0037041

JUN 14 1994 (11)

Station # 12

ENGINEERING DATA TRANSMITTAL

Page 1 of 1

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2	1	QA: W.R. Thackaberry		6.10.94	H4-16	Richland, WA 99352					
2	1	~~Safety~~: N.R. Kerr EHP&S		for	H4-67	IRA (2)			H4-17	3	
		Env.				EPIC (2)			H6-08	3	
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Part 1

SUPPORTING DOCUMENT

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5/17/94 N. Dolis

6. Author

Name: K. J. Koegler

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7. Abstract

WHC, 1994, *In-Situ Bioremediation Drilling and Characterization Work Plan*, WHC-SD-EN-TI-034, Rev. 0, prepared by L. A. Doremus and D. R. Newcomer, Pacific Northwest Laboratory for Westinghouse Hanford Company, Richland, Washington.

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9. Impact Level QS

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A-6400-073 (11/91) (EF) WEF124

METRIC CONVERSION CHART

Measurements used in this report are actuals. The following conversion chart is provided to the reader as a tool to aid in conversion.

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
short ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32 then multiply by 5/9ths	Celsius

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	short ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 5/9ths, then add 32	Fahrenheit

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1.0 INTRODUCTION

This work plan covers all planned field characterization activities in support of the in situ bioremediation task for FY 1994. Most of the activities described herein are associated with drilling of new wells and sampling at the in situ bioremediation site. In situ bioremediation is one of the technologies being demonstrated under the Volatile Organic Compounds-Arid Integrated Demonstration (VOC-Arid ID). Background information and objectives of the VOC-Arid ID Project are described in detail in *FY 93 Site Characterization Work Plan for the VOC-Arid ID and 200 West Area Carbon Tetrachloride ERA* (Rohay et al. 1993).

1.1 BACKGROUND

The In-Situ Bioremediation of Contaminated Ground Water Subtask of the R&D for In-Situ Treatment Task (TTP No. RL311104) is directed toward demonstrating biodegradation of carbon tetrachloride (CCl_4) in ground water as part of the VOC-Arid ID at the Hanford Site. The ongoing demonstration involves developing and implementing a method to stimulate native microorganisms to degrade CCl_4 in ground water. The experimental approach is to add nutrients to the ground water and disperse them into the aquifer using an injection and withdrawal circulation system in a network of wells.

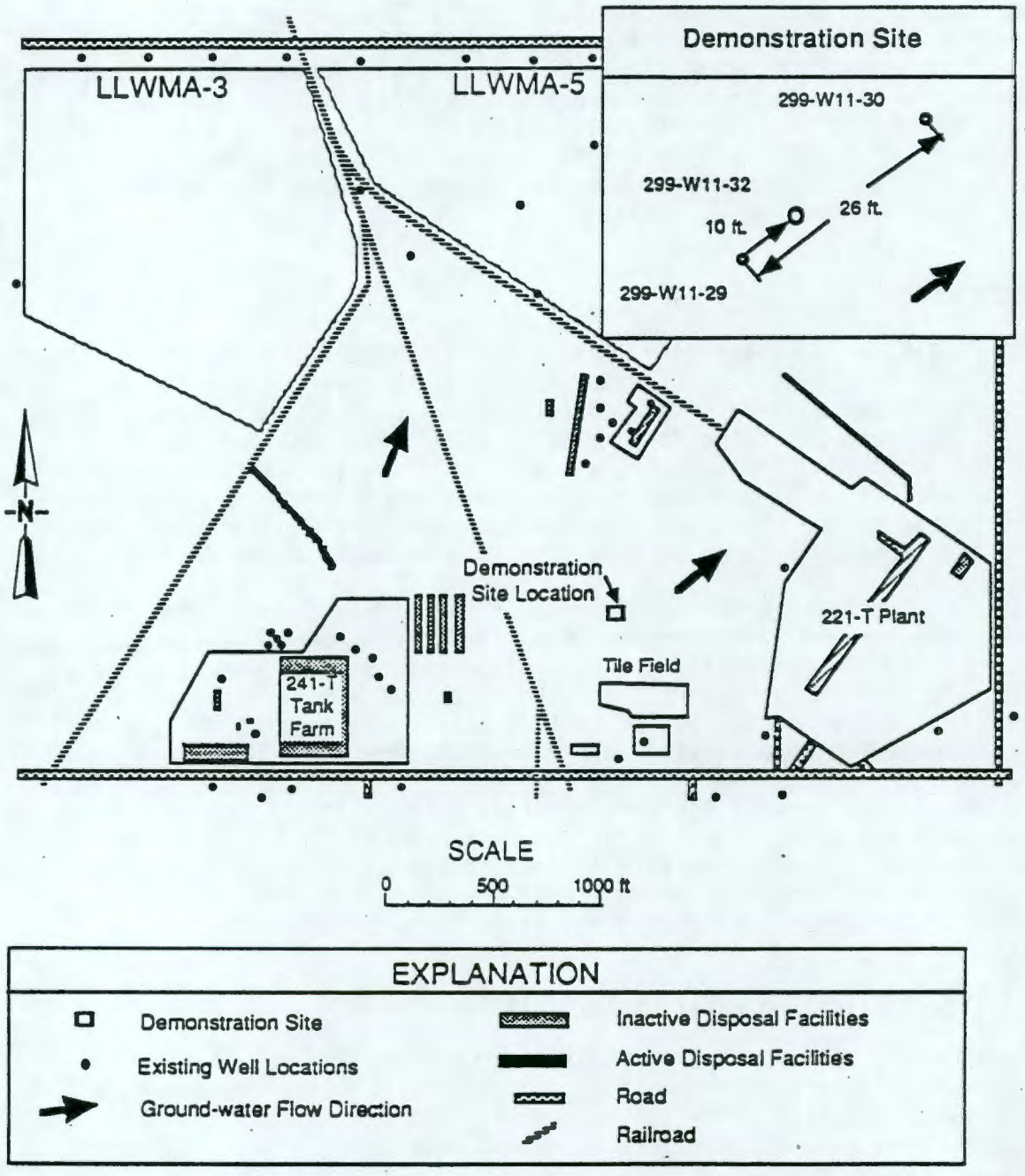
To better anticipate the consequence of the bioremediation demonstration at the site, the ground water recirculating flow field, chemical reactions, and microbiologic biodegradation are being simulated using a numerical model. The results of the simulations will be used to design a more effective injection and withdrawal circulation system, including locating the planned wells whose installation activities are described herein.

The in situ bioremediation demonstration site is located between 241-T Tank Farm and 221-T Plant in the 200 West Area of the Hanford Site, shown in Figure 1-1. The field site is located approximately 0.7 to 0.9 mi northeast of the Plutonium Finishing Plant, the location where CCl_4 was disposed of to the ground during Hanford production operations.

1.2 SITE INFORMATION FROM PREVIOUS INVESTIGATIONS

Three wells, 299-W11-29, 299-W11-30, and 299-W11-32, have been constructed for the in situ bioremediation demonstration. Site characterization activities were conducted at these wells in FY 1992 and FY 1993. Some of the FY 1993 activities carried over into the early part of FY 1994. Analyses performed on samples collected during previous well installations have been used to determine the conditions under which the native microorganisms are capable of degrading CCl_4, the sediment and ground water chemistry, and the lithology of those sediments. Various hydrologic tests performed in these wells provided hydraulic properties of the formation. A summary of the well construction, stratigraphy, hydrology, ground water and sediment chemistry, contaminant distribution of CCl_4, and microbiology is provided.

Figure 1-1. Location of the In Situ Bioremediation Demonstration Site and Locations of Existing Wells 299-W11-29, 299-W11-30, and 299-W11-32.



1.2.1 Well Construction

Three wells penetrate the uppermost part of the unconfined aquifer and are completed with stainless steel casing and screen. Two of the wells (4-in. ID) are completed with open screen intervals between approximately 243 and 279 ft. The water table lies at a depth of approximately 247 ft. The third well (8-in. ID) was installed with three separate screened intervals between depths of 243 to 258 ft, 273 to 278 ft, and 293 to 298 ft. Bentonite was placed around the blank casing between the screen intervals to hydraulically isolate each zone. For each well, artificial filter packs were installed in the annular space adjacent to the screens. Figure 1-2 shows the depths of the screen intervals relative to each other.

1.2.2 Stratigraphy

The stratigraphy of the saturated zone consists of alluvial sediments, primarily sandy gravels and muddy sandy gravels, of the Middle Ringold Formation. The particle size distribution of the clay, silt, and sand size fractions below the water table are relatively uniform with depth. However, the sediments contain varying degrees of cementation and weathering. The clay size fraction makes up only 5 to 10% of the sediments, with about half this fraction actually containing clay minerals. A 9-ft-thick caliche zone lies just above the water table between a depth of 238 and 247 ft. A stratigraphic column in Figure 1-2 summarizes the lithology between depths of 240 and 310 ft.

1.2.3 Hydrology

A series of constant-rate pumping tests, slug tests, laboratory hydraulic conductivity tests, and tracer tests were performed at the site to estimate hydraulic properties of the formation. The constant-rate pumping tests and slug tests indicated a range of approximately 10^{-2} to 10^{-4} cm/sec for hydraulic conductivity. The laboratory hydraulic conductivity values measured with a falling head permeameter range between 10^{-3} to 10^{-7} cm/sec. The tracer tests, performed in the fully screened wells, indicate higher flow in the upper 13 to 18 ft of the test interval versus the lower part of the test interval. The tracer test profiles and the equivalent hydraulic conductivity estimated for each test interval are summarized in Figure 1-2. The hydraulic conductivity ranges shown adjacent to the lithologic log in Figure 1-2 are estimates for each equivalent lithologic unit. These ranges were estimated primarily from the field and laboratory hydraulic tests, but also from supporting characterization data, including lithology encountered during drilling and geophysical logging. The specific capacity for the units corresponding to the upper and lower screen intervals of the multi-screened well is also shown.

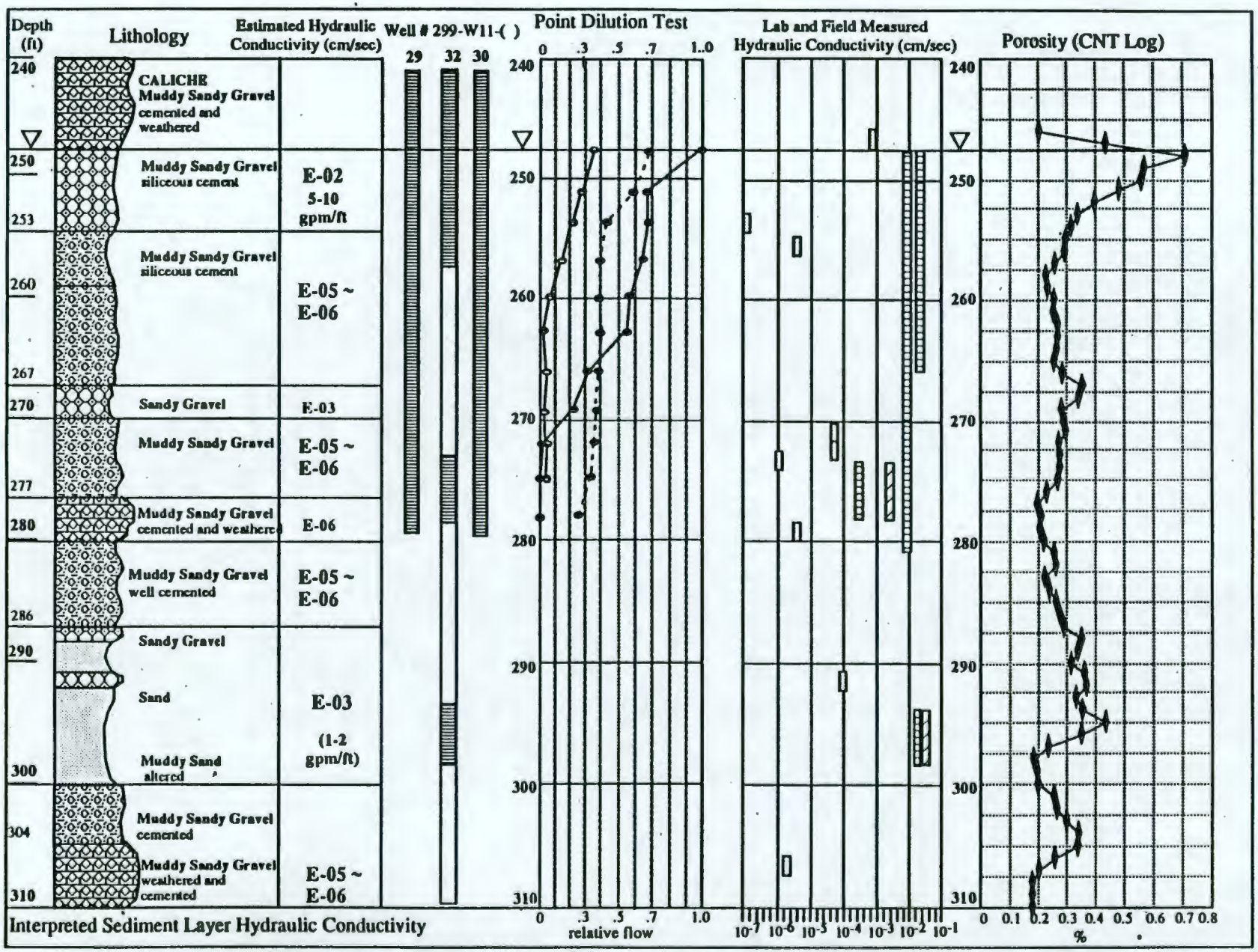


Figure 1-2. Summary of Site Characterization Information for the Upper Portion of the Unconfined Aquifer at the In Situ Bioremediation Site.

The neutron porosity log, shown in Figure 1-2, provides an indication of the relative porosity profile with depth. The neutron log is a measure of the hydrogen content of the formation. The log shows that the highest relative porosity is located in the upper zone between a depth of about 247 and 258 ft, and in the lower zone between a depth of 287 and 306 ft. The highest porosity values correspond to zones of high permeability estimated from the hydrologic tests.

The characterization data summarized in Figure 1-2 indicate two distinct permeable units separated by a low-permeable unit. The high-permeable units lie at depths of approximately 247 to 265 ft and 286 to 300 ft, with an intervening low-permeable unit at a depth of 265 to 286 ft. The variation in hydraulic conductivity with depth is attributed primarily to variations in the degree of cementation of sediment clasts. The direction of ground water flow is generally to the northeast with a horizontal gradient of roughly 0.002.

1.2.4 Ground Water Chemistry

The ground water chemistry at the site is typical for the unconfined aquifer conditions at the Hanford Site. Redox (Eh) ranges between 235 and 357 mV, indicating oxidizing conditions. The dissolved oxygen content is depressed, approximately half of saturation (4.29 to 5.05 mg/L at 19.8°C). Total dissolved solids averaged about 440 mg/L. The most predominant anion constituent present is nitrate, which ranges between 190 and 310 ppm. Sulfate and chloride ranged between 50 and 67 ppm and between 20 to 26 ppm, respectively. Metal ions detected in the ground water include barium, calcium, chromium, iron, magnesium, manganese, potassium, sodium, and zinc, the highest being calcium, sodium, and magnesium.

1.2.5 Contaminant Distribution

Samples collected from the drilling of the wells show a higher concentration of volatile organic compounds (VOC) dissolved in the ground water than sorbed to the aquifer sediments by one to two orders of magnitude. The lower solid phase values suggest that either there is little sorption of these VOCs to the sediments or that some of the volatile analytes may have been lost during the collection of solid samples. Sediment and ground water samples from all boreholes showed a relatively uniform CCl_4 concentration profile with depth, with concentrations ranging between 10 and 300 ppb for the sediment samples and between 722 and 3,789 ppb for the ground water samples. Chloroform was detected with CCl_4 in both the solid and the aqueous phases in the majority of the samples taken. The solid phase concentration of chloroform, ranging up to 200 ppb in sediments, is similar to that of CCl_4, that is, relatively constant with depth. The aqueous phase chloroform concentrations ranged up to 540 ppb.

In all boreholes, CCl_4 was not detected in sorbed (solid) phase above the water table. However, CCl_4 was detected in the gas phase at the contact between the Upper and Middle Ringold Formations (approximately 170 ft in depth below ground surface). The upward migration of the gas phase from the saturated zone is likely to have been arrested by the finer-grained sediments of the Upper Ringold Formation.

1.2.6 Microbiology

The initial demonstration will rely on microorganisms that use nitrate as an electron acceptor to degrade CCl_4. Studies have been done to determine the most probable number of microorganisms that are denitrifying bacteria in the subsurface. Also, the denitrifier enzyme concentrations have been measured to determine the denitrification potential. In addition, the most probable number of other microorganisms that may be capable of degrading CCl_4 has been determined. These include:

- sulfate-reducing bacteria
- iron-reducing bacteria
- aerobic heterotrophs.

2.0 OBJECTIVES AND SCOPE

This work plan describes the design and construction of proposed wells and outlines the characterization activities to be performed in support of the In Situ Bioremediation Task for FY 1994. The purpose of the well design is to facilitate implementation and monitoring of in situ biodegradation of CCl_4 in ground water. However, the wells will also be used to characterize the geology, hydrology, microbiology, and contaminant distribution, which will all feed into the design of the technology. Implementation and design of this remediation demonstration technology will be described separately in an integrated test plan.

2.1 OBJECTIVES

Specifically, the primary objectives of this subtask for FY 1994, as described herein, are to:

- characterize the physical, hydrologic, and transport characteristics of the unconfined aquifer
- characterize the chemical properties of the sediment and ground water in the unconfined aquifer
- characterize the in situ microbial populations
- install a well network that will facilitate implementation and monitoring of the demonstration technology.

2.2 SCOPE OF WORK

During FY 1994, three new wells will be installed near existing wells 299-W11-29, 299-W11-30, and 299-W11-32 to complete the final well network. The new wells will be drilled to a depth of about 310 ft and completed in the saturated zone in the upper part of the unconfined aquifer. During drilling, sediment and ground water sampling will focus on the saturated zone between the capillary fringe and total depth drilled. Baseline ground water sampling will be routinely performed in existing wells 299-W11-29, -30, and -32.

Hydrologic testing will be conducted before and after the new wells have been installed. A series of slug displacement tests will be conducted at various depths during drilling of the first well. Other hydrologic tests, which include step-drawdown and constant-rate pumping tests and a tracer test, will be performed after the wells are completed.

The initial phase of the demonstration will be implemented during the latter part of the year, after the drilling and hydrologic testing activities have been completed. The role of site characterization during the demonstration will be to provide field support. This will primarily involve design and installation of downhole equipment used for the demonstration, collection of ground water samples, and water level pressure monitoring. These activities will be described in the integrated test plan.

2.3 SITE CHARACTERIZATION DATA NEEDS

Implementation of in situ biodegradation of CCl_4 requires an understanding of the existing subsurface biological and hydrological conditions. With a better understanding of the conditions favorable for microbial growth, the microbial reactions can be effectively enhanced by a nutrient-feeding strategy to degrade CCl_4 in the subsurface. With a better understanding of the hydrologic flow and transport system, the hydraulics of an induced ground water flow field can be more effectively utilized as a mechanism to distribute the nutrients.

An increased understanding of the distribution of and conditions favorable to biodegradation of CCl_4 requires ongoing collection of sediment and ground water samples from the aquifer. These samples will be used to establish a relationship between the subsurface conditions and the microbiologic population distribution. Hydrochemistry data are also needed from discrete depths in the saturated zone to establish baseline ground water conditions at the demonstration site. Those parameters of significance include: dissolved oxygen, redox conditions, pH, nutrient availability (carbon, nitrogen, phosphorous, potassium), sediment mineralogy, and contaminant distribution. Some hydrochemical parameters will be analyzed in the field during drilling and sample collection. Additional samples may be collected during the hydrologic tests.

Numerical simulations are being conducted to better predict the interactions between the microbial populations, the geochemistry of the sediments, and transport in the hydrologic system over the course of the demonstration. Important hydraulic properties for the simulations are hydraulic conductivity, degree of heterogeneity, residence time, radius of influence, and anisotropy. Transport of CCl_4 and injected nutrients through the aquifer are a function of these properties.

3.0 WELL INSTALLATION, DESIGN, AND SCHEDULE

Three wells, 299-W11-33, -34, and -35, will be installed in FY 1994. All wells will be drilled from land surface to a maximum total depth of approximately 310 ft. Wells 299-W11-33 and -34 will be dual-screened to

access the zones corresponding to an upper and lower permeable unit encountered during previous drilling of wells 299-W11-29, -30, and -32. Well 299-W11-35 will consist of two piezometers in a single borehole, one open to each permeable unit. The planned well locations and previously installed wells are shown in Figure 3-1. A diagram of the proposed installation for both the injection/withdrawal wells and the piezometer set is shown in Figure 3-2

A fourth well may be drilled as a test hole to test drilling equipment and casing materials and will not be used for sampling. Because of the uncertainty associated with this test, this well may or may not be a part of the well network design. Therefore, the construction of this well is not described in this work plan, but will be addressed via engineering change notice. If this well becomes a part of the well network design, the well number will be 299-W11-36.

A cross section of the final well design placement, including the existing wells, is shown in Figure 3-3. This well network was selected because it provides acceptable hydraulic control, allows for various three-spot well spacings, provides flexibility to operate in either of two permeable units, and includes an acceptable number of monitoring wells. An example of a three-spot well spacing would be wells 299-W11-32, -33, and -34, with wells 299-W11-29 and -35 as monitoring wells.

The majority of the sampling effort will be conducted in well 299-W11-33 to confirm the findings of previous characterization activities. Sampling will be reduced during the installation of wells 299-W11-34 and -35. Sampling will be concentrated from the capillary fringe, through the saturated zone, to the total depth of the borehole. Samples will not be collected between land surface and the capillary fringe, a depth of about 230 ft.

3.1 WELLS 299-W11-33 AND -34

Wells 299-W11-33 and -34 will be dual-screened to access the zones corresponding to the upper and lower permeable units encountered during previous drilling. The wells will be completed with nominal 4-in. ID stainless steel casing and screens to a total depth of about 310 ft. The screens will be 10-slot (0.010 in.), continuous wire-wrap, completed over two depth intervals (approximately 247 to 262 ft and 287 to 302 ft). The screened intervals will be separated by a 25-ft length of blank casing. The annular space around the blank casing will be sealed with bentonite grout. A 5-ft length of blank casing will be located below the lower screen at a depth of 302 to 307 ft to facilitate installation of testing equipment in the borehole.

Adjacent to each of the screened intervals, a sand-pack filter will be placed in the annulus, extending upward from 3 ft below the bottom of the screen to 3 ft above the top of the screen. Above the top screen, a layer of bentonite pellets will be installed from the top of the sand pack 3 to 5 ft thick, overlain with bentonite crumbles extending upward to the surface grout seal.

Figure 3-1. Current and Proposed In Situ Bioremediation Well Locations.

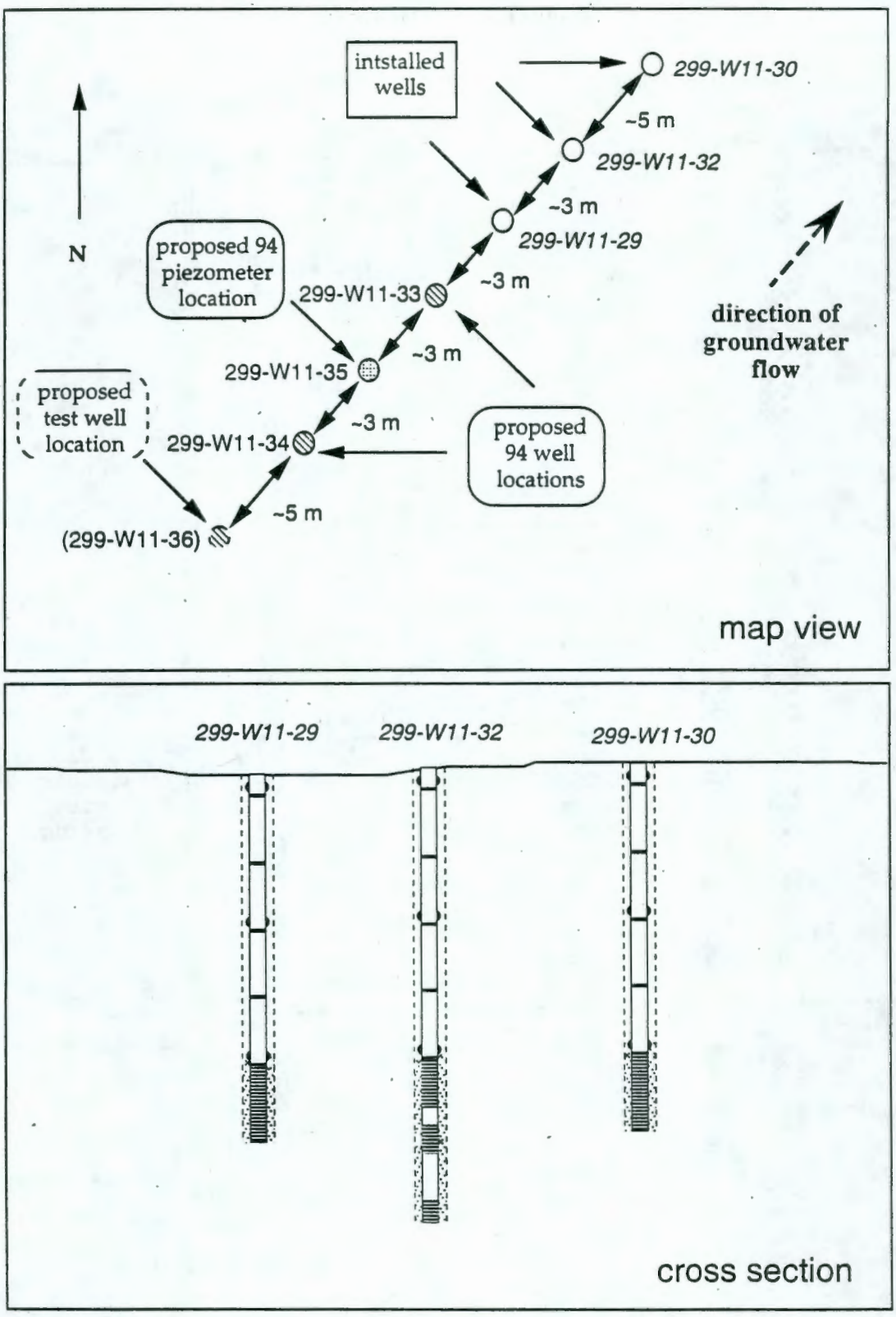


Figure 3-2. Configurations for Proposed Injection/Extraction Wells and Piezometer.

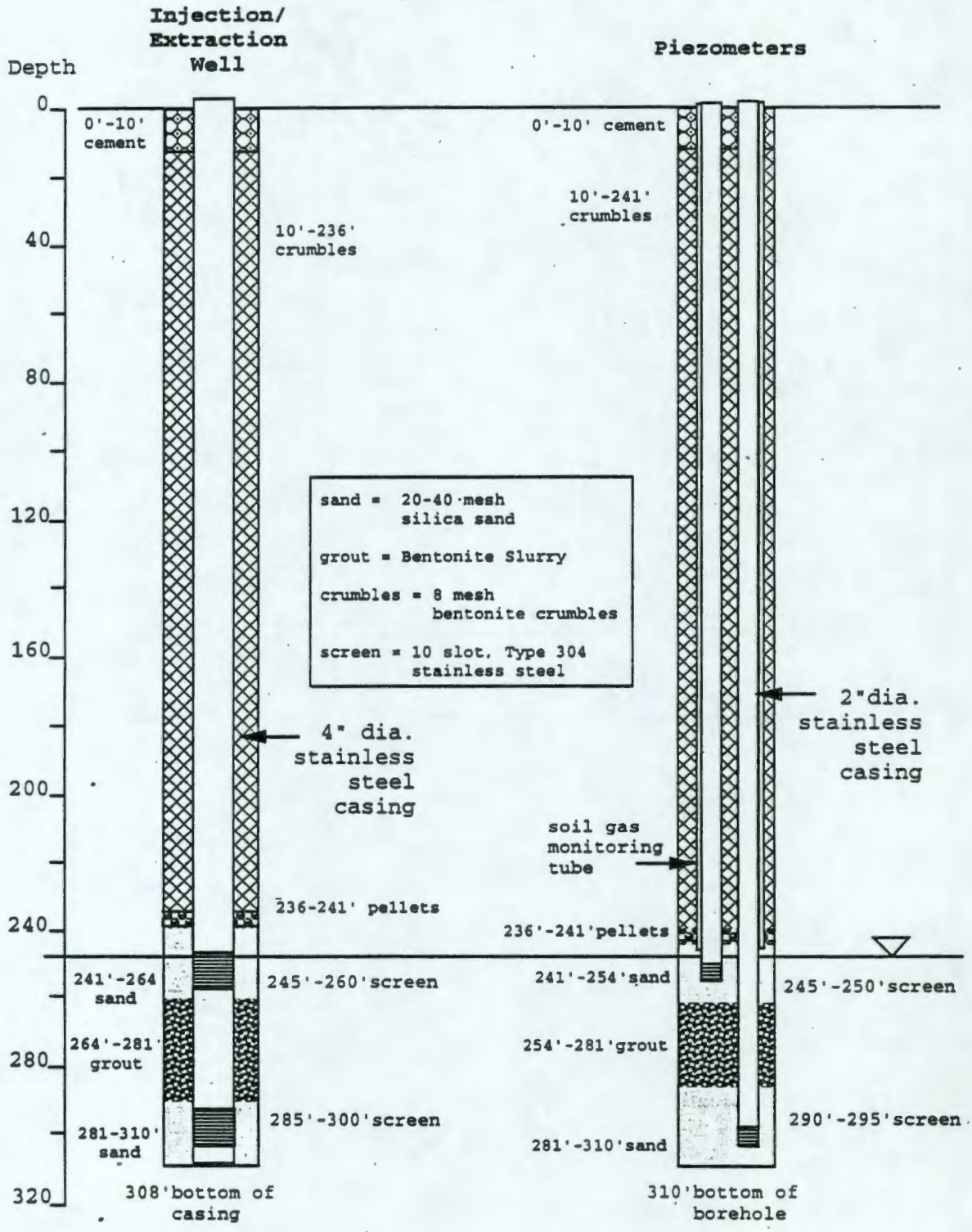
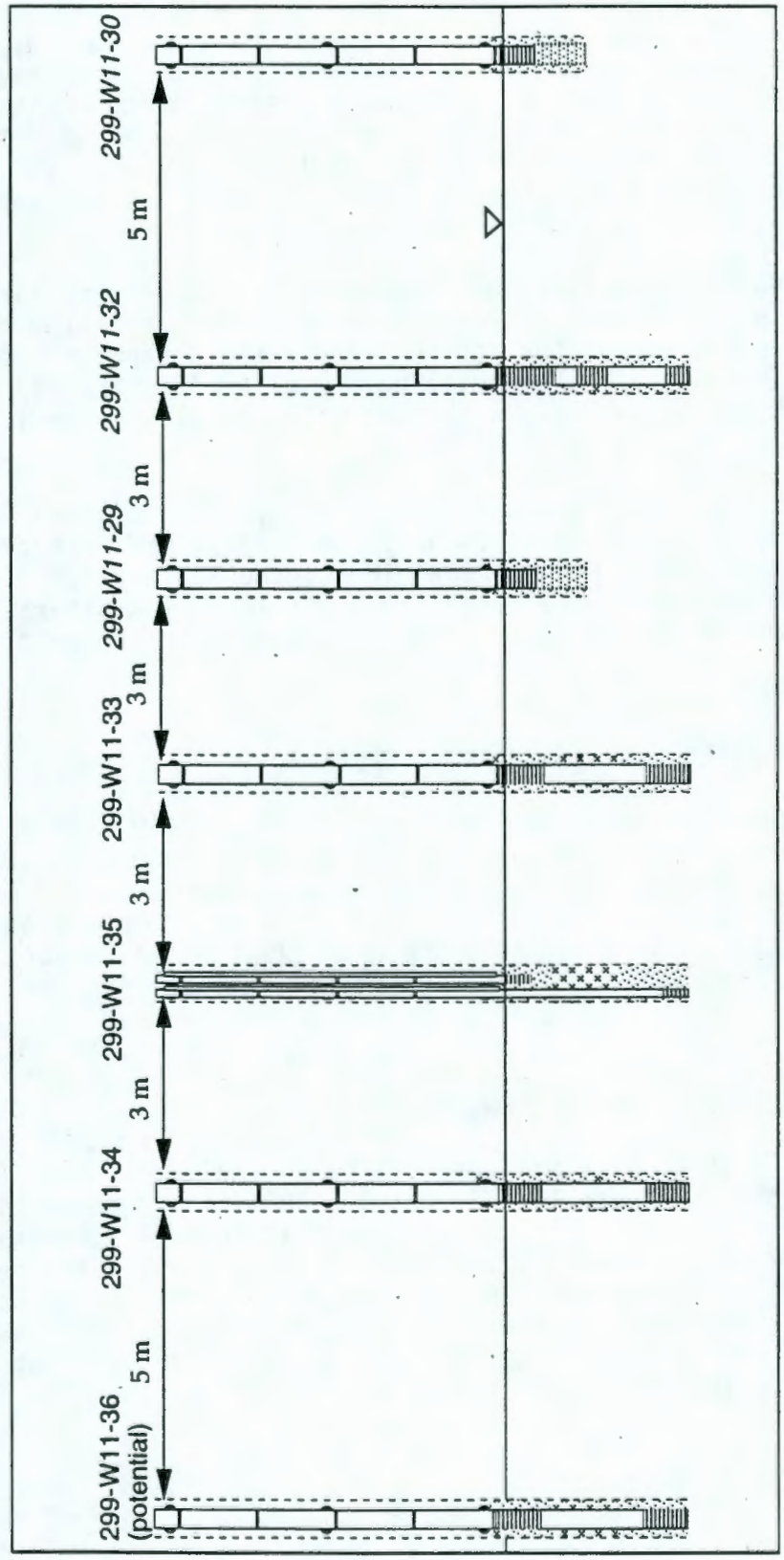


Figure 3-3. Cross Section of the Final Well Design for the In Situ Bioremediation Implementation.



3.2 WELL 299-W11-35

Well 299-W11-35 will be a single borehole completed with two piezometers, one accessing the upper permeable unit and one accessing the lower permeable unit. The piezometers will be completed with 3-in. ID stainless steel, 10-slot (0.010 in.), wire-wrap screens at depths of approximately 247 to 252 ft and 290 to 295 ft. A 2-ft length of blank pipe will be placed below the bottom of each screen. The exact location of screen placement will be determined after reaching total depth. The annular space between the screens will be sealed with bentonite grout.

Adjacent to each of the screened intervals, a sand pack filter will be placed in the annulus, extending upward from 3 ft below the bottom of the screen to 3 ft above the top of the screen. Above the uppermost piezometer screen, a layer of bentonite pellets will be installed from the top of the sand pack 3 to 5 ft thick, overlain with bentonite crumbles extending upward to the surface grout seal.

In addition to the stainless steel piezometer, four 0.25-in. ID tubes will be installed in the borehole to connect the capillary fringe zone above the water table to monitoring equipment at the ground surface for collection of soil-gas samples from above the water table. Filter pack material will be placed around the end of the tubes to provide access to soil gas in the formation.

3.3 REMEDIATION OF WELLS 299-W11-29 AND 299-W11-30

To complete the final well network design, wells 299-W11-29 and -30 need to be reconfigured to allow access only to the upper permeable zone. The reconfiguration will involve sealing the bottom portion of the screen interval (and filter pack) for each well with bentonite grout or cement, from a depth of about 263 ft to the well bottom at a depth of 279 ft. The upper portion of the screens, from 247 to 263 ft in depth, must be available for the demonstration.

3.4 SCHEDULE OF WELL DRILLING AND CONSTRUCTION

The proposed FY 1994 wells will be drilled beginning in June 1994. The wells must be completed no later than August 30, 1994, followed by post-completion hydrologic testing. It is preferred that the wells be installed by the end of July 1994 to allow more time for hydrologic testing before the demonstration begins in September 1994. During drilling of the proposed wells, access to existing wells 299-W11-29, -30, and -32 must be provided for collecting baseline ground water samples. The schedule for drilling, sampling, and testing activities for the proposed wells is shown in Table 3-1.

Table 3-1. Schedule for Drilling, Sampling, and Hydrologic Testing Activities for FY 1994.

Activity	Planned Schedule
Drilling	June - September 1994
Sampling	Late June - September 1994
Sample Analysis[a]	July - September 1994
Baseline Sampling[a]	May - September 1994
Hydrologic Testing[a]	June - July, September 1994
Analysis and Reporting[a]	July - September 1994

[a]These activities will continue into early FY 1995.

4.0 SAMPLING AND TESTING ACTIVITIES OVERVIEW

This work plan describes the samples to be collected (Figure 4-1), analyses to be conducted, tests to be conducted, and applicable methods for these activities to meet the objectives for demonstrating in situ bioremediation. The data collection approach for each of the well types to be installed is shown in Table 4-1.

4.1 SAMPLING COLLECTED DURING DRILLING

Sediment samples will be collected to determine the spatial variability of physical and chemical properties and to further characterize the microbial populations, primarily in the depth intervals that will be screened. Samples will be collected from the saturated zone only, at similar depth intervals, and using similar sample collection methods as those taken in FY 1993. Results from these samples will be used to evaluate the lateral variability or continuity in each sampled interval.

For the first well drilled (299-W11-33), samples will be taken for microbiologic and sediment chemistry characterization for two planned screen depth intervals. These two screen depth intervals correspond to an upper and lower permeable zone encountered during previous drilling. Samples for sediment physical property characterization and VOC analyses will be taken at regular intervals throughout the entire saturated zone. For the remaining wells, microbiologic samples and sediment chemistry samples will also be collected at the two screen depth intervals; however, fewer microbiologic samples will be collected from each interval. VOC analyses and physical property samples will be collected at the same spacing as the previous well unless there are difficulties with sample collection. The planned analyses and sample collection depths are shown in Table 4-2 and 4-3.

Ground water samples will be collected from the new wells during drilling for establishing baseline constituent concentrations and determining the distribution of CCl_4 in the aquifer. The analytes, similar to those examined during the FY 1993 work, are as listed in Tables 4-2 and 4-3.

Figure 4-1. Sediment and Ground Water Samples to be Collected During Drilling Activities.

SEDIMENT CORE SAMPLE SET

sample type	ASEPTIC	ASEPTIC	ASEPTIC	INTACT	INTACT	ASEPTIC
data use	*Flow Cell*	*Microbiologic Characterization*	*Archive*	*Sediment Physical and Chemical Properties*		*Microbiologic Analysis*
Principal Investigator	Skeen	Peyton		Doremus		Gorby
delivery location	324 Building	324 Building	324 Building	Sigma 5		LSL 2
scale						

feet 0 1 2 3 4 5

note: the length and number of microbilogic cores will vary for each interval

GROUNDWATER SAMPLES

Datachem	Veverka
Alkalinity ICP Metals Anions	Volatile Organics (VOA)

Table 4-1. In Situ Bioremediation Demonstration Well Investigations Summary. (Sheet 1 of 2).

Injection/Extraction Well 299-W11-34

Location	West of T Plant, approximately 3 meters southeast of 299-W11-30
Depth	308 ft
Completion	Injection/extraction well with screened intervals at 245'-260', 285'-300'
Potential Contamination	Unsaturated Zone: carbon tetrachloride, chloroform Saturated Zone: Carbon tetrachloride, chloroform, trichloroethylene.
Rationale	Collect data about the hydraulic properties of the aquifer in which carbon tetrachloride bioremediation will be performed. Characterize microbe populations capable of degrading carbon tetrachloride; and sediment chemistry of those intervals

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	Unsaturated Zone:
SPLIT-BARREL SAMPLING	• At 1 interval, approximate depth of 238', 1' length aseptic core sample.
	Saturated Zone:
DRILL CUTTING SAMPLES	• Every 1.5 meters (5 feet) for sediment volatile organic analyses • Samples collected from 7 specified intervals (no less than 1.5 meters or 5 feet apart) for archive.
SPLIT-BARREL SAMPLING	• Aseptic samples will be collected from to 2 specified depth intervals which correspond to the proposed screen depths, 7 feet of core will be collected from each interval. • Sediment physical property and chemical characterization samples will be collected from 7 selected depths, archive samples will be collected at with these samples.
GROUNDWATER SAMPLING	• Five total sample sets to be collected from the 2 specified depth intervals which correspond to the proposed screen depths. Analyses of: metals, anions, alkalinity, VOC. • In situ measurement of dissolved oxygen (DO), Eh, pH, temperature, total dissolved solids (TDS) at same 4 depths as groundwater sample sets.
HYDROLOGIC TESTING	• slug displacement tests • constant-rate discharge test (after well completion)

Table 4-1. In Situ Bioremediation Demonstration Well Investigations Summary. (Sheet 2 of 2).

Injection/Extraction Well 299-W11-35 and Piezometers in 299-W11-36

Locations	West of T Plant, approximately 6 meters and 9 meters east-southeast of 299-W11-30
Depth	2 piezometers to depths of: 76-77 m (245-250 ft), 88-89 m (290-295 ft)
Completion	Two (2" diameter) piezometers (Figure 3.1), and two gas intake tubes in the vadose zone.
Potential Contamination	Unsaturated Zone: carbon tetrachloride, chloroform Saturated Zone: Carbon tetrachloride, chloroform, trichloroethylene.
Rationale	Characterize distribution of microbes capable of degrading carbon tetrachloride and the chemistry of the environment in which they thrive; collect data about the distribution of hydraulic conductivity of the aquifer and spatial variability of carbon tetrachloride concentration in the aquifer
Terms	VOC: Volatile Organic Compound, TOC: Total Organic Carbon

- - - - - - - - - - - - - - - - SAMPLING / ANALYSES - - - - - - - - - - - - - - - -

Unsaturated Zone:

NONE

Saturated Zone:

DRILL CUTTING SAMPLES	•	Every 1.5 meters (5 feet) for sediment volatile organic analyses
	•	At specified intervals (no less than 1.5 meters or 5 feet apart) for archive, no more than 10 total intervals.
SPLIT-BARREL SAMPLING	•	Sediment core sample sets for physical property analysis at 7 selected intervals
	•	Aseptic sample collection for microbiologic analyses, 2 ft for microbiologic characterization property characterization, bracketed on each end with (0.5 ft) samples for sediment chemistry characterization.
GROUNDWATER SAMPLING	•	6 samples collected every 10 feet for volatile organic content analysis
	•	In situ measurement of dissolved oxygen (DO), Eh, pH, temperature, total dissolved solids (TDS) at 4 depths corresponding to screened interval locations.
HYDROLOGIC TESTING	•	Constant Discharge Test (after completion)

Table 4-2. Summary of Split-Spoon Samples to be Collected During Drilling Activities of First Well Drilled (299-W11-33).

planned screened interval	Depth (feet)	Depth (meters)	ASEPTIC: Gorby micro biologic	ASEPTIC: Skeen micro biologic	SEDIMENT PHYSICAL: PNL Doremus density porosity	SEDIMENT PHYSICAL: PNL Doremus K	SEDIMENT PHYSICAL: PNL Doremus archive (lithologic)	SEDIMENT CHEM: Huffman TP, TKN TOC	SEDIMENT CHEM: PNL Veverka VOA	WATER CHEMISTRY: PNL Doremus in situ	WATER CHEMISTRY: PNL Veverka VOA	WATER CHEMISTRY: DataChem metals	WATER CHEMISTRY: DataChem alka-linity	WATER CHEMISTRY: DataChem anions	total # of (1') cores per depth
	container		a	a	b or c	b	c	b (d)*	e	n/a	d	h		j	
	240-245	73.2-74.7	1						1						1
top ~245'	(water table)														
	245-250	74.7-76.2		2	1	1	2	1	1	1	2	1	1	1	2
	250-255	76.2-77.7		5			2	1	1	1	2	1	1	1	5
	255-260	77.7-79.2			1	1			1						
bottom~ 265'	260-265	79.2-80.8			1	1	2		1	1	2				1
	265-270	80.8-82.3							1						
	270-275	82.3-83.8			1	1	2		1	1	2				1
	275-280	83.8-85.3							1						
	280-285	85.3-86.8			1	1	2		1	1	2				1
top~285'	285-290	86.8-88.4							1						
	290-295	88.4-89.9		2	1	1	2	1	1	1	2	1	1	1	2
	295-300	89.9-91.4		5			2	1	1	1	2	1	1	1	5
bottom~ 300'	300-305	91.4-93.0	1		1	1			1	1	2	1	1	1	1
	305-310	93.0-94.5							1						
	Estimated total #		2	14	7	7	14	4	14	8	16	5		5	19

* sample collected in container b and transferred to d for shipment

Container Key

a) 1 ft length sediment core
b) 0.5 ft length sediment core
c) pint canning jars
d) 40 ml amber vial
e) 40 ml amber vial w/ methanol
h) 500 ml polypropylene bottle
j) 250 ml polypropylene bottle
k) 500 ml glass amber
l) 100 ml glass (aspetic)

Table 4-3. Summary of Split-Spoon Samples to be Collected During Drilling Activities of Remaining Wells Drilled.

			ASEPTIC	SEDIMENT PHYSICAL			SEDIMENT CHEM		WATER CHEMISTRY		
				PNL Doremus			Huffman	PNL Veverka	PNL Doremus	PNL Veverka	
planned screened interval	Depth (feet)	Depth (meters)	archive micro biologic	density porosity	K	archive (lithologic)	TP, TKN TOC	VOA	in situ	VOA	total # of (1') cores per depth
	container		a	b or c	b	c	b (d)#	e	n/a	d	
	240-245	73.2-74.7									
top=245'	(water table)										
	245-250	74.7-76.2	2	1	1	2	1	1	1		3
	250-255	76.2-77.7		1*	1*	2	1	1		2	1
	255-260	77.7-79.2						1			
bottom= 260'	260-265	79.2-80.8		1*	1*	2		1		2	1
	265-270	80.8-82.3						1			
	270-275	82.3-83.8		1	1	2		1		2	1
	275-280	83.8-85.3						1			
	280-285	85.3-86.8		1*	1*	2		1		2	1
top=285'	285-290	86.8-88.4						1			
	290-295	88.4-89.9	2	1	1	2	1	1	1	2	3
	295-300	89.9-91.4		1*	1*	2	1	1			1
bottom= 300'	300-305	91.4-93.0						1		2	
	305-310	93.0-94.5						1			
	Estimated total		4	7	7	14	4	13	2	12	11

sample collected in container b and transferred to container d for shipment

* samples collected only if drilling schedule and conditions permit

Container Key

a) 1 ft length sediment core
b) 0.5 ft length sediment core
c) pint canning jars
d) 40 ml amber vial
e) 40 ml amber vial with methanol
h) 500 ml polypropylene bottle
j) 250 ml polypropylene bottle
k) 500 ml glass amber
l) 100 ml glass (aspetic)

4.1.1 Physical Property Samples

Samples will be collected from the saturated zone every 10 ft during borehole advancement, with closer spacing in the screened intervals (245- to 260-ft depth and 285- to 300-ft depth). An attempt will be made to collect physical property samples from all three wells from depth intervals similar to those collected from well 299-W11-32. The actual number and specific depths of samples collected for physical property analysis will depend on the drilling conditions and schedule. These samples will be collected with a split-spoon sampling tool. Samples will be specifically analyzed for hydraulic conductivity, density, and porosity.

4.1.2 Microbiologic Samples

Samples will be collected for microbiologic characterization from depths corresponding to the planned screen intervals to yield further characterization of the microbial populations. The microbiologic samples will be collected using aseptic sampling techniques.

Sixteen feet of intact sediment samples will be collected from well 299-W11-34 using aseptic sampling tools. A 1-ft sediment core will be collected from the capillary fringe, between a depth of 230 and 245 ft. Seven feet of intact sediment core will be collected from depths corresponding to each screened interval. The aseptic cores will be interspersed with two sediment chemistry samples, which require a minimum of sediment to collect (may be taken from the split-spoon casing shoe or a designated sample core). A final 1-ft sediment core will be collected at a convenient interval in the saturated zone, either during or directly following collection of the aseptic samples described.

Microbiologic samples will also be collected from wells 299-W11-34 and -35. Two 1-ft sediment cores will be collected from each of the two screened intervals, a total of 4 ft of core for each well. Proposed depth intervals for microbiologic sample collection are shown in Table 4-2.

4.1.3 Sediment Chemistry Analyses

Samples for sediment chemistry analyses will be collected only from the planned screened intervals, two samples for each interval in all of the wells drilled. Sample locations and analyses are shown in Table 4-2. The samples will be analyzed for total organic carbon (TOC), total phosphorous (TP), and total Kjeldahl nitrogen (TKN). The samples may be collected as subsamples from sediment cores or drive tools, depending on the specific drilling circumstances.

Sediment samples for VOC analyses will be collected from the saturated zone every 5 ft. These samples will be used to evaluate the distribution of CCl_4 in the solid phase as well as to determine the disposal method for the drill cuttings generated from these intervals. The samples may be collected from sediment cores, from drive shoes, or from drill cuttings generated during borehole advancement.

4.1.4 Ground Water Chemistry Samples

Ground water samples will be collected for ground water chemistry characterization and VOC analysis. Samples for analyses of ground water chemistry will be collected from five depths during drilling of 299-W11-33, corresponding to the screened intervals, as shown in Table 4-2. Those constituents that will be analyzed are also listed in Table 4-2. Samples for VOC analysis will be collected every 10 ft during borehole advancement and every 5 ft in the screened intervals. Samples will not be collected for water chemistry characterization during drilling of the remaining two wells. However, samples for VOC analysis will be collected every 10 ft during borehole advancement, for a total of six depths. Except for long-term baseline sampling, samples will not be collected after the wells are completed.

An in situ sensor will be used to measure geochemical conditions in the ground water at selected depths. The sensor will measure: dissolved oxygen content, specific conductance (total dissolved solids), redox potential, pH, temperature, and depth below the water table. These measurements will be taken approximately every 10 ft during drilling of 299-W11-33, with closer spacing in the planned screened intervals, as shown in Table 4-2. During the drilling of the two remaining boreholes, measurements will be made once at each of the two depths that correspond to the planned screened intervals.

4.2 SAMPLE DESIGNATION

Soil and ground water samples taken will be assigned a unique Hanford Environmental Information System (HEIS) sample number by the site geologist. However, multiple ground water samples collected during one sampling event from the same sampling location will be assigned the same HEIS number. Subsamples to be analyzed for chemicals and radionuclides will maintain the HEIS number of the original sample. If additional ground water samples are collected for quality assurance purposes, new HEIS numbers will be assigned to those samples. The HEIS numbers will be used on all documentation of the samples, and for data accessibility to other persons working on Hanford environmental activities. Table 4-1 summarizes the activities planned to meet the objectives of this task.

4.3 SAMPLE LOCATIONS AND FREQUENCIES

Samples will be collected from the saturated zone; most samples will be collected from depths corresponding to the screened intervals. However, to better define the lateral and vertical variation in hydraulic properties, sediment cores for physical analyses will be collected between screen depths at a spacing of 10 ft (depending on drilling conditions). Sediment samples will be taken from depths similar to previous sample depths during FY 1993. Specific depths for which samples have been collected are: 248 ft, 253 to 256 ft, and 275 to 292 ft.

Within the screened intervals, the following samples will be collected:

- two sediment chemistry samples
- two 1-ft microbiologic samples
- two physical property samples

- ground water chemistry (in 299-W11-33 only)
- 5 ft of sediment core for microbiologic analysis (in well 299-W11-33 only).

To examine the spatial variability of CCl_4 concentration and hydraulic properties, samples will be collected between screened intervals and below the lower screened interval for:

- sediment VOC analysis (every 5 ft)
- ground water VOC analysis (every 10 ft)
- physical properties (every 10 ft).

The planned sample depth location for each parameter is shown in more detail in Table 4-2.

5.0 SAMPLING PROCEDURES

Sample collection will adhere to procedures defined by Westinghouse Hanford Company (WHC) in *Environmental Investigations and Site Characterization Manual* (1988) or by Pacific Northwest Laboratory (PNL) in *Procedures for Ground-Water Investigations* (1986). Decontamination of sampling tools and archiving of lithologic samples procedures will follow those defined by WHC (1988). Chain-of-custody and collection and handling of samples sent to the laboratory for analysis will follow PNL procedures (PNL 1986). Requirements for collection and handling are defined herein for each specific sample. The general procedure governing sample handling, from collection through analysis, is consistent in scope for all samples. All samples must be released from radiation contamination before removal from the drill site. All sampling activities will be coordinated by PNL. PNL is responsible for sample collection, handling, transport, and analysis.

5.1 RADIATION RELEASE RECORDS

All samples must be released by the responsible health physics technician (HPT) before they are removed from the drill site. No sediment or ground water sample can be removed from the site without a radiation release record signed by the responsible HPT. When a sample is cleared for transport, a radiation release record sticker is generated to notify sample handlers that the sample is free of radioactive contamination. Sediment samples must be unconditionally released, which requires laboratory analysis of sediment from the sampled interval. Ground water samples require onsite screening using field instruments before they are released.

Once a sample is collected (according to the defined procedure), a total activity analysis must be done. A sediment subsample will be collected in a 20-mL plastic container for radiologic activity screening at 222S Laboratory. Before transport to 222S, the sample will be surveyed by the site HPT, and an appropriate sticker generated to indicate the sample is approved for shipping. The HPT will sign the radioactive shipment record of the person who transports the sample denoting that fact. The sampling person will fill out a request for special analysis, which will also be signed by the HPT; the request for

special analysis is required for sample analyses to be completed by the 222S Laboratory personnel. In addition, the sampling person will call the 222S Laboratory to have a specific analysis number (E-number) assigned to each sample that is to be submitted. This number will also be written on the request for special analysis form, and on the specific sample. Samples must be transported to 222S on the day that the HPT survey has been completed.

5.2 SAMPLE PROCESSING

While the radioactivity screening is being done, samples will be stored onsite according to the appropriate preservation technique. Once the results of the total activity analysis have been received from 222S Laboratory, samples will be transported (under the appropriate preservation method) to either the PNL Field Sampling and Analysis Group for offsite distribution, or to the specific onsite laboratory personnel responsible for analysis. Remaining sampled material will be disposed of at the collection site, or by the laboratory personnel according to laboratory procedures. The steps for handling the samples are shown in Figure 5-1. All sample handling will be documented on chain-of-custody forms.

5.3 CHAIN-OF-CUSTODY FORMS

All sample handling will be documented on chain-of-custody forms, as specified in PNL (1986, AD-2, Rev. 2 and AD-4, Rev. 0). Chain-of-custody forms will be generated for every solid and liquid sample collected. There may be more than one sample on a chain-of-custody form. Sample chain-of-custody requires the following information on each original chain-of-custody form:

- chain-of-custody number = temporary well number and sampling interval, in feet (e.g., ID-4, 90-92 or CT-5, 150.5)
- custody form initiator (person(s) collecting sample)
- company contact and telephone number
- project designation/sampling location (well number and depth of sample or sampled interval in feet and [meters])
- collection date and time (24-hr clock, e.g., 11:20 or 15:45)
- field logbook number/page (if applicable)
- method of shipment
- shipped to (laboratory name and/or person)
- possible sample hazards/remarks
- sample identification
- HEIS number of each sample
- specific sample type, container, and depth
- preservation method and temperature of refrigeration
- signature and date when sample custody is transferred.

Figure 5-1. Steps for Handling the Samples.

Activity	Steps
1. Sample Collection	• collect sample • fill out chain of custody form • remove subsample for radiologic analysis • package sample for transport • store sample under appropriate conditions
2. Radiologic Release (total activity)	• deliver sample to 222S for total activity analysis • receive results of analysis
3. Distribution and Transport	• divide samples up into appropriate container if necessary • deliver samples to appropriate laboratories (locations and investigators listed in figure 4.1) • sign over custody to receiving personnel • retain copy of chain of custody form
4. Analysis	• analyses will be performed by laboratory personnel according to specified procedures
5. Reporting	• analyses results are reported in hard copy and digitial copy (if possible) to L. Doremus or D. Newcomer who distribute them to other project personnel

When samples are divided into new containers or transferred to a new chain-of-custody form for any other reason, the following information must be transferred from the original chain-of-custody form to the new one, and is in addition to any preprinted information on the new form:

- original chain-of-custody number (e.g., transferred from chain-of-custody ID-4, 80-85)
- date and time of collection for each sample
- HEIS number of each sample
- preservation method and temperature of refrigeration
- possible sample hazards/remarks.

The original chain-of-custody form will be marked with all new chain-of-custody numbers to which samples were transferred (e.g., transferred to chain-of-custody #95738).

All chain-of-custody forms generated for each sample will be filed together in their respective well folders. Figure 5-2 shows an example of a chain-of-custody form for samples to be transported to analytical laboratories.

5.4 SAMPLING DURING DRILLING

During drilling of the first well (299-W11-33), sediment samples will be collected for geologic characterization and archived by the site geologist, beginning at a depth of approximately 240 ft. Samples for geologic characterization will be collected at the surface from the cuttings that settle out from the containment box, and archived. A lithologic description will be recorded for each of the sediment samples taken. A visual estimate of the particle size distribution will be evaluated, if possible, for each sample. Split-spoon sample collection will begin at 230 ft for microbiologic analysis.

5.5 LITHOLOGIC SAMPLING

Lithologic samples will be collected below 240 ft between split-spoon sample intervals, or from drill cuttings removed from the borehole to clean out the borehole before split-spoon sample collection. Samples will not be collected during drilling from the surface to the 240-ft depth.

5.5.1 Sampling Strategy

During drilling in the saturated zone, from a depth of 240 to 310 ft, samples for lithologic characterization will be recovered from the slough taken from the borehole after split-spoon sampling. If slough samples are not determined to accurately represent the subsurface sedimentary environment by the site geologist, the sampling personnel or the site coordinator, samples for lithologic characterization will be taken from the sediment recovered in the split spoon.

Figure 5-2. A PNL Chain-of-Custody Form for Samples to be Transported to Analytical Laboratories.

Surveyed : Yes ____ No ____? Less than 200 counts/minute: Yes ____ No ____? By (initials) _____

Pacific Northwest Laboratories Battelle Boulevard Richland, Washington 99352	CHAIN OF CUSTODY	Test User ID: C-of-C:

Company Contact: _____ Telephone: _____

Samples Collected by: _____ Date: _____ Time: _____

ID/Sample No.: _____

Ice Chest No.: _____ Field Logbook Page No.: _____

Remarks: _____

Possible Sample Hazard Identification: _____ Contract No.: _____

Destination: _____ Carrier/Waybill No.: _____

Ground-Water _____ Soil _____ Other _____

Shipping container internal temperature when samples sealed in it _____.

Shipping container internal temperature when opened in laboratory _____.

Sample Identification

Chain of Possession

Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Relinquished by:	Received by:	Date/Time:
Disposed by:	Disposal Method:	Date/Time:

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Samples for VOC analysis will be taken to define the distribution of CCl_4 in the solid phase. These samples will be collected every 5 ft from sediments collected during drilling, or during the split-spoon sampling.

5.5.2 Sampling Equipment and Sample Containers

Lithologic sampling equipment:

- rubber gloves
- metal scoop
- waterproof markers
- two pint glass jars w/screw-on lid (mason jar).

VOC analysis samples:

- metal spatula
- small metal sediment scoop
- 40-mL amber vial with teflon septum caps, containing methanol.

5.5.3 Decontamination Procedures

Equipment used to collect samples for lithologic characterization and archive do not require decontamination. These samples will not be used for chemical analyses that normally require container and sampling tool decontamination procedures. VOC sample collection tools will be decontaminated at the 100-K Laboratory according to EII 5.5, 1706 KE Laboratory Decontamination of RCRA/CERCLA Sampling Equipment (WHC 1988).

5.5.4 Sample Collection Procedures

Sample collection will adhere to WHC procedures (1988) for archiving and PNL procedures (1986) for lithologic description. Radiation release samples are taken from all sediment samples collected, as described in Section 5.1.

5.5.4.1 Archive Lithologic Samples. Two sediment samples will be collected for archive at intervals listed in Table 4-2 and at changes in sediment lithology from the sediments collected during drilling. The sediments are first dropped into a sediment collection bucket. A metal scoop is used to transfer sediments to the two pint glass jars.

The procedure to archive samples in the WHC Geotechnical Sample Library, as described in EII 5.7A, Hanford Geotechnical Sample Library Control (WHC 1988), will be followed. A lithologic description will be recorded for each sediment sample taken. A lithologic log will be recorded on the borehole log and on the as-built diagram constructed for the borehole, as specified by PNL (1986, Procedure DO-1, Rev. 1).

5.5.4.2 VOC Analysis Samples. The procedure for collecting VOC samples is:

- Immediately after sampling tools are opened and sediments are exposed, use the small metal sediment scoop to dig 5 to 10 g of sediment out from at least 1-in. below the top of the sediment.

- Tip the sample vial slightly.
- Let the sediment slide down the inside of the vial into the methanol preservative.

NOTE

Do not get sediment on the vial's threads. Even if the threads are wiped off, volatiles can be lost.

- Cap the vial firmly, but not so tight as to tear the teflon liner.

5.5.5 Sample Preservation Procedures

No special preservation techniques are required for the archive lithologic samples. VOC analysis samples will be placed immediately after collection into a cooler containing ice, or into a refrigerator. The sample containers must remain upright during the sample storage period before analysis takes place.

5.5.6 Sample Handling and Analysis

5.5.6.1 Archive Lithologic Samples. Archive lithologic samples will be transported to the WHC Geotechnical Sample Library at 2101-M Building, 200 East Area for archiving per EII 5.7A (WHC 1988, Rev. 3).

5.5.6.2 VOC Analysis Samples. VOC samples will be transported to the PNL Sigma 5 Building, Sediment Chemistry Laboratory (Room 1417), and sample custody transferred to laboratory personnel. Samples will analyzed using an internal procedure modified for sediment samples.

5.6 CONTINUOUS SPLIT-SPOON SAMPLING

Continuous split-spoon sampling will be conducted in the capillary fringe and saturated zone below 230 ft to the total drill depth reached. Radiation release samples are taken with all sediment samples collected, as described in Section 5.1.

5.6.1 Sampling Strategy

During installation of the wells, samples will be collected to evaluate the spatial variability of CCl_4, sediment physical properties, and microbiologic populations. Samples will be collected with the split-spoon sampler in the saturated zone and capillary fringe. Split-spoon samples will be taken for microbiologic characterization, sediment physical property characterization, and sediment chemical characterization at specific intervals listed in Table 4-2. Microbiologic characterization samples will be collected from depth intervals corresponding to locations of the well screens.

Physical property samples will be collected approximately every 10 ft during borehole advancement, with closer spacing in the screened intervals (245- to 260-ft and 285- to 300-ft depth). To better define the lateral variability in the physical properties of the aquifer sediments, samples for this parameter will be collected at depths corresponding to those collected during the installation of well 299-W11-32. These depths, including the results, for samples taken from well 299-W11-32 are listed in Table 5-1.

Sediment chemical characterization analyses that will be performed are:

- VOC
- TKN
- TP content
- TOC content
- sorption of CCl_4 and acetate.

Table 5-1. Physical Property Sample Depths and Results for Well 299-W11-32.

Depth, ft	Laboratory-measured sorption value, cm/s
247.5	2.14E-04
252.8 to 253.3	2.75E-07
255 to 256.5	6.19E-06
274.5 to 275	7.46E-05
275 to 275.5	6.06E-05
278.5 to 279	5.17E-06
292 to 292.5	1.07E-04
304 to 305	3.09E-06

An attempt will be made to collect physical property samples from all three wells from depth intervals similar to those collected from 299-W11-32. The actual number of and specific depth of samples collected for physical property analysis will depend on the drilling conditions and schedule. These samples will be collected with a split-spoon sampling tool. Samples will be analyzed for:

- hydraulic conductivity
- density
- porosity.

Ground water chemistry samples and in situ hydrochemical measurements will be taken also.

5.6.2 Sampling Equipment and Sample Containers

For each split-spoon sample interval and any other samples transported from the drill site, an associated radiologic release sample must be collected (in a 20-mL plastic container) and analyzed before the samples are removed

from the drill site. The equipment required for retrieving split-spoon samples is listed below:

- split-spoon halves
- split-spoon head
- split-spoon shoe
- spring (core-catcher)
- spacer
- Lexan liners (1- and 2-ft length, 0.33-ft diameter)
- Lexan liner end caps (0.33-ft diameter)
- core-borer subsampling tool
- metal scoop
- metal spatula.

Equipment needed for collecting physical property samples are:

- rubber gloves
- waterproof markers
- tamper-evident tape
- plastic baggies with 'zip' closure openings
- chain-of-custody forms
- one 0.5-ft length, 0.33-ft diameter Lexan liner
- vinyl end caps for Lexan liners.

Microbiologic sample collection equipment and sample containers needed are:

- laboratory sterilized, (2) 1- or 2-ft length Lexan liner (wrapped in sterile brown paper)
- laboratory sterilized liner caps (sealed in whirl pack bags)
- sterile plastic gloves
- laboratory sterilized brown paper
- ethanol and sprayer (to apply ethanol to sample equipment)
- striker (or matches or lighter)
- tray (for onsite sampling equipment sterilization)
- chlorine bleach (for onsite sampling equipment sterilization)
- buckets and brushes (for onsite sampling equipment sterilization)
- plastic tape and markers
- heavy-duty plastic transport bag (to place samples in once retrieved)
- argon tank (requires approved transport to site)
- argon regulator and tube
- large cooler (4-ft length) and frozen blue ice.

The sediment chemistry sampling equipment needed is the same as the split-spoon sampling equipment listed above. The subsample containers (for each sampled interval) for sediment chemistry analyses are:

- 40-mL amber glass vial containing 5 mL methanol, with screw-on cap and teflon septum
- three 40-mL amber glass vials (TOC, TKN, TP)
- one 40-mL amber glass vial with screw-on cap (TOC).

5.6.3 Decontamination Procedures

Decontamination procedures will vary, depending on the type of sample to be collected for each of the analyses performed. The decontamination procedures for split-spoon type sampling are described for sediment physical properties, microbiologic characterization, and sediment chemistry. Decontamination procedures will apply for samples collected in both the saturated and unsaturated zones.

For all sample analysis types, the split-spoon sampling equipment will initially be decontaminated by washing the split-spoons and head with a nonphosphate detergent and deionized water, followed by rinsing with deionized water. The equipment will be allowed to dry, and then wrapped in plastic.

The split-spoons, head, shoe, spacer, core-catcher, and liners will be assembled by personnel wearing new disposable rubber or plastic gloves. The entire assembly will be wrapped in plastic until it is needed.

Decontamination procedures will be documented as described in EII 5.4, Field Cleaning and/or Decontamination of Equipment (WHC 1988, Rev. 2). Rinsate from field decontamination procedures will be collected if their is evidence of downhole contamination detected by field screening instruments.

5.6.3.1 Physical Property Samples. For physical property samples, the initial decontamination procedure is sufficient for the split spoons, the head, the shoe, the core-catcher, and the spacer. Lexan sleeves that line the split-spoon sampler do not require decontamination after arriving from the manufacturer when used for physical property sampling. Physical property samples will frequently be taken with microbiologic samples. In this situation, the physical property sample collection equipment will require the additional decontamination procedures that aseptic microbiologic sampling entails.

5.6.3.2 Microbiologic Samples. Microbiologic samples will be collected using split spoons, Lexan liners, and sample-handling equipment that have been sterilized.

Aseptic samples will be taken using a split-spoon sampler having a Lexan liner that has been sterilized prior to sampling. The sterilization procedure is:

- The Lexan liner will be autoclaved in a laboratory and wrapped in sterile packaging before being brought out to the drill site.
- Pick up the liner at the PNL Microbiology Laboratory in the 324 Building.
- The split spoon and head (used to attach the barrel to the drilling tools) will be washed in a 5% bleach solution at the drill site and allowed to air dry.
- The shoe of the split-spoon assembly, the springs (core-catcher) used to retain the sediment inside the split-spoon, and the spacer will be sprayed with ethanol, set on fire (flamed), and allowed to cool in the air.

- The split spoons, head, shoes, springs, spacer, and sterile Lexan liner are assembled using sterile gloves, then wrapped and sealed in sterile paper. If the sealed assembly is not used immediately, it is wrapped in plastic and taped until used for sample collection.

5.6.3.3 Sediment Chemistry Samples. Sediment sampling equipment for chemical analyses will be decontaminated at the 100-K Laboratory per EII 5.5 (WHC 1988, Rev. 2). Laboratory-cleaned equipment must be transported to the drill site before sampling proceeds. The split-spoon shoe, core-catcher, spacer, Lexan liners, liner caps, and core-borer subsampling tools will also be decontaminated according to EII 5.5 and wrapped in aluminum foil. Sediment samples for VOC analysis will be collected from the same split-spoon sediment from which other chemical characterization samples are collected.

5.6.4 Sample Collection Procedures

Sample collection will adhere to the procedure for split-spoon sampling (PNL 1986, DO-2, Rev. 1). Radiation release samples are taken with all sediment samples collected, as described in Section 5.1. Specific sample collection procedures associated with VOC sample collection and aseptic sample collection are described.

Split-spoon sample collection will require two persons (in addition to the drilling crew) onsite to ensure that sample collection and handling procedures are completely and adequately carried out.

Six steps will be completed for collection of all split-spoon samples. Once the split-spoon sample is retrieved from the bottom of the borehole, it is placed on a plastic-covered sampling table and opened. The microbiologic samples must be immediately covered with sterilized endcaps and the caps taped in place. Then, the rest of the subsampling and liner capping will proceed.

The priority for split-spoon subsampling and liner capping of VOC, chemical, porosity and bulk density, and physical property samples, is:

1. microbiologic sample processing
2. VOC core-borer subsampling
3. sediment chemistry sample Lexan liner capping
4. porosity and bulk density liner capping
5. hydraulic conductivity liner capping
6. radioactivity release subsampling.

5.6.4.1 Microbiologic Sample Processing. Because analyses will be done in a 'clean' laboratory, samples with high VOC content will not be accepted for analysis, as these would contaminate the laboratory. Concentrations above 100 ppm, as determined by field screening of sampled core in the vapor phase, constitutes high VOC content.

Aseptic split-spoon sampling consists of the following steps:

1. Clean borehole out using either drive barrel or bailer.

2. Measure and record depth-to-bottom of borehole.

3. Attach sampler to drill string with paper seal in place.

4. Remove paper seal and lower sampler to bottom of borehole.

5. Drive split-spoon sampler into sediment, recording number of blow counts for sampler to advance each 0.5 ft.

6. Retrieve split spoon from bottom of borehole. Place split spoon on a clean, plastic-covered sampling table.

7. Open split spoon and collect a small sample from shoe for submission to HPT for analysis.

8. Seal ends of liner with previously sterilized endcaps and plastic tape. Label liner with borehole number, depth interval sample was recovered from, date, and time of recovery.

9. See Section 5.5.5 for sample preservation and Section 5.5.6 for sample handling and analysis.

5.6.4.2 VOC Core-Borer Subsampling. Subsampling for VOC is conducted after the split-spoon sampler has been retrieved, as follows:

- Immediately after sampling tools are opened and sediments are exposed, use small metal sediment scoop to dig 5 to 10 g of sediment out from at least 1 in. below top of the sediment.

- Tip sample vial slightly.

- Let sediment slide down inside of vial into methanol preservative.

NOTE

Do not get sediment on the vial's threads. Even if the threads are wiped off, volatiles can be lost.

- Cap vial firmly, but not so tight as to tear teflon liner.

- Preserve and handle sample according to that described in Sections 5.5.5 and 5.5.6, respectively.

5.6.4.3 Sediment Chemistry Sample Liner Capping. Capping the sample liner for sediment chemistry is conducted after the split-spoon sampler has been retrieved, as follows:

- Cap both ends of chemical liner with vinyl endcaps.

- Use teflon tape and tamper-evident tape to seal endcaps. Write date and time of sampling, well number and depth, and sampler's initials on Lexan liner.

- Mark on liner: (1) HEIS number; (2) "SS" for split-; (3) "chem"; and (4) an arrow pointing in the up direction.

- Preserve and handle sample according to that described in Sections 5.5.5 and 5.5.6, respectively.

After the chemical liner is released by the HPT, liners will be taken to Sigma 5 Building for subsampling. Subsamples for chemical characterization analyses will be transferred from the chemical liner and put in pre-labeled containers for transport to analytical laboratories. The pre-labeled containers and the respective chain-of-custody forms will be prepared by the Field Sampling and Analysis Group staff. Chemical subsamples will be transported to their respective laboratories and analyzed within specified holding times, as listed in Table 5-1. The site coordinator and the Field Sampling and Analysis Group staff will be responsible for distributing the samples to the laboratories within the holding time limits; and receiving and distributing the analytical results.

5.6.4.4 Hydraulic Conductivity, Porosity, and Bulk Density Sampling. The liner designated for hydraulic conductivity analyses must be completely full of sediment. This will ensure that the sediment structure is not destroyed during transport and that sediment samples are representative of the particle size fraction present in the sampled interval.

5.6.5 Sample Preservation Procedures

Holding times, sample containers, preservation, and laboratory for the sediment chemistry samples are listed in Table 5-2.

5.6.4.5 Microbiologic Samples. The sealed core is placed inside a plastic bag and the bag is filled with argon. Gas is purged from the plastic bag three times and the plastic bag, filled with argon, is sealed around the core. Purging is done by the following steps:

1. Stand core (inside the plastic bag) upright vertically, inside bag, with bag open at top.

2. Inserting tube from argon tank into plastic bag and holding bag opening (at the top) closed by hand.

3. Fill plastic bag with argon from tank until fully inflated, then turn down pressure from argon tank.

4. While continuing to hold bag closed by hand, compress bottom of bag to push argon out top opening.

5. Continue compressing bag and move vertically up core, until all argon is pushed out of bag, while holding top closed (loosely, to allow argon to escape, but no air to enter bag).

6. Repeat steps 3 through 5 two more times.

7. Bag should retain positive pressure, so air does not enter bag, pull tube from argon tank out of bag.

8. Twist top of bag, fold it over onto itself, and tape 'twist' down onto bag firmly with green tape.

9. Mark bag with (1) borehole number; (2) depth interval; (3) date and time of recovery; (4) sampler's initials; and (5) "ASEPTIC SAMPLE".

10. Place sealed sample in cooler with blue ice, ensure a temperature in cooler of 10°C or less until transfer to laboratory.

Table 5-2. Sediment Chemistry Sample Containers, Quantities, Preservation, and Holding Times.

Analysis	Container	Quantity	Preser-vation	Holding Time	Laboratory
VOC	40-mL amber glass w/teflon septum	5 to 10 g	Methanol, 4°C	14 days[a]	PNL
Chemical Anions ICP metals	 250-mL glass " "	 45 g 100 g	 4°C Refriger-ation	 ASAP 6 mo	 DataChem[b] "
TOC TP TKN	40-mL amber " " " "	fill " "	4°C " "	ASAP " "	HL[c] " "
Sorption	1-qt glass	1 kg	4°C	ASAP	PNL

NOTE: Holding times begin at time of collection.

[a]Although the EPA recommended holding time for VOC is 14 days, a much shorter holding time is desired, and may be achieved by efficient and timely communication and transport between the sampler and HPT, and between the sampler and analyst.

[b]DataChem Laboratories, Salt Lake City, Utah.

[c]Huffman Laboratories, Golden, Colorado.

Samples in the sealed Lexan liner and argon atmosphere will be transported to the laboratory under refrigeration within 48 hr of sampling.

5.6.5.2 VOC Samples. Because the analytes are volatile, care must be taken to collect and preserve VOC samples as soon as the sediment has been removed from the borehole. Sediment will be placed in a 40-mL amber jar containing a methanol preservative to fix the VOCs in the methanol solution. VOC sample vials must be vertical and under refrigeration (at a temperature of <10°C) at all times. Only when the sample is actually extracted from the sediments should the VOC vial be out of a refrigerated container.

5.6.5.3 Sediment Chemistry Samples. The liner designated for sediment chemistry characterization will be sealed with endcaps and refrigerated until subsampling takes place. Subsampling will be done in the Soil Physics Laboratory (Room 1522) of Sigma 5 Building within 48 hr of sample collection.

5.6.5.4 Porosity and Bulk Density/Hydraulic Conductivity Samples. Porosity/bulk density samples must retain the sediment structure intact to the highest degree possible during sample collection and transport. To ensure that the sediment structure of the samples taken for these analyses remains intact, the Lexan liners in which these samples are collected must be completely full of sediment. The sampled sediment will be sealed inside the liners with liner caps, and the caps taped in place. Samples do not require refrigeration during transport. The holding time limit for the porosity and bulk density samples is 90 days. There is no holding time limit for the hydraulic conductivity samples.

5.6.6 Sample Documentation

Any samples taken for analyses require unconditional radioactivity release before being removed from the drill site, as described in Section 5.1.

- Submit sediment or slurry from the sample interval to the HPT for analysis.
- Place completed radiation release sticker on each sample container.

Chain-of-custody forms will be filled out for each sample, as described in Section 5.3. There may be more than one sample on a chain-of-custody form.

5.6.7 Sample Handling and Analysis

Physical property analyses and their respective governing procedures are listed in Table 5-3.

Table 5-3. Procedures (PNL 1986) for Sediment Physical Property Analyses.

Analysis	Procedure Number	Procedure Title
Water Suction	SA-6	Water Retention Procedure
Particle Size	SA-2	Sieve Procedure
Particle Size	SA-3	Particle-Size Analysis (Hydrometer Method
Bulk Density	SA-8	Clod Density/Bulk Density
Particle Density	SA-9	Determining Particle Density
Hydraulic Conductivity	SA-4	Constant Head Hydraulic Conductivity Determination
or		
Hydraulic Conductivity Procedure	SA-5	Falling Head Hydraulic Conductivity

5.6.7.1 Microbiologic Samples. The sample will be transferred offsite once unconditionally released by the responsible HPT. The sample will be delivered to the 324 Building or LSL 2 Building and custody transferred for analyses.

5.6.7.2 VOC Samples. VOC samples will be handled as described in Section 5.5.6. Samples will analyzed using a PNL procedure modified for sediment samples.

5.6.7.3 Sediment Chemistry Samples. The liner designated for sediment chemistry analysis will be sealed with endcaps until subsampling takes place. Subsampling will be conducted in the Soil Physics Laboratory (Room 1522) in Sigma 5 Building after custody is transferred to laboratory personnel. For subsampling, the sample is divided into the appropriate volumes and placed into new sample containers for distribution to the analytical laboratory.

5.6.7.4 Porosity and Bulk Density Samples. Porosity and bulk density samples will be transported to the Soil Physics Laboratory (Room 1522) at Sigma 5 Building for analyses. During transport, the sample must be protected from physical shock to retain sediment structure integrity. Samples may be refrigerated to prevent any microbiologic growth on the sampled sediments if the holding time exceeds 5 days. Custody will be transferred from field personnel to laboratory personnel at the Sigma 5 Building, Soil Physics Laboratory (Room 1522), upon sample delivery. The porosity samples will be analyzed using PNL procedures (PNL 1986, SA-5, Rev. 1 and SA-9, Rev. 1). The bulk density samples will be analyzed using PNL procedures (PNL 1986, SA-5, Rev. 1 and SA-8, Rev. 1).

5.6.7.4 Hydraulic Conductivity Samples. Hydraulic conductivity samples will be transported from the drill site to the Soil Physics Laboratory (Room 1522) at Sigma 5 Building for analyses. Custody will be transferred to laboratory personnel. During transport, the sample will be protected from physical shock to retain sediment structure integrity. Samples will be frozen once they arrive at the laboratory. Hydraulic conductivity samples will be analyzed by PNL procedures (PNL 1986, SA-4, Rev. 1, or SA-5, Rev. 1).

5.7 GROUND WATER SAMPLING

Ground water chemistry data will be used to establish a baseline for designing the in situ bioremediation demonstration and to evaluate ground water chemistry changes resulting from the biodegradation process. In addition, ground water chemistry data will be used to supply information for studying the microbiologic activity in the aquifer. Samples taken from various depths will allow evaluation of changes in ground water chemistry with depth. Ground water samples will be collected per PNL procedure (PNL 1986, GC-1, Rev. 3). Ground water sample containers will be cleaned and prepared for use by PNL sampling staff.

5.7.1 Sampling Strategy

For all wells drilled, ground water samples will be collected for VOC analyses approximately every 10 ft to define the distribution of CCl_4 with depth. Ground water samples will be collected for metals, anions, and alkalinity only during drilling of well 299-W11-33, at 5-ft intervals

corresponding to the planned locations of the well screens. These 5-ft-interval samples will also be analyzed for VOC. Planned ground water sample depths are shown in Table 4-2. Actual sample collection depths may vary, depending on the specific drilling conditions.

Measurements of in situ geochemical parameters will be made using an in situ probe during drilling of each borehole. In situ measurements will be made at depths corresponding to the ground water sample collection depths during the installation of well 299-W11-33, for a total of eight measurement depths. For the other two well installations, only two in situ measurements will be made at depths corresponding to the planned screened intervals.

5.7.2 Sampling Equipment and Sample Containers

Sample collection equipment includes:

- laboratory-cleaned teflon bailer wrapped in plastic
- downhole sampling equipment including tripod and pulley, string, and motorized reel (to raise and lower bailer)
- laboratory-prepared sample containers
- cooler and ice, or frozen blue ice (to transport samples)
- markers (to mark sample containers)
- plastic or rubber gloves
- tamper-evident stickers
- field sampling plan and QA project plan.

Sample containers and chain-of-custody forms will be prepared by PNL sampling staff. See Table 5-4 for containers used for each sampled interval.

Table 5-4. Containers Used for Each Sampled Interval.

Analysis	Sample Container
ICP metals	500-mL plastic (2)
Anions	125-mL plastic
VOCs	40-mL amber glass septum (2)
Dissolved organic carbon	500-mL amber glass septum

5.7.3 Sample Collection and Preservation Procedures

The depth to the bottom of the borehole will be measured, and the depth to water will be measured before collecting ground water samples. Ground water sampling tools will then be set up over the borehole. The sampling tools include a tripod with a standardized pulley to determine the depth of sampling, and the line and motorized reel that lowers and lifts the bailer from the borehole. Ground water will be bailed from the hole before sampling. The volume of water to be removed will be determined by field personnel at the time of sampling. After bailing the borehole, it will be allowed to recover until the water level is at least 5 ft above the bottom of the borehole (a depth of 3 ft is required for the sampling bailer to collect a sample).

Ground water samples will be collected using a teflon bailer. The samples should be as free of sediment as possible. Two full bailers will be removed from the borehole and dumped into the purge water barrels before collecting the ground water samples. The actual sample water will be poured from the bailer into opened sample jars with minimal spilling and jostling of the water, as described by PNL (PNL 1986, GC-1, Rev. 3).

Containers for VOC and TOC analyses should be filled to the top of the jar, forming a convex meniscus at the top of the container. The lid should be screwed on immediately, eliminating any air capture in the container. Then the containers should be tipped to see if an air bubble has been sealed in the container. If so, the containers should be opened and more water added. Containers for other analyses will not seal without trapping some air, but the amount of air contained should be minimized.

One 20-mL water sample will be collected for total activity analysis at the 222S Laboratory. The results of these analyses must show that the water does not exceed total activity of 2 nCi/mL before ground water samples can be transported to an offsite laboratory. If the total activity exceeds this level, U.S. Department of Transportation protocols must be followed before the samples can be shipped to an offsite laboratory.

Once collected, the samples will be kept under refrigeration at approximately 4°C. Bottles will be marked with the date, time, well number, depth, HEIS number, and sampler. Tamper-evident tape will be placed over the lids. VOC samples will be placed in plastic bags and the tamper-evidence tape placed on the bag, not the jars. Chain-of-custody forms will be completed.

Once the results have been received from the 222S Laboratory and cleared for transport, the samples will be delivered to the Sigma 5 Building. Custody will be transferred to the PNL laboratory staff, who will distribute the samples to the analytical laboratories. Samples for VOCs will be delivered to chemistry analysis personnel at the Sigma 5 Building.

Most ground water samples will be taken with the teflon bailer and placed in the appropriate container for shipment to a laboratory offsite for analysis. Some of the chemical analyses may be done in the field during the drilling and sample collection. Analyses that may be performed onsite are described below.

5.7.4 In Situ Hydrochemical Parameter Measurements

After ground water samples are collected, in situ measurements of ground water chemistry will be taken by inserting a sensor into the borehole. The sensor will measure the following parameters from each depth interval:

- dissolved oxygen content
- Eh potential
- pH
- temperature
- specific conductance
- depth below the water table.

These measurements will be taken only where ground water samples are collected. However, the number of measurements will be made at the discretion of the site geologist, site coordinator, or other project personnel.

The sensor consists of a downhole probe, a cable by which it is lifted from and lowered into the borehole, and a datalogger. The datalogger is connected to the probe with a cable that is attached to a power source. The cable passes over a pulley, which is connected to the well casing, and attaches to the probe directly over the borehole. The probe will be lowered to the specific depth from which ground water samples were collected. Once in place, the probe will be allowed to record measurements for at least 0.5 hr to determine if there is a change in the parameters over the collection period. If the drilling schedule permits, the probe will be left in the borehole overnight to collect data for an extended period. The probe must be calibrated before and after data collection, as recommended by the manufacturer of the sensor.

5.7.5 Decontamination Procedures

The teflon bailer will be cleaned with nonphosphate detergent, and rinsed three times with deionized water before it is used to collect ground water samples. Decontamination activities will be documented per EII 5.4 (WHC 1988, Rev. 5).

The downhole probe must be washed with detergent, then rinsed with deionized water before it is lowered into the borehole. The portion of the connecting cable that is submersed must be washed, and then rinsed with deionized water before the probe is lowered into the borehole.

5.8 BOREHOLE LOGGING

If geophysical tools are readily available for logging neutron porosity and density, the wells will be logged after the holes have been drilled to total depth. However, not all new wells drilled will necessarily be logged, depending on schedule and availability of the geophysical tools. The decision for logging each hole will be left to the discretion of the task manager or site geologist.

6.0 HYDROLOGIC TESTING AND ANALYSIS

The purpose of the hydrologic field tests for FY 1994 is to estimate hydraulic properties of the aquifer formation, to assure lateral hydraulic communication between corresponding well screens, and to determine the pumping efficiency of the well screens. Also, results from slug tests conducted during drilling will be used to identify the zones for screen placement. Well development will be conducted before post-completion hydrologic tests, which include step-drawdown and constant-rate pumping tests and a tracer test.

Hydrologic test data are necessary for continued support of the field test design for demonstrating in situ bioremediation. The specific aquifer parameters needed to facilitate design of the field demonstration include

specific capacity, horizontal distribution of hydraulic conductivity, dispersivity, and effective porosity. Other parameters that may be important, but not critical for the demonstration design, include anisotropy ratio and vertical distribution of hydraulic conductivity.

Hydrologic testing activities will be performed by PNL with field support provided by WHC Environmental Field Services. Since mechanical surging and bailing is part of the completion process, this activity will be covered by the drilling contractor.

6.1 WELL DEVELOPMENT

Development of the new dual-screened wells will involve a combination of light mechanical surging, bailing, and pumping similar to development of well 299-W11-32, constructed in FY 1993. During completion, a mechanical surge block will be used to form a tight filter pack around each screen interval. During surging of each screen interval, a surge block will be placed adjacent to the screen, after the sandpack material has been placed around the screen, but before the bentonite seal is placed above that particular screen interval. Sediment entering the screen as a result of the light surging action will be removed with a sand bailer. A bentonite seal will then be placed above the screen and allowed to set for a few hours before the next screen interval is surged. The nested well, with two 3-in. ID piezometers, will be developed by bailing and pumping, but mechanical surging will not be necessary. This well will be used only for ground water sample collection, which will require minimal pumping.

Following completion, well development by pumping will proceed according to PNL procedure (PNL 1986, AT-4, Rev. 1). An electric submersible pump without a check valve will be installed with inflatable packers to hydraulically isolate each screen interval. Each screen interval will be developed by pulsed pumping (pump on and off) in a stepwise fashion. The pumping pulses will increase in steps of approximately 5 to 10 gal/min, over a range between about 5 to 30 gal/min. The pump may be turned on and off several times during each flow rate step, the number of pulses dependent on the turbidity levels observed. Development will be conducted until the turbidity level reaches 5 NTU or less at the maximum flow rate step. A higher turbidity level may be accepted if 5 NTU cannot be achieved within several hours of pumping. Water level pressures will be monitored to ensure that dewatering of the water column to the pump intake will not occur.

The flow rate will be measured at the surface and the total volume of water purged will be estimated from the measured flow rate. It is expected that up to 4,000 gal of water will be purged during each development test. All water pumped from the well will be contained and transported for proper disposal. If necessary, a tee in the discharge line at the wellhead shall be configured with valves to allow for outflow to more than one tank.

6.2 PRE-COMPLETION HYDROLOGIC TESTING

Hydrologic testing will be conducted during drilling of the first well after reaching the water table. A series of slug displacement tests will be run at various depths between the water table and total depth. Slug tests will be conducted according to PNL procedure (PNL 1986, AT-6, Rev. 1).

Up to five slug displacement tests will be conducted in the temporary casing of the first well drilled after reaching the water table, but before final well completion. The purpose of conducting slug tests is to provide relative differences in hydraulic conductivity over various depths within the saturated interval. These qualitative results can be used to identify zones for selecting screen placement. Most of the tests will be conducted at depths corresponding to the upper and lower permeable units identified at the existing wells.

Based on hydrologic testing results and other characterization data collected thus far from the existing wells, it is anticipated that slug tests will be conducted at depths of approximately 250, 268, 288, 295, and 305 ft. These depths may change as the drilling progresses through the saturated zone if the results or character of the sediments differ from that expected or if there is a distinct change in the character of the formation. Multiple tests will be run at each depth interval. It is expected that each set of tests will take approximately 3 hr to complete.

For each slug test, water level pressure data will be processed and analyzed using conventional methods (i.e., Bouwer and Rice 1976) to estimate hydraulic properties. However, derivative type-curve matching techniques may also be employed, as described by Spane and Wurstner (1993).

6.3 POST-COMPLETION HYDROLOGIC TESTING

Hydrologic testing will be conducted in each of the newly drilled, 4-in. diameter wells following well completion. Tests include step-drawdown tests, constant-rate pumping tests, and a multi-well tracer test.

All post-completion hydrologic tests will be governed by procedures written specifically for this site in the form of standard operating procedures. The standard operating procedure for conducting step-drawdown and constant-rate pumping tests is a modification of PNL procedure (PNL 1986, AT-5, Rev. 1). Standard operating procedures are used because a documented procedure governing the test does not exist or is not applicable for this study. Copies of the procedures will be placed in a binder and stored at the field site trailer.

6.3.1 Step-Drawdown Tests

Two step-drawdown tests will be conducted in each 4-in. ID, dual-screened well, one in each screen interval. For these tests, inflatable packers will be used to hydraulically isolate each test interval. Step drawdown tests will not be conducted in the nested well with the 3-in. ID piezometers. The purpose in conducting step-drawdown tests is to determine the maximum producing capacity (specific capacity) of the well screen.

6.3.2 Constant-Rate Pumping Tests

A constant-rate pumping test will be conducted in the lower screen interval after the first well is completed. Up to two additional tests will be conducted after all the wells have been drilled and completed, but before

the demonstration begins. The goal of these tests will be to corroborate previous test results from FY 1993 and FY 1994, to confirm hydraulic continuity between corresponding screens of the existing wells, and to estimate the horizontal distribution of hydraulic conductivity.

The test will involve pumping at a constant producing rate from a newly drilled or existing well while monitoring water level pressures in the pumping well and one or more observation wells. The design of the tests (i.e., identification of the pumping and observation wells) will be determined from results of the step-drawdown tests. The duration of pumping will be roughly 12 to 24 hr, but may be extended, depending on the pressure responses observed during the test. For dual-screened wells, an inflatable packer will be used to hydraulically isolate each test interval.

Water level pressure data will be processed and analyzed using derivative type-curve matching techniques described by Spane and Wurstner (1993).

6.3.3 Multi-Well Tracer Test

A multi-well tracer test will be conducted after completing all the newly drilled wells, but before the demonstration begins. The well design of the test, which will be similar to the design for the demonstration, will be determined using analytical and numerical predictive computer programs. The purpose of this test will be to:

- estimate hydraulic control based on tracer recovery
- confirm pumping (extraction and injection) rates
- demonstrate well-to-well interactions
- validate transport modeling
- confirm hydraulic properties of the formation
- qualitatively assess heterogeneities in the aquifer formation.

The test will involve extraction from one or more wells and reinjection into a single well via a closed system (i.e., the total withdrawal will be equal to the total reinjection). Initially, ground water will be purged to a tank and turbidity will be monitored. As soon as turbidity is reduced to 10 NTU or less, the stream will be rerouted via a valve to the injection well. If necessary, a high-capacity inline filter will be used to filter out suspended sediment.

After reaching near steady-state conditions, a conservative tracer, lithium bromide, will be injected into the closed line by a metering pump either as a step or a pulse. The input concentration and mass of tracer used will be determined using analytical or numerical predictive computer programs. Recirculation will continue until the tracer slug has passed one or more observation wells. The tracer will be monitored continuously with downhole probes and verified with analysis of time-discrete samples. Also during the tracer test, ground water samples will be collected every few hours for determining changes in VOC concentrations.

After sufficient tracer concentration data have been collected, recirculation will continue until the tracer has been diluted to concentrations less than about 3 ppm.

6.3.4 Hydrologic Testing Schedule

The slug tests will be conducted during drilling of the first well after reaching the water table (see Section 3). As soon as this well is completed, hydrologic tests will be performed in the lower screen interval. These tests will include development, a step-drawdown test, and a constant-rate pumping test. The schedule for these three tests will be coordinated around the drilling schedule.

All remaining hydrologic tests will be conducted after the last drilled well has been completed. (See Section 3 for drilling and completion schedule.) The tests planned for each well will be conducted sequentially to minimize removal and reinstallation of downhole equipment. The general sequence of tests for each well will be development, followed by a step drawdown test, then a constant-rate test. A constant-rate test will not be conducted in every well. After all development, step-drawdown, and constant-rate tests have been conducted and preliminary analyses of the data are available, the multi-well tracer test will be designed and conducted according to a draft procedure approved by the project manager. The latest draft procedure, dated June 1994, is titled "Procedure for Conducting a Two-Well Groundwater Recirculation Tracer Test".

6.4 WATER LEVEL MONITORING

Water level measurements will be collected quarterly from wells 299-W11-29 and -30 to monitor the change in the water table elevation. Water levels will also be measured in a network of wells in the vicinity of the field site on a quarterly basis to monitor the regional hydraulic gradient. Measurements in the multi-screened wells will be taken to evaluate the vertical hydraulic gradient. Because of the difficulty in obtaining these measurements, routine water level monitoring will not be taken in these wells. Routine water level measurements will be conducted by PNL (PNL 1986, WL-1, Rev. 2).

7.0 BASELINE WATER CHEMISTRY AND MICROBIOLOGY SAMPLING

A series of measurements will be performed to determine the baseline concentrations of important constituents in the ground water at the bioremediation field site. Sampling will continue in FY 1994 and proceed through the end of September 1994, when demonstration operations begin. Samples will be withdrawn from wells 299-W11-29, -30, and from the upper and middle screened intervals of well 299-W11-32.

7.1 SAMPLING CONSTITUENTS AND FREQUENCIES

The sampling constituents and their measured frequencies are presented in Table 7-1. The VOCs include carbon tetrachloride, chloroform, dichloromethane, tetrachloroethylene, and trichloroethylene. The anions include nitrate, nitrite, sulfate, phosphate, chloride, and fluoride.

7.2 SAMPLING PROTOCOLS

The sampling protocols for VOCs, anions, and microbiologic samples are described. For each sample location, three wellbore volumes will be purged before collecting samples. Purge water will be contained in a purge water tank and then transported to an approved disposal facility.

Table 7-1. Constituents and Measurement Frequencies for Baseline Ground Water and Microbiologic Samples.

Constituent	Frequency	Number per Event
Ground water		
VOCs	Biweekly	4
Anions	Bieekly	4
Microbiological		
Denitrifiers	Monthly	4
Sulfate reducers	Monthly	4
Coliforms	Monthly	4

7.2.1 VOC Sampling Protocol

Samples will be obtained using a flow-through cell equipped with a septa for withdrawing samples that have not been exposed to the atmosphere. A 1-mL sample will be withdrawn from the cell into a syringe containing 1 mL of hexane. The syringe contents will then be dispensed directly into a screw-cap-graduated cylinder containing 4 mL of hexane with the cylinder in a beaker with ice. The hexane and sample will be thoroughly mixed to extract the VOCs and then allowed to settle so that the hexane and water phases separate. The volumes of sample and hexane will be recorded and the hexane portion dispensed into gas chromatography vials so that no headspace remains. Vials will be immediately crimp-sealed and placed on ice with the septa on the bottom. Three samples from each sampling location will be collected. A hexane blank will be prepared for each sampling event. Samples will be transported to the 324 Building for analysis by gas chromatography.

7.2.2 Anion Sampling Protocol

Sampling will consist of 5-mL aliquots dispensed through 0.2- m sterile syringe filters into sterile 15-mL, snap-capped sample tubes. Three samples from each sampling location will be collected. Samples will be placed in a cooler on ice and transported to the 324 Building for analysis by ion chromatography.

7.2.3 Microbiological Sampling Protocol

Samples will be obtained using a flow-through cell equipped with a septa for withdrawing samples that have not been exposed to the atmosphere. A 15-mL sample will be withdrawn from the cell and dispensed into sterile pre-purged test tubes sealed with hungate septa. Six samples from each sampling location will be collected. Samples will be placed in a cooler on ice and transported to the 324 Building. Three samples will be used for analysis of denitrifiers

and sulfate reducers, using the most-probable-number technique. Three samples will be packaged for overnight shipment to Washington State University, Pullman, Washington, for analysis of coliforms using the membrane filter technique.

8.0 DISPOSAL OF DRILL CUTTINGS AND PURGE WATER

Drill cuttings derived from the drilling operations will be disposed of per EII 4.3, Control of CERCLA and Other Past-Practice Investigation Derived Waste (WHC 1988). Management of drill cuttings will be different for sediments retrieved from the saturated zone than those retrieved from the unsaturated zone. All cuttings retrieved from the saturated zone will be contained in barrels, sealed, and the barrels marked. The disposal method for saturated zone sediments will be based on the results of VOC analyses. Samples for sediment VOC concentration will be collected every 5 ft during drilling. Sediments with a concentration of any organic constituent of <1 ppm will be disposed of at the drill site. Those sediments with higher concentrations will be disposed of at a regulated facility.

Sediments from the unsaturated zone will be stored at the surface on a plastic sheet. These sediments will be monitored daily for radiologic and VOC content using field screening instruments. If contamination is detected, samples will be contained in barrels and samples taken for laboratory analysis. Disposal will be determined based on the results of the analyses. Samples that are found to be free of contamination with field instruments will be disposed of onsite. Waste handling practices will conform to EII 4.3, Rev. 2 (WHC 1988).

All ground water purged from wells at the site must be contained and disposed of properly, as required by *Strategy for Handling and Disposal of Purgewater at the Hanford Site* (WHC 1990). This necessitates use of tanker trucks to transport the purge water to an approved disposal facility (e.g., the modutanks near 200 East Area). A temporary holding tank will be used at the wellsite to handle purge water before it is transported.

Performance of the multi-well tracer test, which requires extraction to the surface followed by reinjection to an adjacent well, will be an exception to the purge water management strategy. This exception will be requested from the U.S. Environmental Protection Agency and the Washington Department of Ecology, and permission to proceed with aboveground recirculation will be upon review by these agencies.

Hydrologic testing will require purging of large volumes of ground water. Table 8-1 provides a summary of the estimated volumes of water that is expected be withdrawn from the unconfined aquifer for each type of hydrologic test.

Table 8-1. Summary of Estimated Purge Water Volumes for Each Type Hydrologic Test.

Type of Hydrologic Test	Estimated Volume Purged	
	Gal	L
Well Development	4,000	5,000
Step Drawdown	6,000	23,000
Constant-Rate	20,000	76,000
Tracer	20,000	76,000

9.0 DOCUMENTATION OF WORK

Geologic and drilling data will be recorded daily on geologist's log forms. Sample collection and measurement data will be recorded on geologist's log forms or field logbooks, and appropriate specific forms (e.g., chain-of-custody forms and aquifer test data sheets) as indicated previously in the specific sections. A laboratory record book will be used to document all field sampling activities. Field data pertaining to the hydrologic tests (e.g., flow rate, time pump turned on, etc.) will be recorded on "aquifer test data sheets" per PNL procedure (PNL 1986, AT-5, Rev. 1). All automatically recorded data will be stored on disks. All other data not specific to hydrologic testing, such as tracer concentration, field chemistry analysis, will be recorded on standard log sheets or field notebooks. Calibration and/or verification of all measurement and test equipment used for this work will be documented.

10.0 DELIVERABLES/MILESTONES

The deliverable product of this work plan will be the results of the geologic, hydrologic, and hydrochemical analyses. The results will summarize the field activities performed, the data that were collected, the analysis methods used, and data analysis. Geological and geophysical logs will be included to support the results. The product will be delivered as a draft summary PNL report approximately 3 mo after the last field activity has been completed.

11.0 SAFETY AND SECURITY

WHC will have oversight regarding safety and security at the field test site as field drilling, sampling, and testing activities are in progress. Safety and security practices on the job will comply with guidelines established in PNL's health and safety plan and with the project health and safety plan documented by WHC (Rohay et al. 1993, Appendix B, Rev. 2). All personnel shall have had the required training necessary prior to stepping into the field area and performing field work. Each staff member will be responsible for their actions regarding safety at the field site. Only those authorized to run the field equipment will be allowed to do so.

The wellheads will be covered when the site is not occupied during or between the hydrologic field tests. All field equipment will be secured during off-normal hours and may need to be locked up for safe keeping.

Safety-related hazards associated specifically with preparation and performance of the hydrologic tests include tripping over cables and lines, pressurization of nitrogen bottles used to inflate the packer system, electrical hazards associated with the generator and pump mechanism, and climbing the ladder on the purge water tanks to insert the discharge line. Only authorized staff will be allowed to enter the test site during testing activities.

12.0 QUALITY ASSURANCE

Quality assurance requirements as set forth in the most current version of QAPjP EES-073, which is based on PNL's quality assurance program description (PNL-MA-70, Parts 1 & 2), will apply to the quality related activities performed in support of the work described in this work plan.

Data quality objectives (DQOs) are located in the integrated test plan which will apply to the work described in this work plan.

Oversight activities will be coordinated between WHC and PNL quality assurance staff. At least one surveillance will be performed jointly during the first quarter of the work. Additional surveillances may be performed, dependent on the results of the first.

13.0 RESPONSIBILITIES

The WHC field team leader is responsible for overall management and field operations of well drilling and construction activities, including disposal of waste generated during drilling. The field team leader is also responsible for health and safety at the drilling site; however, safety is the responsibility of all staff working at the site.

PNL is responsible for sample collection, handling, transport, and analysis and for documenting well drilling and completion activities. The sampling will require coordination with the field team leader as it pertains to drilling. Baseline sampling will also be conducted by PNL. Samples will be analyzed by the appropriate laboratory, which may include PNL or DataChem. Hydrologic testing activities and data analysis will be performed by PNL with field support provided by WHC Environmental Field Services.

It is the responsibility of the PNL site coordinator and site geologist to ensure that samples are taken according to procedures outlined in this work plan and at the intervals specified herein. It is the responsibility of the site coordinator to ensure that samples are transported and distributed according to the protocols defined herein and within the holding times identified for the appropriate sample. It is the responsibility of the Field

Sampling and Analysis Group staff to ensure that samples are distributed to the correct offsite laboratory within the holding times prescribed once the samples are in their custody. It is the responsibility of the site coordinator and the sampling coordinator to ensure that samples analyzed in the Soil Physics Laboratory are completed within the required holding times and according to the correct procedure. It is the responsibility of the Field Sampling and Analysis Group staff to ensure that the results of offsite laboratory analyses are reported to the site coordinator. It is the responsibility of the site coordinator to assemble and report to the PNL task manager all data collected during the activities described herein.

During hydrologic testing activities (including well development by pumping), PNL will be responsible for coordinating all field activities and for analyzing the test data. Coordination of field activities includes scheduling field support, preparing of measuring and recording equipment, and performing the tests. It is expected that the WHC Environmental Field Services will provide support for preparing and installing packers, pumps, tubing strings, and wellhead assemblies. A generator will be needed to power the pumps. Support will also be needed for setting packers during baseline sampling.

14.0 REFERENCES

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