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Description of Work (DOW) for Two DNAPL Investigation Wells at the 216-Z-9 Trench

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1.0 INTRODUCTION

This description of work (DOW) is applicable to the drilling, construction, and associated sediment/groundwater sampling of two wells to support the dense non-aqueous phase liquid (DNAPL) investigation at the 200-ZP-1 Operable Unit. The two wells will consist of one injection and one extraction well. The wells are being installed for use in a partitioning interwell tracer test to be performed in the area of the 216-Z-9 Trench in fiscal year (FY) 1996. The need for conducting the tracer test and the choice of location are described in *Engineering Evaluation/Conceptual Plan for the 200-ZP-1 Operable Unit Interim Remedial Measure* (BHI 1994a), *200-ZP-1 Dense Non-Aqueous Phase Liquids Investigation Plan* (BHI 1995a), and *200-ZP-1 Dense Non-Aqueous Phase Liquids Investigation Alternatives Assessment* (BHI 1995b). The DNAPL investigation will support design of the 200-ZP-1 Interim Remedial Measure (IRM) as described in *Interim Remedial Measure Proposed Plan for the 200-ZP-1 Operable Unit, Hanford Site, Washington* (DOE-RL 1994b).

The drilling of these wells and associated testing comprise portions of Phases I and III of the DNAPL investigation. The three phases of the DNAPL investigation are described in BHI (1995a) and can be generally described as follows.

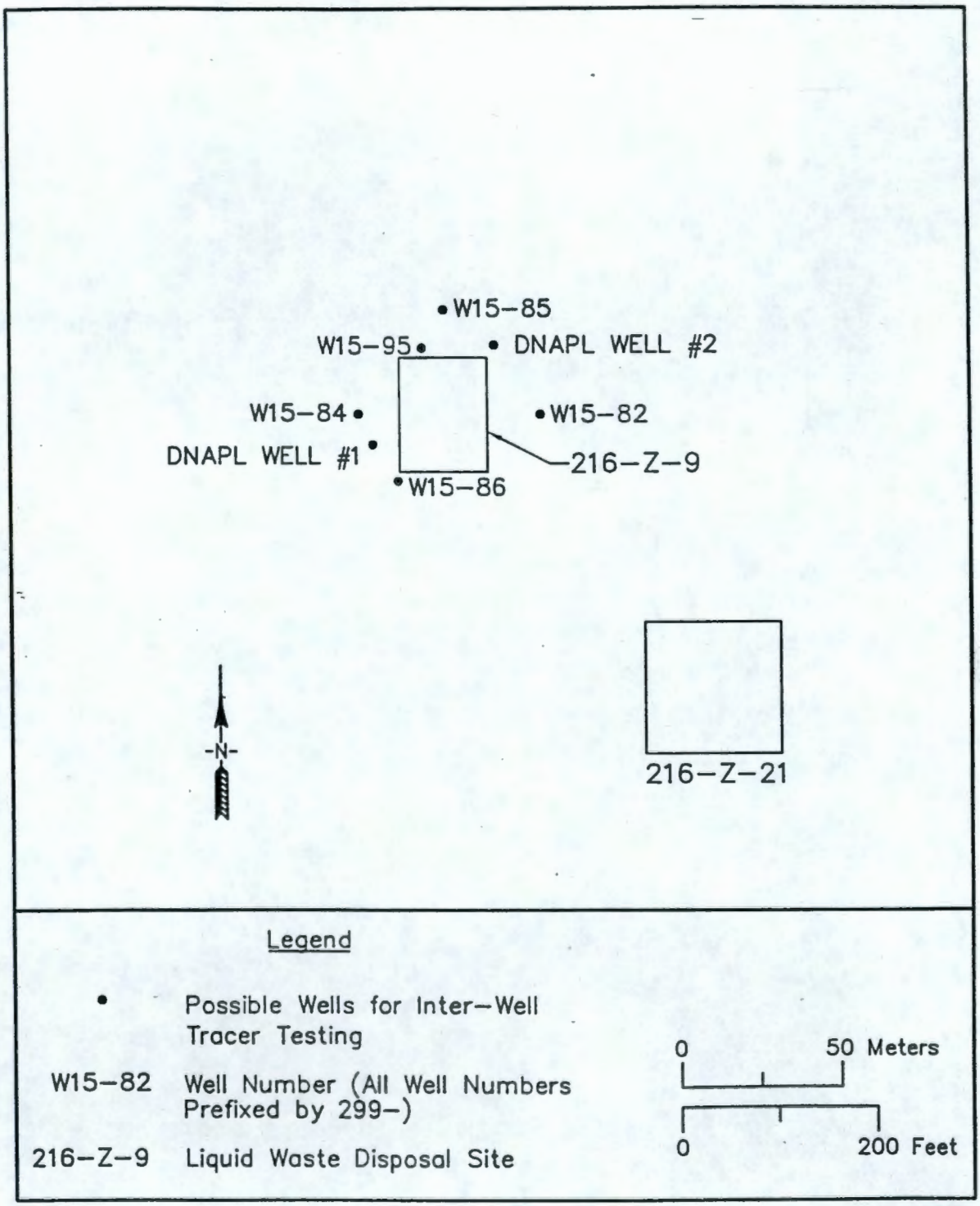
- Phase I will consist of constructing one well, preparing and characterizing the test site, performing laboratory tests to identify tracers, and modeling the tracer test.
- Phase II will consist of evaluating information gained from Phase I and determining if Phase III is needed and feasible. If needed and feasible, a second well will be constructed.
- Phase III will consist of constructing the second well, conducting a partitioning interwell tracer test, evaluating results, and preparing the final report.

Data quality objectives (DQOs) applicable to this task are documented in Appendix A of this document, "Data Quality Objectives for Well Construction to Support the DNAPL Investigation at the 216-Z-9 Trench."

1.1 BACKGROUND

The DNAPL investigation will be focused in the immediate vicinity of the 216-Z-9 Trench in the 200 West Area (Figure 1). The 216-Z-9 Trench operated from July 1955 to June 1962, receiving solvent and aqueous wastes from the RECUPLEX facility in the 234-5Z building. The trench received approximately 1.07 million gal of low salt, acidic, aqueous, and organic waste. It is estimated that 21,912 to 79,200 gal (291,000 to 1,051,785 lb) of carbon tetrachloride were disposed to the sediment column at this site. The waste stream also included plutonium, tributyl phosphate, dibutyl butyl phosphate, and lard oil. Discharge of this waste to the ground has resulted in extensive contamination of the vadose zone and groundwater in the 200 West Area.

Figure 1. Location Map.



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The choice of the area of the 216-Z-9 Trench for the DNAPL investigation is discussed in BHI (1995b). The 216-Z-9 Trench was selected for the DNAPL investigation for the following reasons: (1) large quantities of carbon tetrachloride were discharged to the trench and underlying sediment column, (2) pore-volume estimates indicate the DNAPL may have saturated the vadose zone and reached the groundwater, (3) sampling activities near the trench indicate a substantial carbon tetrachloride vapor phase is present near the water table, and (4) high concentrations of dissolved-phase carbon tetrachloride are present in the groundwater. Additional information regarding the 216-Z-9 Trench can be found in *Z Plant Source Aggregate Area Management Study Report* (DOE-RL 1992a) and *200 West Groundwater Aggregate Area Management Study Report* (DOE-RL 1992b).

A partitioning interwell tracer test is planned to be conducted between two wells in the area of the 216-Z-9 Trench to determine if carbon tetrachloride is present as a DNAPL in the saturated zone (BHI 1995a). The tracer test will interrogate the upper portion of the unconfined aquifer to determine if DNAPL is present as a residual phase. The approximate location of each well is shown in Figure 1. The location of the westernmost well is tentative at this time and may change based on the results of tracer test modelling.

Originally, the tracer test was to be performed between two existing vadose zone wells (299-W18-85 and 299-W18-86) that would have been deepened for the test. An evaluation of the designs and histories indicated that deepening the existing wells would prove impractical. Therefore, construction of new groundwater monitoring wells will support the DNAPL investigation.

1.2 GENERAL SITE GEOLOGY AND HYDROLOGY

A general discussion of the geology and hydrology of the 200-ZP-1 Operable Unit area is found in *200-ZP-1 Extraction and Injection Wells Description of Work* (BHI 1994b). A generalized stratigraphic column is shown in Figure 2 depicting stratigraphic relationship expected in the vicinity of the 216-Z-9 Trench. The estimated depth to the water table is approximately 203 ft.

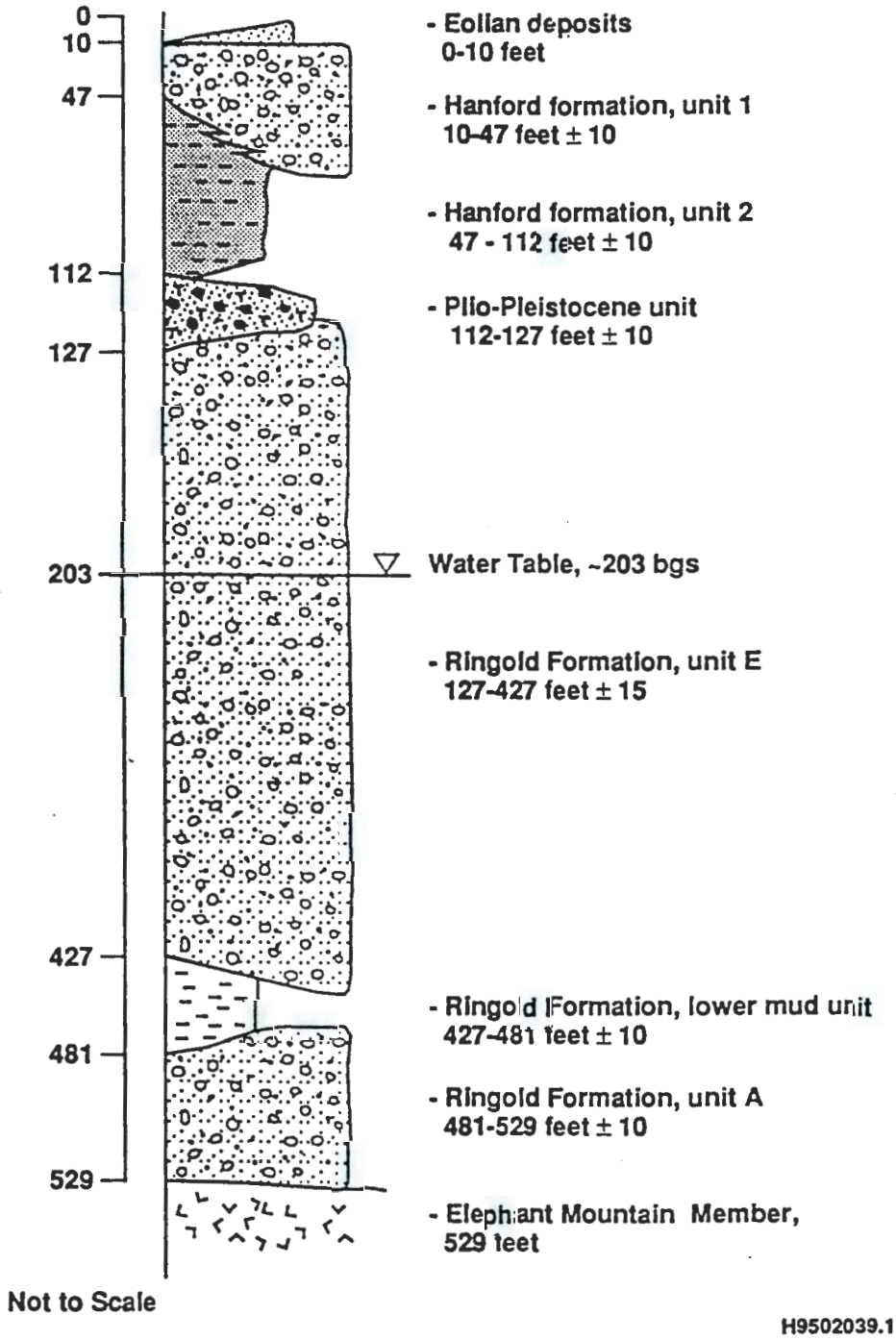
2.0 GENERAL REQUIREMENTS

2.1 HEALTH AND SAFETY

All personnel working to this DOW will have completed the 40-Hour Hazardous Waste Site Worker Training Program and will perform all work in accordance with the following:

- BHI-EE-01, *Environmental Investigations Procedures* (BHI 1994c)
- BHI-EE-02, *Environmental Requirements* (BHI 1995c)
- HSRCM-1, *Hanford Site Radiological Control Manual* (BHI 1994d)
- BHI-SH-02, *Safety and Health Procedures*, Vol. 2 (BHI 1994e)
- *Quality Management Plan* (BHI 1994f)

Figure 2. Generalized Stratigraphic Column Beneath the 216-Z-9 Trench.



- BHI-QA-02, *Quality Program Procedures* (BHI 1994g)
- WHC-CM-8-7, *Operations Support Services*, Section 503.1, "Excavation Permit"
- Site-specific health and safety plan/radiation work permit/job safety analysis, waste control plan - as applicable.

2.2 TECHNICAL PROCEDURES/SPECIFICATIONS

This section identifies technical procedures and specifications applicable to sampling, drilling, and well construction in the 200-ZP-1 Operable Unit.

(1) Environmental Investigations Procedures (EIPs) (BHI 1994c)

EIP 1.5	Field Logbooks
EIP 1.6	Surveying
EIP 1.10	Groundwater Measuring and Testing Equipment Calibration
EIP 1.11	Purgewater Management
EIP 2.0	Sample Event Coordination
EIP 2.2	Sampling Documentation Processing
EIP 3.0	Chain of Custody
EIP 3.1	Sample Packaging and Shipping
EIP 4.0	Soil and Sediment Sampling
EIP 4.1	Groundwater Sampling
EIP 4.2	Sample Storage and Shipping Facility
EIP 6.0	Documentation of Well Drilling and Completion Operations
EIP 6.1	Drilling and Sampling in Radiological Contaminated Areas
EIP 6.2	Field Decontamination
EIP 6.3	Well Development
EIP 7.0	Geologic Logging
EIP 7.3	User Calibration of Groundwater Measuring and Testing Equipment
EII 4.14	Control CERCLA and Other Past Practice Investigation Derived Waste (WHC 1988)

(2) *Technical Specification for Environmental Drilling Services*, BHI-SPEC-00008 (BHI 1994h)

3.0 SAMPLING AND FIELD ACTIVITIES

Sampling and field activities associated with this DOW are described in this section.

3.1 SCREENING FOR WASTE MANAGEMENT/HEALTH AND SAFETY

Screening requirements applicable to waste management and health and safety shall be specified in a waste control plan, radiation work permit, and/or a hazardous waste operation permit.

3.2 SEDIMENT SAMPLING AND ANALYSIS

The priorities for sampling are as follows: (1) first priority are for partitioning tracer column testing analysis and total organic carbon (TOC) analysis, (2) second priority are samples for visual examination for DNAPL presence, (3) third priority are samples for physical properties testing, and (4) fourth priority are samples for geologic logging.

3.2.1 Geologic Logging

Geologic samples shall be evaluated at 5-ft intervals for geologic description and identification of stratigraphic units during drilling. Geologic logging shall be conducted according to EIP 7.0, "Geologic Logging." The geologists shall also note on the log geologic contacts, significant moisture changes, and contamination as determined with screening instrumentation. Samples shall be disposed of with other drill cutting after evaluation.

3.2.2 Sampling and Visual/Chemical Analysis of Sediments

Samples shall be collected in accordance with EIP 4.0, "Soil and Sediment Sampling," and other applicable procedures identified in Section 2.0.

Split-spoon samples shall be collected in liners continuously between 195 ft below ground surface (bgs) to total depth. The area above the water table contains the capillary fringe and is a critical sampling point. Samples collected above the water table that do not represent the capillary fringe may be discarded at the discretion of the geologist. Samples shall be collected with a split spoon equipped with liners to total depth after the water table is intersected. Samples will be analyzed using visual methods as described in Appendix B of this document, "Visual Sample Analysis Methods to Support the DNAPL Investigation at the 216-Z-9 Trench." Samples in liners collected during the investigation shall be sealed immediately to prevent volatilization of DNAPL/volatile organics and provided to personnel onsite to perform the visual analyses. Following visual analysis, the samples will be photographed to provide detailed information to be used in modelling the tracer test.

An option to core drill from 195 ft bgs to total depth may be attempted in this investigation. The decision to core shall be made by the project manager before the start of drilling. The sampling strategy would be the same as described in the paragraph above. The core barrel would be equipped with clear plastic liner tubes. The core barrels and associated sampling equipment shall be decontaminated according to the applicable EIP described in Section 2.0. Coring shall be conducted continuously from 195 ft to total depth using 5-ft runs. The clear plastic liner tubes shall be sealed immediately to prevent volatilization of DNAPL. If coring is not required by the project manager, drilling would proceed as noted in the preceding paragraph. Visual analysis methods would be used as described in the preceding paragraph.

In addition, at the discretion of the well site geologist, as many as six soil samples may be collected during drilling through the vadose zone.

3.2.2.1 Physical Properties Analysis. Physical properties testing will be conducted on samples collected below 195 ft bgs. Samples will be collected at 5-ft intervals to total depth and at significant lithologic changes. It is anticipated that approximately 10 samples per borehole will be submitted for physical properties testing. Physical properties to be determined include the following:

- Particle-size distribution (sieve/hydrometer analysis)
- Specific gravity
- Dry bulk density and porosity
- Saturated hydraulic conductivity (permeameter)
- Weight-percent $CaCO_3$.

General sampling and analysis requirements are provided in Table 1.

3.2.2.2 Partitioning Tracer Column Testing Analysis. Soil samples will be collected to perform partitioning tracer column tests in the laboratory. Samples will be collected at 20-ft intervals beginning at the water table and at significant lithologic changes. It is anticipated that approximately four samples will be collected from the first borehole to support laboratory column testing activities. Minimum quantity per sample is 1 kg. General sampling and analysis requirements are provided in Table 1.

3.2.2.3 Total Organic Carbon Analysis. Soil samples will be collected to perform TOC analysis. Sample intervals for TOC analysis will be collected from the same intervals sampled to support partitioning tracer column testing analysis. It is anticipated that approximately four samples will be collected from the first borehole. Minimum quantity per sample is 20 g. General sampling and analysis requirements are provided in Table 1.

3.3 GROUNDWATER SAMPLING AND ANALYSIS

During development of the well, one or more groundwater samples and splits will be collected. These samples will be analyzed using the visual methods described in Appendix B of this document, "Visual Sample Analysis Methods to Support the DNAPL Investigation at the 216-Z-9 Trench."

After construction and development, each well shall be sampled to establish the baseline concentrations of major contaminants (carbon tetrachloride, chloroform, trichloroethylene), gross alpha, and gross beta in the groundwater. Samples will be collected and handled using the protocols defined in EIP 4.1, "Groundwater Sampling," and other applicable procedures identified in Section 2.1, (e.g., EIP 3.0, "Chain of Custody"). The concentration of major contaminants (carbon tetrachloride, chloroform, trichloroethylene) gross alpha, and gross beta will be determined by offsite analysis (Level III). Quality control samples, specified in Section 4.0, will be collected and shipped offsite for analysis using Level III methodologies (as applicable). Holding times, bottle, and preservation requirements are identified in Table 2.

3.4 SAMPLING SUMMARY

A summary of sample collection requirements for each analysis described in Section 3.0 is shown in Table 3.

Table 1. General Requirements for Geologic Sediment Sampling and Analysis.

Analysis	Container	Quantity	Preservation	Holding Time	Method
Physical Properties					
Particle size distribution, specific gravity, dry bulk density and porosity, saturated hydraulic conductivity	Soil in sealed lexan liner	Full lexan liner	None	1 year	ASTM D422-63, D854-83, and D2434-68, respectively
Weight-percent $CaCO_3$	Soil core in sealed lexan liner	3 kg	None	1 year	Approved laboratory procedure
Partitioning Tracer Laboratory Column Testing Analysis					
Partitioning coefficients for tracer compounds	Soil core in sealed lexan liner or mason jar	1 kg	None	Not applicable	Approved laboratory procedures
Total Organic Carbon Analysis					
Total organic carbon	40-mL amber jar	20 g	Refrigeration	28 days	EPA SW-846 procedure 9060 or approved field screening procedure if available

Table 2. Holding Time and Bottle Requirements for Groundwater Samples.

Analyte	Method	Holding time	Bottle/volume
Carbon tetrachloride Chloroform TCE	SW-846, 8240, or 8260	14 days	Gs 3X40 mL, HCl to pH <2 cool 4°
Gross alpha Gross beta	EPA 900 or lab specific	6 months	P/G 1,200 mL, HNO_3 to pH <2
Total activity	lab specific	6 months	P/G 20 mL

G = glass; Gs = glass w/septum cap - zero headspace; P = plastic.

Table 3. Sampling Summary.

Depth (ft)	Geologic Sampling	Physical Analysis	Chemical Analysis of Sediments	Chemical Analysis of Groundwater
0 to 195	Continuously for geologic description	Not required	Not required (up to six samples may be collected at the discretion of the wellsite geologist.)	Not required
195 to Total Depth	Continuously for geologic description	At 5-ft intervals to total depth	Split-spoon or core samples will be collected every 5 ft (Maximum of 8) for visual evaluation as described in Appendix B. Samples will also be collected for column testing and TOC analysis on samples collected at 20 ft intervals and at significant lithologic changes.	One at completion of well development. One or more during development for visual examination described in Appendix B.

3.5 DRILLING AND WELL CONSTRUCTION

Drilling and well construction shall be conducted in accordance with the *Technical Specification for Environmental Drilling Services* (BHI-SPEC-00008) and specific technical requirements in this report. The specification outlines basic requirements for drilling operation and well completion that are consistent with Chapter 173-160, *Washington Administrative Code*, "Minimum Standards for Construction and Maintenance of Wells."

3.5.1 Well Drilling

A number of drilling methods are available to extend boreholes in the subsurface. A percussion-type drilling method that is fast, cost-effective, and capable of meeting sampling, drilling, and contamination control concerns will likely be used to advance DNAPL wells in the subsurface. Other types of drill rigs may also be used provided contamination can be controlled, representative samples can be collected, and borehole disturbance can be minimized. A split-spoon sampler shall be used to collect sediment samples for analysis. The split-spoon sampler and associated sampling equipment shall be decontaminated according to the applicable EIP described in Section 2.0.

After the water table is intersected, the option to core across the screen interval may be available. The decision to core shall be made by the project manager before the start of drilling. Coring, if required, will be conducted according to the technical specification (BHI-SPEC-00008). In summary, this requires 5-3/4- x 4-in. conventional coring equipment with double tube, ball bearing, swivel-type core barrels. The core barrel shall be equipped with clear plastic liner tubes. The core barrels and associated sampling equipment shall be decontaminated according to the applicable EIP described in

Section 2.0. Coring shall be conducted continuously from the water table to total depth using 5-ft runs. If coring is not required by the project manager drilling shall proceed as noted in Section 3.3.1, paragraph 1.

The following describes minimum casing requirements for construction of the first well:

- Conductor casing to 12 ft - optional
- First casing string - 16-in. inside diameter (ID) to 50+-10 ft (Hanford, unit 1)
- Second casing string - 12-in. ID to 115+-10 ft (Plio-Pleistocene unit)
- Final casing string - *10-in. ID to total depth.

*If coring is used during this investigation, reaming will be necessary to comply with minimum well construction requirements.

The following describes minimum casing requirements for construction of the second well:

- Conductor casing to 12 ft - optional
- First casing string - 12-in. inside diameter (ID) to 50+-10 ft (Hanford, unit 1).
- Second casing string - 10-in. ID to 115+-10 ft (Plio-Pleistocene unit)
- Final casing string - *8-in. ID to total depth.

*If coring is used during this investigation, reaming will be necessary to comply with minimum well construction requirements.

3.5.2 Well Construction

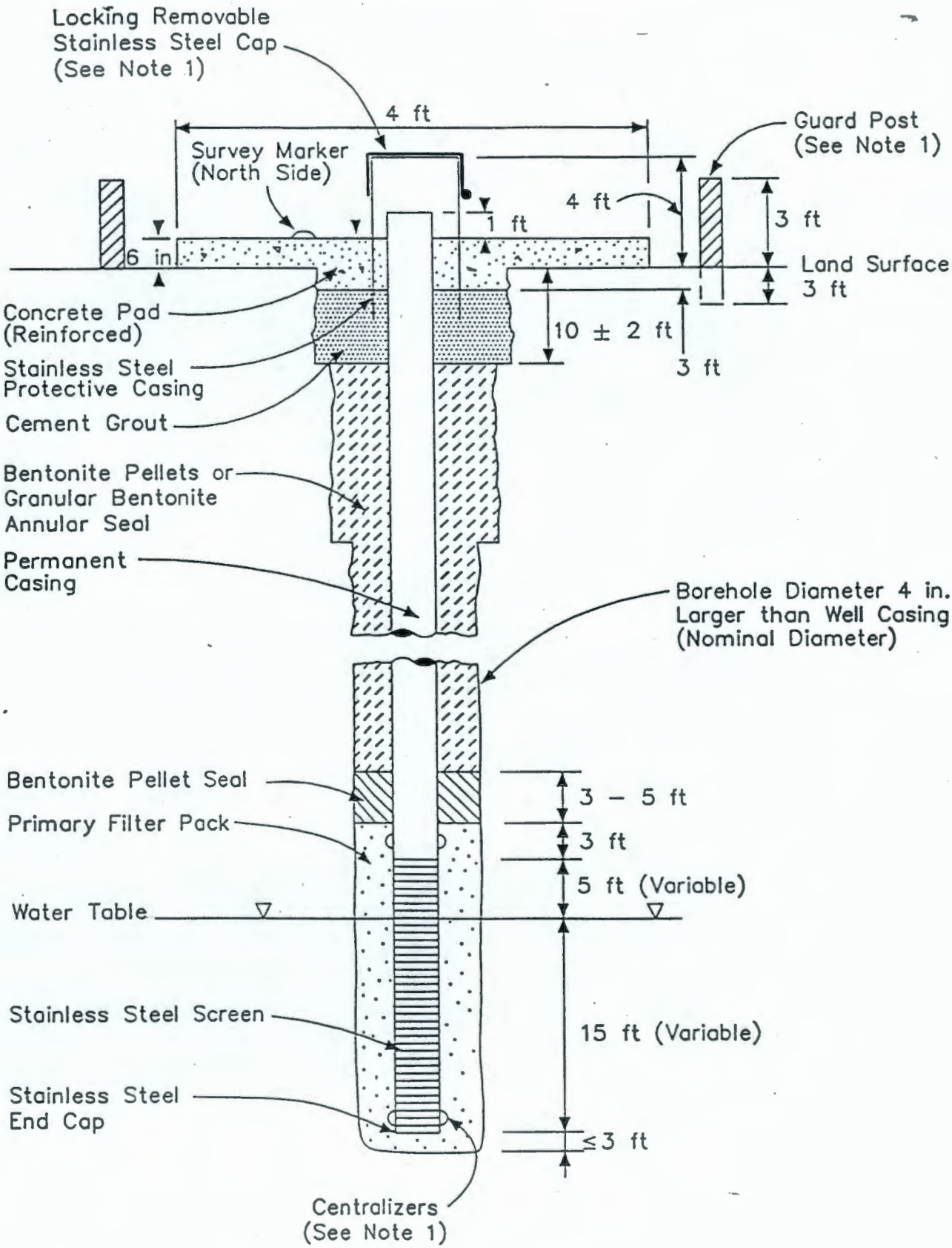
The DNAPL study wells described in this DOW will be completed in the unconfined aquifer, screened approximately 40 ft into the saturated zone. The extended screen section is necessary because of the current rate of decline of the water table as precipitated by the overall reduction in effluent discharge in the 200 West Area. At the current rate of decline (0.3 m/year [1 ft/year]) the wells may provide access to the water table in excess of 25 years. The design of the wells shall be shallow, as currently outlined in the *Technical Specification for Environmental Drilling Services* (BHI-SPEC-00008) and will be 4- and 6-in. completions. A generic design of a shallow well is shown in Figure 3. The subject wells shall be developed after completion.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Data quality is controlled by this DOW and the Quality Assurance Project Plan (QAPjP) presented in *200-ZP-1 Groundwater Sampling and Analysis/Project Quality Assurance Plan*, Appendix A (BHI 1994i). The quality assurance (QA) document that covers the test activities is the *Quality Management Plan* (BHI 1994). Quality control/verification samples for Level III analyses should be collected at the following frequency.

- One trip blank shall be collected to accompany each shipment of groundwater samples/sample bottles to the laboratory.

Figure 3. Generic Design of a Shallow Well



- One equipment blank shall be collected for every 20 groundwater/sediment samples submitted to the laboratory or per sampling episode.
- One duplicate sample shall be collected for every 20 groundwater/sediment samples submitted to the laboratory or per sampling episode.
- One split sample shall be collected for every 20 groundwater/sediment samples submitted to the laboratory or per sampling episode.

5.0 SCHEDULE

The schedule for activities described in this DOW is shown in Figure 4.

6.0 REFERENCES

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BHI, 1994i, *200-ZP-1 Groundwater Sampling and Analysis/Project Quality Assurance Plan*, Appendix A, BHI-00038, Rev. 00, Bechtel Hanford, Inc., Richland, Washington.

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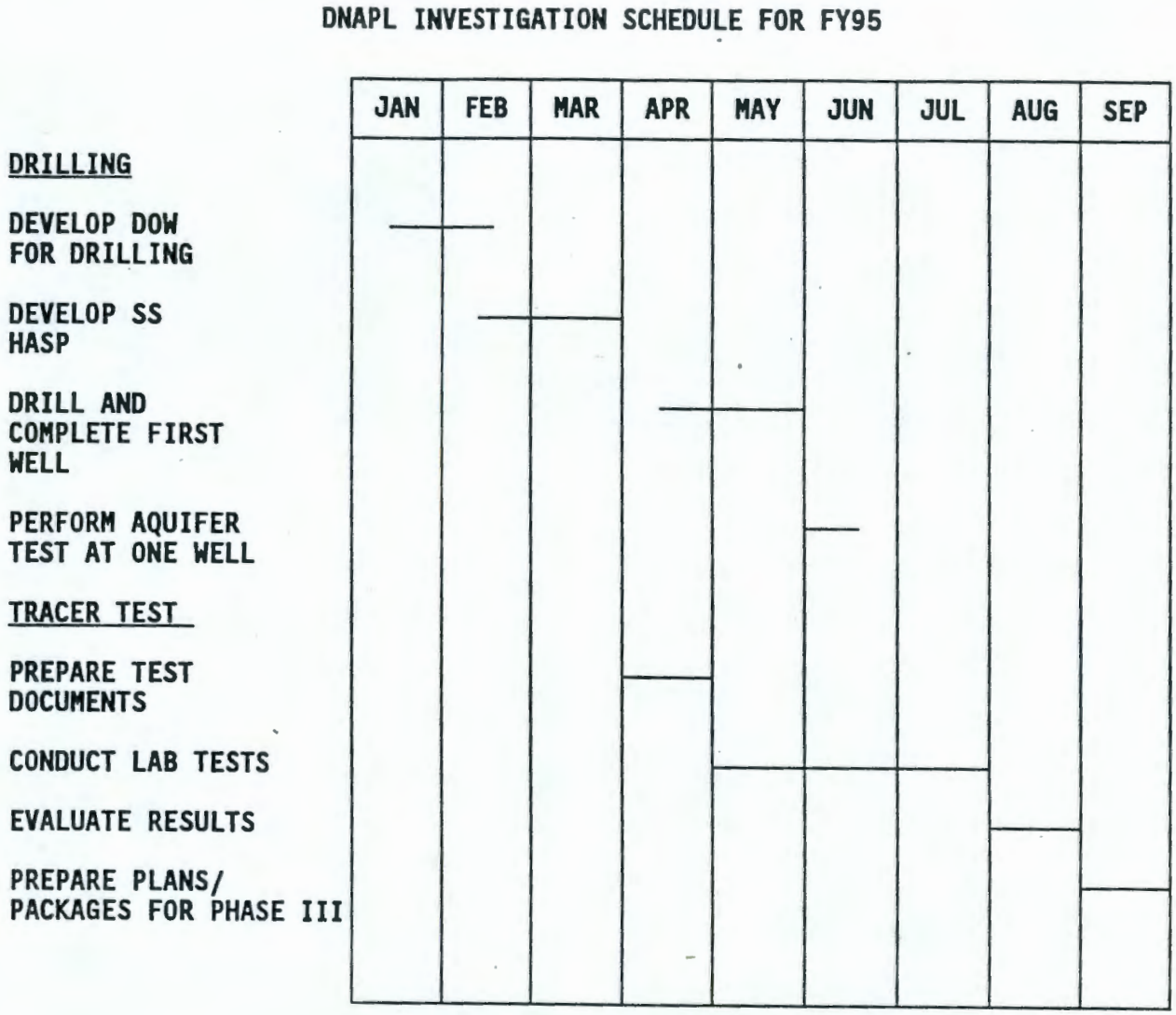
Figure 4. Schedule of Activities.



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WHC, 1988, *Environmental Investigations Instructions*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

DATA QUALITY OBJECTIVES FOR WELL CONSTRUCTION TO SUPPORT THE DNAPL INVESTIGATION AT THE 216-Z-9 TRENCH

1.0 INTRODUCTION

The following describes the Data Quality Objectives (DQO) process as applied to the construction of two wells described in this DOW. The DQO process is the seven-step process identified in *Guidance for the Data Quality Objectives Process* (EPA 1994). The two wells will support an investigation of the presence of dense, non-aqueous phase liquids (DNAPL) beneath the 216-Z-9 Trench. The overall plan for the DNAPL investigation is provided in *200-ZP-1 Dense, Nonaqueous Phase Liquid Investigation Plan* (BHI 1995).

2.0 THE SEVEN-STEP DQO PROCESS

The following addresses each of the seven steps of the DQO process (EPA 1994).

2.1 STEP 1: State the Problem.

A partitioning interwell tracer test is to be conducted to determine if DNAPL is present in the area of the 216-Z-9 Trench (BHI 1995). In preparation for this tracer test, two wells will be constructed near the trench. The drilling of the two wells will provide an opportunity to obtain information concerning DNAPL presence independent of the actual tracer test. In addition, data will be gathered during this activity to support the modelling of the tracer test. The data collected to support the modelling of the tracer test will not in itself be used to make a decision, but will support a modelling effort that will help design the tracer test.

The information to be gained from the sampling and analysis associated with construction of these two wells concerns the presence of DNAPL in the saturated zone. The specific problem to be addressed is: Is DNAPL present in the saturated zone at either of the two wells.

The planning team/decision makers are the Environmental Restoration Contractor (ERC), DOE, EPA, and Ecology.

2.2 STEP 2: Identify the Decision:

The activities identified in this DOW (i.e., construction of two wells and associated testing) constitute a portions of Phases I and III of the DNAPL investigation. The three phases of the DNAPL investigation are described in detail in BHI (1995) and can be generally described as follows:

- Phase I will consist of preparing the test site, constructing one of the two wells needed for the test, gathering hydrologic data, performing laboratory tests to identify tracers, and modeling the tracer test.

- Phase II will consist of evaluating information gained from Phase I, and determining if Phase III is needed and feasible.

- Phase III will consist of constructing the second well needed for the test, conducting a partitioning interwell tracer test, evaluating results, and preparing a final report.

The principal question to be answered by the DNAPL investigation is: "Is DNAPL present in the saturated zone at the 200-ZP-1 Operable Unit?" If it is determined during the activities described in this DOW (i.e., during Phase I activities) that DNAPL is present, the principle question of the DNAPL investigation will have been answered. It would not be necessary to perform additional phases of the DNAPL investigation to answer that question.

Therefore, the alternative actions which may result from completing Phase I are (1) continue the DNAPL investigation as planned and (2) discontinue the DNAPL investigation.

Decision statement: Should the DNAPL investigation be continued as planned.

2.3 STEP 3: Identify the Inputs to the Decision.

The information that will be required to resolve the decision statement will be supplied from the activities described in this DOW. Field methods will be used to identify DNAPL if present. If DNAPL is detected and a sample of the DNAPL can be obtained, a laboratory analysis will be performed to confirm its presence.

The action level for this investigation is direct detection of DNAPL and laboratory confirmation. This will indicate that DNAPL is present beneath the 216-Z-9 Trench, and that the primary objective of the DNAPL investigation has been achieved.

Visual methods for detection of DNAPL are available to be performed in the field (see Appendix B). If DNAPL is detected and a sample can be obtained for laboratory analysis, methods are available for confirming the presence of the DNAPL.

2.4 STEP 4: Define the Study Boundaries.

Soil and groundwater samples from the construction of the two wells will be analyzed. Samples will be collected from the capillary fringe to approximately 40 ft below the water table in each well. This testing will investigate the upper portion of the unconfined aquifer beneath the 216-Z-9 Trench for the presence of residual-phase DNAPL.

Practical constraints on data collection activities are as follows.

- Funds available for this activity are limited. Data-gathering activities described here for detecting DNAPL are of a secondary nature for the DNAPL investigation. The main data gathering activity of the DNAPL investigation for detecting DNAPL will be the partitioning interwell tracer test. (However, if DNAPL presence is confirmed during this testing, the partitioning interwell tracer test will not be performed.)

- Obtaining a representative soil sample may be difficult due to the drilling methods used. Although efforts will be made to obtain representative samples, budget constraints will partially dictate the drilling method used.

- It is expected that DNAPL, if present, will be clear and colorless making visual detection difficult. Also, it is expected that the DNAPL, if present, will be heterogeneously distributed and thus difficult to locate.

- Identification of DNAPL may be difficult due to the silty nature of the samples. The samples may be too muddy to visually identify DNAPL if present.

- The organic compounds of concern are volatile and may evaporate rapidly.

- Although the entry point of the DNAPL is known (i.e., the 216-Z-9 Trench), the route followed as the DNAPL passed through the vadose zone is not known. The location of any DNAPL that reached the saturated zone cannot be accurately determined. The DNAPL investigation is targeting the most likely location for DNAPL, but it is possible that DNAPL migrated to a portion of the aquifer other than the portion being targeted by the DNAPL investigation.

2.5 STEP 5: Develop a Decision Rule

The action level is detection of DNAPL in the saturated zone with laboratory confirmation. If DNAPL is detected and confirmed, the remainder of the DNAPL investigation will be canceled.

If DNAPL is detected and confirmed during the construction of the first well, the first well will be completed as a monitoring well and plans for the second well will be canceled.

If DNAPL is detected and confirmed during the construction of the second well, the well will be completed as a monitoring well.

2.6 STEP 6: Specify Limits of Decision Errors.

The following decision errors are possible:

1. DNAPL is present in the area of the two wells and is not detected. The probability of this occurring is considered moderate. If DNAPL is present and is not detected, the partitioning interwell tracer test will be conducted as planned to assess the presence of DNAPL. There would be no increased risk to human beings in the short term.

2. DNAPL is not present in the area of the two wells and is identified from the visual sample analysis. Probability of this happening are considered low. Before making a decision to modify the test design, the visual identification will be confirmed via laboratory analysis.

2.7 STEP 7: Optimize Design

The design of the data gathering activities has been optimized by:

- Limiting the test to the number of wells adequate for the tracer test.
- Combining conventional detection methods (visual inspection, head space analysis) with more innovative methods (hydrophobic dyes, centrifugation) increases the likelihood of identifying DNAPL should it be present.
- Designing the test to detect residual-phase DNAPL rather than free-phase DNAPL. Actually finding pooled free-phase DNAPL would be even less likely than locating residual phase DNAPL, and would necessitate the drilling of deeper wells to encounter the lower mud unit which would be the likely confining layer.
- Conducting data-gathering activities to support modelling of the tracer test as the wells are constructed.

3.0 SUMMARY OF DATA QUALITY OBJECTIVES

The DQOs are summarized on Tables 1, 2, and 3 of this appendix.

Table 1. Data Quality Objectives for Sediment Sampling and Analysis for DNAPL Presence.

Activity: Sediment Sampling and Analysis
Objectives: Determine if carbon tetrachloride is present as a dense non-aqueous phase liquid (DNAPL) in the saturated zone.
Prioritized Data Uses: Supports design of the Partitioning Interwell Tracer Test to be conducted at these wells.
Parameters to be Obtained: Presence of DNAPL.
Appropriate Analytical Level or Implementation Guidelines: Field screening methods (Analytical levels I and II) will be used to determine the presence of DNAPL. If DNAPL is located and a sample can be obtained, a laboratory analysis will be used to confirm that DNAPL is present (Analytical level III).
Critical Samples or Values: Samples will be collected from the capillary fringe (also known as the tension-saturated zone) and the saturated zone. Critical samples will be from the capillary fringe where DNAPL may pool slightly as it enters the saturated zone.
Constraints: • Analytical methods for detection of DNAPL are not well developed at this time. • It is expected that the DNAPL, if present, will be clear and colorless making visual detection very difficult. • In addition, it is expected that the DNAPL, if present, will be heterogeneously distributed which may make locating DNAPL in the samples difficult. • Identification of DNAPL may be difficult due to the silty nature of the samples. The samples may be too muddy to visually identify DNAPL if present. • A large enough volume of DNAPL may not be obtainable from a sediment sample to analyze. • The organic compounds of concern are volatile and may evaporate rapidly. • Although the entry point of the DNAPL is known (i.e., the 216-Z-9 Trench), the route followed as the DNAPL passed through the vadose zone is not known. The location of any DNAPL which reached the saturated zone can not be accurately determined. The DNAPL investigation is targeting the most likely location for DNAPL, but it is possible that DNAPL migrated to a portion of the aquifer other than the portion being targeted by the DNAPL investigation.

Table 2. Data Quality Objectives for Groundwater Sampling and Analysis for DNAPL Presence.

Activity: Groundwater sampling and analysis for DNAPL presence
Objectives: Identify DNAPL that might be present in the groundwater during well development.
Prioritized Data Uses: Identify DNAPL if present.
Parameters to be Obtained: Presence of DNAPL.
Appropriate Analytical Level or Implementation Guidelines: Visual methods for groundwater identified in Appendix B of this document will be used to determine if DNAPL is present (Analytical Levels I and II). If DNAPL is located and a sample can be obtained, a laboratory analysis will be used to confirm that DNAPL is present (Analytical Level III).
Critical Samples or Values: For DNAPL presence, samples are to be collected during early well development.
Constraints: • Groundwater sampling must be performed per EII 5.8, "Groundwater Sampling" (BHI 1994). • Analytical methods for detection of DNAPL are not well developed at this time. • It is expected that the DNAPL, if present, will be clear and colorless making visual detection very difficult. • Identification of DNAPL may be difficult due to the silty nature of the samples. • A large enough volume of DNAPL may not be obtainable to analyze. • The organic compounds of concern are volatile and may evaporate rapidly. • Although the entry point of the DNAPL is known (i.e., the 216-Z-9 Trench), the route followed as the DNAPL passed through the vadose zone is not known. The location of any DNAPL which reached the saturated zone can not be accurately determined. Therefore DNAPL investigation is targeting the most likely location for DNAPL, but it is possible that DNAPL migrated to a portion of the aquifer other than the portion being targeted by the DNAPL investigation.

Table 3. Data Quality Objectives for Baselining Groundwater Sampling and Analysis.

Activity: Groundwater sampling and analysis for baselining VOC concentrations.
Objectives: Determine carbon tetrachloride concentrations in water from the saturated zone.
Prioritized Data Uses: Baselines carbon tetrachloride concentrations in groundwater.
Parameters to be Obtained: Concentrations of carbon tetrachloride, trichloroethylene, and chloroform in groundwater.
Appropriate Analytical Level or Implementation Guidelines: A single groundwater sample will be taken from each well for laboratory analysis to provide a baseline concentration at the well (Analytical Level III).
Critical Samples or Values: Samples are to be collected after completion and development of the monitoring wells.
Constraints: • Groundwater sampling must be performed per EII 5.8, "Groundwater Sampling" (BHI 1994). • The organic compounds of concern are volatile and may evaporate rapidly.

Table 4. Data Quality Objectives for Sediment Analysis.

Activity: Collect sediment samples during well drilling and analyze samples for physical and chemical and physical properties.
Objectives: Sediment analysis will provide physical property and chemical data to support modelling of the partitioning interwell tracer test.
Prioritized Data Uses: Support modelling of the partitioning interwell tracer test.
Parameters to be Obtained: Particle-size distribution (sieve/hydrometer analysis), specific gravity, dry bulk density and porosity, saturated hydraulic conductivity (permeameter), weight-percent $CaCO_3$, total organic carbon.
Appropriate Analytical Level or Implementation Guidelines: The analytical methods to be used are specified in Table 1 of the Description of Work for this activity.
Critical Samples or Values: Samples for total organic carbon are critical samples and will be collected at 20-ft intervals to total depth, and at significant lithologic changes to correspond to samples taken for column testing. Samples for particle-size distribution, specific gravity, dry bulk density and porosity, saturated hydraulic conductivity (permeameter), and weight-percent $CaCO_3$ will be collected at five intervals to total depth and at significant lithologic changes.
Constraints: None.

4.0 REFERENCES

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APPENDIX B

VISUAL SAMPLE ANALYSIS METHODS TO SUPPORT THE DNAPL INVESTIGATION AT THE 216-Z-9 TRENCH

1.0 PURPOSE

This appendix describes the methods to be used to evaluate soil and groundwater samples for DNAPL presence.

2.0 TEST METHODS

The methods described here are slightly modified from those discussed in "Evaluation of Visual Methods to Detect NAPL in Soil and Water" (Cohen et al. 1992), and in *DNAPL Site Evaluation* (Cohen and Mercer 1993). The order of testing described here, and some of the methods themselves, will likely require further modification during the implementation of this DOW. The order as presented in this DOW is based upon the testing described in Cohen, et al. (1992), and Cohen and Mercer (1993). Because that testing was designed to evaluate the applicability of the methods, rather than to specifically detect DNAPL, the application of the methods as described may not prove optimal. In addition, because these methods have not been tested with samples from the Ringold Formation, it is not known how well they will perform.

The performance and results of testing will be recorded in a Field Logbook per *Environmental Investigations Procedures* (BHI 1994), EIP 1.5, "Field Logbooks." Any modifications to these methods will be recorded in a Field Logbook.

2.1 SEDIMENT SAMPLE ANALYSES

The following describes the analysis methods which will be applied to sediment samples. Samples will be taken from split-spoon or core samples obtained from the capillary fringe and the saturated zone as described in this DOW.

2.1.1 Organic Vapor Analysis

Sediment samples will be examined for organic vapor concentrations using a gas chromatograph. This test will be performed using *Field Screening Procedures* (BHI 1995a), "Analysis of Volatile Organic Compounds in Soil." This will provide a confirmatory analysis of VOC presence to supplement information gained from the visual methods discussed in the following sections.

2.1.2 Unaided Visual Examination

Samples of likely intervals will be taken from core or split-spoon samples and placed in clear plastic sample bags. The sample bags will be manipulated to attempt to identify any DNAPL that may be

present. Although unaided visual examination is generally not very effective with clear and colorless DNAPL such as carbon tetrachloride (Cohen et al. 1992), it may be effective in this case due to the presence of other contaminants (e.g., tributyl phosphate, dibutyl butyl phosphate, and lard oil).

2.1.3 UV-Fluorescence

The sample filled bags will then be examined under a UV light. This is intended to detect any DNAPL that is UV fluorescent. Although carbon tetrachloride by itself does not fluoresce (Cohen et al. 1992), a DNAPL mixture that contains other fluorescing contaminants will fluoresce.

2.1.4 Soil-Water Shake Test

Following the UV-fluorescence testing, approximately 20 cm^3 of sample will be transferred to a 50-mL polypropylene centrifuge tube. Approximately 20 mL of deionized water will be added to the centrifuge tube and the tube will be shaken by hand for approximately 10 seconds to create a soil-water suspension. The contents of the tube will be examined through the tube wall to attempt to identify any DNAPL that may be present.

2.1.5 Centrifugation of Soil-Water Shake Test Suspension

The centrifuge tube will then be centrifuged at approximately 1,250 rpm for 1 minute. The contents of the tube will be examined through the tube wall to attempt to identify any DNAPL that might be present.

2.1.6 Hydrophobic Dye Soil-Water Shake Test

Approximately 2 mg of Sudan IV, Oil Red O, or other hydrophobic dye will be added to the centrifuge tube. The contents of the tube will be mixed by shaking vigorously for 10 to 30 seconds. The contents of the tube will be examined through the tube wall to attempt to identify any DNAPL that may be present.

2.1.7 Centrifugation of Hydrophobic Dye Soil-Water Shake Test Suspension

The centrifuge tube will then be centrifuged at approximately 1,250 rpm for 1 minute. The contents of the tube will be examined through the tube wall to attempt to identify any DNAPL that might be present.

2.1.8 Laboratory Analysis of DNAPL

If DNAPL is found in any of the steps described above, a sample will be obtained using a graduated syringe. The amount of DNAPL obtained with the syringe will be recorded and will be injected into a sample vile containing clean water. The sample vile will be analyzed at an offsite laboratory (analytical level III) to confirm that the material is carbon tetrachloride.

A range of expected carbon tetrachloride concentrations that would indicate DNAPL will be calculated. These calculations will take into account the effects of hydrophobic dyes if used in sample preparation. If the analysis falls into the calculated range, the presence of DNAPL will be confirmed.

2.2 GROUNDWATER SAMPLE ANALYSES

The following describes the analysis methods that will be applied to groundwater samples.

2.2.1 Organic Vapor Analysis

Groundwater samples will be examined for organic vapor concentrations using a gas chromatograph. This test will be performed using *Field Screening Procedures* (BHI 1995b), "Aqueous Headspace Analysis of Volatile Organic Compounds in Water." This will provide a confirmatory analysis of VOC presence to supplement information gained from the visual methods discussed in the following sections.

2.2.2 Centrifugation of Water

Approximately 45 mL of water will be put into a 50-mL polypropylene centrifuge tube. The centrifuge tube will then be centrifuged at approximately 1,250 rpm for 1 minute. The contents of the tube will be examined through the tube wall to attempt to identify any DNAPL that might be present.

The centrifuge tube will then be examined under a UV light. This is intended to detect any DNAPL that is UV fluorescent. Although carbon tetrachloride by itself does not fluoresce (Cohen et al. 1992), a DNAPL mixture that contains other fluorescing contaminants will fluoresce.

2.2.3 Hydrophobic Dye Water Shake Test

Approximately 2 mg of Sudan IV, Oil Red O, or other hydrophobic dye will be added to centrifuge tube. The contents of the tube will be mixed by shaking vigorously for 10 to 30 seconds. The contents of the tube will be examined through the tube wall to attempt to identify any DNAPL that may be present.

2.2.4 Centrifugation of Hydrophobic Dye Water Shake Test

The centrifuge tube will then be centrifuged at approximately 1,250 rpm for 1 minute. The contents of the tube will be examined through the tube wall to attempt to identify any DNAPL that might be present.

2.2.5 Laboratory Analysis of DNAPL

If DNAPL is found in any of the steps described above, a sample will be obtained using a graduated syringe. The amount of DNAPL obtained with the syringe will be recorded and the DNAPL will be

injected into a sample vile containing clean water or air. The sample vile will be analyzed at an offsite laboratory (analytical level III) to confirm the material is in fact carbon tetrachloride.

A range of expected carbon tetrachloride concentrations that would indicate DNAPL will be calculated. These calculations will take into account the effect hydrophobic dyes if used in sample preparation. If the analysis falls into this range, the presence of DNAPL will be confirmed.

Shipment of samples to an offsite laboratory and the results of analyses will be per applicable BHI procedures.

3.0 RECORDING RESULTS

The results of the testing identified here will be recorded in a Field Logbook per applicable BHI procedures. A video camera may also be used to record the detection of DNAPL.

4.0 REFERENCES

BHI, 1994, *Environmental Investigations Procedures*, BHI-EE-01, EIP 1.5, "Field Logbooks, Bechtel Hanford, Inc., Richland, Washington.

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