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ENGINEERING CHANGE NOTICE

Page 1 of 2

1. ECN 190355

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.		4. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	V. J. Rohay, 81231, H6-06, 376-5507		August 25, 1993
	5. Project Title/No./Work Order No. FY 93 Wellfield Enhancement Plan	6. Bldg./Sys./Fac. No.	7. Impact Level 3Q
	8. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-SD-EN-AP-114, Rev. 0	9. Related ECN No(s).	10. Related PO No.

11a. Modification Work	11b. Work Package No.	11c. Modification Work Complete	11d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 11b) [X] No (NA Blks. 11b, 11c, 11d)		Cog. Engineer Signature & Date	Cog. Engineer Signature & Date

12. Description of Change

Incorporate ECNs 169857 and 169883. Add procedural information on VES characterization testing (Section 3.1.6). Add procedural information on baseline monitoring (Sections 3.3.1.3, 3.3.1.4, and 3.4.3). Add procedural information on measuring pressures at various depths (Section 3.2.1.3). Incorporate additional sampling procedures (FSP Section 3.0). Incorporate additional information on project organization and responsibilities (QAPP Section 2.0), QA objectives (QAPP Section 3.0), and analytical procedures (QAPP Section 7.0). Incorporate updated information to Health and Safety Plan.

9313026.2004

13a. Justification (mark one)			
	Criteria Change []	Design Improvement []	Environmental [X]
As-Found []	Facilitate Const. []	Const. Error/Omission []	Design Error/Omission []

13b. Justification Details

14. Distribution (include name, MSIN, and no. of copies)

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DATE SEP 13 1993
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A-7900-013-2 (06/92) GEF095

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15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]		[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision

20. Approvals

Signature	Date	Signature	Date
OPERATIONS AND ENGINEERING		ARCHITECT-ENGINEER	
Cog Engineer V. J. Rohay *V J Rohay*	9/1/93	PE	
Cog. Mgr. A. J. Knepp *A J Knepp*	9/1/93	QA	
QA R. L. Hand *R L Hand*	9/7/93	Safety	
Safety		Design	
Security		Environ.	
Environ. M. C. Hagood *M C Hagood*	9/1/93	Other	
Projects/Programs			
Tank Waste Remediation System			
Facilities Operations		DEPARTMENT OF ENERGY	
Restoration & Remediation		Signature or Letter No.	
Operations & Support Services			
IRM		ADDITIONAL	
Other			

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A-7900-013-3 (06/92) GEF096

Date Received: 8/20/93 DS

INFORMATION RELEASE REQUEST

Reference: WHC-CM-3-4

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ID Number (include revision, volume, etc.)
WHC-SD-EN-AP-114, Rev. 1

List attachments.
N/A

Date Release Required
August 25, 1993

Title FY 93 Wellfield Enhancement Work Plan

Unclassified Category UC-

Impact Level 3Q

New or novel (patentable) subject matter? [X] No [] Yes
If "Yes", has disclosure been submitted by WHC or other company?
[] No [] Yes Disclosure No(s).

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Will proceedings be published? [] Yes [] No
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Classification/Unclassified Controlled Nuclear Information	[ ]	[X]			
Patent - General Counsel	[X]	[ ]	S. W. Berglin	S W Berglin	8/23/93
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Information conforms to all applicable requirements. The above information is certified to be correct.

	Yes	No
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Transmit to DOE-HQ/Office of Scientific and Technical Information	[]	[X]

Author/Requestor (Printed/Signature) Date

V. J. Rohay V J Rohay 8/19/93

Intended Audience

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Responsible Manager (Printed/Signature) Date

A. J. Knepp A J Knepp 8/19/93

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Part 1

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6. Author
Name: V. J. Rohay
V J Rohay 8/19/93
Signature
Organization/Charge Code 81231/P12BD

7. Abstract

WHC, 1993, *FY 93 Wellfield Enhancement Work Plan*, WHC-SD-EN-AP-114, Rev. 1, prepared by V. J. Rohay, Westinghouse Hanford Company, and R. J. Cameron, Ebasco Services, Inc., for Westinghouse Hanford Company, Richland, Washington.

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9. Impact Level 3Q

10. RELEASE STAMP

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Page 1

(2) Title
FY 93 Wellfield Enhancement Work Plan

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release: (5) Cog. Engr.	Authorized for Release: (6) Cog. Mgr. Date
0	(7) Initial release via EDT 159225	V. J. Rohay	A. J. Knepp
1 RS	Incorporate changes via ECN's 169857, 169883, and 190355	V J Rohay 9/10/93	A J Knepp 9/10/93

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1.0 INTRODUCTION

1.1 PURPOSE

This work plan presents a detailed outline for FY 1993 wellfield optimization and enhancement activities to be conducted in and around the carbon tetrachloride contamination site in 200 West Area of the Hanford Site in southeastern Washington. The carbon tetrachloride contamination is the primary focus of the 200 West Area Carbon Tetrachloride Expedited Response Action (ERA), an environmental restoration program to remove carbon tetrachloride from the unsaturated soils in the 200 West Area. This work plan provides the U.S. Environmental Protection Agency (EPA) and the Washington Department of Ecology (Ecology) with the objectives and scope of the FY 1993 wellfield enhancement activities.

A wellfield strategy was developed to optimize removal of carbon tetrachloride from the unsaturated zone. Specific objectives include (1) define the parameters of the present wellfield concentrations of volatile organic compounds (VOC); (2) provide guidance to optimize VOC extraction by the active vapor extraction system (AVES); (3) evaluate possible systems for enhanced passive vapor extraction (PVE) of VOC from the subsurface; (4) provide supplemental data for site characterization and health and safety assessments; and (5) identify needs for innovative technologies to be supplied through the Volatile Organic Compounds - Arid Integrated Demonstration (VOC-Arid ID). The tasks described in this work plan are designed to achieve these objectives.

A wellfield design feasibility study to delineate the optimum design of the existing wells and placement and type of new wells is described in the ERA proposal (DOE-RL 1991, Section 6.2.2). As acknowledged in the proposal, the optimum design of the wellfield will be an evolutionary process as more contaminant and operational information is gathered. One purpose of the FY 1993 wellfield enhancement work is to address this wellfield feasibility study.

1.2 BACKGROUND

An ERA is a provision included in the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) that allows accelerated cleanup activities to be undertaken at waste sites to abate imminent hazards or to prevent significantly increased degradation of the environment that might occur if action were delayed until completion of the remedial investigation/feasibility study and the record of decision. The ERA is implemented according to the requirements outlined in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989), Part 3, Article XIII, Section 38, and in accordance with 40 CFR 300, Subpart E.

In December 1990, the EPA and Ecology requested the U.S. Department of Energy (DOE), Richland Field Office (RL) to proceed with detailed planning, including nonintrusive field work required to implement the ERA for the carbon tetrachloride contamination in the 200 West Area. The request was based on concerns that the carbon tetrachloride residing in the soils was continuing to spread to the groundwater and, if left unchecked, would significantly increase the area of groundwater contamination.

The carbon tetrachloride contamination is linked to past liquid waste disposal practices resulting from operation of Z Plant (now called the Plutonium Finishing Plant) in the 200 West Area near the center of the Hanford Site (Figure 1). The carbon tetrachloride was discharged to three different sites--the 216-Z-9 Trench, the 216-Z-1A Tile Field, and the 216-Z-18 Crib--from 1955 to 1973, when discharge to the ground was ceased (Figure 2).

The first evaluations were conducted at the carbon tetrachloride disposal sites from January through April 1991 as part of the ERA to refine the preliminary conceptual model and to collect data in support of the selection and design of an initial remedial action (Hagood and Rohay 1991). This initial site evaluation included a pilot test of an AVES. Results of the Phase I ERA site evaluation were summarized in June 1991 (Rohay and Johnson 1991). Based on this work and on the engineering evaluation and cost assessment, the preferred alternative for removal of the carbon tetrachloride from the unsaturated zone was identified as soil vapor extraction followed by aboveground treatment (DOE-RL 1991). In January 1992, EPA and Ecology authorized DOE to initiate soil vapor extraction for cleanup of the carbon tetrachloride in the unsaturated soils.

An AVES began operating at the 216-Z-1A Tile Field in February 1992. This same system was operated on a limited basis at the 216-Z-18 Crib during summer 1992. Initiation of AVES operations is planned for the 216-Z-9 Trench in February 1993.

The AVES is composed of three subsystems: wellfield, process, and treatment (Figure 3). The two primary objectives of these subsystems are the capability to control airflow pathways in the subsurface and the ability to remove the VOC from the extracted soil vapor.

The wellfield subsystem includes the extraction and monitoring wells. These wells have one to three perforated intervals that provide access to the soil vapors in the subsurface. The perforated intervals are separately connected to a wellfield manifold at the surface. This manifold provides control of the flow from each perforated interval. The manifold is connected by hose to the process subsystem.

The process subsystem includes a high-efficiency particulate air (HEPA) filter trailer and blower trailer. The hose from each wellfield manifold connects to the manifold at the HEPA trailer. This manifold provides control of the flow from each of the wells. The soil vapor is pulled through this manifold, through a water knockout tank, and then through a dual HEPA filtration unit. The soil vapor then travels through a hose to the blower trailer. The soil vapor passes from the vacuum side of the blower to the positive pressure side, where it is then pushed through a hose to the treatment subsystem.

The treatment subsystem consists of two granular-activated carbon (GAC) canisters in series. The GAC canisters remove the VOC from the soil vapor. After passing through the GAC canisters, the soil vapor is pushed out a stack to the atmosphere.

Figure 1. Map of the Hanford Site, Washington.

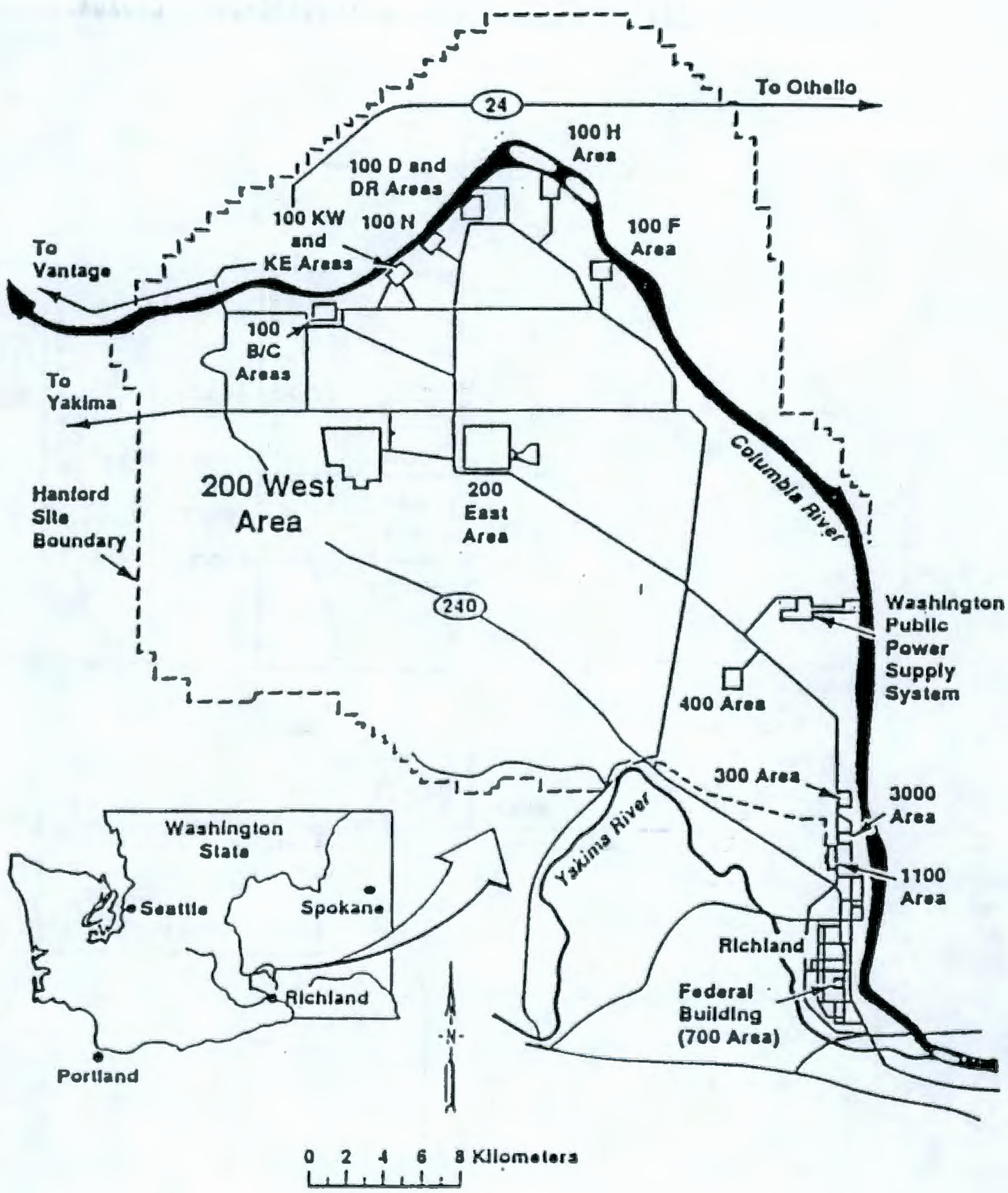

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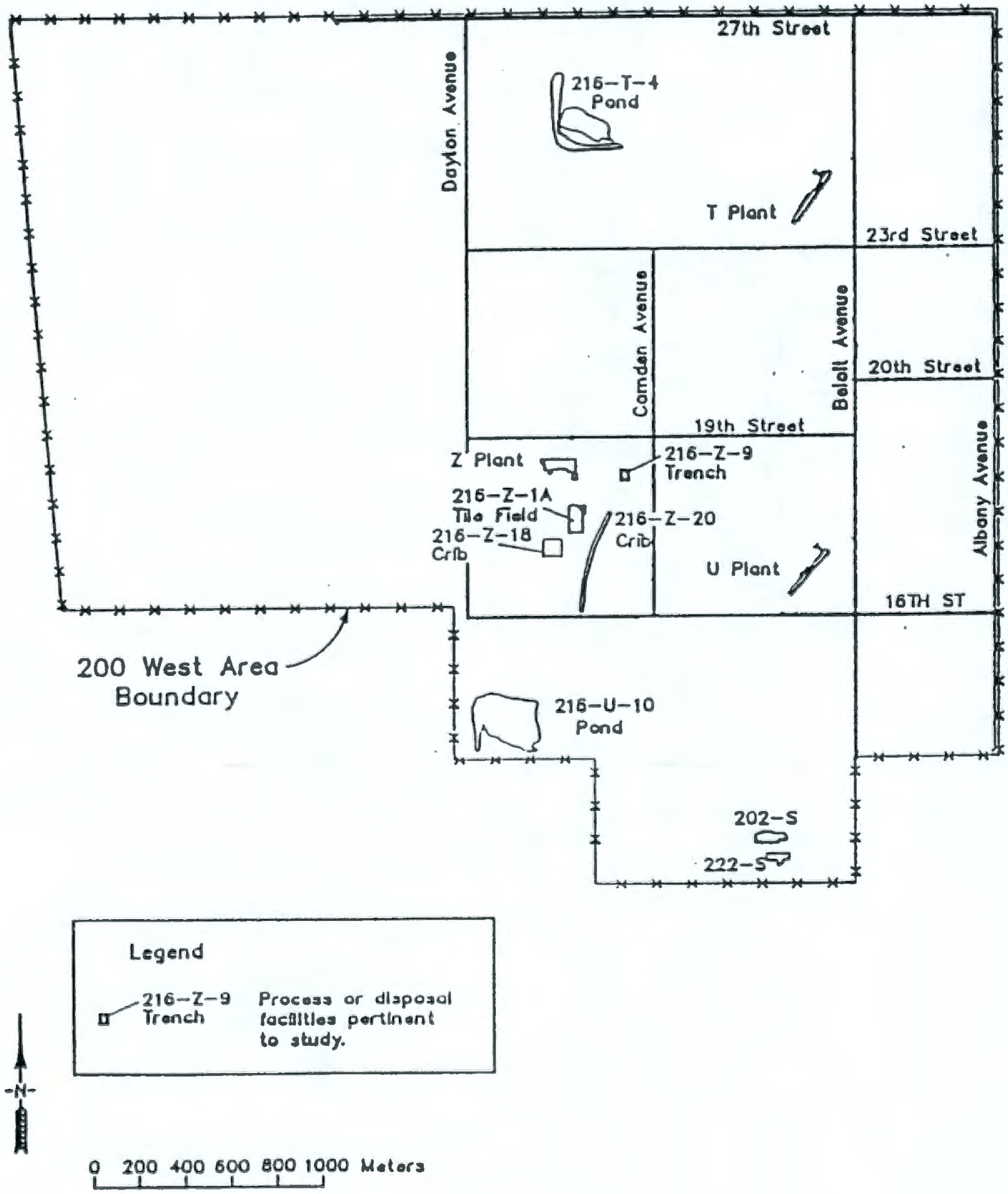
Figure 2. Site Map of the 200 West Area.



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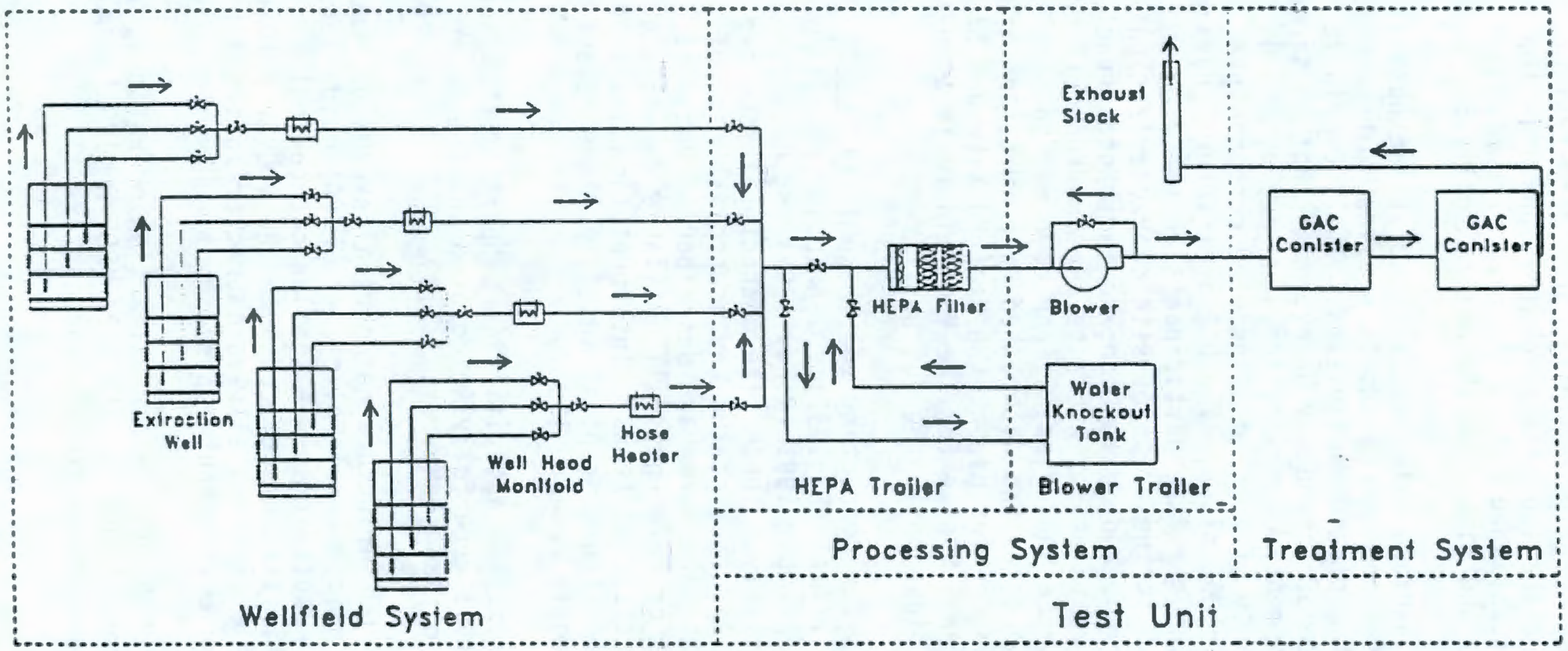

Figure 3. Active Vapor Extraction System Components.

The entire system is monitored by instruments connected to a process controller. The parameters measured and stored include flow rate, pressure, vacuum, temperature, relative humidity, VOC concentration, radon concentration, and alpha and beta concentrations. In the event a parameter varies beyond an established range, the process controller shuts off the blower, effectively shutting down the entire soil vapor extraction process.

In 1991, the Hanford Site was selected as the host site for the VOC-Arid ID, a technology development program to provide improvements to the current methods of conducting cleanup activities. The VOC-Arid ID is a DOE program funded by the Office of Technology Development that is targeted at the acquisition, development, demonstration, and deployment of technologies for evaluation and cleanup of VOC and associated contaminants in soils and groundwaters of arid DOE sites. The DOE contractors, national laboratories, universities, and industry are participants in the program. New technologies will be demonstrated in the areas of site characterization; performance prediction, monitoring, and evaluation; contaminant extraction and ex situ treatment; in situ remediation; and site closure and monitoring. The performance of these technologies will be compared to baseline (i.e., conventional) technologies and documented to promote the transfer of the new technologies to industry for use at the Hanford Site and other DOE sites. The initial demonstration site for the VOC-Arid ID is also the area of carbon tetrachloride contamination in the 200 West Area.

Detailed plans for conducting the Phase II (FY 1992) of the ERA site evaluation and the initial (FY 1992) VOC-Arid ID site characterization efforts were submitted in September 1991 (Rohay 1991) and November 1991 (Last and Rohay 1991), respectively. These site characterization and evaluation efforts were conducted jointly. The status and accomplishments of the combined FY 1992 characterization program are described by Rohay et al. (1992). That report also includes or references all available raw data collected as part of the FY 1992 characterization tasks. Interpretation and integration of the data, and the updated site conceptual model, will be reported in a separate document to be issued in January 1993.

Site characterization activities in support of both the ERA and the VOC-Arid ID for FY 1993 were fully integrated and are described in a unified site characterization plan (Rohay et al. 1992).

In March 1991, DOE granted a categorical exclusion, under Section D of the DOE's National Environmental Policy Act (NEPA) guidelines, for the ERA site characterization activities. A similar categorical exclusion for site characterization activities associated with the VOC-Arid ID was granted by DOE in March 1992. These exclusions allowed characterization activities to proceed without performing an environmental assessment.

Before implementation of vapor extraction operations, an environmental assessment was written to comply with NEPA (DOE-RL 1991). A finding of no significant impact was issued by DOE Headquarters.

1.3 SCOPE

During FY 1992, several activities were initiated as part of site characterization or vapor extraction operations, as described by Rohay (1992) and Green (1992), respectively, which contribute to the wellfield enhancement work. The scope of these activities include baseline monitoring of carbon tetrachloride at wellheads and soil gas points, baseline monitoring of groundwater, collection of data from the AVES, carbon tetrachloride soil flux measurements, and measurement of passive airflow in existing wells. These activities will be continued in FY 1993 and are pulled together in this work plan. The additional scope of this work plan includes expanded evaluation and guidance for the AVES, investigation of the feasibility of using an enhanced PVES, expanded baseline monitoring of the effluent from the wells and soils, and management of the data gathered during the various wellfield activities.

Wellfield enhancement activities will focus on the known carbon tetrachloride disposal sites, but will also include the farfield areas underlain by the carbon tetrachloride groundwater plume.

2.0 SUMMARY OF SITE CHARACTERISTICS

This section provides a brief summary of site characteristics as background for this work plan. More detailed discussions of site characteristics are provided by Rohay and Johnson (1991), Last et al. (1991), and Rohay et al. (1992).

2.1 SITE OPERATIONS

This section describes the operational and disposal history of carbon tetrachloride at and near Z Plant (Figure 2).

Z Plant was designed to process plutonium to a final product form on one of three process lines. Each of these process lines generated side streams that contained recoverable quantities of plutonium. The Recuplex facility and the Plutonium Reclamation Facility (PRF) were established to recover plutonium from these streams and were the primary contributors of carbon tetrachloride to 200 West Area soils.

Carbon tetrachloride was used in mixtures with other organics to recover plutonium from aqueous streams. The aqueous waste stream, characterized as high-salt aqueous waste, was primarily a concentrated nitrate solution that had a pH of 1 (neutralized to a pH of 2.5 prior to discharge). The chemical processes used to recover plutonium resulted in the production of actinide-bearing aqueous and organic waste liquids. The primary radionuclide components of these liquids were plutonium-239/240 and americium-241.

Both aqueous and organic phase wastes were discharged to the same liquid waste disposal sites. The carbon tetrachloride was periodically discharged batch-wise as an organic phase mixture and was also a minor (<1%) component of the aqueous phase. The aqueous wastes were continuously discharged.

Organic liquids discharged to the disposal sites consisted of carbon tetrachloride in mixtures with tributyl phosphate, dibutyl butyl phosphonate, or lard oil. Degradation products of carbon tetrachloride include chloroform and methylene chloride. Breakdown products of tributyl phosphate include dibutyl phosphate and monobutyl phosphate. In addition to the plutonium and americium, other constituents of the waste streams discharged to the sites include aluminum, cadmium, calcium, chromium, fluoride, chloride, iron, iodine, magnesium, nickel, nitrate, rubidium, sodium, sulfate, sulfamate, cesium-137, cobalt-60, uranium, ruthenium-106, and strontium-90.

The carbon tetrachloride disposal sites, located near Z Plant in the 200 West Area, are the 216-Z-9 Trench, 216-Z-1A Tile Field, and 216-Z-18 Crib (Figure 4). The 216-Z-9 Trench was used from 1955 to 1962 to receive all organic and aqueous waste from the Recuplex facility. Organic and aqueous waste from the PRF was discharged to 216-Z-1A Tile Field from 1964 to 1969 and to 216-Z-18 Crib from 1969 to 1973. Discharge of carbon tetrachloride to the soil column was discontinued in 1973.

Estimates of the volumes and quantities of various liquids and contaminants discharged to the three carbon tetrachloride disposal sites are summarized in Table 1. A total of 363,000 to 580,000 L of carbon tetrachloride is estimated to have been discharged to the soil column between 1955 and 1973.

Boreholes were drilled from 1949 to 1978 to characterize and/or monitor the three carbon tetrachloride disposal sites, primarily with regard to the radionuclide concentrations. Six boreholes were installed in FY 1992 as part of the joint VOC-Arid ID/ERA characterization program. Fifty-two boreholes are potentially available in the vicinity of the carbon tetrachloride disposal sites for additional characterization, monitoring, and remediation (Figure 3). Construction details for these boreholes are summarized in the ERA proposal (DOE-RL 1991, Appendix C) and the FY 1992 characterization status report (Rohay et al. 1992).

2.2 HYDROGEOLOGY

The geology of the 200 West Area consists primarily of fluvial and glaciofluvial sediments underlain by basalts. The sediments are, from oldest to youngest (Figure 5):

- Ringold Formation - a series of consolidated alluvial sands and gravels, and overbank and lacustrine deposits, of late Miocene to Pliocene age.
- Plio-Pleistocene unit - basaltic ditritus and carbonate-rich paleosol, often referred to as the caliche layer.
- Early "Palouse" soil - eolian silt and fine-grained sand.
- Hanford formation - unconsolidated glaciofluvial gravels, sands, and silts deposited by Pleistocene cataclysmic flood waters.

Figure 4. Available Existing Wells Around the Three Disposal Sites.

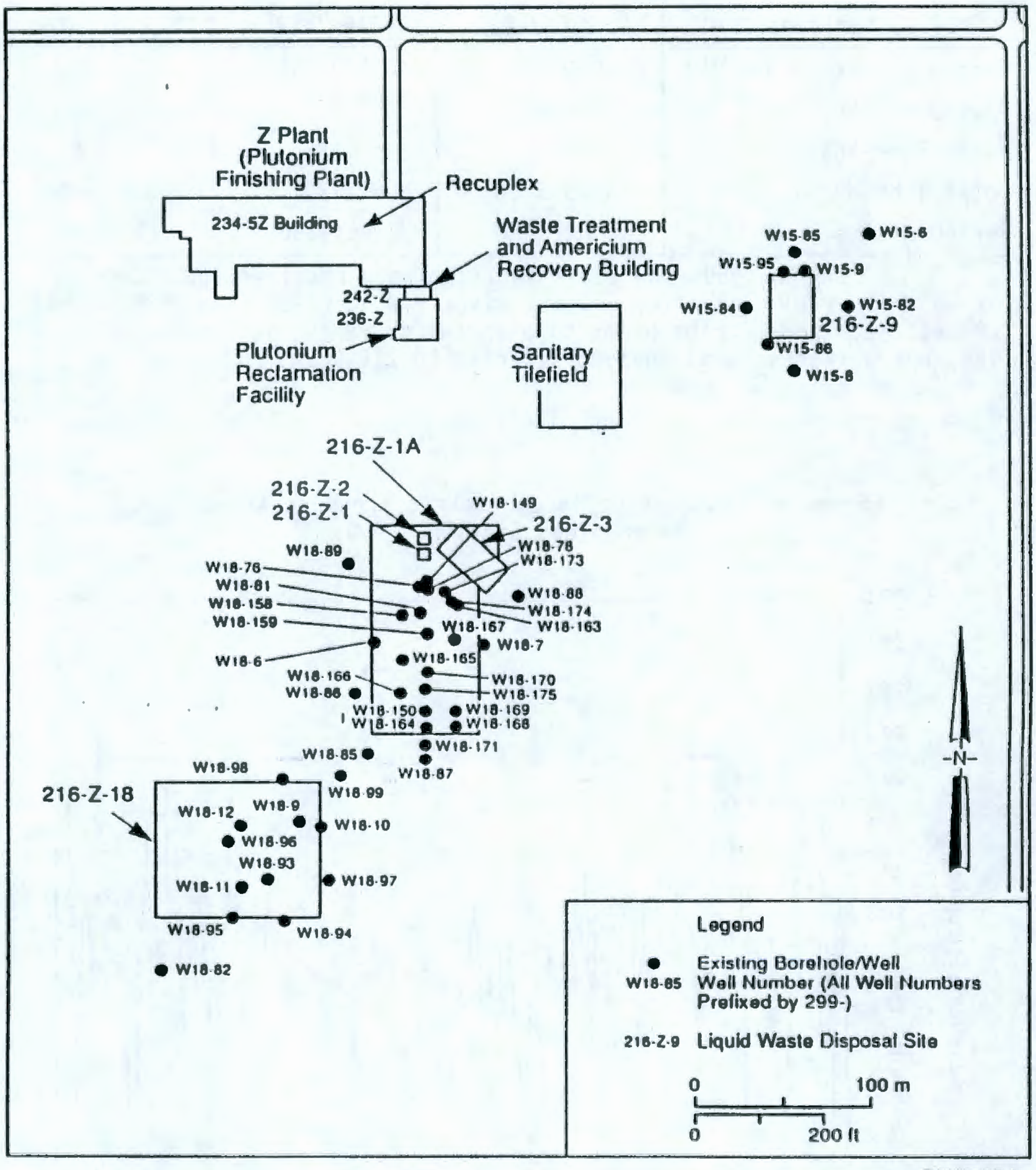

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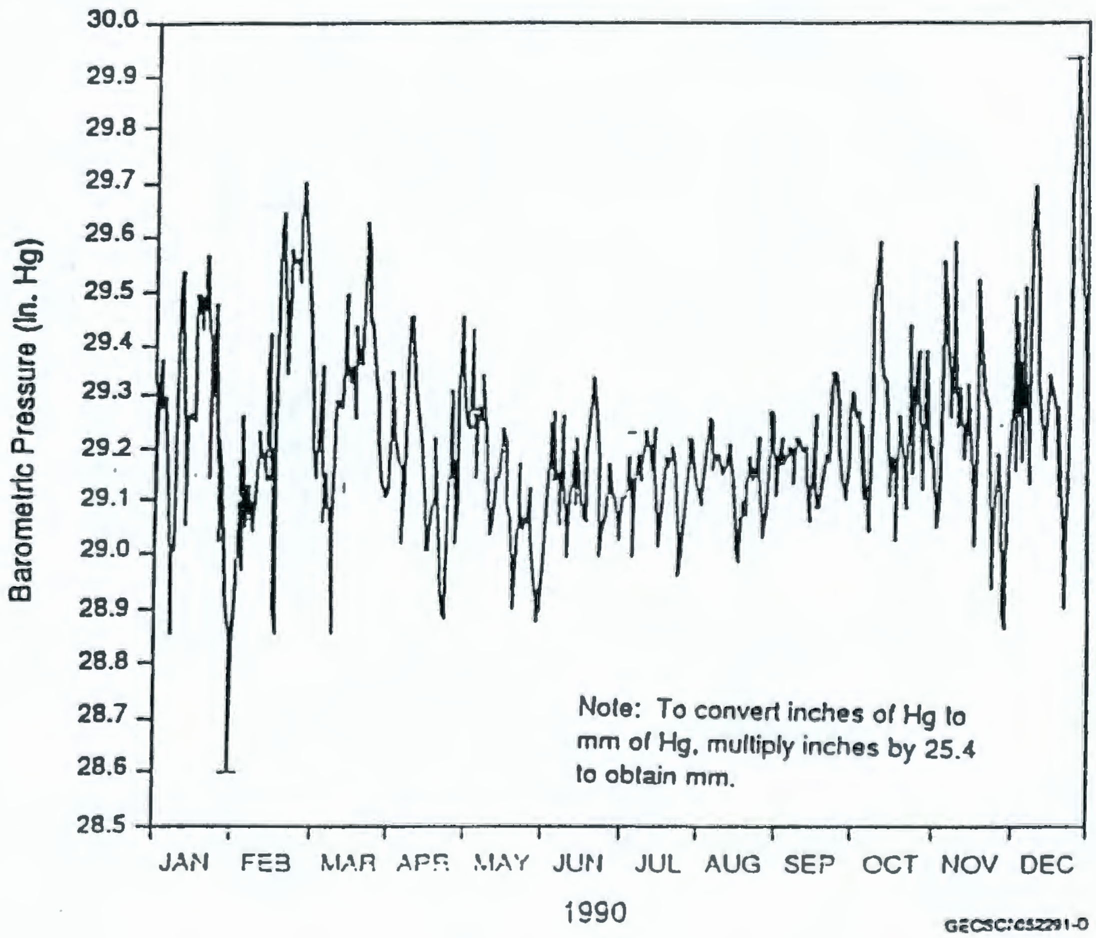
Table 1. Contaminant Inventory in Carbon Tetrachloride Liquid Waste Disposal Sites.

Contaminant	216-Z-9	216-Z-1A[a]	216-Z-18
Carbon tetrachloride (L)	83,000-300,000	170,000	110,000
Plutonium (kg)	106[b]	57	23
Americium (kg)	2.5	1	~0.4
Total liquid (L)	4.09×10^6	5.2×10^6	3.96×10^6
Period of use	1955-1962	1964-1969	1969-1973

[a]From 1949 to 1959, the 216-Z-1A Tile Field received approximately 1×10^6 L of slightly basic, aqueous waste via overflow from associated 216-Z-1, -2, and -3 cribs prior to disposal of PRF waste. From 1964 to 1969, PRF wastes were discharged directly to 216-Z-1A.

[b]58 kg was later removed.

Figure 5. Average Daily Barometric Pressure at Hanford Meteorology Station, 1990.



The unsaturated zone, consisting of sediments of the Ringold Formation, Plio-Pleistocene unit, early "Palouse" soil, and Hanford formation, ranges in thickness from 58 to 82 m across the 200 West Area and from 60 to 66 m beneath the carbon tetrachloride disposal sites. Because the Plio-Pleistocene unit is less permeable than the other units, it may temporarily divert or perch liquids and/or dense vapors. The top of this unit is approximately 40 m below ground surface. The topography of the Plio-Pleistocene surface suggests that it locally forms a ridge that extends south-southwest beneath the three carbon tetrachloride disposal sites and may divert fluids laterally to the west-northwest.

The uppermost aquifer in the 200 West Area is unconfined and located within the Ringold Formation. The saturated thickness of the uppermost aquifer ranges from 67 to 113 m. Groundwater flow directions are generally radial outward from the southwest portion of the 200 West Area primarily because of the continuing influence of the residual groundwater mound underlying the decommissioned 216-U-10 Pond (Figure 2). Recharge to the aquifer is primarily artificial recharge from waste disposal activities.

Moisture data have been collected from most of the wells drilled in the 200 West Area for the *Resource Conservation and Recovery Act of 1976* (RCRA) program. The moisture in the Hanford formation ranges from 0.31% to 33.16% and averages 5.3%. In the early "Palouse" soil, the moisture content ranges from 2.7% to 29.5% and averages 13.9%. The moisture content in the Plio-Pleistocene unit averages 3.8% and ranges between 1.8% and 5.8%. The Ringold Formation moisture content ranges from 0.87% to 11.4% and averages 4.5%.

2.3 METEOROLOGY

The climate of the Hanford Site is classified as mid-latitude semiarid or mid-latitude desert. The summers are warm and dry with abundant sunshine and winters are cool with occasional precipitation. Overcast skies and fog occur periodically in the winter (DOE 1988).

The mean surface temperature at the Hanford Meteorological Station (located about 0.4 km east of the 200 West Area) averages approximately 12°C. July tends to be the warmest month of the year with temperatures averaging 24.7°C. January tends to be the coolest month of the year with temperatures averaging -1.4°C.

Mean annual precipitation at the Hanford Meteorological Station is about 16 cm. On average, 42% of the annual precipitation falls during November, December, and January. January is the wettest month with an average of nearly 100 h of precipitation producing 2.3 cm of water. July is the driest month with an average of only 10 h of precipitation producing <0.4 cm of water.

The average atmospheric pressure for the Hanford Site is 29.2 in. of mercury (Figure 5). In general, the atmospheric pressure is higher in the winter than in the summer, although both the highest and lowest recorded pressures at the Hanford Site occurred during winter (DOE 1988).

Prevailing near-surface wind in the vicinity of the Hanford Meteorological Station is primarily from the west to northwest with an average wind speed of 4.8 km/h. Seasonal changes in the average wind direction are not very large, but seasonal changes in the average wind speed are more variable. June has the highest average monthly wind speed at 5.8 km/h, and the prevailing wind direction is from the west-northwest. In November and December, average wind speeds fall to about 3.8 km/h, and the prevailing wind direction is from the northwest (Stone et al. 1983).

2.4 CARBON TETRACHLORIDE BEHAVIOR

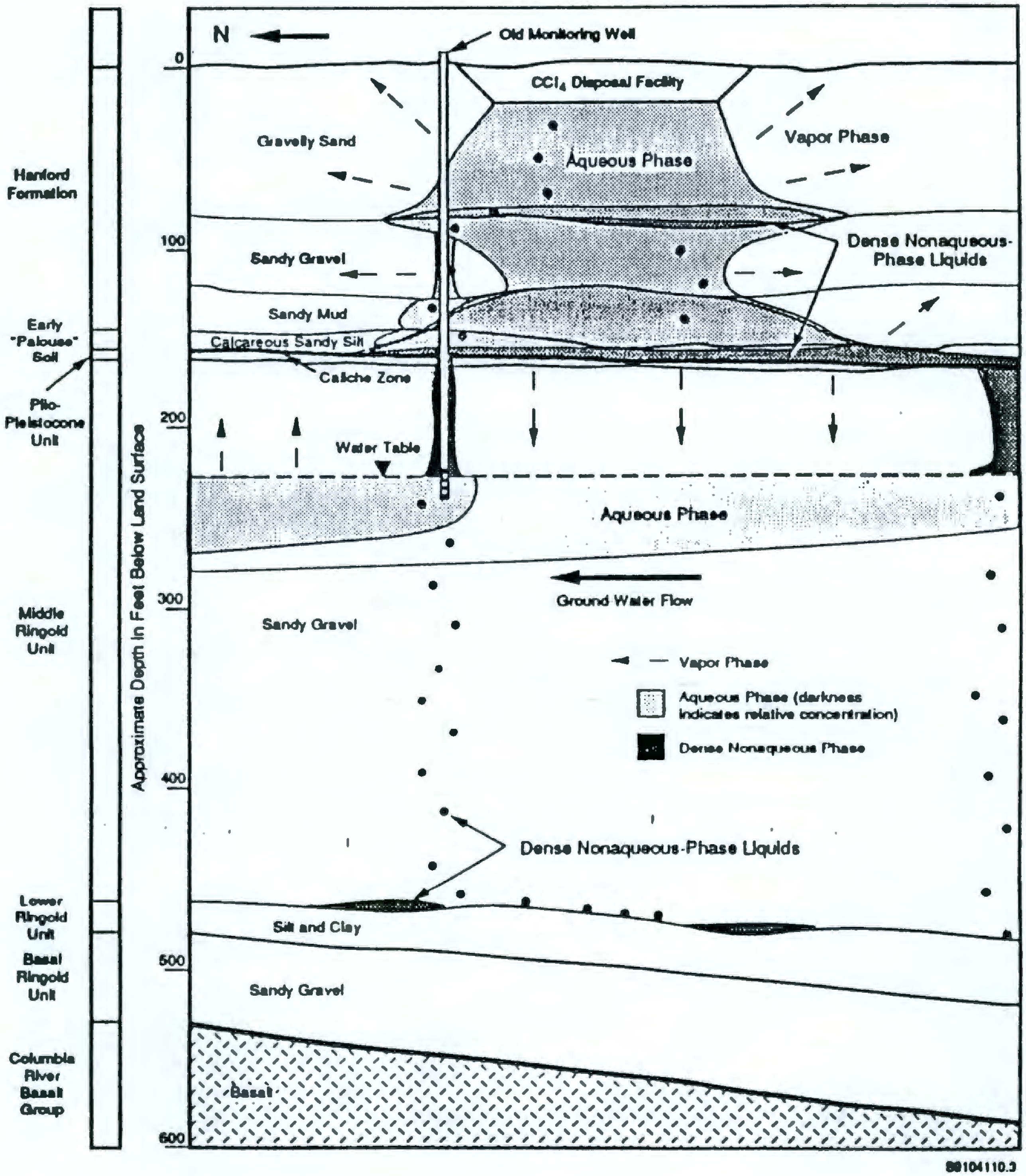
Carbon tetrachloride was discharged to the subsurface in the Z Plant area both in an aqueous solution and as a nonaqueous phase liquid. It is assumed that, initially, carbon tetrachloride was present and migrated in the unsaturated zone as an aqueous phase and as a separate, dense nonaqueous phase liquid (DNAPL). Subsequently, volatilization of the carbon tetrachloride has produced a vapor phase. Figure 6 illustrates the conceptual pathways and distribution of carbon tetrachloride released to the cribs. The conceptual behavior and distribution mechanisms are briefly described.

Aqueous phases containing dissolved carbon tetrachloride may have migrated directly to the groundwater by exceeding the water retention capability of the soils beneath the crib. Pore volume estimates indicate that 216-Z-9 Trench is the most likely to have exceeded this capacity. Soil-gas surveys also indicate highest concentrations of carbon tetrachloride in the vicinity of the 216-Z-9 Trench. Volume estimates for the dissolved carbon tetrachloride plume in the upper 10 m of the unconfined aquifer account for <2% of the discharge inventory. This suggests that significant amounts of carbon tetrachloride may still be present in the unsaturated zone, potentially providing a continuous source of contamination to the groundwater. At a well 40 m northeast of the 216-Z-9 Trench, dissolved carbon tetrachloride is found in the aquifer 52 m below the water table; however, the borehole itself may have provided the pathway by which the carbon tetrachloride reached this depth.

Separate nonaqueous phase carbon tetrachloride may have settled deep in the aquifer via preferential pathways (such as unsealed wells) and remained undetected, providing a continuous source of contamination by dissolution. Residual DNAPL contamination may also remain trapped in the unsaturated zone pores. Separate, nonaqueous phase carbon tetrachloride has not been encountered in either the aquifer or the unsaturated zone.

Liquid carbon tetrachloride has a moderately high vapor pressure and limited solubility, making it relatively volatile. Carbon tetrachloride vapors have been detected in gases extracted from soil pores in the unsaturated zone near the carbon tetrachloride disposal sites; measured concentrations have been highest at the 216-Z-9 Trench. In addition, carbon tetrachloride vapors have been detected at the wellhead during drilling throughout most of the 200 West Area since 1987. The density of carbon tetrachloride vapor is greater than uncontaminated vapors in the unsaturated zone. This contrast in vapor densities can result in density-driven

Figure 6. Conceptual Model of Carbon Tetrachloride Migration Pathways and Phase Distributions.



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advection, which can act to move carbon tetrachloride downward. Zones of relatively impermeable soils may laterally divert the carbon tetrachloride away from the disposalsites. In addition, carbon tetrachloride vapors in the unsaturated zone, which equilibrate with perched water and/or percolating waste water from other sources, may then be transported to the water table in dissolved form. Recent borehole drilling and sampling has indicated that the highest concentrations of carbon tetrachloride have been found in a silt and fine-grained sand (early "Palouse" soil) overlying a low-permeability caliche horizon (Plio-Pleistocene unit).

Differences in crib sizes, in quantities, frequencies, and concentrations of liquid wastes received and in heterogeneities of soil properties can impact mechanisms by which carbon tetrachloride is distributed in the soil.

3.0 WELLFIELD ENHANCEMENT TASKS

The FY 1993 wellfield enhancement tasks include the Z-Crib area and other portions of the 200 West Area that have soils potentially impacted by VOC. This section outlines the wellfield enhancement objectives and describes the specific tasks planned to accomplish them.

3.1 OPTIMIZE EXTRACTION OF THE AVES

During FY 1993, the AVES operations will be extracting from wellfields at all three carbon tetrachloride disposal sites (216-Z-1A Tile Field, 216-Z-18 Crib, and 216-Z-9 Trench). The three sites are also referred to in this work plan as the "Z-Crib area." A wellfield strategy will be developed that will provide the AVES operations with a plan for optimizing extraction of VOC from the subsurface in the Z-Crib area. The wellfield strategy encompasses well placement, target horizons, and pumping rates and durations.

3.1.1 Short-Term Extraction Tests

Short-term extraction tests (also known as VES characterization tests) will use the AVES to pull soil gas from a single perforated interval at a time. These tests will be performed at each perforated interval of each extraction well and monitoring well in the near vicinity of the AVES. Selection of flow from each location is accomplished through connecting hoses and aligning valves on the AVES; the testing procedure is described by Green (1992, Section 4). The testing will be performed approximately once every 2 weeks for the duration of the AVES operations.

The results of the short-term extraction tests will provide the equilibrium concentration of VOC in the area near the extraction zone and the available air flow at a given vacuum. The results will also provide insight into the changes of location and concentration of the VOC vapor plumes and their migrations with time.

3.1.2 Characterization Sampling

Routine characterization sampling of the extracted soil gas will be performed at sample locations on the AVES. This sampling will provide an understanding of the presence and concentrations of the VOC co-contaminants not measured by the AVES detectors. It will also provide confirmation sampling of the carbon tetrachloride concentrations measured by detectors on the AVES.

The characterization sampling will aid in the detection of carbon tetrachloride and its rate of degradation by the presence of its breakdown products (e.g., chloroform and methylene chloride). The characterization sampling will also provide a check for combustible gases (such as methane, associated with sanitary tile fields) and corrosive gases that the AVES may pull in.

The characterization sampling procedure is described by Green (1992, Section 4). The sampling will be performed approximately once per month for the duration of the AVES operations. The analysis of the samples will be performed by a mobile laboratory, the 222-S laboratory, or an offsite laboratory, as appropriate.

3.1.3 Airflow Pathways

A study of the subsurface airflow pathways induced by the AVES will be undertaken. The success of a vapor extraction system is dependent on understanding and controlling the airflow in the subsurface. The understanding of the airflow will be gained through an evaluation of the existing AVES production, tracer gas testing, and airflow modeling.

3.1.3.1 Evaluate Existing Production Data. The evaluation of the existing production data for the AVES operations will provide input for understanding the airflow permeabilities, radii of influence, and airflow pathways. The AVES production data have been electronically logged since February 1992. This data will be graphed and correlations will be made (if possible) of the effects on wells (such as the radii of influence) of the vacuum created in the subsurface. This correlation must take into account the effects of changes in the barometric pressure. After the existing production data are evaluated, the data from ongoing AVES operations will be evaluated on a routine basis.

3.1.3.2 Perform Tracer Gas Testing. A tracer gas will be used to specifically determine the subsurface airflow pathways, rate of transport of VOC, and the radii of influence of the extraction wells. A known quantity of a tracer gas will be injected into the subsurface at a certain interval. The tracer gas may then be pulled by airflow in the subsurface to an extraction well where it will be pulled through the AVES equipment. A detector placed on the AVES will monitor the concentration of the tracer gas in the extracted soil gas. A tracer gas that may be used is sulfur hexafluoride (SF_6), an inert gas that can be detected at the part-per-trillion levels. The tracer gas testing will be performed at each of the three disposal sites at some time during the operation of the AVES at the discretion of the project scientist.

3.1.3.3 Perform Airflow Modeling. Established computer codes will use input from existing AVES production data, tracer gas work, and known stratigraphy to model the extraction process airflows. This modeling will provide an understanding of the extraction process and the airflow pathways, and will help determine the soil permeabilities and radii of influence of the extraction wells. The modeling will help select locations requiring new extraction wells and monitoring wells and/or new perforated intervals in existing wells. The modeling will also aid in the optimization of the AVES operations by selecting flow rates and extraction points. The computer code HyperVentilate, distributed by the EPA, will be used initially for the modeling work. A more sophisticated code may be utilized later on.

3.1.4 Radii of Influence

The vacuum placed on a perforated interval in an extraction well by the AVES creates a vacuum in the soils surrounding the interval and is commonly termed the radius of influence. This influence is theoretically a circular cylinder with the extraction well as the axis. The magnitude of this influence is affected by many factors including soil porosity, permeability in relation to a source of unobstructed airflow (such as the surface), total vacuum created by the extraction process, and time of continuous applied vacuum. The radius of influence is critical because it determines the distance from the well from which VOC will be extracted. Extraction intervals must be located such that all of the soils potentially impacted by VOC are within a radius of influence. An understanding of the effective radii of influence created by multiple operating extraction intervals is essential for understanding the effective remediation zone in the subsurface. The radii of influence are determined by vacuum measurements, tracer gas work, and airflow modeling. A new determination of radii of influence will be made with each significant change in an extraction parameter, such as flow rate or location.

3.1.5 AVES Production Data

The AVES uses a process controller to record measured operating parameters. These data will be useful for gaining an understanding of the effect of the AVES operations on the wellfield. Production data from all three disposal sites will be separately evaluated. The findings will contribute to the extraction strategy for each disposal site.

3.1.5.1 Production Data for 216-Z-1A. The AVES has been operating regularly at 216-Z-1A since February 1992. Considerable data have been recorded that will be analyzed for improving operations. The data will be evaluated by the wellfield strategy group to gain an understanding of the subsurface trends in the operations. This understanding will be useful in developing a strategy for AVES operations in this area. After the existing production data are evaluated, the data from the ongoing AVES operations will be evaluated on approximately a monthly basis. The parameters recorded by the present AVES operating at 216-Z-1A are:

- Alpha radiation
- Radon concentrations
- Vacuums
- Beta radiation
- Temperatures
- Pressures

- Flow rates
- Carbon tetrachloride concentrations
- Relative humidity

3.1.5.2 Production Data for 216-Z-9. Data will be gathered by the AVES at the 216-Z-9 site when operations begin. The parameters measured will be similar to those listed in Section 3.1.5.1. The data gathered by the AVES operations at 216-Z-9 will be evaluated by the wellfield strategy group to gain an understanding of the actual operating conditions, such as flow rates and VOC concentrations. This understanding will be used in revising the initial AVES operating strategy. The production data will be evaluated on approximately a monthly basis.

3.1.5.3 Production Data for 216-Z-18. The existing AVES data associated with the operations at 216-Z-18, though limited, will be evaluated by the wellfield strategy group to gain an understanding of the operations to date. The parameters measured are similar to those listed in Section 3.1.5.1. Evaluation of the data will be useful in developing a strategy for the initial full-scale AVES operations at 216-Z-18. Following the initial period, the production data will be evaluated on approximately a monthly basis.

3.1.6 Wells and Intervals

The factors used in determining the extraction strategy will also be used as input in selecting the locations for additional extraction and monitoring wells and new perforated intervals within existing wells. The additions are intended to improve the ability to measure and control the subsurface airflows and to contain subsurface areas within an extraction point radius of influence. The selection of the locations will be communicated to site characterization operations for integration with that program.

The locations for additional wells will be selected based on the airflow pathway results, the known radii of influence of the existing extraction points, and the physical limitations such as access restrictions. The intervals within the wells will be selected based on airflow pathway results, radii of influence, limitations imposed by the construction of the wells (such as grout in the annular space), the number of packer pipes that will fit within the well casing, and the known stratigraphy in the area of the wells. The stratigraphy of the area is a critical determinant because a high permeability zone (e.g., coarse sands and gravels) provides a ready pathway for airflow and the VOC from that zone is rapidly depleted. However, a low permeability zone (e.g, clays and silts) typically holds a greater unit volume of VOC than the highly permeable zone and must be included in the subsurface airflow pathways to remove the subsurface VOC. The ideal situation is to locate an interval in both a high permeability zone and a low permeability zone, providing significant airflow across the low permeability zone to withdraw the VOC.

A small-scale vapor extraction device, labeled the "VES characterization unit," will be used to perform pilot tests on selected wells at the VES site. This testing will provide information on flows, vacuums, and initial VOC concentrations associated with the selected wells. The information will be used to assist in extraction strategy and wellfield design. The VES characterization unit will operate in a similar manner as the full-scale AVES, but at lower flows and pressures. Operation will follow the appropriate hazardous waste operations permit, radiation work permit, and safety assessment document. All information obtained from VES characterization unit testing will be entered in a controlled logbook. VES characterization unit operation personnel will be trained in operation, sampling, instrument usage, and shutdown of the unit. This training will be verified prior to personnel commencing unit operation.

Other technologies to collect in situ soil-gas samples from these wells will be used if available to provide additional characterization of the soil gases.

Approximately seven new extraction and/or monitoring wells are planned for FY 1993. The focus of this work will be at the 216-Z-9 area. However, the number of new wells at each disposal site, and the locations of those wells, have yet to be determined. Two existing wells will be deepened and completed as extraction wells.

3.1.6.1 Wellfield at 216-Z-1A. Eleven existing wells in the vicinity of 216-Z-1A were selected for extraction and monitoring purposes for the AVES. These wells were perforated in specific intervals to provide access to the subsurface in those intervals. In addition, two new wells were installed during FY 1992, which were completed for use as extraction and/or monitoring wells.

The present wellfield at 216-Z-1A is presented in Table 2.

Although the wells are designated as primarily extraction or monitoring, all of the wells are constructed for use in either function. The typical extraction and monitoring well constructions are shown in Figures 7 and 8. The wells with a single perforated interval have a cap welded on at the top of casing to seal the well. The cap is equipped with a quick-connect fitting and instrumentation hook-ups.

One to two new wells will be installed during FY 1993 and completed for extraction and/or monitoring. One well inside the tile field, 299-W18-174, will be deepened to 140 ft (top of the caliche layer) as part of the site characterization program (Rohay et al. 1993) and completed for vapor extraction. A second unsaturated zone well may be drilled at this site, outside of the tile field boundaries. This well will be completed with two perforated intervals, one above and one below the caliche layer, similar to well 299-W18-246 installed in FY 1992.

3.1.6.2 Wellfield at 216-Z-9. The existing wells at 216-Z-9 have been evaluated for availability, access, depth, condition, stratigraphic horizons, and relative proximity to each other in designing the initial wellfield. Four existing wells were selected for the initial extraction wellfield and are presented in Table 3. These initial wells will not be perforated until they are tested because they have demonstrated relatively high VOC concentrations during the wellhead baseline monitoring as they exist with their bottoms unplugged. The opening at the bottom of an 8-in.-diameter casing compares with the open area in a 5-ft perforated interval of a 6-in.-diameter casing with 4% open area (typical at 216-Z-1A). Similar to the wells used at 216-Z-1A and 216-Z-18, the wells will have caps welded on for extraction and

Table 2. Present Wellfield at 216-Z-1A Tile Field.

Well number	Primary use	Casing diameter (in.)	Perforated interval[a]
299-W18-87	Monitoring	6	A 33-38 B 65-70 C 125-130
299-W18-150	Extraction	6	A 65-70 B 85-90 C 113-118
299-W18-158	Extraction	6	A 75-80 B 89-94 C 119-124
299-W18-159	Extraction	6	A 113-120
299-W18-163	Monitoring	6	A 69.5-79.5 B 92.5-99.5 C 114.5-119.5
299-W18-165	Monitoring	6	A 122-127
299-W18-166	Monitoring	6	A 124-129
299-W18-167	Monitoring	8	A 114-119
299-W18-168	Monitoring	8	A 118-123
299-W18-171	Monitoring	8	A 20-25 B 57-77 C 115-130
299-W18-175	Extraction	6	A 68-75 B 87-94 C 115-120
299-W18-246	Monitoring	4	A 120-130[b] B 165-175[b]
299-W18-248	Monitoring	4	A 123-139[b]

[a]Depths are in feet below the top of the casing unless otherwise noted.

[b]Depths are in feet below land surface.

Figure 7. Typical Extraction Well Construction.

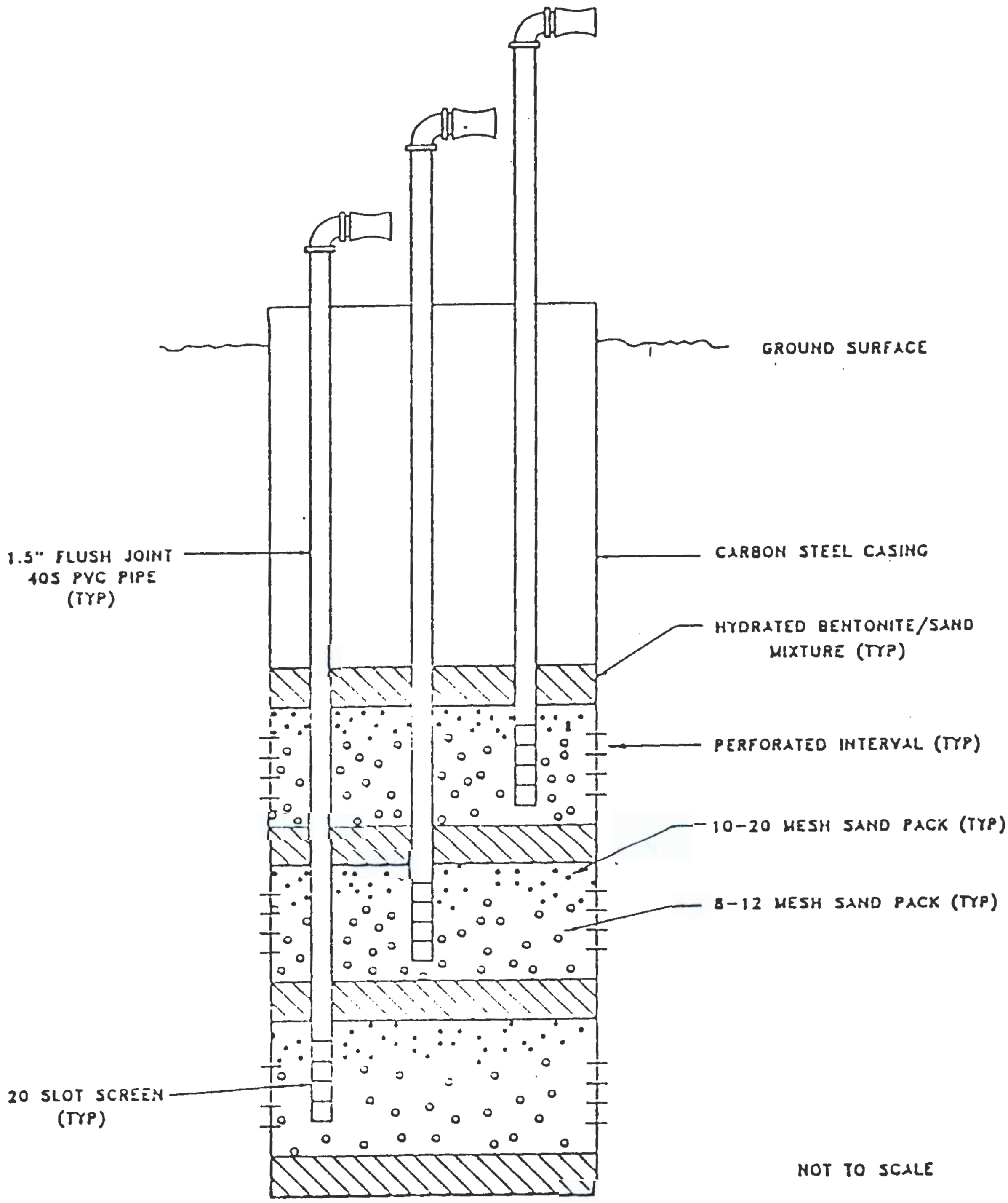

Figure 8. Typical Monitoring Well Construction.

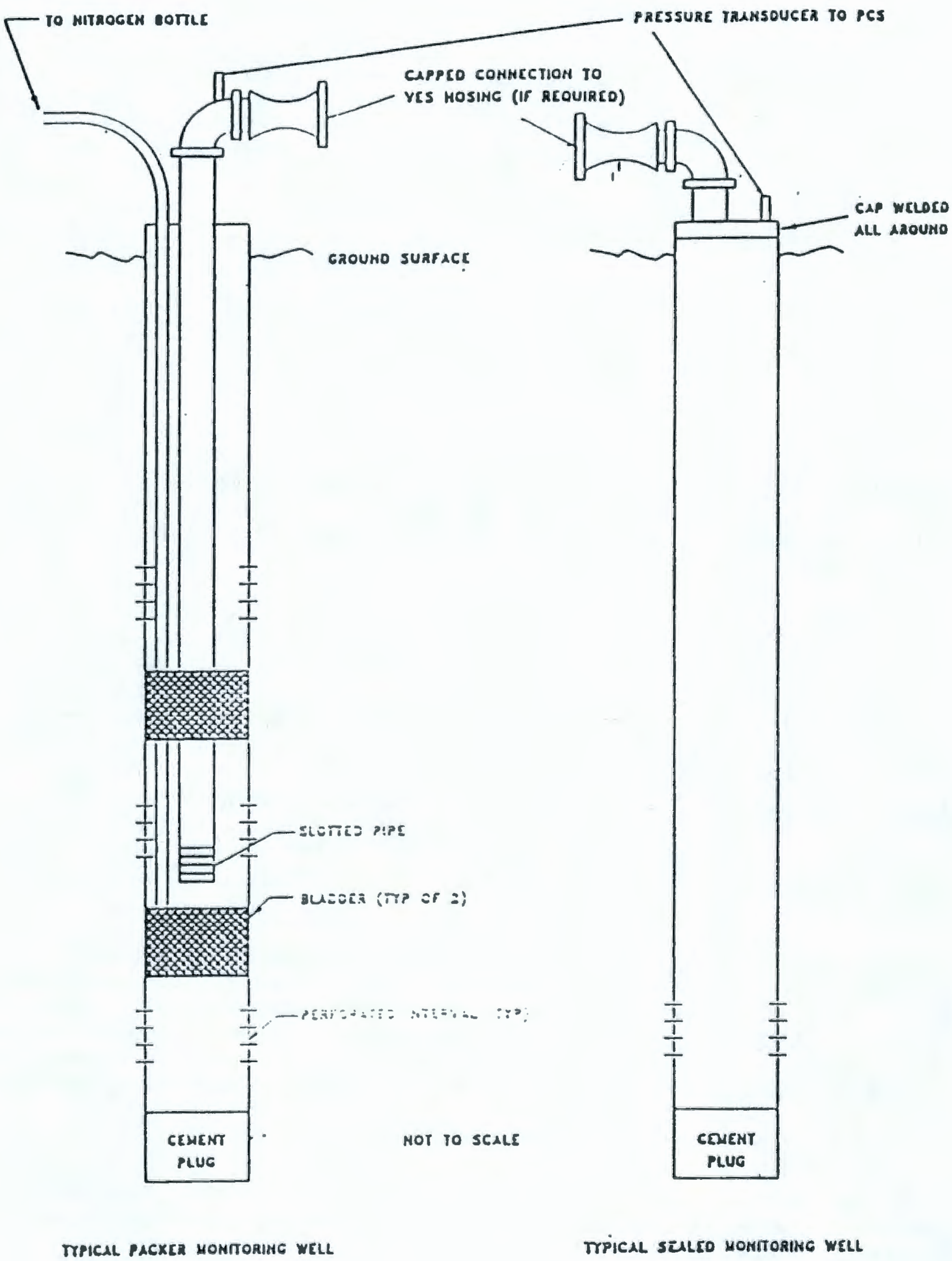

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Table 3. Present Wellfield at 216-Z-9.

Well number	Primary use	Casing diameter (in.)	Total depth (ft[a])	Perforated interval[b]
299-W15-82	Extraction	8	99	
299-W15-84	Extraction	8	106	
299-W15-85	Extraction	8	104	
299-W15-95	Extraction	8	99	
299-W15-216	Monitoring	4		A 70-80 B 175-185
299-W15-217	Monitoring	4		A 106-121

[a]Depths are in feet below top of casing.
[b]Depths are in feet below land surface.

monitoring purposes. Each cap will have a quick-connect fitting, flow control valve, pressure transducer, and manual vacuum gage. In addition, two new wells were installed in FY 1992 and were completed as extraction and/or monitoring wells.

Four to six new vapor extraction and/or monitoring wells will be installed at this site during FY 1993. One well, 299-W15-218, will be drilled approximately 100 ft north of the trench and completed with two perforated intervals, one above and one below the caliche layer, similar to well 299-W15-216 installed in FY 1992. The location was selected based on the results of the FY 1992 soil gas sampling and flux rate measurements made during FY 1992 (Rohay et al. 1992), the baseline monitoring data, and the locations of existing wells. Finally, a slant well is planned for FY 1993 to be drilled at an angle. Drilling of this well will be a demonstration of drilling technology through the VOC-Arid ID. Although this well is part of the site characterization program (Rohay et al. 1993), it is intended to be completed for extraction.

3.1.6.3 Wellfield at 216-Z-18. Nine existing wells in the vicinity of 216-Z-18 were selected for extraction and monitoring purposes for the AVES. All of these wells have a single perforated interval. Caps with a quick-connect fitting and instrumentation hook-ups were welded on the tops of two wells (299-W18-10 and 299-W18-87). In addition, two new wells were installed during FY 1992 and were completed as extraction and/or monitoring wells.

The present wellfield is shown in Table 4.

The wellfield may be expanded to include more wells or more perforated intervals within the existing wells as puffer testing and/or operational experience dictate.

Table 4. Present Wellfield at 216-Z-18.

Well number	Primary use	Casing diameter (in.)	Perforated interval[a]
299-W18-10	Extraction	6	180-218
299-W18-93	Monitoring	6	130-140
299-W18-94	Monitoring	6	103-118
299-W18-96	Monitoring	6	69-79
299-W18-97	Extraction	6	60-72
299-W18-98	Monitoring	6	68-78
299-W18-99	Monitoring	6	90-100
299-W18-247	Monitoring	4	A 119-129[b] B 162-172[b]
299-W18-249	Extraction	4	122-137[b]

[a]Depths are in feet below the top of the casing unless otherwise noted.
[b]Depths are in feet below land surface.

One well inside the crib, 299-W18-96, will be deepened to 140 ft (top of the caliche layer) as part of the site characterization program (Rohay et al. 1993) and completed for vapor extraction. A second vadose zone well may be drilled at this site, outside of the crib boundaries. This well will be completed with two perforated intervals, one above and one below the caliche layer, similar to well 299-W18-247 installed in FY 1992.

3.1.7 Cone Penetrometer Wells

The factors used in determining the extraction strategy and locating additional wells and intervals will be used in selecting locations for new cone penetrometer (CPT) wells. These CPT wells will be useful in many of the same ways as the conventional wells (i.e., providing access to the subsurface for extraction, monitoring, and air and tracer gas injection). A CPT well may be used where and when it is capable of being installed and when the benefits exceed those of a conventional well for the particular application. In addition to the installation of wells, the CPT may be used to install monitoring points and pressure transducers.

It is anticipated that up to 34 CPT locations will be distributed among the 3 carbon tetrachloride disposal sites. The maximum target depth for each well is 120 ft. An additional 12 CPT locations may be chosen at farfield locations for tracer gas testing. This work will also be supported by the VOC-Arid ID for demonstration of CPT capabilities.

3.1.8 Wellfield Extraction Strategy

Based on factors including production data, determination of the radii of influence, and the results of modeling, the strategy for extraction by the AVES will be determined. This information will be communicated to AVES operations for implementation. The strategy will provide for adjustments to be made monthly or at the discretion of the project scientist. The strategy will be in the form of recommended flow rates, extraction locations, and other airflow control functions (e.g., opening a nonextraction interval to ambient air to increase airflow to subsurface from that point). An overall 216-Z-9 wellfield recommendations report will be completed around mid-February. A similar wellfield recommendations report for 216-Z-1A and 216-Z-18 will follow.

3.1.8.1 Wellfield Extraction Strategy for 216-Z-1A. The AVES has been operating regularly at 216-Z-1A since February 1992. Considerable data have been produced that will be analyzed for improving operations. These data, along with the ascertained radii of influence of the extraction wells, will contribute toward the development of a strategy providing direction for AVES operations in the 216-Z-1A area. Also, locations for additional wells and additional intervals within the existing wells will be selected for further improving the AVES operations.

3.1.8.2 Wellfield Extraction Strategy for 216-Z-9. An AVES is scheduled to begin operating at 216-Z-9 in February 1993. Modifications to existing wells in the area will be performed to create the initial AVES wellfield. Prior to the operation of the AVES, a puffer unit will provide a pilot test to gather data for determining initial extraction strategy. When the AVES begins operating, data will be produced that will be analyzed for improving operations. A new extraction strategy will be produced to provide direction for future AVES operations in this area. Also, locations for additional wells and additional intervals within the existing wells will be selected, further improving the AVES operations.

The results of the puffer tests and the airflow modeling will provide input to the determination of the initial extraction strategy to be used by the AVES at 216-Z-9. This initial extraction strategy will be used to develop production data. Because of the higher concentrations of VOC detected from several of the wells during wellhead baseline monitoring and because of the proximity of the wellfield to a sanitary crib (potential for methane gas), a significantly different strategy for the 216-Z-9 AVES operations may be created.

3.1.8.3 Wellfield Extraction Strategy for 216-Z-18. The AVES operating primarily at 216-Z-1A operated on a limited basis at 216-Z-18 during the summer of 1992. This data will be analyzed for improving operations at 216-Z-18 when the AVES begins full operations there. A strategy will be produced to provide direction for the AVES operations in this area. Also, locations for additional wells and additional intervals within the existing wells will be selected, further improving the AVES operations.

3.2 PVES EVALUATION

During FY 1993, factors affecting the natural flows from wells and soils will be evaluated, the feasibility of enhancing those flows will be investigated, prototype PVES equipment may be tested, and administrative issues dealing with PVES will be addressed. The purpose of implementing these tasks is to determine the feasibility, design, and effectiveness of enhancing the natural flow of VOC from the subsurface. The development of methods to enhance the passive extraction may be significant for the future reduction of costs and complexities associated with the present AVES removal of VOC from the subsurface. In addition to providing input for the PVES, an understanding of the mass flux of VOC from the wells and surface soils will provide a tool for inventorying the VOC remaining in the subsurface.

3.2.1 Factors Affecting Natural Flow from Wells

An understanding of the factors affecting the natural flow of soil gas and VOC from wells is essential for designing and developing methods of enhancing this passive extraction. Initial indications are that the effluent of VOC from the wells could be significant and that methods to control and increase this effluent are worthwhile and necessary.

3.2.1.1 Wellhead Monitoring System Development. Systems that monitor parameters associated with the natural flow from wells will be developed. The parameters monitored may include mass flow rate into and out of the well, pressures and temperatures at various depths in the well, relative humidity, and VOC and radon concentrations. The measurements will be stored in dataloggers. The data will be routinely downloaded from the dataloggers and the data compiled and analyzed. The wellhead monitoring systems may eventually incorporate process equipment such as flow control valves or heat tape to provide the ability to vary parameters.

Initial wellhead monitoring indicates that flows in excess of 10 scfm and carbon tetrachloride concentrations approaching those seen in the AVES are possible. During one 24-h period in which concentration data were available, 34 g of carbon tetrachloride was released from a single well (Rohay and Cameron 1992).

3.2.1.2 Wellhead Monitoring System Implementation. The wellhead monitoring systems will be implemented first on wells in the Z-Crib area and eventually may include farfield wells. Each wellhead monitoring system will operate independently. The data from the systems will provide insight into understanding the factors responsible for natural flow from the wells and will also provide a baseline for comparison to enhanced PVES techniques. The wellhead monitoring systems will be operated on wells with caps in place (which are known to leak, as demonstrated by the wellhead baseline monitoring data) and with the caps removed. The "cap on" data will provide an understanding of how much mass flow the wells have historically released, which is significant for inventorying the subsurface VOC. The "cap off" data will demonstrate the total mass flow the wells are capable of when obstructions to the flow are removed.

3.2.1.3 Pressures at Various Depths. The pressure gradient between air at the surface (barometric pressure) and air in the subsurface has been identified as a primary factor in creating the natural air flow into and out from the wells. A greater understanding of the magnitude and development of this gradient and the elements affecting it is necessary. The pressures at various depths will be measured by transducers that are vented at different depths. Stainless steel (1/8-in. diameter) transducer vent lines will be attached to the exterior of the permanent well casing during well construction, or plastic transducer vent lines will be placed at different depths during CPT placement.

3.2.1.4 Site Meteorologic Conditions. The meteorologic conditions at the site may be the primary driver for the natural air flow of the wells. Two meteorologic stations are presently set up and operating in the Z-Crib area to measure the site-specific conditions. These measurements are stored in a datalogger on each station. The measurements will be used in correlating the meteorological conditions to parameters measured by the wellhead monitoring systems.

Meteorologic data are also available from the Hanford Meteorological Station, located about 0.4 km east of the 200 West Area.

3.2.1.5 Literature Search. A literature search of the available published information regarding the natural flow from wells will be conducted. This will provide a basis from which the site-specific testing can be extended.

3.2.1.6 Tracer Gas Testing. Tracer gas testing will provide a fundamental role in providing information on airflow pathways and VOC movement in the subsurface. Application of tracer gas techniques will supply information that could be used for the following:

- Estimate horizontal gas phase migration rate in the unsaturated zone
- Develop predictive model input parameters and validate selected unsaturated zone models
- Estimate VOC migration out of wells and the surface soils
- Create a database that will greatly improve mass balance calculations aimed at reconciling past and present levels of VOC in the subsurface.

Tracer gas testing will be performed by injecting a known quantity of a tracer gas into a well. Air flowing out of the well and out of the soils around the well will be measured for the tracer gas. These concentration measurements with time will provide mass flux rates from the well and from the soils and will eventually be used to establish a correlation of mass flux rates associated with the VOC. A tracer gas that may be used is sulfur hexafluoride (SF_6), an inert gas that can be detected at the part-per-trillion levels.

3.2.1.7 Soil Gas Characterization. The soil gas flowing out of the wells will be collected and analyzed to characterize the constituent makeup of the gas. This may be done several times to confirm the results of the wellhead monitoring system detectors and to note changes in concentrations of constituents not routinely measured by the system detectors. An example of a change may be increased levels of carbon dioxide or chloroform relating to increased microbial degradation of carbon tetrachloride. The analysis of the collected soil gas will be performed by a mobile laboratory, the 222-S laboratory, or an outside laboratory, as appropriate.

3.2.1.8 Effect of Earth Tides. Earth tides are the rising and falling crustal movements of the earth's surface due to gravitational influences by the sun and moon, analogous to the ocean tides. Anecdotal reference by several people to the potential effect of earth tides on the rate and volume of air flow and VOC movement through the soils and wells has been noted. An initial investigation of these possible effects was begun in FY 1992, and further work will be done to evaluate the effects during FY 1993. A gravimeter or other such device may be set up in the Z-Crib area to measure the magnitude of the gravitational changes causing the earth tides. Further investigation through available literature, software programs indicating earth tide potential, and/or other resources may be pursued. The effect of earthtides is not expected to be significant; hence, study of this phenomenon is a low priority task requiring minimal resources.

3.2.1.9 Natural Flow Data Evaluation. The factors measured and investigated will be pulled together, and an evaluation will be made regarding the causes and controllable elements of natural flow. This information will serve the design effort of enhancing the passive extraction of VOC from the subsurface. This information will also be used for inventory calculations of the VOC remaining in the subsurface.

3.2.2 Feasibility of Enhanced PVE from Wells

The feasibility of enhancing the passive extraction of VOC from the wells will be investigated. The feasibility is dependent upon controlling the factors identified that affect the natural flow from the wells and the inventory of VOC in the subsurface. Several devices may be tested in the laboratory and in the field to establish the feasibility of a PVES. Testing will be performed according to a test plan completed specifically for each test. An outline for the test plan is shown in Figure 9.

3.2.2.1 Venturi Evaluation and Testing. A venturi is a device that utilizes the nearly omnipresent site wind (year around average of about 5.1 mi/h at 7 ft off the ground) to increase the pressure gradient between the surface and the subsurface, thus potentially inducing increased flow from the well. A venturi is shaped with a cone going into and coming out of a smaller middle section. The change in airstream velocities through the venturi develop the suction in the smaller middle section. Venturi of various sizes and designs may be tested in the Pacific Northwest Laboratory (PNL) wind tunnel and on wells out in the field if initial bench-scale tests demonstrate reasonable results. An evaluation of the testing will determine their relative effectiveness.

Figure 9. Passive Vapor Extraction Test Plan Outline.

I. Test Objective and Scope

The objective and scope of the test are described. The objective is brief and to the point. The scope identifies who will be involved in the test, what will be done, where the test will be performed, and the length of the test (who, what, where, and when).

II. Data Requirements

The data to be obtained during the test are identified. The required data precision and accuracy are listed.

III. Special Equipment

All special equipment required for the test will be listed. This can be used as a checklist while performing the test.

IV. Test Procedure

The level of detail contained in the procedure will depend on the scope of the test. In general, only enough detail is provided to ensure that the test is performed satisfactorily.

V. Schedule

The test plan schedule is used to identify key test items and to provide input to the overall task schedule. The complexity of the schedule will vary with test scope.

3.2.2.2 Wind Turbine Evaluation and Testing. A wind turbine is also a device that utilizes the site wind to increase the pressure gradient between the surface and the subsurface, thus potentially inducing increased flow from the well. Wind turbines are commonly used to ventilate attics. Wind turbines of various sizes and designs may be tested in the PNL wind tunnel and on wells out in the field if initial bench-scale tests demonstrate reasonable results. An evaluation of the testing will determine their relative effectiveness.

3.2.2.3 Induced Convection Evaluation and Testing. Inducing convective currents created by increasing the temperature of the air at the top of the well casing may increase the flow from the well. This concept will be investigated and may be tested in the PNL wind tunnel and on wells out in the field if initial bench-scale tests demonstrate reasonable results.

3.2.2.4 Other Concept Evaluation and Testing. It is anticipated that other concepts for enhancing passive extraction will be created as more information is gathered and the factors affecting flow are better understood. These concepts will be evaluated and may be tested.

3.2.3 Factors Affecting Natural Flow from Surface

An understanding of the factors affecting the natural flow of soil gas and VOC from the surface is essential for designing and developing methods of enhancing this passive extraction. Initial indications are that the effluent of VOC from the surface is significant and methods to control (e.g., check valves on wells) and increase this effluent are worthwhile.

3.2.3.1 Soil Flux Studies. Soil flux studies will provide a measurement of the rate at which VOC are moving out of the soil to the atmosphere and help establish VOC concentration contours. This information will provide a baseline against which future enhancements may be compared. The studies will be conducted using flux chambers set on the soil surface and online detectors or absorbers analyzed later in a laboratory.

3.2.3.2 Soil-Gas Studies. Soil-gas studies, similar to the soil flux studies, will provide a baseline measurement of the VOC rate of movement and will also help establish VOC concentration contours. The studies will be conducted using the existing soil-gas points and may require the placement of new points. The VOC concentrations are determined through routine sampling with a field instrument.

3.2.3.3 Literature Search. A literature search of the available published information regarding the natural flow of soil gas and VOC from the surface will be conducted. This will provide a basis from which the site-specific testing can be extended.

3.2.4 Feasibility of Enhanced PVE from Surface

Based on the information collected, the feasibility of enhancing the passive extraction of VOC from the surface will be investigated. If feasible, enhanced PVES devices may be tested in the laboratory and/or field to demonstrate proof of concept and effectiveness.

3.2.5 Modeling of PVE

Modeling will be performed to predict the effectiveness and radii of influence of a PVES. This input to the modeling will be from data gathered to evaluate the factors affecting natural flow and the testing of enhancing devices. Recently Massmann and Farrier (1992) have modeled the effect of atmospheric pressures on gas transport in the vadose zone for a system analogous to that at the Z-Crib area. Their work indicates that modeling may be an effective tool for understanding and optimizing passive extraction from wells and soils.

3.2.6 Prototype Enhanced PVES Equipment

Based on the information gathered regarding natural flow, the testing of PVES devices, and modeling of the PVES, a prototype enhanced PVES may be installed for demonstration testing. If installed, the effectiveness of this equipment as compared to the baseline data will be measured. Based on this information, other enhancing devices may be selected and tested, if feasible.

3.2.7 Feasibility Study of PVE

All the natural flow factors studied and the results of modeling and the known administrative issues will be integrated into a feasibility study of implementing a PVES. The feasibility study will be documented in a report that details the pertinent findings and will provide recommendations for future testing and implementation. The report will be completed around the end of June.

The feasibility study will address issues such as regulations, cost/benefit comparisons, and comparisons with other technologies. These administrative considerations, along with the technical considerations, will determine the overall potential for application of PVES.

3.2.7.1 Analyze Regulatory Issues on PVES. An analysis of regulatory issues, such as limitations on VOC emission levels, will be performed. This assessment will include federal, state, DOE, and Westinghouse Hanford Company (WHC) requirements.

3.2.7.2 Compare Costs and Impacts of PVES and AVES. A comparison of the anticipated extraction rates, costs of operation, and other impacts will be made. This comparison will help decide when (if ever) PVE could be implemented and to what extent.

3.2.7.3 Compare PVES to Other Technologies. In addition to comparing the costs and impacts of PVE to AVES, a comparison is necessary of PVE to other technologies. This comparison will include baseline and innovative technologies. This comparison will provide a rating of PVE in relation to other technologies for this application and will further provide a direction for the remediation technologies to be implemented in the future.

3.3 BASELINE MONITORING

During FY 1993, baseline monitoring in the Z-Crib area and farfield (outside the Z-Crib area, within the 200 West Area) will be continued and will include the measurements of VOC concentrations at wellheads, from soil-gas probes, and in the groundwater. The purpose of Z-Crib area baseline monitoring is to help characterize the magnitude of the VOC plume and to provide a baseline against which to evaluate the impact of the AVES and the PVES on the plumes. The purpose of farfield baseline monitoring is to help characterize the magnitude of the VOC plume, identify unknown VOC plumes, and provide a baseline to analyze VOC plume migration.

Baseline monitoring of wellheads and soil-gas points in the Z-Crib area has been performed since December 1991. This routine sampling has begun to establish a base of information by which future changes may be identified. Wellhead monitoring of farfield wellheads will be initiated in FY 1993.

3.3.1.1 Z-Crib Area Wellhead Baseline Monitoring. Routine baseline monitoring involves field measurement of carbon tetrachloride at wellheads and soil-gas points in the Z-Crib area. The monitoring is performed two times per week using a field instrument outfitted for response to halogenated hydrocarbons.

The monitoring will continue to be performed at least through the end of January 1993. At that time, the sampling protocol used during the baseline monitoring, sample locations, and schedule of sampling will be evaluated and modified at the discretion of the project scientist.

3.3.1.2 Farfield Wellhead Baseline Monitoring. As a means of screening for unknown VOC plumes, a sample of the soil gas emitting from available wells in the 200 West Area will be field measured as time allows in the same manner as the wellheads are measured by the Z-Crib area wellhead monitoring program. This sampling will be performed once. The results from sampling all 200 West Area wells will establish the need for a farfield monitoring program. If such a program is implemented, the results from the initial monitoring will also be used to establish the sampling locations and schedule for sampling.

3.3.1.3 Monitoring Instruments. Baseline monitoring will be performed with a photoionization detector (PID) equipped with an 11.8-eV lamp. Monitoring instruments should be maintained and calibrated according to Environmental Investigations Instruction (EII) 3.2, "Calibration and Control of Monitoring Instruments" (WHC 1988).

3.3.1.4 Sampling Protocol. To begin the wellhead sampling routine, the sampler obtains a background reading 1 m upwind from the wellhead, then lifts the well cap and inserts the PID probe a few inches into the well. At each wellhead, air is drawn through the instrument for at least 10 seconds to fully equilibrate the system.

At soil-gas probes, a background reading is taken 1 m from the sample tube. The PID is directly coupled to the tube and at least two purge volumes are extracted from the tube before the sample is taken.

At wellheads and soil-gas probes, the sampler draws air through the instrument while monitoring the real-time readings. This continues while the readings increase. Once the reading has reached a maximum peak, the maximum value is recorded on a data sheet and internally within the instrument. If instrument readings appear to change without apparent reason, the instrument will be challenged. If the challenge is not within 10% of the original calibration, the instrument will be recalibrated. If the challenge indicates that the calibratiion is off by more than 20%, data collected since the last calibration will be discarded.

All acquired data from the baseline monitoring of the unsaturated zone are recorded by the field technician on a field form or stored in the memory of the instrument. A printed copy of the sampling and analysis results from each day of monitoring is given to the project scientist.

3.3.2 Routine Groundwater Baseline Monitoring

Groundwater from wells in and around the Z-Crib area and at the perimeter of the groundwater plume are monitored for concentrations of VOC. This helps provide an understanding of changing volume and movement of the VOC in the groundwater.

Groundwater samples will be collected from approximately 26 wells, as shown in Table 5. The initial list of wells to be sampled was chosen based on sampling conducted during FY 1991 and FY 1992 and in coordination with other groundwater monitoring programs. Construction details and analytical results for these wells are reported by Rohay et al. (1992). At the discretion of the project scientist, wells may be added or subtracted from this list based on results of current sampling and new wells that become available for sampling. Sampling during FY 1993 will occur twice, once in November and once in May.

Ongoing Hanford Site groundwater monitoring programs that include 200 West Area wells are (1) the Operational Groundwater Monitoring Network, (2) the RCRA program, (3) the 200 West Aggregate Area Management Study under CERCLA, (4) any groundwater monitoring required by liquid waste discharge permits, and (5) PNL site-wide monitoring. The various sampling efforts are coordinated by the Operational Groundwater Program. Table 5 indicates which wells are already being sampled under an existing program. Duplication of sampling efforts will be avoided whenever possible.

Groundwater samples will be analyzed for VOC using a gas chromatograph/ mass spectrometer (GC/MS) in the laboratory and/or with portable field screening equipment, if feasible. Samples from wells that have carbon tetrachloride concentrations at or below 5 ppb (e.g., 699-43-88 and 699-49-79) will be analyzed using a more sensitive GC method.

3.3.3 Baseline Monitoring Data Analysis

The data compiled during the routine wellhead baseline monitoring and routine groundwater baseline monitoring will be analyzed and will provide input to the extraction operations and other site investigators.

3.3.3.1 Data Analysis. The baseline monitoring data will be used to establish soil-gas VOC concentration contours and update groundwater VOC concentration contours. The trends of the baseline monitoring data will be identified and used as input for determining the extraction strategies. Also, the overall flux rates of VOC from the different media and the movement of the vapor plumes will be determined.

Table 5. Groundwater Wells to be Sampled.

Well	Responsible program
299-W7-4	RCRA
299-W7-5	RCRA
299-W10-4	N/A
299-W10-15[a]	RCRA
299-W10-17[a]	RCRA
299-W10-18[a]	RCRA
299-W11-28[a]	RCRA
299-W14-12[a]	RCRA
299-W15-6	200 West Aggregate Area Management Study
299-W15-8	Operational Groundwater Monitoring Network
299-W15-12	N/A
299-W15-16[a]	RCRA
299-W15-22[a]	RCRA
299-W18-2	N/A
299-W18-9[a,b]	N/A
299-W18-17	Operational Groundwater Monitoring Network
299-W18-20	Operational Groundwater Monitoring Network
299-W18-25[a]	RCRA
299-W18-29	RCRA/Operational Groundwater Monitoring Network
299-W18-30[a]	RCRA
299-W19-32[a]	RCRA
299-W23-13[a]	RCRA
699-38-70	N/A
699-39-79	N/A
699-43-88	N/A
699-49-79	N/A

[a]VOA samples added for November and May sampling.
[b]Bailed sample.

3.3.3.2 Input to AVES Operations and PVE Feasibility. The information gathered regarding the VOC concentrations will be provided to those operating the AVES and to the feasibility study of PVE. This information will also be available to the site principal investigators of innovative technologies for the VOC-Arid ID.

3.3.3.3 Overall Flux Rates and Movement. Overall flux rates of VOC from the different media and the movement of the vapor plumes will be determined.

3.4 DATA MANAGEMENT

During FY 1993, environmental baseline data, AVES production data, PVES testing and characterization data, and drilling information will be gathered. The data obtained during baseline monitoring and AVES production will be compiled and analyzed to assist in developing the wellfield strategy. Record data will be officially maintained by WHC's Environmental Restoration Program Information Center (EPIC) as per EII 1.6 (WHC 1988). The data gathered during PVE testing and wellfield characterization will be compiled, maintained, and analyzed.

The objective of data management is to keep all wellfield data readily available and up to date at all times. All original data will be logged, compiled, and maintained in both hard copy and, where appropriate, electronic form. Baseline and AVES data will be logged and compiled.

As all data are received, they will be logged in according to applicable quality assurance (QA) procedures. The data will be assigned a chronological number in the form ERL-WHC/93-02-SD-9X-YYY where X is the calendar year and Y is the assigned chronological source data number. A file log (presented as Figure 10) entry containing the assigned number, material description, transmitter, file location, and date shall be completed prior to filing the data. Data received in electronic format will be printed, and the hard copy plus the disk copy will be assigned the source data number.

All data will be compiled and entered into electronic spreadsheet format. This will allow for consistent presentation of the data (tabular and graphic formats) and will simplify data analysis.

All original data will be maintained in a retrievable form with duplicates stored separately from the original.

Data analysis will be performed using a variety of methods (principally computerized analysis). The principal tool will be computer spreadsheets.

3.4.1 AVES Production Data

The data gathered during operation of the AVES will assist in optimization of VOC extraction from the subsurface in the Z-Crib area. Data received from the project scientist will be compiled and analyzed to assist in the wellfield characterization effort. Data reports will be prepared as requested by the project scientist.

3.4.2 PVES Testing Data

The data gathered during PVE testing will assist in determining the feasibility, design, and effectiveness of enhancing the natural flow of VOC from the subsurface. Data will be logged, compiled, maintained, and analyzed to assist in the PVE development/testing effort. Data reports will be prepared as necessary to support publication of PVE test results and as requested by the project scientist.

9 3 1 3 0 2 6 2 0 4 5

E-93-02
WESTINGHOUSE HANFORD COMPANY
SOURCE DATA LOG

Chrono #	File #	Date	From	Subject
ERL-WHC/93-02-SD-9___-____				
ERL-WHC/93-02-SD-9___-____				
ERL-WHC/93-02-SD-9___-____				
ERL-WHC/93-02-SD-9___-____				
ERL-WHC/93-02-SD-9___-____				
ERL-WHC/93-02-SD-9___-____				
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ERL-WHC/93-02-SD-9___-____				

Figure 10. File Log Sheet.

3.4.3 Baseline Monitoring Data

The baseline monitoring data will be entered into a database that will be used for evaluation through maps, graphs, and other data analysis tools. Baseline monitoring data collected from December 1991 through September 1992 have been compiled in a data package (Fancher 1993).

3.4.3.1 Z-Crib Area Baseline Monitoring Data. Baseline monitoring is used to assist in characterizing the magnitude of the VOC plume and to provide a baseline against which to evaluate the impact of the AVES and PVE on the plumes. Baseline monitoring will include routine determination of wellhead, groundwater, and ambient air concentrations of VOC. The routine wellhead data will be compiled on a monthly basis. The monthly report will include data sorted by date and sample point, and will include graphs of each sample point along with monthly meteorologic data.

Groundwater and ambient air concentration data will be logged, compiled, and analyzed. Reports will be submitted at the discretion of the project scientist.

3.4.3.2 Farfield Baseline Monitoring Data. Farfield baseline monitoring data will be used to assist in characterizing the magnitude of the VOC plume, identifying unknown VOC plumes, and to provide a baseline to analyze VOC plume migration. Farfield baseline monitoring will include wellhead, soil gas, groundwater, and ambient air VOC concentrations. All data received from the project scientist will be logged and compiled. Data management will begin when this program is implemented in FY 1993. Reports will be submitted on request.

3.4.4 Additional Monitoring Data

Soil-gas sampling and soil flux characterization measurements will logged, compiled, maintained, and analyzed. Data will be reported as requested by the project scientist. Drillers' notes and existing Science & Engineering Associated Membrane Instrumentation and Sampling Technique (SEAMIST) (tradename of Science and Engineering Associates, Santa Fe, New Mexico) results will be logged and reviewed to extract any information that will assist wellfield characterization.

A report will be prepared for the work completed during FY 1993. A draft report, presenting the status of the FY 1993 activities and the resulting data, will be submitted at the end of July. The final report, including data evaluations, will be submitted mid-August.

3.5 VOC-ARID ID TECHNOLOGIES

During FY 1993, several VOC-Arid ID technologies may be evaluated and demonstrated in the Z-Crib area. Technologies presented by the VOC-Arid ID Remediation Technical Steering Group will be assessed and demonstrated to estimate their effectiveness if implemented. These technologies have the potential to improve the design and construction of the wellfields and may improve the extraction of soil gas from the subsurface.

3.5.1 Wellfield Technology Evaluation

One or more wellfield enhancement proposed technologies recommended by the Remediation Technical Steering Group will be evaluated regarding potential effectiveness and applicability for demonstration.

3.5.2 Wellfield Technology Demonstration

One or more wellfield enhancement proposed technologies will be demonstrated. A demonstration will include aspects of writing the test plan, setting up the necessary testing equipment, arranging the necessary permissions to perform the demonstration, conducting the demonstration, and evaluating the findings of the demonstration.

4.0 SCHEDULE

The tentative schedule for FY 1993 wellfield enhancement activities is presented as Figure 11.

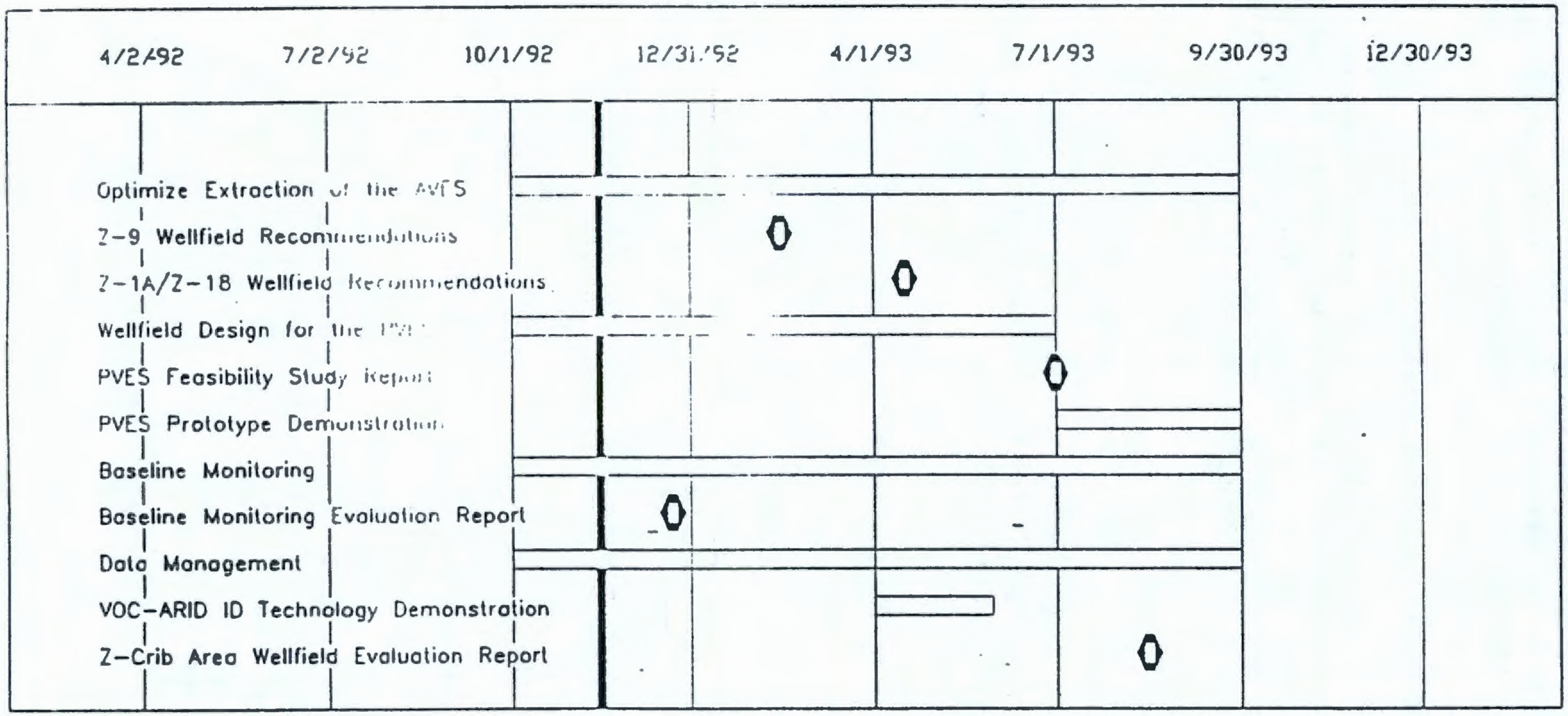

Figure 11. FY 1993 Wellfield Enhancement Schedule.

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APPENDIX A

200 WEST AREA CARBON TETRACHLORIDE EXPEDITED RESPONSE ACTION (ERA) WELLFIELD ENHANCEMENT

SAMPLING AND ANALYSIS PLAN

PART 1 - FIELD SAMPLING PLAN

PART 2 - QUALITY ASSURANCE PROJECT PLAN

PART 1

FIELD SAMPLING PLAN

CONTENTS

1.0 OBJECTIVES

This field sampling plan addresses sampling activities to be performed during the FY 1993 200 West Area Carbon Tetrachloride Expedited Response Action (ERA) Wellfield Enhancement. Background information can be found in Section 1 of this work plan. The wellfield enhancement tasks described in Section 3 of this work plan are summarized in Table FSP-1.

Table FSP-1. Wellfield Enhancement Tasks.

Short-Term Extraction Testing:

Location: At each perforated interval of each extraction well and monitoring well in the AVES wellfields
Frequency: Once every 2 wk for duration of AVES operations
Reference: Testing procedure described by Green (1992, Section 4)

Characterization Sampling:

Location: At the sample locations on the AVES
Frequency: Once every month for duration of AVES operations
Target Analytes: Carbon tetrachloride and degradation products (e.g., chloroform, methylene chloride); combustible gases (e.g., methane); corrosive gases
Reference: Testing procedure described by Green (1992, Section 4)

Tracer Gas Testing:

Location: At each of the three carbon tetrachloride disposal sites; at up to four farfield locations
Frequency: At least once during AVES operations; at least once at each farfield location

Installation of up to 46 Cone Penetrometer Wells:

Location: 216-Z-9 Trench (10); 216-Z-1A Tile Field (12); 216-Z-18 Crib (12); Farfield (12)

NOTE: Final determination of the distribution of the new wells among the three sites and the locations for farfield testing will be based on the optimization activities described in this work plan.

Depth: 120 ft
Completion: Vadose zone monitoring/vapor extraction well; air and tracer gas injection well; installation of monitoring points and pressure transducers
Potential Contamination: Carbon tetrachloride, chloroform, tributyl phosphate, dibutyl phosphate, dibutylbutyl phosphonate, plutonium, americium, cadmium (at 216-Z-9 Trench)
Sampling/Testing: Soil-gas sampling, air and tracer gas testing

Wellhead Monitoring:

Location: Z-Crib area wells; possibly farfield wells
Parameters: Well caps on and off, pressures with depth, temperatures with depth, mass flow rate, relative humidity, VOC concentrations, radon concentrations

Z-Crib Area Soil Gas Baseline Monitoring:

Location:

216-Z-9 Wells	216-Z-1A Wells	216-Z-18 Wells	General Wells	Near-surface soil-gas probes	Deep soil-gas probes
W15-6	W18-6	W18-9	W18-1	C-1	W15-6
W15-8	W18-7	W18-11	W18-2	E-2	W15-84
W15-82	W18-85	W18-12	W18-17	E-3	
W15-84	W18-86	W18-82	W18-18	N-2	
W15-85	W18-87	W18-93	W18-19	N-3	
W15-95	W18-88	W18-94	W18-24	N-5	
	W18-89	W18-95	W18-153	N-6	
	W18-171	W18-98	W18-157	N-7	
				N-9	
				W-1	
				W-5	

Frequency: Twice per week through at least through January 1993.
Target Analytes: Carbon tetrachloride

Farfield Soil-Gas Baseline Monitoring:

Location: Available wells in 200 West Area
Frequency: At least once during FY 1993
Condition: Sample only when barometric pressure is 29.0 in. Hg or less
Target Analyte: Carbon tetrachloride

Installation of New Extraction/Monitoring Wells:

Location: 216-Z-9 Trench; 216-Z-1A Tile Field; 216-Z-18 Crib

NOTE: Final determination of the distribution of the new wells among the three sites will be based on the optimization activities described in this work plan.

Depth: ±60 m (0.5 m below static water level)
Completion: Unsaturated zone monitoring/vapor extraction well
Potential Contamination: Unsaturated Zone: carbon tetrachloride, chloroform, tributyl phosphate, dibutyl phosphate, dibutylbutyl phosphonate, plutonium, americium, cadmium (at 216-Z-9 Trench)
Groundwater: Iodine-129, uranium, cyanide, carbon tetrachloride

<u>Sampling</u>:

- Drive-barrel or hard tool sampling every 1.5 m
- Split-spoon samples may be obtained at the project scientist's discretion
- Lithologic, moisture, $CaCO_3$, and VOC samples at the project scientist's discretion
- Physical properties and chemical samples at the project scientist's discretion
- Soil-gas sampling at the project scientist's discretion
- Groundwater sampling at perched and static water level.

Field sampling activities for installation of the new vapor extraction/monitoring wells are stated below. The field sampling activities are designed to complement those activities conducted in support of ERA site characterization whenever feasible (Rohay et al. 1992). Other tasks outlined in this work plan will be documented in the associated test plans, letters of instruction, etc., for those specific tasks. Field conditions may preclude sampling at predefined locations, intervals, or frequencies. Changes in sample locations, intervals, or frequencies may be made at the discretion of the well site geologist and documented in field activity reports. Additional samples may be collected at the project scientist's discretion during drilling activities. Any additional test plans, letters of instruction, etc., for sampling not specified in this field sampling plan will follow, as a minimum, the guidelines in Section 2.0, "Sample Designation;" Section 3.0, "Sampling Procedures;" and Section 4.0, "Sampling and Analysis."

2.0 SAMPLE DESIGNATION

Each sample will be assigned a unique Hanford Environmental Information System (HEIS) sample number. Subsamples to be analyzed for chemicals will keep the sample number of the original sample. All groundwater samples from the same sampling location will have the same HEIS number. The HEIS numbers will be used on all documentation of the samples.

3.0 SAMPLING PROCEDURES

3.1 GENERAL REQUIREMENTS

Samples will be handled according to the requirements defined for each specific sample. The general procedure governing sample handling, from collection through analysis, is similar in scope for all samples. Once collected, samples will be screened for radiation by Health Physics before further handling can proceed. During this screening, samples will be stored onsite according to the appropriate preservation technique. Once released by Health Physics, samples will be transported to either the Pacific Northwest Laboratory (PNL) sampling group for offsite distribution or to the specific laboratory responsible for analysis.

Prior to split-spoon sampling, the borehole will be cleaned out with the drive barrel and measured for depth to bottom. The number of blow counts for the sampler to advance each 0.15 m will be recorded as the sampler is driven.

To obtain a baseline of split-spoon sampler temperatures, selected samplers will have the pre-sampling and post-sampling temperatures recorded. The frequency performed will be as directed by the field team leader. Temperature-sensitive tape may be applied to the inside of the split tube approximately 1 in. above the bottom of the threads. If the ambient air temperature is 80°F or greater, sampler components should be stored in a shaded or cooled area and assembled immediately prior to use.

Chain-of-custody forms will be generated for solid and liquid samples. Soil-gas field sampling records will be generated for soil-gas samples.

3.2 LITHOLOGIC CHARACTERIZATION SAMPLING

Samples will be obtained at 1.5-m intervals for lithologic characterization. These samples will be analyzed for $CaCO_3$ content and moisture content. $CaCO_3$ samples will be collected from both the saturated and unsaturated zones. Moisture content samples will not be collected from the saturated zone or from the slurry recovered during hard-tool drilling. Samples will be collected in accordance with EII 5.2 (WHC 1988a).

3.3 POROSITY/BULK DENSITY AND AIR PERMEABILITY SAMPLING

3.3.1 Data Needs That Define Sampling Intervals

Samples may be obtained for bulk density, porosity, and air permeability analyses at the project scientist's discretion.

3.3.2 Sample Collection and Preservation Procedures

Samples for air permeability, bulk density, and porosity will be obtained with a split-spoon sampler lined with four 15-cm Lexan (a trademark of E. I. du Pont de Nemours & Company) tubes. The sampling equipment will be decontaminated onsite per EII 5.4 (WHC 1988a). A minimum of two full Lexan liners will be designated for these analyses, one for air permeability and one for bulk density and porosity.

Each sample and liner will be capped immediately upon removal from the split spoon. The samples will be marked with the sampling information and HEIS number. Samples should be protected from physical shock and freezing during both the sampling and transport process.

3.4 PHYSICAL PROPERTY SAMPLING

3.4.1 Data Needs That Define the Sampling Locations

Physical property samples may be obtained at the project scientist's discretion. These samples may be analyzed for moisture content, unsaturated hydraulic conductivity, clay mineralogy, diffusion coefficients, and particle size. Pore water may be extracted during the course of the analyses and analyzed for its chemical constituent content and carbon tetrachloride content.

3.4.2 Sample Collection and Preservation Procedures

Samples taken for physical property analysis will be collected using a split-spoon sampling tool. The sampling equipment will be decontaminated onsite per EII 5.4 (WHC 1988a). A minimum of one full 0.15-m Lexan liner is needed for the physical property analysis.

Each liner will be capped immediately upon removal from the split spoon. The samples will be marked with the sampling information and HEIS number. Samples should be protected from physical shock and freezing during both the sampling and transport process.

The physical property samples will be transported from the drill site to the Washington State University (WSU) Tri-Cities laboratory for analysis. There is no holding time limit for the physical property samples.

3.5 CHEMICAL SAMPLING

3.5.1 Data Needs That Define the Sample Locations

Chemical samples may be obtained at the project scientist's discretion.

3.5.2 Sampling Procedures

Chemical samples will be obtained with a split-spoon sampler lined with four 15-cm Lexan tubes in accordance with EII 5.2 (WHC 1988a). The sampling equipment will be decontaminated onsite per EII 5.5 (WHC 1988a).

Equipment that requires decontamination per EII 5.5 will be decontaminated at the 100K laboratory. Laboratory-cleaned equipment must be transported to the drill site before sampling proceeds. The split-spoon shoe, core-catcher, spacer, Lexan liners, and liner caps will be decontaminated per EII 5.5 and wrapped in aluminum foil.

3.6 VOA SAMPLING

3.6.1 Data Needs That Define the Sample Locations

Volatile organic analyses (VOA) will be performed to identify the presence of carbon tetrachloride and other volatile organic contaminants in sediment from the unsaturated zone.

3.6.2 Sample Collection and Preservation Procedures

VOA samples will be obtained at the project scientist's discretion. Samples will be placed in amber glass 40-mL VOA vials. Vials for dry soil samples will contain methanol preservative. Once collected, samples must be refrigerated in an upright position.

Samples will be taken using a core-borer to remove soil directly from the sampler (split-spoon or drive barrel) or with a metal scoop from composited cuttings. Samples will be placed in vials immediately to prevent loss from evaporation.

During hard-tool drilling, VOA samples will be collected with a metal scoop from the cuttings slurry.

3.7 GROUNDWATER SAMPLING

3.7.1 Data Needs That Define the Sample Locations

Each borehole will be advanced to approximately 1.5 m below static water level to obtain groundwater samples.

3.7.2 Sample Collection and Preservation Procedures

Groundwater samples will be collected at static water level in each borehole. The samples will be collected with a Teflon (trademark of E.I. du Pont de Nemours & Company) bailer in accordance with EII 5.8 (WHC 1988a).

The samples will be transported by PNL sampling staff, who will distribute the samples to the analytical laboratories. The sample containers and chain-of-custody forms will be prepared by PNL sampling staff.

3.8 SOIL-GAS SAMPLING

3.8.1 Data Needs That Define Sample Locations

Soil-gas samples may be obtained at the project scientist's discretion. Samples will be obtained using the Science and Engineering Associates Membrane

Instrumentation and Sampling (SEAMIST) (tradename of Science & Engineering Associates, Inc., of Santa Fe, New Mexico) sampling system and/or BoreSampler.

3.8.2 Sample Collection and Preservation Procedures

Gas phase samples will be obtained using the SEAMIST sampling system. The samples will be pumped from the subsurface into glass bulbs and/or syringes or Tedlar (a tradename of E.I. du Pont de Nemours & Company) bags. Samples do not require refrigeration before analysis. Samples will be analyzed within 24 h of collection.

SEAMIST in situ air permeability tests may be performed at each soil-gas sampling interval.

4.0 SAMPLING AND ANALYSIS

Samples will be handled and transported as specified in the procedures. Results of chemical and volatile organic laboratory analyses will be sent to the sampling staff at PNL. Analysis results will be entered into the HEIS database. Results of physical property analyses will be published in report form.

Once samples have been analyzed, the samples will be disposed of by the sampling personnel or the laboratory analysis personnel. Sampled material that remains on the Hanford Site will be disposed of at the drill site where it was collected. If samples are contaminated, dispose of per WHC (1988b).

5.0 REFERENCES

Green, J. W., 1992, *Design, Operation, and Monitoring of the Vapor Extraction System at the 216-Z-1A Tile Field*, WHC-SD-EN-TI-010, Rev. 0-C, Westinghouse Hanford Company, Richland, Washington.

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PART 2

QUALITY ASSURANCE PROJECT PLAN

CONTENTS

TABLES:

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1.0 PROJECT DESCRIPTION

The primary objective of the 200 West Area expedited response action (ERA) is to remove carbon tetrachloride from the unsaturated soils in the 200 West Area. The FY 1993 wellfield enhancement work plan presents a detailed outline for optimization activities to be conducted in and around the carbon tetrachloride contamination site in 200 West Area. The description of the physical characteristics of the ERA site, and the nature and extent of the contamination, are included in Section 2.0, "Summary of Site Characteristics," in this work plan. The description of the physical characteristics of the ERA site and the nature and extent of the contamination is included in Section 2.0, "Summary of Site Characteristics." Field activities conducted to support site characterization for the ERA are described in a separate work plan (Rohay et al. 1992).

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

Overall responsibility of wellfield enhancement activities for the ERA will be maintained by the Westinghouse Hanford Company (WHC) project manager. A WHC field team leader will be responsible for coordinating onsite drilling activities with Kaiser Engineers Hanford (KEH) drilling personnel. WHC will be responsible for site geologist support. Pacific Northwest Laboratory (PNL) will be responsible for coordinating sampling and analytical activities at the drill site, and reporting analytical results. A WHC field team leader will be responsible for baseline monitoring.

3.0 QA OBJECTIVES FOR MEASUREMENT

The data quality needs are defined by the analytical levels required to meet the ERA objectives. Table QAPP-1 lists the analytical levels and expanded definitions (adapted from EPA 1987). In general, the ERA analytical data should be reproducible and reliable, and realtime, but do not need to be validated in accordance with Contract Laboratory Program (CLP) procedures. The data quality needs are identified in Table QAPP-2, which lists the analytical levels to be applied to each type of analysis. Data quality needs in this context apply only to laboratory or field analyses.

Most sediment and soil-gas samples will be analyzed with a portable gas chromatograph or other field-screening equipment. Field screening with a calibrated instrument is adequate for determining concentrations, and the results are required in real time. Accuracy, precision, and detection limits of the instrument will be determined during field calibration and documented. Laboratory screening will be technically correct using a calibrated instrument and documented. Groundwater samples submitted to PNL for comparative analysis will be analyzed for volatile organics according to applicable procedures in

Table QAPP-1. EPA Analytical Levels.

Level I	Field screening or analysis using portable instruments. Results are often not compound specific and not quantitative, but results are available in real time. It is the least costly of the analytical options.
Level II	Field analysis using more sophisticated portable analytical instruments; in some cases, the instruments may be set up in a mobile laboratory onsite. There is a wide range in the quality of data that can be generated. Quality depends on the use of suitable calibration standards, reference materials, and sample preparation equipment; and the training of the operator. Results are available in real time or several hours.
Level III	All analyses performed in an offsite analytical laboratory. Level III analyses usually use EPA (1986) analytical methods, but may also elect to use Contract Laboratory Program (CLP) procedures. Level III analyses do not usually utilize the validation or documentation procedures required of CLP Level IV analysis. The laboratory may or may not be a CLP laboratory.
Level IV	CLP Routine Analytical Services (RAS). All analyses are performed in an offsite CLP-qualified analytical laboratory following CLP protocols. Level IV analyses are characterized by rigorous QA/QC protocols and prescribed documentation.
Level V	Analysis by nonstandard methods. All analyses are performed in an offsite analytical laboratory which may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits. CLP Special Analytical Services (SAS) are Level V.

Table QAPP-2. Data Quality Needs.

Subsurface Material	Type of Analysis	EPA Analytical Level
Soil	Volatile organic analysis of soil samples	I, II, III
	Geotechnical testing of cores	I, II, III
	Chemical analyses of soil samples	I, II, III
	Soil-gas volatile organic analysis	I, II
	Microbial analyses	I, II, III
		I, II, III
Groundwater	Chemical analyses	I, II, III, IV

the February 1988 EPA Contract Laboratory Program Statement of Work for Organics Analysis Multimedia/Multiconcentrations, Exhibit D (EPA 1988).

4.0 SAMPLING PROCEDURES

The procedures that will be used to support the field sampling plan are stated in the *Environmental Engineering, Technology, and Permitting Function Quality Assurance Program Plan* (WHC 1990). Other procedures include environmental investigations instructions (EII) from the *Environmental Investigations and Site Characterization Manual* (WHC 1988a); quality requirements (QR) and quality instructions (QI) from the *Quality Assurance Manual* (WHC 1988b); and detailed field sampling procedures and protocols as described in the field sampling plan.

Procedural approval, revision, and distribution control requirements applicable to EII are addressed in EII 1.2, "Preparation and Revision of Environmental Investigations Instructions." Deviations from established EII required in response to unforeseen field situations may be authorized in compliance with EII 1.4, "Deviation from Environmental Investigations Instructions" (WHC 1988a).

Borehole sampling will be performed as defined in the field sampling plan. Sample types, locations, and other site-specific considerations will also be defined in the field sampling plan.

5.0 SAMPLE CUSTODY

Sample custody will be maintained using chain-of-custody forms if sample analysis does not immediately follow sample collection. Results of analyses will be traceable to original samples through the unique code or identifier assigned to the sample in the field and recorded on the chain-of-custody form and/or sampling form.

6.0 CALIBRATION PROCEDURES

Calibration of measuring equipment will be done according to manufacturer's manuals governing its use. Calibration of WHC, participant contractor, or subcontractor analytical equipment shall be as defined by applicable standard analytical methods.

7.0 ANALYTICAL PROCEDURES

Wellfield enhancement tasks are identified in Section 3 of this work plan. Analytical procedures for these methods will be selected or developed prior to use, and will be in compliance with WHC procedures and/or procurement control requirements where applicable. EPA Level III and V analyses will be performed by qualified WHC and PNL employees or offsite laboratories. Analytical procedures and reporting units for different sample types that may be collected during well drilling activities are given in Table QAPP-3.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

The task coordinator will be responsible for preparing a detailed data package. As a minimum, data packages for Level III and V analyses will include:

- Sample documentation, including identification of the organization and individuals performing the extraction and/or analysis; documentation of any sample custody; and the date/time of sample receipt, extraction, and analysis
- Instrument calibration documentation, including equipment type and model, for the time period in which the sample analysis was performed
- QC data for the methods used
- Analytical results or data deliverables, including reduced data, reduction formulae or algorithms, and identification of data outliers or deficiencies.

The project managers/principal investigators will be responsible for preparing a report summarizing and interpreting the results of analyses.

9.0 INTERNAL QC

Internal QC methods will be used for chemical and radiological sampling and analysis for new wells, and include:

- field duplicate samples
- equipment blanks
- trip blanks.

One set of duplicate samples and blanks will be collected and analyzed for each well. As feasible, duplicate samples will be analyzed by laboratory screening equipment.

Table QAPP-3. Sampling, Analysis, and Reporting Summary.

SOIL Sample Type	Container	Quantity	Preservation	Holding Time	Analytical Level	Prep Method/ Analytical Procedures	Detection Limit	Report Units
VOA	40 ml Amber glass w/Teflon® septa	5-10 gm	Methanol Refrigeration	14 days	III	PNL: VOA-3	PID: 10 pb ELCD: 40 ppo	ppb
ICP Metals	250 ml glass jar	5 gm	Refrigeration	6 months	III	3010/6010 (1)	300-30000 (2)	µg/kg
Pb	250 ml glass jar	5 gm	Refrigeration	6 months	III	7421 (1)	500 µg/kg	µg/kg
Hg	250 ml glass jar	5 gm	Refrigeration	28 days	III	7421 (1)	400 µg/kg	µg/kg
Anions	250 ml glass jar	5 gm	Refrigeration	ASAP after collection	III	300.0, EPA-600/4-84-017	200-1000 (2)	µg/kg
Gross Alpha Gross Beta	40 ml amber glass	(full jar)	none	15 business days	III	135/136	N/A	pci/g
Gamma Scan	250 ml glass jar	(full jar)	none	20 business days	III	140	N/A	pci/g
Sr-90	100 ml plastic jar	50 gm	none	30 business days	III	140	N/A	pci/g
Pu, Am	100 ml plastic jar	100 gm	none	25 business days	III	140	N/A	pci/g
TOC	40 ml amber glass	20 gm	Refrigeration	28 days	III	9060 (1)	N/A	µg/kg
Cyanides	250 ml glass jar	30 gm	Refrigeration	14 days	III	9010 (1)	1000 µg/kg	µg/kg
SVOA (ABN)	250 ml glass jar	120 gm	Refrigeration	7 days	III	3540 or 3550/8270 (1)	650-66000 (2)	µg/kg
CaCO3 content	moisture tin		none	N/A	III	N/A	N/A	%
Moisture Content	moisture tin		none	ASAP after collection	III	N/A	N/A	%
Particle Size Distribution	500 ml glass "mason" jar	1 kg (approximate)	none	N/A	III	N/A	N/A	%
Geochemical	5 gallon bucket	5 gallons	none	14 days	III	N/A	N/A	N/A
Physical Properties (unsat K, Pore water, Moisture)	(2) 0.5' length sediment cores	1' core	none	28 days	III	N/A	N/A	N/A
Microbiologic	2' (4" diameter) sediment core	core	Argon Atmosphere	ASAP after collection	III	N/A	N/A	N/A
Soil Gas	750 ml glass bulb Tedlar (or chemically inert) bag syringe	750 ml 1 l 1-10 µl	Al foil wrap Refrigeration N/A	24 hours 24 hours ASAP after collection	III III III	N/A N/A N/A	N/A N/A N/A	ppb ppb ppb
GROUNDWATER Sample Type								
ICP Metals	1000 ml poly jar	(full jar)	Nitric Acid w/pH < 2	6 months	III	3010/6010	3-300 (2)	µg/L
Ions	125 ml poly jar	(full jar)	none	Per procedure	III	300.0, EPA-600/4-84-017	100-500 (2)	µg/L
SVOA (ABN)	2000 ml glass amber	(full jar)	none	7 days	III	3510 or 3520/625 (1)	10-1000 (2)	µg/L
Gross Alpha Gross Beta	1000 ml poly jar	(full jar)	Nitric Acid w/pH < 2	15 business days	III	135/136	N/A	pci/g
Gamma Scan	1000 ml poly jar	(full jar)	Nitric Acid w/pH < 2	20 business days	III	140	N/A	pci/g
VOGC	40 ml amber glass w/Teflon® septum	40 ml	Methanol w/Refrigeration	14 days	III	PNL: VOA-3	PID: 10 ppb ELCD: 40 ppb	ppb

(1) SW 846, EPA, 1987 (2) Depends on constituent

10.0 PERFORMANCE AND SYSTEMS AUDITS

Audits in environmental investigations are considered to be systematic checks that verify the quality of operation of one or more elements of the total measurement system. Performance audit requirements will be met by the use of internal QC methods. Systems audits will be scheduled if requested by the project manager or the U.S. Department of Energy, Richland Operations Office.

11.0 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field that directly affects the quality of the analytical data will be subject to preventive maintenance measurements that ensure minimization of measurement system downtime. Field equipment maintenance instructions will be as defined by the procedures governing their use.

12.0 DATA ASSESSMENT PROCEDURES

Measurement data will be assessed and documented by the task coordinator responsible for that measurement. Any data evaluation will be documented in field and laboratory notebooks in which information related to the sampling activities is recorded.

13.0 CORRECTIVE ACTIONS

Corrective actions are procedures that might be implemented on samples that do not meet QA specifications. A corrective action request might be generated, for example, by an audit. Corrective actions may include resampling or reanalyzing samples, if feasible. The primary responsibility for corrective action resolution is assigned to the WHC cognizant engineer.

14.0 REFERENCES

EPA, 1986, *Test Methods for Evaluating Solid Waste - Physical/Chemical Methods*, 3rd Ed., SW-846, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

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WHC, 1988b, *Quality Assurance Manual*, WHC-CM-4-2, Westinghouse Hanford Company, Richland, Washington.

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APPENDIX B

HEALTH AND SAFETY PLAN

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HEALTH AND SAFETY PLAN

This health and safety plan (HSP) addresses potential health and safety issues in a generic manner for wellfield characterization during the 200 West Area Carbon Tetrachloride Expedited Response Action (ERA). The HSP consists of the site description, types/sources of contamination, general training and medial surveillance requirements, and plans for general site control and emergency actions.

Specific information such as personal protective equipment, monitoring strategies, and decontamination procedures will be specified in site-/task-specific safety plans for each new task taking the form of a site-specific safety plan or a hazardous waste operations permit (HWOP). These safety plans will expand on subjects such as site control, emergency plans, and training requirements in more detail depending on the complexity and degree of hazard associated with each task. The standard operating procedures used to carry out the major tasks are found in environmental investigations instructions (EII) (WHC 1988). No confined space entry will be required for this work.

Radiological safety requirements and controls are identified in site- or task-specific radiation work permits (RWP). The RWP identifies radiological conditions expected to be encountered, dosimetry and protective clothing requirements, and Health Physics Technologists (HPT) coverage.

SITE DESCRIPTION

The ERA is focused on three retired liquid waste disposal facilities associated with Z Plant plutonium recovery processes: (1) the 216-Z-1A Tile Field, (2) the 216-Z-9 Trench, and (3) the 216-Z-18 Crib. The ERA activities include use of existing structures (e.g., boreholes, vents, and piping) and installation of wells located within and near these facilities. These three cribs received the bulk of the carbon tetrachloride disposed to the ground between 1955 and 1973, when soil column disposal of carbon tetrachloride associated with Z Plant processes ceased. Locations and descriptions of the cribs are summarized in this work plan, Section 2.1, "Site Operations." Detailed information is available in the ERA proposal (DOE-RL 1991).

TYPES/SOURCES OF CONTAMINATION

The three principal carbon tetrachloride disposal sites received acidic and organic, actinide-bearing liquid wastes (work plan, Section 2.1). Based on existing information, the contaminants discharged to the cribs are both chemical and radiological.

Aqueous solutions discharged to three principal carbon tetrachloride disposal sites were concentrated, acidic, metal nitrate salt wastes. Organic material, including carbon tetrachloride, tributyl phosphate, dibutyl butyl phosphonate, and fabrication oil, were disposed in saturation amounts in the aqueous solution and also separately in batches. Carbon tetrachloride degradation products such as chloroform and methylene chloride, and tributyl phosphate degradation products such as dibutyl phosphate and monobutyl phosphate, are also likely. A cadmium nitrate solution was sprayed on the soil at the 216-Z-9 Trench.

The principal radiological contaminants in the unsaturated zone underlying the three disposal sites are plutonium-239/240 and americium-241. Minor amounts of cesium-137 and strontium-90 are also indicated in the Waste Information Data System database for the 216-Z-9 Trench and the 216-Z-1A Tile Field.

Groundwater contaminants identified in the 200 West Area include carbon tetrachloride, chloroform, cyanide, fluoride, hexavalent chromium, trichloroethylene, nitrate, strontium-90, tritium, technetium-99, iodine-129, and uranium.

GENERAL SAFETY ISSUES

Aside from the chemical and radiological contamination present in the area, this project will involve a number of industrial safety issues. Some of the disposal sites involve the potential for cave-in. This could cause personnel injury or equipment damage and will be controlled through strict compliance with safety plans. Equipment used for some tasks will expose personnel to mechanical hazards such as pinch points and overhead hazards. Noise, possible flying objects, and lifting heavy tools and equipment will be involved. Potentially encountering underground utility lines is a concern when driving soil-gas probes or drilling holes; these activities are controlled by excavation permits/geophysical surveys. All equipment used will be in good condition and equipped with the proper safety devices. Safety plans will be developed for the specific work tasks and will adequately address both chemical and industrial safety issues. These plans are reviewed and approved by Westinghouse Hanford Company (WHC) internal safety organizations prior to work initiation.

TRAINING

Work crews at the site will have routine safety meetings and will have received the appropriate training based on the work being carried out. Other specific training will be spelled out in site-specific safety plans as they are developed.

SITE CONTROL/EMERGENCY PLANS

With the exception of the well-drilling tasks, tasks supporting the FY 1993 wellfield enhancement (work plan, Section 3.0) will require relatively few individuals to complete. Site control should not be an issue when inside the 216-Z-1A Tile Field because the tile field is fenced. Site control at the 216-Z-9 Trench, the 216-Z-18 Crib, and other areas will be controlled through the use of control zones where necessary. The field team leader/site safety officer will control and coordinate access to the site. Visitors will be kept at a safe distance from field activities at all times. Only trained team members will be allowed routine access to field activities. Further site control requirements will be identified in safety plans where necessary.

Response to possible emergencies at the site will generally require notification of emergency response personnel either by phone or plant radio. Minor personnel injuries can be treated at the 200 West Area first aid station. Site personnel will discuss actions to be taken in regular safety meetings held at the site. With the exception of the well drilling tasks, field investigation tasks will not require detailed emergency plans as they are relatively simple, low hazard tasks. As the remedial action decisions are made and tasks become more complex, both emergency plans and safety plans will become detailed.

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