampling method.

This sampling method was designed to enable evaluation of the magnitude of the carbon tetrachloride rebound at relatively discrete depths. Carbon tetrachloride concentrations in samples collected from extraction wells using the sample pump will be compared to those collected using the SVE systems prior to and after the rebound study to evaluate how these two sampling methods compare.

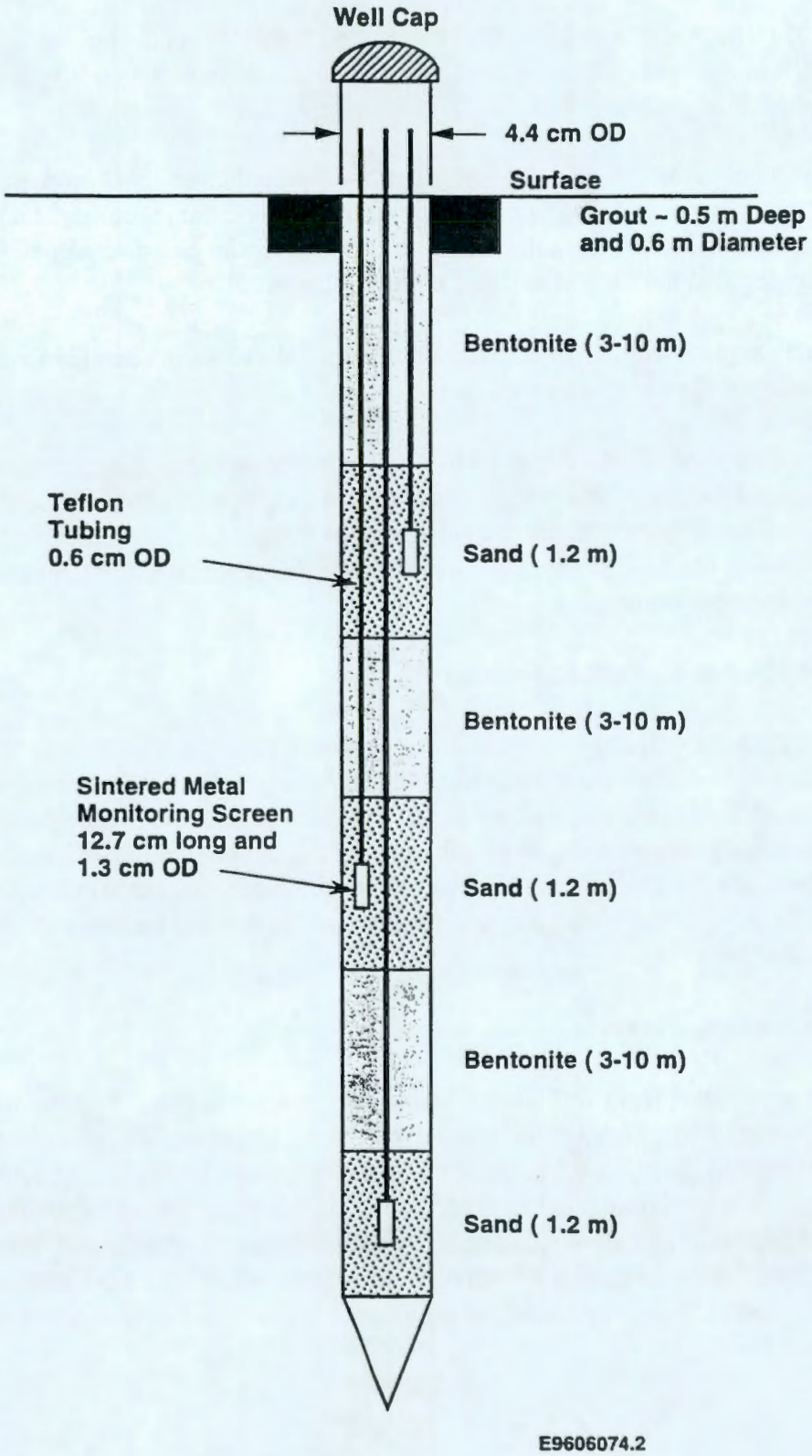
3.3.2 Soil Vapor Extraction Systems

The SVE systems will not be used to collect samples during rebound periods because the higher flow rates might disturb the equilibrium at neighboring wells and probes as well as at the target well. The SVE systems will be used to collect samples before and after periods of rebound for comparison to the discrete-depth sampling using the sampling pump. The SVE systems will be used to evaluate the rate of decline in carbon tetrachloride concentrations when operations resume. Soil vapor extraction soil gas samples will be collected at the wellhead in 1-L Tedlar bags for analysis.

3.3.3 Barometric Pressure

Subsurface air vents from wells when barometric pressure is low. On days when wells would be venting, samples will be collected manually at the wellhead in 1-L Tedlar bags for analysis. Because the well is sealed between sampling events, subsurface air will be drawn progressively toward the well each time it is sampled, providing information on the distribution of carbon tetrachloride relative to the well. The samples will be used to provide additional observations of soil gas concentrations from intervals open above and below the Plio-Pleistocene unit. The data will be compared to data collected using the sample pump to evaluate how the sampling methods compare.

Figure 9. Construction of Deep Soil Gas Monitoring Probes Installed Using Cone Penetrometer.



Alternatively, wellhead concentrations can be monitored automatically using a sensor installed at the wellhead. This sampling method may be used if resources are available for configuration of the instrumentation.

3.4 SOIL GAS SAMPLE FREQUENCY

For the first 10 working days, soil gas samples will be collected at least on alternate days. Fifty locations will be sampled using the sample pump; four of these locations will be sampled twice per day to evaluate whether diurnal barometric pressure fluctuations affect the observed carbon tetrachloride concentrations. An additional 15 wells will be sampled during periods of natural venting. The data will be evaluated during the first 10 working days to determine if sampling frequency should change. For example, a decrease in sampling frequency would be recommended if the same trend in the observed concentration was predictable using fewer data points. Changes in sample frequency will be recommended by the technical lead in consultation with key study participants and implemented upon approval by the project engineer. Changes in sampling frequency will be documented in the field logbook. The sampling frequency will be adjusted to determine the rate of carbon tetrachloride rebound.

The shallow soil gas probes will be sampled once per month to evaluate long-term changes. Monthly sampling at shallow probes will continue after SVE operations resume until near-surface concentrations have declined to baseline levels.

The SVE systems will be used to collect one set of baseline characterization data at selected wellheads prior to initiation of the rebound study. When SVE operations resume following the rebound study, carbon tetrachloride concentrations will be monitored at selected wellheads on the first day of operations and at most on alternate working days following until concentrations have declined to levels comparable to those observed during baseline characterization.

3.5 SOIL GAS SAMPLE ANALYSIS

Soil gas samples will be analyzed using a Bruel & Kjaer Type 1302 photo-acoustic infrared spectrometer (B&K, a trademark of Bruel & Kjaer, DK-2850) Samples collected in Tedlar bags will be transported to a B&K located at Z-9 or Z-1A for field-based analysis. The B&Ks are the analytical instrument used to monitor concentrations at the extraction wells and SVE inlet during SVE operations.

Soil gas samples will be analyzed primarily for carbon tetrachloride. The samples will also be analyzed for chloroform and methylene chloride, which are degradation products of carbon tetrachloride, because the B&Ks are configured to analyze for all three contaminants and because data on the rebound of all three contaminants may shed light on the location of the remaining carbon tetrachloride. These three contaminants are routinely monitored during SVE operations.

The B&K detectors are factory calibrated a minimum of once a year to detect carbon tetrachloride, chloroform, and methylene chloride. The B&Ks will be challenged in the field with a gas of known carbon tetrachloride concentration once per week. The lower detection limit for the B&K is approximately 1 ppmv; measurements between 0 and 1 ppmv will be considered equivalent to 0 ppmv.

3.6 PRESSURE MONITORING

Differential pressure will be measured at each sampling depth using a pressure transducer at the time of collection of each soil gas sample. At a minimum of one location, barometric pressure will be monitored hourly using a pressure transducer and recorded on a datalogger. At selected locations (at least one above the Plio-Pleistocene layer and one below), subsurface differential pressure will be monitored hourly using a pressure transducer and recorded on a datalogger. In addition, plastic bags will be used at selected wells (at least one open above and one below the Plio-Pleistocene layer) to indicate the direction of natural airflow.

The pressure data are needed to evaluate the impact of naturally induced subsurface pressure gradients on the observation of magnitude and rate of carbon tetrachloride rebound.

3.7 DATA MANAGEMENT

Data collected as part of the rebound study will be submitted to the 200-ZP-2 project file and included in the evaluation report.

3.8 WASTE MANAGEMENT

All waste generated during this study will be handled in accordance with the 200-ZP-2 waste control plan.

4.0 ORGANIZATION AND RESPONSIBILITIES

The organization chart for the operation of the SVE systems and other activities in the 200-ZP-2 Operable Unit is depicted in Figure 10. The general responsibilities of the key personnel associated with implementation and performance of the rebound study are discussed in the following sections.

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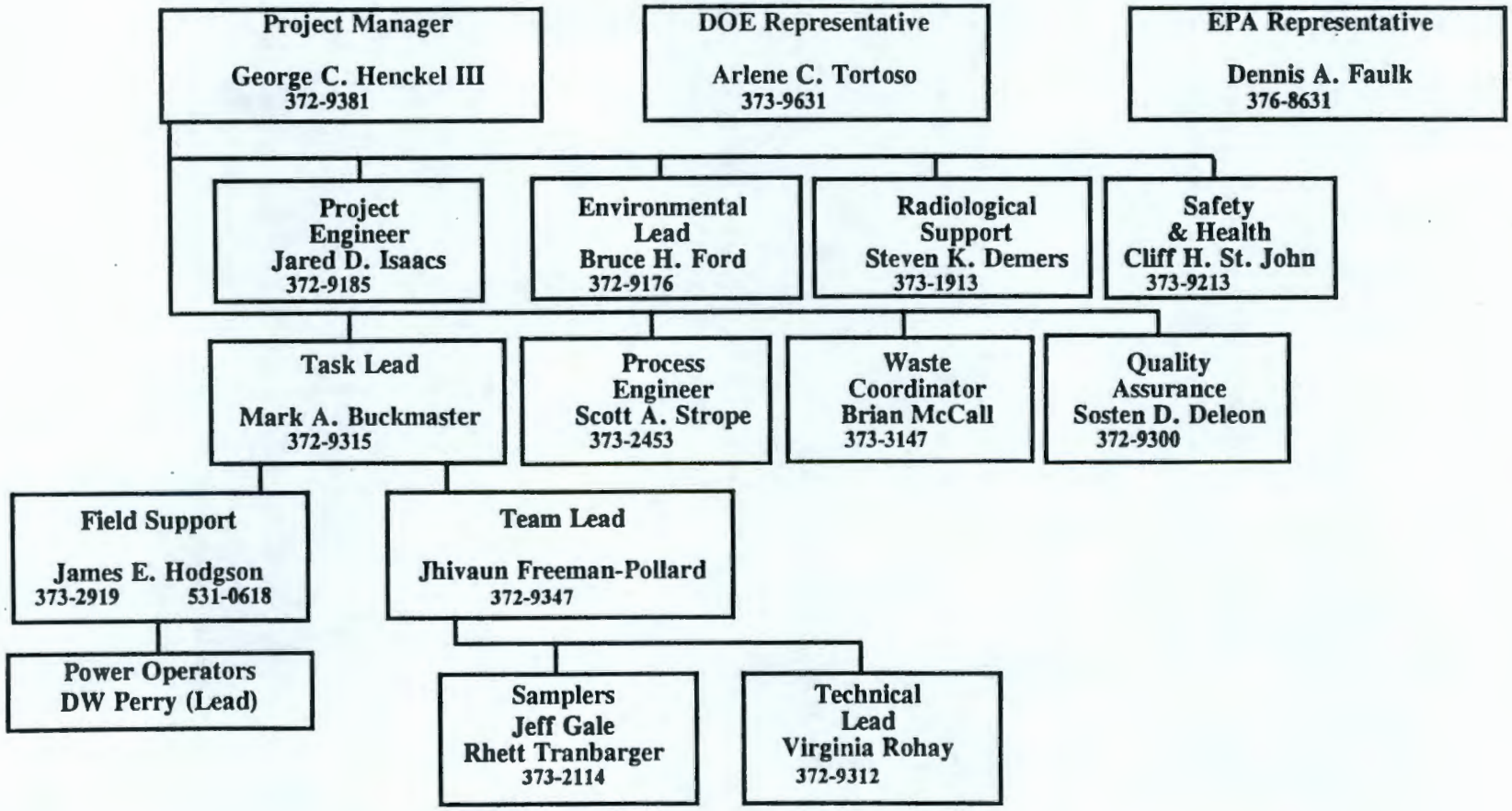


Figure 10. 200-ZP-2 Project Team Organization Chart.

4.1 200-ZP-2 KEY DECISION MAKERS

Representatives from the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency are the key decision makers for the 200-ZP-2 Operable Unit. The key decision makers authorize major changes in SVE operations, including the shutdown of the SVE systems during the rebound study.

4.2 PROJECT ENGINEER

The project engineer defines the technical scope of work to be performed and provides overall technical direction for the 200-ZP-2 Operable Unit. The project engineer provides final concurrence on all project deliverables.

4.3 ENVIRONMENTAL LEAD

The environmental lead provides technical support and oversight on rebound study activities pertaining to geohydrologic investigations, the DQO process, groundwater monitoring, and sampling and field-screening processes and procedures.

4.4 TASK LEAD AND TEAM LEAD

The task lead and team lead are responsible for the overall management and coordination of the technical scope, schedule, and budget for the rebound study and associated activities.

4.5 FIELD SUPPORT

The operation of the SVE systems and the coordination of field activities are the responsibility of Field Support. Field Support is responsible for the coordination of personnel in support of installation, maintenance, and/or removal of equipment and materials for the rebound study.

4.6 POWER OPERATORS

The power operators are responsible for operating the SVE systems and performing characterization activities associated with the extraction wells during SVE systems operation. Other power operator activities include reconfiguration of on-line extraction wells and flow adjustments needed to baseline the rebound study.

4.7 SAMPLER

The sampler is responsible for the rebound data collection activities including soil gas sampling and analysis, pressure monitoring, data recording and reporting, and interfacing with Field Support regarding day-to-day activities.

4.8 TECHNICAL LEAD

The technical lead is responsible for designing the tasks of the rebound study, evaluating the data, and preparing the final report summarizing the findings.

4.9 SAFETY AND HEALTH LEAD

The safety and health project lead is responsible for revising the site-specific health and safety plan, if needed. The safety and health project lead may perform routine visits to the site to ensure compliance with the plan and advise management of conditions requiring correction.

4.10 QUALITY ASSURANCE

The project quality assurance (QA) representative may perform oversight activities such as surveillances and assessments on this study. In addition, the QA representative will provide guidance on QA issues that may arise such as documentation and calibration.

5.0 REBOUND STUDY TASKS

5.1 REBOUND STUDY

The tasks outlined in this section are described in detail in Appendix A.

5.1.1 Task 1: Baseline the Rebound Study

The purpose of this task is to use the SVE systems to provide a known starting point for the rebound study. The systems will be used to sweep the unsaturated zone of carbon tetrachloride. The carbon tetrachloride concentration, flow, and vacuum will be measured at a minimum of 12 intervals. The induced vacuum will be measured at selected deep soil gas probes. The concentration data will be compared to the rebound data to evaluate contaminant sources. For example, concentrations at a given location may decrease after SVE system shutdown, indicating that the contaminant source was being drawn to the monitoring point. The vacuum and airflow data will indicate the zone of influence of the SVE systems. The soil gas survey conducted in May 1996 will provide the baseline data for the shallow soil gas probes.

All of the extraction wells at the 216-Z-1A and 216-Z-9 sites will be on-line during this baseline task (Table 7). The prioritization of wells for characterization of concentration, flow, and vacuum is indicated in Table 7. The wells at the 216-Z-18 site were not included because there is not enough extraction hose onsite to connect every well to a SVE system and evaluation of rebound at 216-Z-1A, where soil gas concentrations are higher, is a higher priority. Soil gas samples will be collected from locations at the 216-Z-18 site during the rebound study for comparison to concentrations at 216-Z-1A.

Table 7. Baseline Extraction Wells.

Z-9 Wells	Characterization Priority	Z-1A/12 Wells	Characterization Priority
W15-6U		W18-6U	
W15-6L	4	W18-6L	8
W15-9U		W18-7	7
W15-9L	3	W18-89	
W15-82	2	W18-152	
W15-84		W18-153	
W15-85		W18-158U	
W15-86	13	W18-158L	
W15-95		W18-159	
W15-216U		W18-163U	
W15-216L		W18-163L	
W15-217	1	W18-165	
W15-218U	11	W18-166	
W15-218L	12	W18-167	10
W15-219U		W18-168	
W15-219L		W18-169	
W15-220U		W18-171U	
W15-220L		W18-171L	
W15-223		W18-174	6
		W18-246U	
		W18-246L	
		W18-248	5
		W18-252U	9
		W18-252L	

5.1.2 Task 2: Prepare for Rebound Study Data Collection

This task entails taking all three SVE systems off-line and installing tubing for rebound sample collection in each well (Figure 8).

5.1.3 Task 3: Collect Soil Vapor Samples and Differential Pressure Data

Soil vapor sample collection will commence immediately following shutdown of the SVE systems. The concentrations measured immediately following system shutdown will be compared to those measured during characterization on the last days of SVE operation (Task 1) to evaluate how these two sampling methods compare.

Soil vapor samples will be collected from the "sample pump" wells and soil gas probes (Table 5) using the soil gas and differential pressure sampling apparatus (Figure 11) per Appendix B, "Soil Vapor Sampling and Pressure Measurement Procedure." A duplicate sample will be collected for every 20 samples to verify the sampling method.

Soil vapor samples will be collected from up to 15 "manual barometric venting" wells (Table 5) when outward flow is indicated at corresponding indicator bags. Soil vapor samples will be collected from the shallow soil gas probes (Table 5) during periods of low barometric pressure.

5.1.4 Task 4: Analyze Soil Vapor Samples

The soil vapor samples collected in Tedlar bags (Task 3) will be analyzed using a B&K analyzer located at the 216-Z-9 site or at the 216-Z-1A site.

5.1.5 Task 5: Evaluate the Data and Sample Frequency

The carbon tetrachloride concentration and differential pressure data will be evaluated during the first 10 working days to evaluate the sampling frequency. Changes in the sampling frequency will be recommended by the technical lead in consultation with key study participants and implemented upon approval by the project engineer.

When concentrations begin to change slowly, indicating approach to equilibrium, the SVE systems may be used, if available, to collect samples at individual wells for comparison to the rebound concentrations (Task 6). For example, slowly changing concentrations at a sampling point would be indicated by seven successive concentration values within 10% of each other. The impact on rebound concentrations at other nearby wells will also be considered prior to using the SVE systems for sampling. This situation may occur before the end of the 4 months allotted for the rebound study. In that event, at least one SVE blower train may be restarted between November 1996 and February 1997 as recommended by the technical lead and pending approval by the project engineer.

Shallow soil gas probes will be sampled once a month during the rebound study.

5.1.6 Task 6: Compare the Rebound Concentrations to Extraction Concentrations Using the Soil Vapor Extraction Systems

This task may be conducted during the rebound study if concentrations approach equilibrium (Task 5) and will be conducted at the conclusion of the rebound study. The purpose of this task is to obtain soil gas samples using the SVE systems to compare to those collected using the sample pump. At selected individual wells, a minimum volume of air will be extracted initially to obtain a representative sample of the concentration adjacent to the well ("puffer test") (Figure 12). Soil vapor extraction will then continue to determine the carbon tetrachloride concentration at progressive distances from the well. The area of influence during the extraction test can be estimated using vacuum gauges at selected monitoring points. This testing will indicate the distance between the well and the carbon tetrachloride source, but may not indicate the direction.

Figure 11. Schematic Drawing of Soil Gas and Differential Pressure Sampling Apparatus.

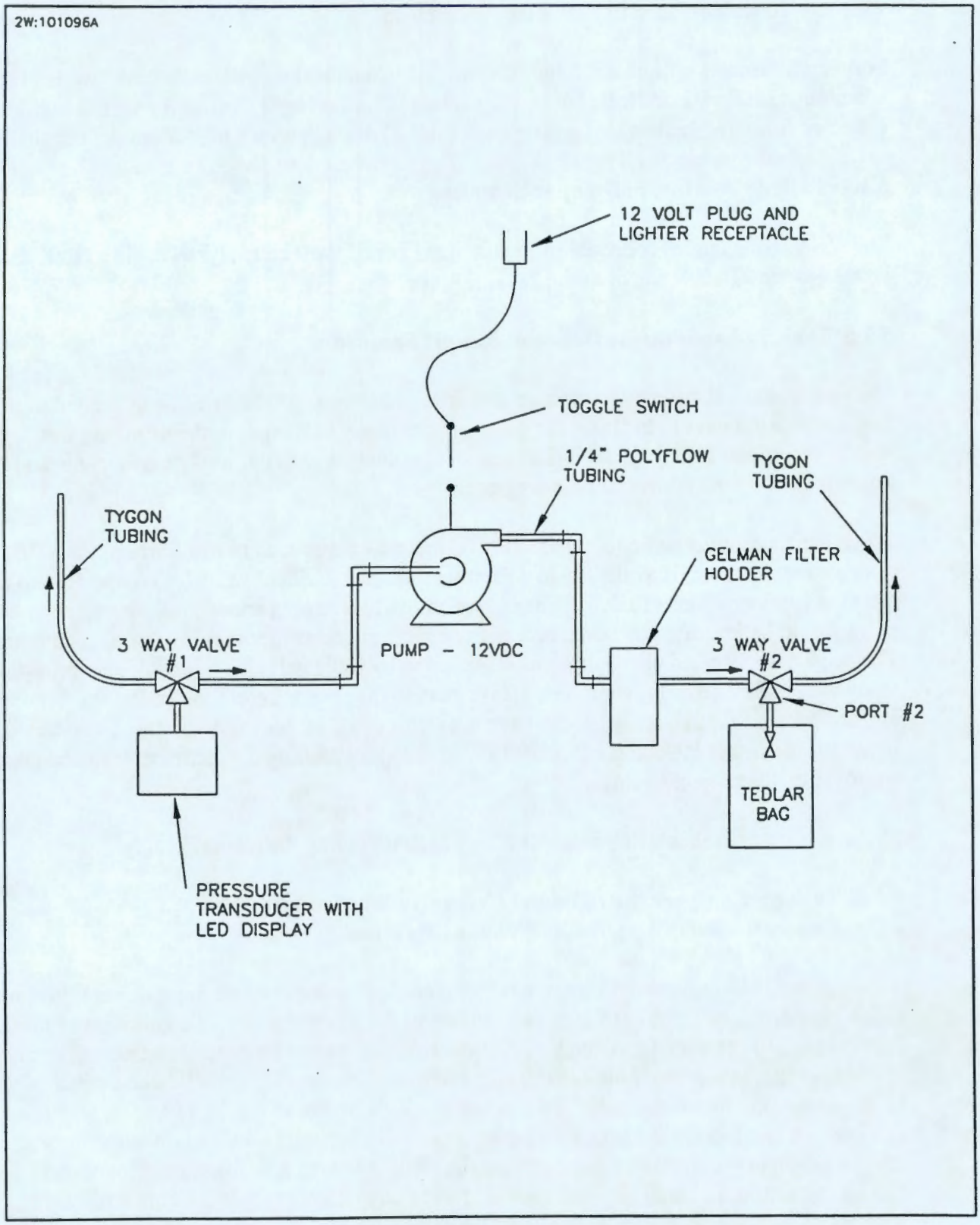
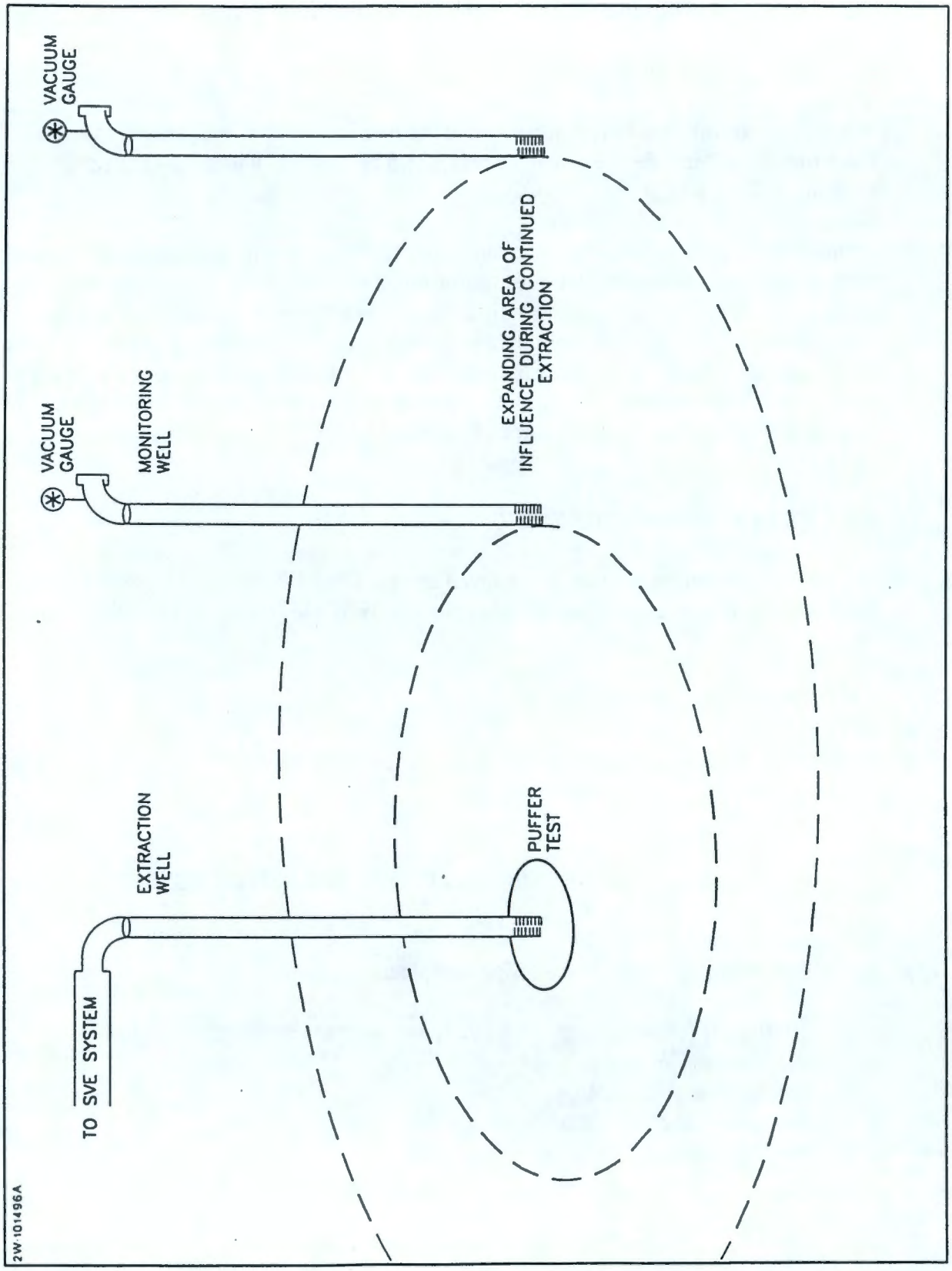


Figure 12. Schematic for Soil Gas Sampling Using the Soil Vapor Extraction Systems.



When concentrations have declined to levels comparable to those observed during baseline characterization (Task 1), rebound concentration monitoring will be resumed. This will allow the rebound test to be repeated or to be conducted at additional locations.

5.1.7 Task 7: Conclude the Rebound Study

When near-equilibrium has been reached at the monitoring locations, and/or at the conclusion of the 4 months allotted for the rebound study, the SVE systems will be used to sample individual wells as in Task 6.

Finally, at the conclusion of the rebound study, all the wells will be placed on-line under the same conditions as when the baseline testing concluded (Task 1). The carbon tetrachloride concentrations will be monitored the first day at selected wellheads and then at most on alternate working days following until concentrations have declined to levels comparable to those observed during baseline characterization (Task 1). Monthly monitoring of shallow soil gas probes will continue until near-surface concentrations have declined to levels comparable to those observed during baseline characterization (the May 1996 soil gas survey).

5.2 CPT LOCATION SURVEYING

The CPT wells and probes will be surveyed using a Global Positioning System to provide more accurate locations relative to the vapor extraction wells and carbon tetrachloride sources.

5.3 REPORTING

An evaluation of the rebound testing will be completed in July 1997.

6.0 EQUIPMENT AND SITE SERVICES

Soil gas sampling requires the following equipment:

- Four-door four-wheel drive vehicle to transport the sampling assembly
- 12-V power for pump
- Tedlar bags for sampling
- Sampling tubes with screens
- Field logbook.

Manual carbon tetrachloride monitoring at barometrically venting wells requires the following equipment:

- Indicator bags (2)
- Tedlar bags.

Automatic carbon tetrachloride monitoring at a barometrically venting well requires the following equipment:

- Flowmeter
- 4-in.-diameter straight pipe, 8 ft long
- B&K and heated enclosure
- Datalogger
- Differential pressure gauge
- Barometric pressure gauge
- One-way valve
- In-line granular activated carbon canister
- 110-V power and extension cord
- Field logbook.

Carbon tetrachloride rebound monitoring at all of the selected wells and probes would be enhanced by the following:

- Flexibility to extract from wells using at least one blower train at Z-9 and at Z-1A at any time (with reasonable notice) depending on rate and magnitude of rebound

- Flexibility to implement mid-course corrections and improvements.

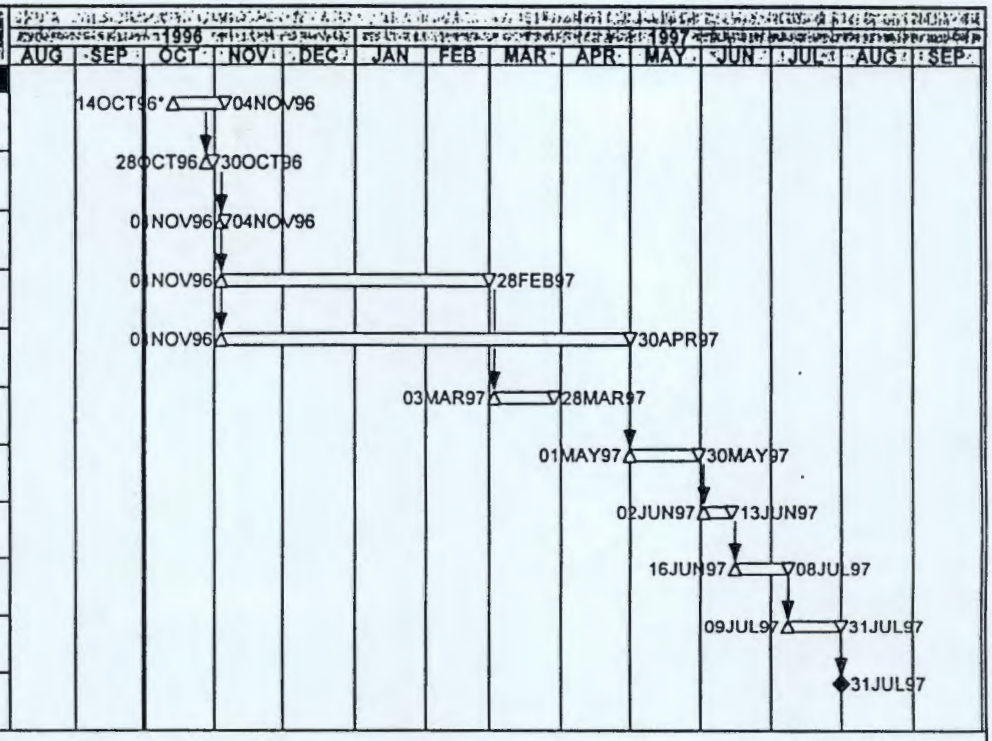
7.0 SCHEDULE

The schedule for the 200-ZP-2 rebound study is depicted in Figure 13.

8.0 SAFETY

The rebound study sampling and analysis will be conducted according to the site-specific health and safety plan for the 200-ZP-2 carbon tetrachloride site.

Activity ID	Activity Description	Original duration
REBOUND STUDY		
001	EXTRACT FROM ALL Z-9 & Z-1A WELLS SIMULTANEOUSLY	16*
005	CHARACTERIZE SVE WELLS	3
010	TURN SVE SYSTEMS OFF	1
015	COLLECT DATA FOR REBOUND STUDY	79
020	EVALUATE DATA FOR REBOUND STUDY	122
025	USE SVE SYSTEM FOR SOIL GAS SAMPLING	20
030	PREPARE DRAFT REBOUND STUDY REPORT	21
035	ERC REVIEW OF REBOUND STUDY	10
040	DISPOSITION COMMENTS FOR REBOUND STUDY	15
045	INCORPORATE COMMENTS AND PREPARE REV 0	17
050	SUBMIT REV 0 TO DOE	0



Project Start	01OCT96	Early Bar
Project Finish	31JUL97	Progress Bar
Data Date	01OCT96	Critical Activity
Plot Date	12NOV96	

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ZP02

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200-ZP-2
Rebound Study

Sheet 1 of 1

Date	Revision	Checked	Approved

Figure 13. 200-ZP-2 Rebound Study Schedule.

9.0 REGULATORY COMPLIANCE

9.1 NATIONAL ENVIRONMENTAL POLICY ACT

The *National Environmental Policy Act* (NEPA) is the basic federal charter for protecting the nation's environment and ensures that federal agencies such as the DOE give appropriate consideration to environmental impacts in their decision-making processes.

In March 1991, DOE approved the use of a categorical exclusion under Section D of DOE's NEPA Guidelines for expedited response action characterization activities. The activities discussed in this test plan, and the environmental impacts associated with these activities, are within the scope of activities and impacts discussed in the NEPA documentation supporting the NEPA categorical exclusion approval. It has, therefore, been determined that the activities described in this test plan are adequately addressed by this existing NEPA documentation and that no further NEPA documentation need be performed for these activities.

Before implementation of vapor extraction operations for remediation of the carbon tetrachloride contamination, an environmental assessment was included as part of the Expedited Response Action Proposal to comply with NEPA (DOE-RL 1991). In February 1992, DOE-Headquarters issued a Finding of No Significant Impact in response to that environmental assessment.

9.2 CULTURAL RESOURCES REVIEW

Two cultural resource reviews conducted at the carbon tetrachloride site found no known cultural resources or historic properties. These reviews were titled Cultural Resource Review of the 200 West Carbon Tetrachloride Interim Response Action (HCRC #91-200-002) and Cultural Resources Review of the 200 West Carbon Tetrachloride Vapor Extraction Project (HCRC #94-200-053).

Portions of the 200-ZP-2 Operable Unit were also surveyed for sensitive biological resources in June 1994 (#94-WHC-191). The survey identified no species of plants or wildlife that are listed as threatened or endangered in the vicinity.

10.0 REFERENCES

Barna, M.G., 1995, "The Use of Sulfur Hexafluoride to Investigate Active and Passive Soil Vapor Extraction," M.S. thesis, Washington State University, Pullman, Washington, 146 pgs.

DOE-RL, 1991, *Expedited Response Action Proposal (EE/CA & EA) for 200 West Area Carbon Tetrachloride Plume*, DOE/RL-91-32, Draft B, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Driggers, S.A., 1994, *Summary of Canister Overheating Incident at the Carbon Tetrachloride Expedited Response Action Site*, WHC-SD-EN-TI-203, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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Wright, J., J. L. Conca, and X. Chen, 1994, *Hydrostratigraphy and Recharge Distributions from Direct Measurements of Hydraulic Conductivity Using the UFA Method*, PNL-9424, Pacific Northwest Laboratory, Richland, Washington.

APPENDIX A

REBOUND STUDY DETAILED TASKS

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APPENDIX A
REBOUND STUDY DETAILED TASKS

The tasks described in this appendix will not be initiated at the wells identified for soil gas sampling until they are modified as necessary to accept rebound monitoring and sampling equipment (Figure A-1).

Task 1: Baseline the Rebound Study

a. Operate the three soil vapor systems per applicable procedures BHI-00059, BHI-00060, or BHI-00061 (BHI 1996a, 1996b, 1996c) to extract simultaneously from the wells listed in Table A-1. At each site logbook, note the wells included in this task and the day/time this task was initiated.

b. After continuous operation of the systems for at least 72 hours, measure and record the flow and vacuum from each extraction interval. The duration of continuous operation may be shortened based on unscheduled shutdowns.

c. After continuous operation of the systems for at least 72 hours, record the vacuum at the deep soil gas probes listed in Table A-2. The vacuum data will indicate the zone of influence of the SVE systems. The vacuum may be measured using magnehelic gauges.

d. After 14 days of continuous operation, record the carbon tetrachloride, chloroform, and methylene chloride concentrations from each extraction interval. The duration of continuous operation may be shortened based on unscheduled shutdowns. The priority for characterization is indicated in Table A-1. The flow and vacuum data (Task 1.b) may be collected at the same time as the concentration data.

Task 2: Prepare for Rebound Study Data Collection

NOTE: The steps described in this task must be completed in sequence and in as short a period as possible. Soil vapor sample collection (Task 3) may commence immediately after shutdown of the SVE systems and will continue for at least 10 consecutive working days. The initial concentrations measured immediately after system shutdown will be compared to those measured during characterization on the last days of SVE operation (Task 1.c).

a. Turn off the SVE systems per applicable procedure BHI-00059, BHI-00060, or BHI-00061 (BHI 1996a, 1996b, 1996c). At each site logbook, note the day/time this task was initiated.

b. Disconnect from the well, and cap all extraction hoses and wells.

c. Install tubing for sample collection into each well.

Task 3: Collect Soil Vapor Samples and Differential Pressure Data

a. Measure the differential pressure at each sampling location. Record measurement on Rebound Study Data Collection Form (Figure A-2).

b. Collect one Tedlar (registered trademark of E. I. du Pont de Nemours & Company) bag sample from the wells and soil gas probes listed on the Rebound Study Data Collection Form (Figure A-2) using the soil gas and differential pressure sampling apparatus (Figure A-3) per Appendix B, "Soil Vapor Sampling and Pressure Measurement Procedure." A duplicate sample will be collected at a maximum of every 20 samples to verify the sampling method. In the event of a failure of the 12-V sample pump (Figure A-3), use the gas generator and 110-V pump used for characterization during SVE operations to draw the sample to the Tedlar bag.

c. Collect one Tedlar bag sample from manual "barometric wells" listed on the Rebound Study Data Collection Form (Figure A-2) when outward flow is indicated at corresponding indicator bags.

d. At each shallow soil gas probe, measure the differential pressure, then collect a Tedlar bag soil gas sample per Appendix B, "Soil Vapor Sampling and Pressure Measurement Procedure," once per month during a period of low barometric pressure, if possible.

e. Record all the measurements for each day on a new Rebound Study Data Collection Form (Figure A-2).

f. The sampling frequency for the wells and probes in Task 3.a will be every other day for the first 10 working days and thereafter per the direction of the technical lead following consultation with key study participants and approval by the project engineer.

Task 4: Analyze Soil Vapor Samples

a. Ensure that the B&K analyzer is calibrated and record the current calibration in the field logbook. The soil vapor samples collected in Task 3 will be analyzed for carbon tetrachloride, chloroform, and methylene chloride using a B&K analyzer located at the 216-Z-9 Trench site or the 216-Z-1A Tile Field site. Record the analysis time, pressure, and concentrations on the Rebound Study Data Collection Form (Figure A-2).

b. Analyze the duplicate (second) sample with the same instrument as the original (first) sample.

c. Within 1 working day following analysis of each day's samples, photocopy and transmit the Rebound Study Data Collection Form to the technical lead. Store the original Rebound Study Data Collection Forms in a notebook at the B&K site.

Task 5: Evaluate the Data and Sample Frequency

a. Evaluate data each sampling day. Recommend changes in the sampling frequency as necessary to key study participants and obtain approval for changes from the project engineer. Document changes in the field logbook.

b. When concentrations begin to change slowly, indicating approach to equilibrium, use the SVE systems, if available, to collect samples at individual wells for comparison with the rebound concentrations (Task 6). For example, slowly changing concentrations at a sampling point would be indicated by seven successive concentration values within 10% of each other.

Task 6: Compare the Rebound Concentrations to Extraction Concentrations Using the SVE Systems

a. At selected individual wells, initially pull a minimum volume of air to get a representative sample of the concentration adjacent to the well ("puffer test") (Figure A-4). Then extract continuously from each well and sample at frequencies per the technical lead in consultation with key study participants to determine the carbon tetrachloride concentration at progressive distances from the well. The expanding area of influence during the test can be estimated by pumping until vacuum gauges at selected monitoring points register the induced vacuum. This testing will indicate the distance between the well and the carbon tetrachloride source, but may not indicate the direction.

b. When concentrations have declined to levels comparable to observed during baseline characterization (Task 1.c), resume monitoring the rebound concentration. Consider changing the rebound monitoring locations based on the results of the previous testing.

Task 7: Conclude the Rebound Study

a. When near-equilibrium has been reached at the monitoring locations, and/or at the conclusion of the 4 months allotted for rebound, use the SVE systems to sample individual wells as in Task 6.

b. At the conclusion of the rebound study, reconnect all the wells on-line under the same conditions as when the baseline testing concluded. Monitor concentrations at selected wellheads on the first day and then at most on alternate days following until concentrations have declined to levels comparable to those observed during baseline characterization (Task 1.c).

c. Continue to monitor shallow soil gas probes monthly until near-surface concentrations have declined to levels comparable to those observed during baseline characterization (the May 1996 soil gas survey).

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BHI, 1996a, *500 CFM Soil Vapor Extraction System Startup, Surveillance, Shutdown, and GAC Canister Changeout*, BHI-OP-00059, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1996b, *1,00000 CFM Soil Vapor Extraction System Startup, Surveillance, Shutdown, and GAC Canister Changeout*, BHI-OP-00060, Bechtel Hanford, Inc., Richland,Washington.

BHI, 1996c, *1,500 CFM Soil Vapor Extraction System Startup, Surveillance, Shutdown, and GAC Canister Changeout*, BHI-OP-00061, Bechtel Hanford, Inc., Richland,Washington.

Figure A-1. Schematic Drawing of Soil Gas Sampling at an Extraction Well.

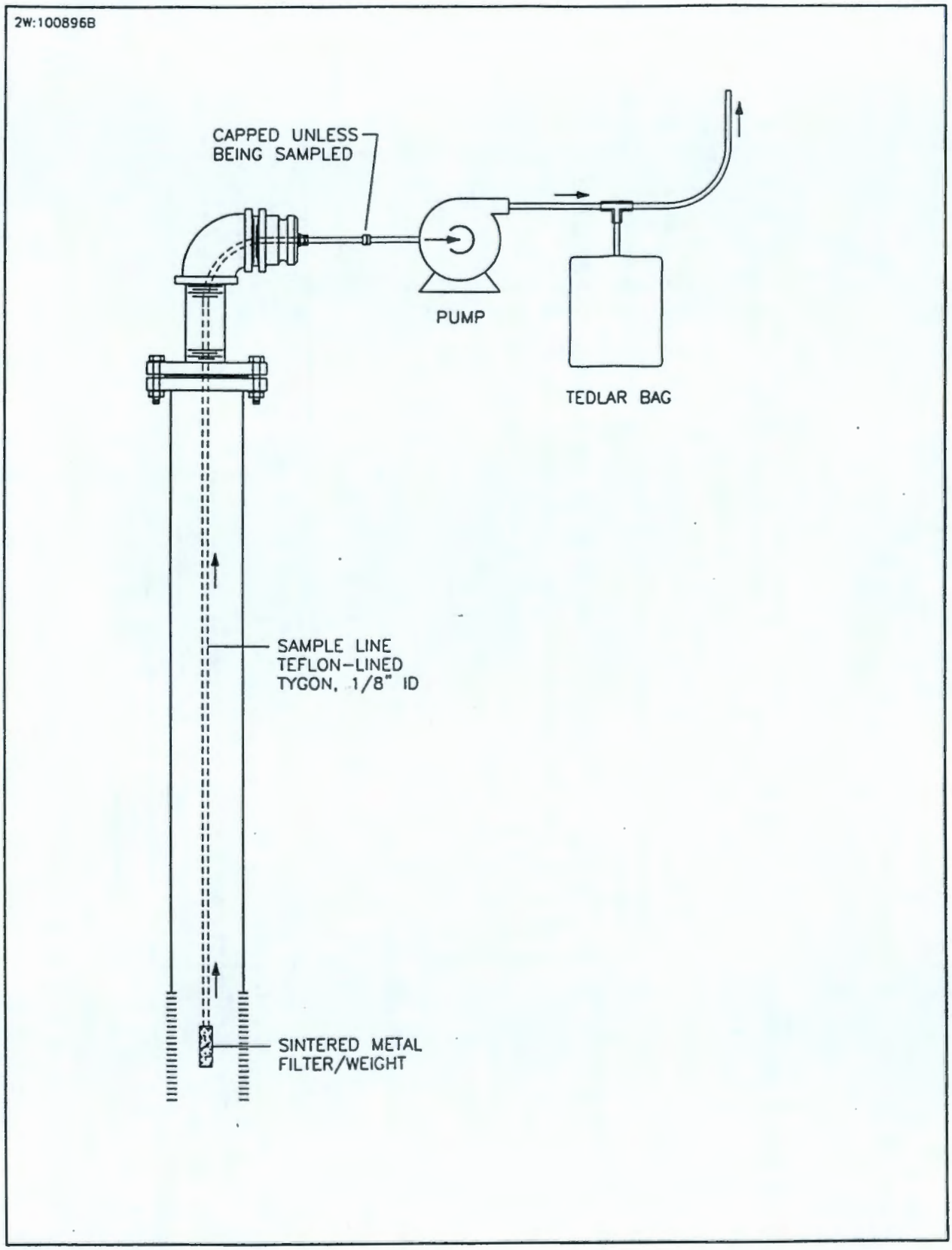

Figure A-2. Rebound Study Data Collection Form. (sheet 1 of 6)

Rebound Study Data Collection Form								
DATE:					SAMPLERS NAME:			
B&K SERIAL NUMBER:								
STANDARD CONCENTRATION:					ANALYZERS NAME:			
Location (Well or Probe)/feet bgs	Color Code	Differential Pressure (inches w.c.)	Purge Time	Sampling Time	Analysis Time	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	Methylene Chloride (ppmv)
W15-9L (am Measurement)								
W15-9L (pm Measurement)								
W15-217 (am Measurement)								
W15-217 (pm Measurement)								
W15-6L								
W15-82								
W15-86								
W15-218U								
W15-218SST/86								
W15-219SST/70	red							
W15-219SST/130	yellow							
W15-219SST/155	blue							
W15-220SST/52	blue							
W15-220SST/118	red							
W15-220SST/185	yellow							
CPT-8AEX								
CPT-9A/60	blue							
CPT-9A/91	red							

Figure A-2. Rebound Study Data Collection Form. (sheet 2 of 6)

Rebound Study Data Collection Form								
DATE:					SAMPLERS NAME:			
B&K SERIAL NUMBER:								
STANDARD CONCENTRATION:					ANALYZERS NAME:			
Location (Well or Probe)/feet bgs	Color Code	Differential Pressure (inches w.c.)	Purge Time	Sampling Time	Analysis Time	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	Methylene Chloride (ppmv)
CPT-21A/45	green							
CPT-21A/86	red							
CPT-24/95	blue							
CPT-24/118	red							
CPT-27/33	red							
CPT-28/40	green							
CPT-28/87	red							
W18-7 (am Measurement)								
W18-7 (pm Measurement)								
W18-174 (am Measurement)								
W18-174 (pm Measurement)								
W18-248								
W18-167								
W18-89								
W18-252U								
W18-252SST/100	red							
W18-252SST/145	yellow							
W18-252SST/210	blue							

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Figure A-2. Rebound Study Data Collection Form. (sheet 3 of 6)

Rebound Study Data Collection Form								
DATE:					SAMPLERS NAME:			
B&K SERIAL NUMBER:								
STANDARD CONCENTRATION:					ANALYZERS NAME:			
Location (Well or Probe)/feet bgs	Color Code	Differential Pressure (inches w.c.)	Purge Time	Sampling Time	Analysis Time	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	Methylene Chloride (ppmv)
CPT-4C/75	yellow							
CPT-4C/107	red							
CPT-4E/75	yellow							
CPT-4E/103	red							
CPT-4F/75	yellow							
CPT-4F/109	red							
CPT-1A/35	unmarked							
CPT-1A/91	red							
CPT-2EX								
CPT-7A/52	red							
CPT-13A/30	blue							
CPT-13A/70	red							
CPT-30/68	red							
CPT-31/76	red							
CPT-32/70	red							
CPT-33/80	red							
CPT-34/40	green							
CPT-34/86	red							

Figure A-2. Rebound Study Data Collection Form. (sheet 4 of 6)

Rebound Study Data Collection Form								
DATE:					SAMPLERS NAME:			
B&K SERIAL NUMBER:								
STANDARD CONCENTRATION:					ANALYZERS NAME:			
Location (Well or Probe)/feet bgs	Color Code	Differential Pressure (inches w.c.)	Purge Time	Sampling Time	Analysis Time	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	Methylene Chloride (ppmv)
W18-99 (Indicator Well)		N/A						
W15-9U		N/A						
W15-216U		N/A						
W15-223		N/A						
W18-96		N/A						
W18-152		N/A						
W18-168		N/A						
W18-169		N/A						
W18-249		N/A						
W18-9 (Indicator Well)		N/A						
W15-32		N/A						
W15-216L		N/A						
W18-1		N/A						
W18-2		N/A						
W18-6L		N/A						
W18-247L		N/A						
W18-252L		N/A						

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Figure A-2. Rebound Study Data Collection Form. (sheet 5 of 6)

Rebound Study Data Collection Form								
DATE:					SAMPLERS NAME:			
B&K SERIAL NUMBER:								
STANDARD CONCENTRATION:					ANALYZERS NAME:			
Location (Well or Probe)/feet bgs	Color Code	Differential Pressure (inches w.c.)	Purge Time	Sampling Time	Analysis Time	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	Methylene Chloride (ppmv)
85-01R								
86-03								
86-04								
86-06								
94-02								
94-03R								
94-05								
94-09								
95-07								
95-09								
95-11								
95-12								
RST4-1								
71-04								
79-02								
79-03								
79-11								
79-13								

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Figure A-2. Rebound Study Data Collection Form. (sheet 6 of 6)

Rebound Study Data Collection Form								
DATE:					SAMPLERS NAME:			
B&K SERIAL NUMBER:								
STANDARD CONCENTRATION:					ANALYZERS NAME:			
Location (Well or Probe)/feet bgs	Color Code	Differential Pressure (inches w.c.)	Purge Time	Sampling Time	Analysis Time	Carbon Tetrachloride (ppmv)	Chloroform (ppmv)	Methylene Chloride (ppmv)
87-01R								
87-03								
87-04								
95-01								
C-1								
N-5								
N-9								
DUPLICATE SAMPLE ANALYSIS								
Comments:								

Figure A-3. Schematic Drawing of Soil Gas and Differential Pressure Sampling Apparatus.

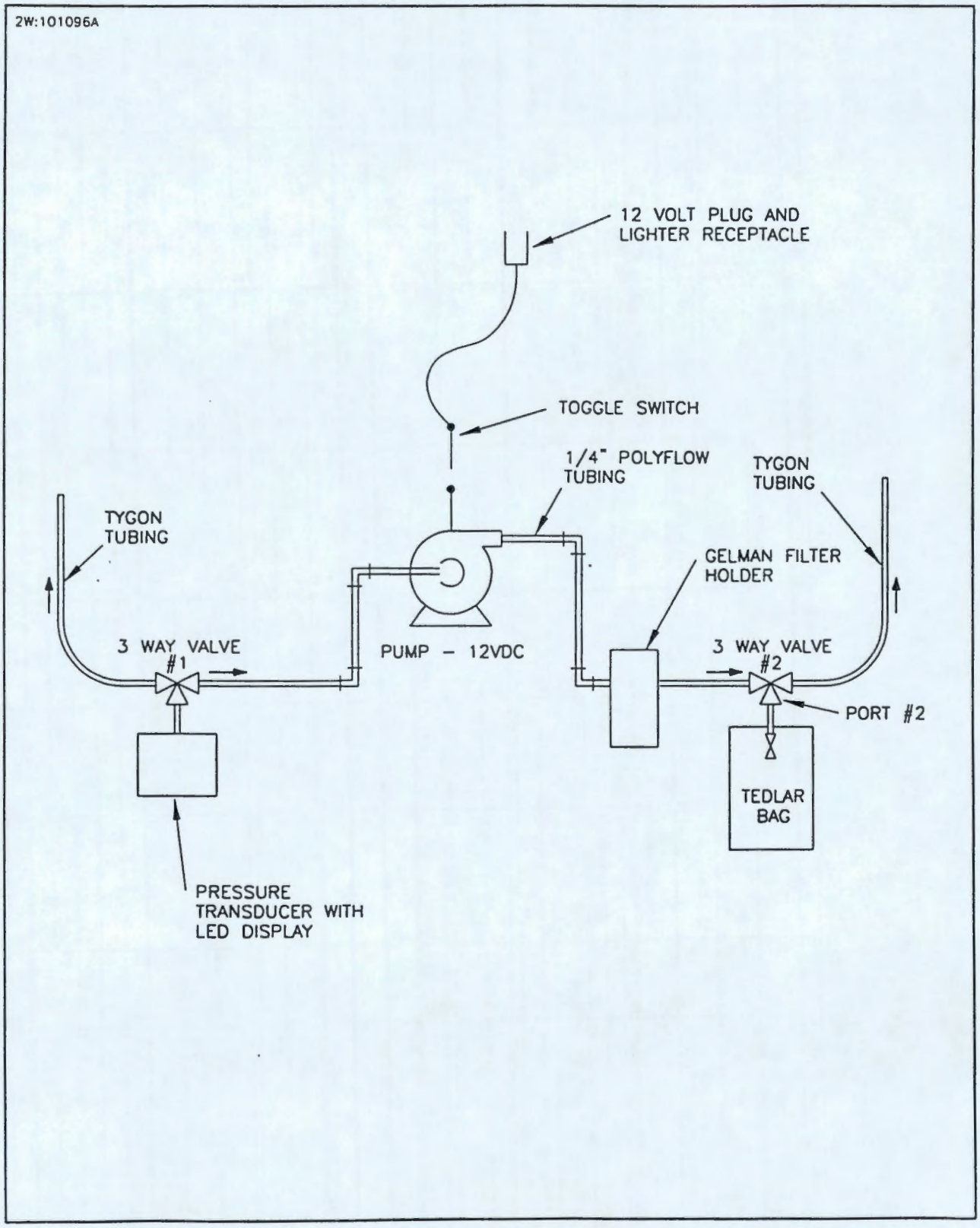

Figure A-4. Schematic for Soil Gas Sampling Using the Soil Vapor Extraction Systems.

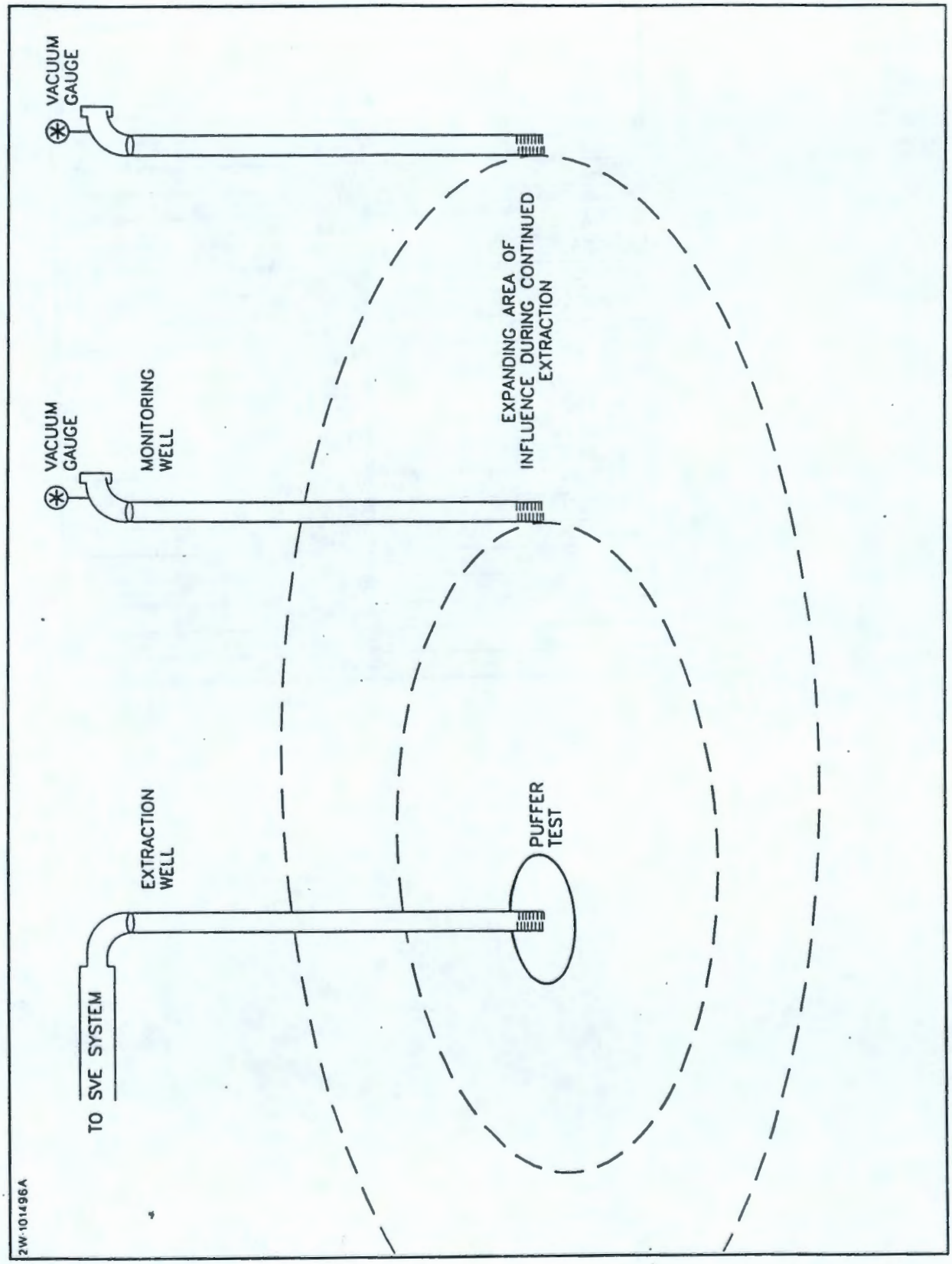

Table A-1. Baseline Extraction Wells.

Z-9 Wells	Characterization Priority	Z-1A/12 Wells	Characterization Priority
W15-6U		W18-6U	
W15-6L	4	W18-6L	8
W15-9U		W18-7	7
W15-9L	3	W18-89	
W15-82	2	W18-152	
W15-84		W18-153	
W15-85		W18-158U	
W15-86	13	W18-158L	
W15-95		W18-159	
W15-216U		W18-163U	
W15-216L		W18-163L	
W15-217	1	W18-165	
W15-218U	11	W18-166	
W15-218L	12	W18-167	10
W15-219U		W18-168	
W15-219L		W18-169	
W15-220U		W18-171U	
W15-220L		W18-171L	
W15-223		W18-174	6
		W18-246U	
		W18-246L	
		W18-248	5
		W18-252U	9
		W18-252L	

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Table A-2. Selected Sampling Locations. (sheet 1 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Comment
Sample Pump	12 Wells	Z-9	6 Wells	W15-9L	56	Rge near gw	6	
	38 Probes		17 Probes	W15-217	35	top of PP	3	
				W15-6L	56	Rge near gw	6	alternate = W15-218L
				W15-82	25	Hf	2	historic high concentrations
				W15-86	37	bottom of PP	4	
				W15-218U	33	top of PP	3	
				W15-218SST/26	26	Hf	2	
				W15-219SST/23	23	Hf	2	
				W15-219SST/39	39	bottom of PP	4	
				W15-219SST/47	47	Rge	5	
				W15-220SST/16	16	Hf	2	
				W15-220SST/36	36	bottom of PP	4	
				W15-220SST/56	56	Rge near gw	6	
				CPT-8AEX	34	bottom of PP	4	
				CPT-9A/18	18	Hf	2	perimeter
				CPT-9A/28	28	Hf/top of PP	3	perimeter
				CPT-21A/14	14	Huc	2	
				CPT-21A/26	26	Hf	2	high in 1996 soil gas survey
				CPT-24/29	29	top of PP	3	high in 1996 soil gas survey
				CPT-24/36	36	bott of PP	4	high in 1996 soil gas survey
				CPT-27/10	10	Huc	2	near bottom of trench
				CPT-28/12	12	Huc	2	perimeter
				CPT-28/27	27	Hf/near PP	2	perimeter
		Z-1A	6 Wells	W18-7	62	Rge near gw	6	
			21 Probes	W18-174	37	top of PP	3	alternate = W18-165
				W18-248	40	top of PP	3	
				W18-167	38	PP	3	38 - 39 m = open hole
				W18-89	35	Hlc/top of PP	3	
				W18-252U	36	Hlc/top of PP	3	
				W18-252SST/31	31	Hlc/top of PP	3	
				W18-252SST/44	44	Rge near PP	4	
				W18-252SST/64	64	Rge near gw	6	
				CPT-4C/23	23	Hf	2	
				CPT-4C/33	33	Hlc/top of PP	3	
				CPT-4E/23	23	Hf	2	
				CPT-4E/31	31	Hlc/top of PP	3	
				CPT-4F/23	23	Hf	2	
				CPT-4F/33	33	Hlc/top of PP	3	
				CPT-1A/11	11	Huc	2	perimeter

Table A-2. Selected Sampling Locations. (sheet 2 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Geologic Unit	Zone	Comment
				CPT-1A/28	28	Hf	2	perimeter
				CPT-2EX	12	Huc	2	perimeter
				CPT-7A/16	16	Hf	2	perimeter
				CPT-13A/9	9	Huc	2	perimeter
				CPT-13A/21	21	Hf	2	perimeter
				CPT-30/21	21	Hf	2	
				CPT-31/23	23	Hf	2	high in 1996 soil gas survey
				CPT-32/21	21	Hf	2	
				CPT-33/24	24	Hf	2	
				CPT-34/12	12	Huc	2	perimeter
				CPT-34/26	26	Hf	2	perimeter
Barometric Venting	Indicator	Z-1A	2 Wells	W18-9	60	Rge		below PP
	Wells			W18-99	29	Hf		above PP
	15 Wells	Z-9	5 Wells	W15-9U	31	Hf, PP	2-3	above PP
				W15-32	56	Rge near gw	6	below PP
				W15-216U	23	Hf	2	above PP
				W15-216L	55	Rge	5	below PP
				W15-223	33	top of PP	3	above PP; prior rebound record
		Z-1A	10 Wells	W18-96	39	Hlf, PP	3	above PP
				W18-168	33	Hlf, PP	2-3	above PP
				W18-169	33	Hlc, Hlf	2-3	above PP
				W18-249	40	Hlf, PP	3	above PP
				W18-152	31	Hlf	2-3	above PP; perimeter; prior rebound record
				W18-6L	61	Rge	5-6	below PP
				W18-1	63	Rge near gw	6	below PP
				W18-2	63	Rge near gw	6	below PP
				W18-252L	53	Rge	5	below PP
				W18-247L	51	Rge near PP	4	below PP; long baro pumping data record
Differential Pressure	2 Wells	Z-1A	2 Wells	W18-246U		top of PP	3	above PP
				W18-246L	53	Rge	5	below PP
Barometric Pressure	1 Well	Z-1A	1 Well	W18-246	N/A	N/A		alternate = Hanford Meteorological Station

Table A-2. Selected Sampling Locations. (sheet 3 of 3)

Sampling Type	Total	Wellfield	Total by Wellfield	Sampling Location	Depth (m bgs)	Zone	Comment
Shallow Probe	25 Probes	Z-9	13	85-01R	1.5	1	perimeter
				86-03	1.5	1	between Z-9 and Z-1A
				86-04	1.5	1	perimeter
				86-06	1.5	1	close to Z-9
				94-02	1.5	1	historic high
				94-03R	1.5	1	historic high
				94-05	1.5	1	historic high
				94-09	1.5	1	perimeter
				95-07	1.5	1	perimeter
				95-09	1.5	1	perimeter
				95-11	1.5	1	close to Z-9
				95-12	1.5	1	close to Z-9
				RST4-1	1.5	1	perimeter
		Z-1A	12	71-04	1.5	1	perimeter
				79-02	1.5	1	perimeter
				79-03	1.5	1	perimeter
				79-11	1.5	1	close to Z-1A
				79-13	1.5	1	perimeter
				87-01R	1.5	1	perimeter
				87-03	1.5	1	between Z-1A and Z-12
				87-04	1.5	1	close to Z-1A
				95-01	1.5	1	perimeter
				C-1	1.5	1	center of Z-18
				N-5	1.5	1	close to Z-1A
				N-9	1.5	1	historic high

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APPENDIX B

SOIL VAPOR SAMPLING AND PRESSURE MEASUREMENT PROCEDURE

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APPENDIX B
SOIL VAPOR SAMPLING AND PRESSURE MEASUREMENT PROCEDURE

1.0 SCOPE AND INTRODUCTION

This procedure outlines the steps for collecting soil vapor samples from soil vapor extraction (SVE) wells and soil gas probes using Tedlar bags. Tedlar bags are used to collect volatile organic compounds for analysis. A 1-L Tedlar bag will most commonly be used to collect the gas samples. Other volumes may be substituted if necessary. When the samples have been collected, the full Tedlar bags should be stored in either a clean cooler or an opaque trash bag to prevent photodegradation. The samples must be analyzed within 18 hours of collection.

2.0 SAMPLING EQUIPMENT

- Rebound Study Data Collection Form (Figure A-2)
- Soil gas and differential pressure sampling apparatus (Figure A-3)
- Tedlar bags
- Clean cooler or opaque trash bag
- Freezer bags
- Duct tape.

3.0 PROCEDURE

1. Install tubing at preselected wells.

   1.1 Remove existing cam-loc cap from wellhead, lower sample line, and connect sample line cam-loc cap to wellhead.

   1.2 If well has a lower interval that has a 2-in. 90° fitting, then remove fitting and lower sample line into well. Pull the end of the sample line through the fitting and reattach to wellhead, secure cam-loc.

The following section of this procedure refers to the Soil Gas and Differential Pressure Sampling Apparatus (Figure A-3) for both wells and soil gas probes (Section 3.3.1 of the test plan).

2. Attach a Tedlar sample bag to the 3-way valve #2, port #2 on the Soil Gas and Differential Pressure Sampling Apparatus (Figure A-3).

3. Open the inlet valve on the Tedlar bag.

4. Position the 3-way valve #2 to bypass the Tedlar bag and exhaust the air stream.

5. Close the pressure sampling 3-way valve #1 to pump.

6. Remove cap of the end of the well/probe sample tube and connect the inlet Tygon (registered trademark of Norton Performance Plastics Corporation) tube from the sampling apparatus.

7. Record the pressure indicator reading on the Rebound Study Data Collection Form (Figure A-2).

8. Open the pressure sampling 3-way valve #1 to pump and turn on the sample pump.

9. Purge the sample line for a minimum of 1 minute and record actual purge time on the Rebound Study Data Collection Form (Figure A-2).

10. Switch the 3-way valve #2 to the Tedlar bag and fill bag.

11. Remove the Tedlar bag and exhaust the contents of the bag (pump continues to run).

12. Reconnect the Tedlar bag and refill.

13. Switch the pump off and close the inlet valve of the Tedlar bag.

14. Remove the Tedlar bag and label it by either a printed label on the edge of the bag or by writing directly on the edge of the bag with a sharpie. Do not write or place labels on the bag itself. Record the sample location, date, time, and the sampler's name on the Rebound Study Data Collection Form.

15. Store Tedlar bag in a cooler or opaque trash bag.

16. Disconnect the Tygon tubing from the sample line and recap the well/CPT tube.

17. Transport the samples to the B&K analyzer located at the 216-Z-9 or 216-Z-1A site for analysis. When performing sample analysis, vent B&K outside, 8 ft above ground level with a carbon scrubber on the end of the venting tube.

The following section of this procedure refers to the barometric pressure sampling as stated in Section 3.3.3 of the test plan. Wells W18-9 and W18-99 will be observation wells with plastic freezer bags taped to them as pressure indicators. When the bags are forced outward, perform the following procedure per Table A-2.

The following procedure is to be performed standing upwind of the sampling well.

18. Observe wind direction, remove well cap and stand upwind.

19. Allow to vent two well volumes.

20. Place Tedlar bag on barbed fitted well cap and open inlet valve.

21. Connect barbed well cap onto venting well and allow to fill Tedlar bag.

22. Close inlet valve, remove Tedlar bag and place into cooler or opaque trash bag.

23. Remove barbed well cap and replace with original well cap.

24. Transport the samples to the B&K analyzer located at the 216-Z-9 or 216-Z-1A site for analysis.

4.0 REFERENCES

EPA, 1992, *Tedlar Bag Sampling*, Standard Operating Procedure 2050, Rev. 1, EPA Environmental Response Team, U.S. Environmental Protection Agency, Washington, D.C.

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