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Activity Plan: Direction Drilling and Environmental Measurements While Drilling

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Abstract: This activity plan describes the testing of directional drilling combined with environmental measurements while drilling at two Hanford Site locations. A cold test is to be conducted at the 105A Mock Tank Leak Facility in the 200 East Area. A hot test is proposed to be run at the 216-B-8 tile field north of the 241-B Tank Farm in 200 East Area. Criteria to judge the success, partial success or failure of various aspects of the test are included.

The TWRS program is assessing the potential for use of directional drilling because of an identified need to interrogate the vadose zone beneath the single-shell tanks. Because every precaution must be taken to assure that investigation activities do not violate the integrity of the tanks, control of the drill bit and ability to follow a predetermined drill path are of utmost importance and are being tested.

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ACTIVITY PLAN: DIRECTIONAL DRILLING AND ENVIRONMENTAL MEASUREMENTS WHILE DRILLING

August 1998

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For

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Richland, Washington

Prepared for
U.S. Department of Energy
Richland, Washington

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LIST OF TERMS

AB	Authorization Basis
ALARA	As Low As Reasonably Achievable
AP	Activity Plan
BHI	Bechtel Hanford Incorporated
CHI	CH2M Hill Hanford
DOE	U.S. Department of Energy
EMWD	Environmental Measurements While Drilling
ER	Environmental Restoration
FDH	Fluor Daniel Hanford
HPT	Health Physics Technician
KUT	Potassium, uranium, thorium
LMHC	Lockheed Martin Hanford Corporation
PNNL	Pacific Northwest National Laboratory
SNL	Sandia National Laboratory
SST	Single-shell tank
TWRS	Tank Waste Remediation System
TWR	Tank Waste Retrieval
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company
WMNW	Waste Management Northwest

ACTIVITY PLAN: DIRECTIONAL DRILLING AND ENVIRONMENTAL MEASUREMENTS WHILE DRILLING

1.0 PERFORMANCE OBJECTIVES AND SCOPE OF WORK

This activity plan (AP) discusses performance specifications for field activities needed to demonstrate the feasibility of directional drilling in Hanford soils and obtaining environmental measurements while drilling. If feasibility of these technologies is demonstrated, they will be used to help support the investigation of the presence of vadose zone contamination beneath the single-shell tank (SST) farms in the 200 Areas of the Hanford Site, which is the responsibility of the Tank Waste Remediation System (TWRS) program. These technologies could possibly be used in other areas outside the tank farms where subsurface contamination is the responsibility of the Environmental Restoration (ER) program. To meet the needs of both programs, this AP was developed as a cooperative venture with input from the Hanford Site Vadose Zone, Groundwater, Columbia River Integration Project. This AP will serve as a field guide for those performing the work. Two boreholes will be drilled horizontally using directional drilling techniques outside of SST Farms. The initial effort will be a demonstration of directional drilling and collection of environmental information during drilling.

1.1 PERFORMANCE OBJECTIVES

The TWRS Vadose Zone Program has identified a need to characterize a series of "most impacted" locations that are contaminated by tank leaks. Such characterization may employ a variety of methods to develop the necessary understanding of subsurface conditions and processes in each "most impacted" location. The TWRS Vadose Zone Program Plan identifies vertical drilling, slant drilling, cone penetrometry and directional drilling (with environmental measurements while drilling [EMWD]) as being likely characterization technologies to be deployed. This demonstration will be conducted to accomplish the following:

- Define and assess the capability of directional drilling to follow a predetermined drill plan through Hanford sediments in a simulated tank farm environment
- Demonstrate the capability of the EMWD to define zones of subsurface radiological contamination using on-board detectors.

The first demonstration will take place at the tank leak simulation site in the 200 East Area. This site provides a means of assessing drill bit control and the ability to collect samples in an uncontaminated environment. This demonstration is planned to include a test of formation sampling capability. An environmental measurements while drilling (EMWD) module developed by Sandia National Laboratory (SNL) will be attached to the drill string. The EMWD contains a sodium iodide (NaI)-based spectral gamma tool. The EMWD will be tested to ascertain its ability to distinguish the distribution of naturally occurring radionuclides; these data may provide additional insight into the distribution of geologic features in the subsurface of the Hanford Site.

The second directional drilling demonstration is planned to be conducted at the 216-B-8 Tile Field. The site was selected from an assortment of contaminated soil columns outside of the tank farms. The selected site has the following characteristics:

- Contains known gamma contamination (from ^{137}Cs or ^{60}Co) in excess of 100 pCi/g
- Contains subsurface contamination at a depth of 40 to 80 ft, which simulates tank farm depth conditions
- Is the subject of a near-term investigation managed by the Environmental Restoration Division.

Subsurface sampling might be done if procedural requirements can be met; otherwise, subsurface sampling procedures will be developed as a separate activity and used to deploy the system beneath a tank farm if this test proves successful.

A Notice of Construction will be prepared and submitted to the Washington State Department of Health before drilling begins in any potentially contaminated zone. Formal notification of environmental drilling activities will be made to the Washington State Department of Ecology at least 72 hours before drilling.

After the directional drilling demonstration, a decision will be made as to the technique's applicability at SST farms. If directional drilling is determined to be suitable, the Authorization Basis for Tank Farm Operations (AB) will be amended to permit its use in this application.

1.2 SCOPE

Directional drilling will be tested through two boreholes: one at the Leak Test Facility in the 200 East Area and one in a contaminated zone outside any SST farm.

1.2.1 Directional Drilling

Directional drilling, coupled with EMWD and sample collection, has been proposed to assess the lateral extent of contamination beneath SSTs that have leaked, and characterize areas beneath tanks that are inaccessible using existing boreholes or vertical drilling techniques. The extent of contamination currently is postulated by extrapolating data from individual vertically oriented boreholes located around individual tanks. Horizontal to sub-horizontal boreholes would provide a means of interrogating the vadose zone directly beneath the tanks. These areas are anticipated to exhibit significantly different characteristics than areas not shielded by tanks. Several tank farms have demonstrated that wastes can exist beneath tanks with no evidence of the waste found through monitoring the adjacent dry wells.

Operating heavy equipment inside the boundaries of the tank farms (including drilling initiated outside the farm boundary) requires analysis to determine if those operations can be conducted in a manner that will not affect the integrity of the tanks. Advancements in directional drilling capabilities have not been demonstrated on the Hanford Site. A test conducted in 1993 (WHC 1994) showed that bit control was a problem using then available machinery. The use of directional drilling to interrogate the tank farm subsurface may require an amendment to the Authorization Basis (AB) under which the tank farms are operated. Critical issues center on the ability to control bit location to within close tolerances in three dimensions. For this reason, directional drilling will be tested outside a tank farm to assess system capabilities and provide a database that can be directly applied to the AB amendment process.

The first test of directional drilling and EMWD will be conducted at the 200 East Area Mock Tank Site. This facility has been used by the Hanford Tanks Initiative to test the applicability of cone penetrometry for gathering vadose zone data. The site was selected because it provides a tank farm-like site without an AB evaluation. The following performance features will be tested:

- The ability to advance the borehole
- The ability to direct the drill bit and know its location. This will be monitored in an environment with numerous electrical interferences.
- A sampling tool is to be tested to assess sample quantity and quality and develop procedures for handling future hot samples.

EMWD will be deployed in this uncontaminated hole to provide independent bit location information and to test the tool's ability to detect geologic features noted by changes in background radiation due to the changes in the distribution of ^{40}K, uranium, and thorium (KUT).

The second directional drilling and EMWD test is proposed to be conducted at the 216-B-8 tile field. This is an ER program site which has been used for the subsurface disposal of tank waste supernate, so it provides an opportunity to test the EMWD in a tank waste environment. The tile field is located north of the 241-B Tank Farm. Drilling will be carried out parallel to the layout of the distribution tiles, northeast to southwest, starting adjacent to the distribution header. Based on nearby groundwater monitoring wells, ^{137}Cs contamination is known to be present 12 m to 24 m (40 to 80 ft) beneath the ground surface.

2.0 VADOSE ZONE GEOLOGY

2.1 MOCK TANK SITE

The mock tank site is located in the north-central part of the 200 East Area (Figures 1 and 2). The mock tank consists of a 15-m (50-ft) diameter steel "tank" (metal ring), with its base approximately 2 m (5-ft) below the ground surface. While smaller than a typical 25 m (75-ft) diameter SST, the surface interferences, while not including a full suite of ancillary piping, are similar to those anticipated to be present around a full-size SST.

The part of the 200 East Area where the test site is located is underlain by an estimated 82 m to 91 m (270 to 300 ft) of slightly consolidated, generally uncemented interstratified gravel, sand, and silt assigned to the informal Pleistocene Hanford formation (Last et al., 1989; Lindsey et al., 1992, 1994

Two of the three informal units forming the Hanford formation in the 200 East Area are present at the test site. They are the sand-dominated unit 2 and the underlying gravel-dominated unit 3. The contact between these two units lies approximately 76 m (250-ft) below the surface at the site. The gravel-poor area surrounding the test site is defined by sand-rich lithologies interpreted from the borehole logs for wells 299-E27-1 and 299–E24-8. The dominant lithology anticipated at the mock tank site is medium- to coarse-grained sand and granules; occasional pebbles and silt-rich intervals may be encountered.

The water table is anticipated to be at approximately 85 m (278-ft) below the surface.

2.2 216-B-8 TILE FIELD (HOT TEST)

The 216-B-8 tile field is located in the north central portion of the 200 East Area, north of the 241-B Tank Farm and east of the 241-BY Tank Farm (Figures 3 and 4). The site is a septic-tank-like system consisting of a receiving tank, a distribution header, and the tile field. The receiving tank and distribution header are located on the southwest side of the facility, with the tile field extending to the northeast. The terrain slopes to the northeast with a total drop of about 3.5 m (11 ft) over a distance of 100 m (310 ft). The site received tank supernate during the 1950's.

The geology of the 216-B-8 site consists predominantly of fine to medium gravel typical of the Hanford formation gravel units; and presents a more difficult sampling and drilling environment.

3.0 GENERAL REQUIREMENTS

3.1 ENVIRONMENT, SAFETY, AND QUALITY

Field personnel working to this AP will have completed a 40-hr Hazardous Waste Site Worker Training Program and a Radiological Worker I or II Training Programs as appropriate. They will perform work in accordance with applicable procedures from the following sources:

- Hanford Site Radiological Control Manual, HSRCM-1 (FDH 1996)
- Sample and Mobile Laboratories Procedures, SML-IP-1127 (WMNW 1997b)
- "Liquid Discharges," WAC 173-216
- "Dangerous Waste Regulations," WAC 173-303
- "Minimum Standards for Construction and Maintenance of Wells," WAC 173-160.

3.2 TECHNICAL PROCEDURES/SPECIFICATIONS

The following technical procedures or specifications apply to this work:

- Environmental Investigation Procedures, BHI-EE-01 (BHI 1997)
- Radioactive Material/Waste Shipments, HNF-157 (FDH 1997)
- Responsibilities and Procedures for all Hazardous Material, HNF-PRO-154 (FDH 1997)
- Sample and Mobile Laboratories Procedures, SML-EP-001 (WMNW 1997a)
- Sample Services Procedures Manual, SSPM-001 (WMNW 1998)
- Well Services Procedures Manual, E'S-WPM-001 (WMNW 1998)

4.0 GENERAL DRILLING ACTIVITIES

All drilling will be conducted following the specifications and guidance presented in the "Minimum Standards For Construction and Maintenance of Wells, Washington Administrative Code (WAC) 173-160, as they pertain to directional drilling (specifically, licensing of well drillers and construction and abandonment of resource protection wells). Drilling and decommissioning operations also will conform to E'S-WPM-001 (WMNW 1998) and Documentation of Well Drilling, Decommissioning, Remediation, and Completion Operations (BHI 1997). All waste will be handled in accordance with the requirements of WAC 173-303 and the site-specific Waste Control Plan.

Because this drilling activity will test the application of directional drilling to the Hanford Site environment, specific measures are to be taken to assess applicability.

4.1 CONTROL OF DRILL BIT

Drill bit location is a prime consideration in the applicability of directional drilling to the TWRS Vadose Zone Program. Figure 1 shows a drill path for the "cold" hole. Drilling in the tank farms will require that the location of the drill bit be known and verifiable to within ± 1.5 m (5 ft) in 3 dimensions. During sampling operations the location must be known to ± 0.3 m (1 ft) in 3 dimensions. The difference in location requirements is due to a need for reproducibility in sampling situations. The mock tank site provides an opportunity to assess drill bit locating devices in a steel-rich environment, which will test those electromagnetic devices.

4.2 MEASURE VADOSE ZONE CONTAMINANTS

Sandia National Laboratory is providing a real-time data collection tool deployed as part of the drill string. This tool, the EMWD, provides a sodium iodide-based spectral gamma detector and analyzer and other instrumentation packages, e.g., formation temperature. At the cold site, this tool will be assessed for its capability to monitor background levels of naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th). This tool will be calibrated with the housing required for operation with the drilling subcontractors equipment.

4.3 COLLECT ENVIRONMENTALLY DISCRETE SAMPLES

An essential element in future characterization of the under-tank environment is the ability to collect discrete samples from known locations with minimal cross contamination. To assess the ability to obtain useful and useable samples, a minimum of three and a maximum of four samples must be collected during the test. Three samples are expected to be collected from the cold site as a proof-of-principal. If sample handling methods can be adapted to meet the requirements for collecting radiologically contaminated samples, one sample may be attempted from the 216-B-8 Tile Field. Samples collected from the mock tank site will be examined to determine their general suitability for laboratory analysis of chemical, radiological and or hydraulic properties. Samples that are obtained from the 216-B-8 site will be handled in accordance with chain-of-custody procedures and retained for possible analysis of hydraulic properties and radiological contaminants.

4.4 DRILLING FLUID USE

The drilling fluid is anticipated to be viscosity enhanced raw water. Raw water will be supplied from a nearby fire hydrant. Consumption (use) of drilling fluid will be monitored and recorded to provide a use rate in units of volume per unit of borehole advance and to identify locations where abnormal fluid loss occurs. Use of drilling fluid in the under-tank environment must be kept to an absolute minimum to limit any mobilization of contaminants.

Drilling in the contaminated tank farm environment may be done based on the successful outcome of this test. Therefore, returning potentially contaminated drilling fluid to the surface must be tightly controlled because it could result in personnel being contaminated or relocating contaminants in the soil column.

4.5 BOREHOLE ABANDONMENT

Both boreholes will be abandoned in conformance with WAC 173-160 (Minimum Standards for the Construction and Maintenance of Wells). This regulation provides for abandonment by placing grout in the bore as the casing or drill rod is extracted. For the cold site, the preferred abandonment grout is Portland Cement. For the contaminated site, grout may consist of either cement or bentonite. The drilling subcontractor maintains the responsibility for abandoning the borehole(s) in conformance with state regulations.

4.6 TEMPORARY CASING

The ability to install temporary casing (removed upon completion of the bore) as the drill bit and measurement tool are advanced is a desirable feature. As noted in Chapter 2, the geologic environment consists of unconsolidated sand and gravel which may be conducive to the collapse of the hole. If the drill string must be withdrawn from the hole to collect a sample, temporary casing may be needed. Temporary casing will be sized to the drill bit/string configuration.

4.7 VERIFICATION OF BOREHOLE PATH

The borehole path will be confirmed independently. Two or more mutually independent systems must be used to assess the path taken by the drill bit.

4.8 RECORDS

A Hanford Site representative will record activities on a field activity report in accordance with BHI (1997). The report will include the following information:

- Borehole number
- Site location drawings
- Downhole tool string drawings
- Participating site personnel
- Sampling types
- Intervals or zones noted by the health physics technician (HPT) as having elevated radiological contaminants
- Instrument readings and the location represented by each reading
- Specific information concerning borehole completion.

5.0 TESTING STRATEGY

Success or failure of directional drilling and measurement collection while drilling will be based on the criteria covered in Sections 5.1 through 5.5. These criteria were developed using the data quality objectives process.

- Success: Meets all requirements
- Partial Success: Meets some requirements, allowing use on more limited basis
- Failure: Unable to meet requirements

Criteria for success, the attributes of partial success and the conditions of failure are summarized in Table 2 at the end of this section.

5.1 WILL DIRECTIONAL DRILLING WORK IN THE HANFORD ENVIRONMENT, AND CAN THE BIT BE LOCATED WITH SUFFICIENT ACCURACY TO AVOID COMPROMISING FACILITY INTEGRITY?

5.1.1 Drilling Success

The success of directional drilling at the Hanford Site will be judged by the criteria covered in Sections 5.1.1.1 through 5.1.1.7.

5.1.1.1 Versatility. The drill will be judged on whether it can advance and be recovered through the following types of material:

- Hanford formation gravels (must)
- Hanford formation sands (must)
- Plio-Pleistocene silt-rich sands (desirable)
- Caliche-rich zone (desirable)
- Cemented Ringold Formation. (bonus).

During this test only the Hanford formation gravels and sands are to be penetrated. Recovery of equipment from the borehole is also necessary.

The Hanford formation will be encountered at all tank farms and the Plio-Pleistocene unit will be encountered in all 200 West Area tank farms. For the drilling method to be reasonably useful across the site, it must be able to penetrate and sample these units, in addition the hole must be capable of being appropriately decommissioned.

The caliche-rich zone is present primarily in the 200 West Area, but calcium-rich sediments also exist in the 200 East Area. This zone presents a known barrier to contaminant movement. Being able to test its resistance to infiltrating contaminants is a significant bonus. The Ringold Formation consists of variably cemented sands and gravels and presents a challenge to most drilling methods.

5.1.1.2 Bit Location. The drilling method must meet the following criteria.

- The bit must be able to follow a planned trajectory through the subsurface. While drilling, the bit location must known and verifiable at all times to within ± 1.5 m (5 ft).
- The system must be capable of permitting independent verification of bit location without unduly inhibiting drilling progress.

The reason for the tolerances noted above is that the nature of the waste remaining in the Hanford Site SSTs is such that the tanks cannot be compromised. Any drilling plan developed for that use must provide the clearances necessary to ensure that tank integrity is maintained. The bit locator must be capable of showing that the drill plan is being followed within the specifications.

Verification of bit location is one of the means by which this technology will be assessed. Therefore, this capability must be available. It is also important that this verification be carried out in a timely and cost-effective manner.

5.1.1.3 Hole Reentry. The directionally drilled hole must be able to be reentered if the drill string is retracted for any reason. The effects of drilling in a radiologically contaminated zone may affect the drilling operation, necessitating retraction of the drill string. The ability to reenter the previously drilled, uncased bore will directly affect some applications of directional drilling at the Hanford Site tank farms. If an open borehole cannot be reentered, and this situation can be anticipated, this requirement may be mitigated by installing casing as the bore is advanced. Use of specialty drilling muds may also be used to maintain the borehole for reentry.

5.1.1.4 Fluid Return. Ideally, the bore would be able to be advanced without returning drilling fluids to the point of entry. The contaminants anticipated to be encountered in a contaminated boring could be water soluble, resulting in contaminants returning to a mud pit. Unacceptable radiological exposure could occur if drilling fluids are returned to the start pit. All drilling fluid use will be monitored on a continuing basis. If drilling fluids are planned to be returned to the entry pit, the pit must be lined, permitting all fluids to be fully contained for disposal. Any drilling fluid that is returned to the ground surface is to be treated as if contaminated. Upon completion of the bore, drilling fluids are to be placed in drums for final disposal.

5.1.1.5 Drill String Decontamination. The drill string is to be decontaminated as it is withdrawn from the bore. Some radiological or chemical contamination of the drill string is anticipated at the 216-B-8 site. If the drill string can be decontaminated before being handled or placed on drilling machinery or racks, potential contamination of the machinery will be reduced. Contamination of the machinery could result in it being retained on the Hanford Site. Handling of the drill string to avoid contamination of the remaining equipment may mitigate drill string decontamination.

5.1.1.6 Additives. Ideally, the bore would be advanced without the use of drilling mud or additives. Measuring radionuclide distribution is the ultimate purpose of the borehole. This can be affected by drilling mud or additives. Drilling additives may be used if necessary to assure that the bore can be advanced and subsequently abandoned. Use of drilling fluids may adversely impact the use of the EMWD and limit the usefulness of samples that are collected. Therefor, any drilling additives are to be closely controlled and monitored by qualified personnel.

5.1.1.7 Drilling Rig Size. The rig is to be sized to meet the requirements associated with penetrating the formations, EMWD and sampling.

5.1.2 Drilling Failure

Failure of directional drilling will be indicated by any of the occurrences described in Sections 5.1.2.1 through 5.1.2.5.

If the drill string is unable to advance the bore the necessary distances through the required formations, the test has failed. If the drill string cannot be recovered or the borehole cannot be properly abandoned, the test has failed.

5.1.2.2 Incompatibility with EMWD Tool. If the system is incompatible with the EMWD tool, the test has failed . To map contaminant distribution, the EMWD tool is an essential part of the drill string. While not the ultimate mapping mechanism, the EMWD will be used ultimately to help select sampling locations.

5.1.2.3 Borehole Closure. If the borehole cannot be kept open when the drill string is removed and the directional drilling rig cannot carry casing along with the drill bit, the test has failed. Sampling and position verification are important features to be assessed. If a sample location is determined by the EMWD and the sampling tool cannot reaccess the selected sampling location, directional drilling is not an applicable tool.

5.1.2.4 Location Verification. If the location of the drill bit cannot be verified, the test has failed. Because the intended use of directional drilling is to map and sample the subsurface beneath the tanks, knowing the location of the bit is essential.

5.1.2.5 Contamination Containment. If contaminated drill fluid cannot be adequately contained and controlled, the test has failed. Drilling fluids returned to the drill pit must be controlled and contained, including their transfer to disposal drums, in a manner that precludes unreasonable exposure, failure to do so is unacceptable. This is an as low as reasonably achievable (ALARA) concern.

5.2 CAN DIRECTIONAL DRILLING BE USED IN COMBINATION WITH ON-BOARD SENSORS TO MAP VADOSE ZONE CONTAMINANT PLUMES?

Success of the EMWD (on board sensors) will be judged based on the system's capabilities under two scenarios, a cold test and a hot test. The system, as configured for this test, is to be calibrated against known standards. Tool calibration is to be documented before deployment in this test.

5.2.1 Cold Test

The cold test, to be conducted at the mock tank site will be judged on the criteria presented in Sections 5.2.1.1 through 5.2.1.3.

5.2.1.1 KUT Concentrations. KUT concentrations must be recognizable using the sodium iodide detector. Potassium-40 is the primary component of the KUT. The system, including the spectrum analyzer at the surface, must be able to identify and determine the abundance of KUT in the surrounding sediments.

5.2.1.2 Geologic System Differentiation. The system must be sufficiently sensitive to detect and locate changes in KUT signatures as small as 0.3 m (1 ft) wide. Successful detection is indicated by being able to record a change of 50% from the average activities.

5.2.1.3 Background KUT Detection. The system must be able to detect background KUT. Background potassium, uranium and thorium in the sediments are 10 to 20 pCi/g ^{40}K, 0.5 to 1 pCi/g ^{238}U, and 0.4 to 1.5 pCi/g ^{232}Th.

5.2.2 Hot Test

The hot test, if conducted at the 216-B-8 tile field will be judged on the criteria presented in Sections 5.2.2.1 and 5.2.2.2.

5.2.2.1 ^{137}Cs Measurement. The EMWD must be able to measure ^{137}Cs concentrations from 10 pCi/g up to 10^4 pCi/g. A wide range of ^{137}Cs concentrations is anticipated in the planned hot location, dead time caused by photon saturation should not become a limiting factor at less than 10^4 pCi/g.

5.2.2.2 Plume Location. The equipment (combination of bit locator and EMWD resolution) should be able to resolve a plume location along the drill path to within ± 0.6 m (2 ft) at the rate of advance of the drill string. Cleanup decisions will be made based on the environmental consequences of plumes, the ability to physically remediate the contamination, and the cost associated with the treatment option. (Treatment options are either leaving the contamination in place, removing it, or otherwise stabilizing it.). This makes knowing the location of a plume essential. Location data will feed the engineering studies. The back-up locator associated with the EMWD must work to the same specifications as the directional drilling bit locator.

5.2.3 Failure

Failure will be defined as the tool's inability to meet the sensitivity requirements and withstand the drilling environment. The tool is defined as both hardware and software elements.

5.3 CAN DIRECTIONAL DRILLING SUPPORT COLLECTION OF SAMPLES USEABLE FOR CHEMICAL, RADIOLOGICAL, PHYSICAL AND HYDROLOGICAL ANALYSES?

5.3.1 Success

Useable samples are successfully recovered from a known location in the borehole.

5.3.2 Failure

Samples are not recovered. If the sample recovery limitations are an artifact of sampler design, sample redesign must be implemented. If samples cannot be recovered without excessive handling (samplers are not simple to use), ALARA concerns become the driving factors and sampling is deemed a failure.

5.4 HOW "GOOD" ARE SAMPLES AND HOW WELL KNOWN ARE THE LOCATIONS FROM WHICH THE SAMPLES WERE TAKEN?

Samples collected during drilling must be suitable for chemical, radiological, physical, and/or hydraulic testing and analysis. Samples must not be altered by the drilling process to the point where they are not suitable for required testing. The location from which the sample is collected must be known to within ± 0.3-m (1-ft) in 3-dimensions. Sampling location requirements differ from general drilling requirements as this location relates to reproducibility of sampling and analysis results.

5.4.1 Success

Successful sample collection relates to the sample size, percent recovery, and quality of the recovered sample.

5.4.1.1 Sample Size. A minimum sample size of 500 g is needed to perform chemical and/or physical testing. Larger sample size is desirable.

Sample recovery depends on the characteristics of the materials being sampled. Therefore, the recovery schedule shown in Table 1 is considered successful. If the sampled sediments are dry, reducing the recovery by an additional 10 percent is acceptable.

Table 1 Sample Recovery Acceptability Criteria

Material	Moist Recovery	Dry Recovery
Sand and clay	95%	85%
Sand and gravel	50%	40%
Gravel	Any recovery acceptable	Any recovery acceptable

5.4.1.2 Sample Quality. Samples recovered need to be representative of the formation from which they were collected. Samples must be sufficiently free of drilling fluids so that the results of analyses which may be run are representative of formation parameters. This is a subjective requirement; samples may be useful for one purpose but not for another.

5.4.2 Failure

If minimum mass and recovery rates cannot be met, the test will have failed.

Failure to meet sample quality requirements means that the samples are not representative of the formation and that representativeness cannot be recovered by reasonable laboratory procedures.

5.5 HOW WELL CAN THE DRILLING MACHINE BE DECONTAMINATED AFTER ADVANCING THROUGH A RADIOLOGICALLY CONTAMINATED ZONE?

5.5.1 Success

Successfully demonstrating the drilling technology depends in part on the ability to maintain the drilling rig in an uncontaminated condition or to decontaminate the drilling rig and associated equipment after having penetrated a radiologically contaminated zone. Downhole portions of the drill string could be contaminated to the extent that decontamination expenses would equal or exceed the cost of replacement. Contamination of downhole equipment is excluded from this judgement criterion.

5.5.1.1 Minimal Equipment Exposure. Engineering design of the drilling machine is such that the potential for contamination is minimized and the machine can be cleaned readily. This might include placing the system hydraulics in a remote location.

5.5.1.2 Fluid Containment. All fluids must be contained. Degrees of success are then determined by small, well-contained returns of drilling fluids. These fluids are to be treated as if radiologically contaminated.

5.5.1.3 Low Worker Exposure. Engineering design of the drilling machine must protect operators and secondary workers from exposure to radiological or hazardous conditions caused by drilling in a contaminated environment.

5.5.1.4 Engineered Barriers Restrict Possible Contamination. Design and operation of the drilling machine and necessary ancillary equipment must allow the use of supplemental barriers to further restrict worker and environmental exposure to contamination.

5.5.1.5 Rig/Site Released. The rig must be able to be decontaminated to the point that it can be released from radiological control and allowed to leave the Hanford Site. In addition, the drill site must be able to be released under the level of access control in effect before drilling. No spread of surface contamination may occur.

5.5.2 Failure

Failure is defined as requiring extraordinary actions to meet any of the success criteria.

6.0 DRILLING PLAN

This section describes the drilling paths to be used to assess the success criterion defined in Chapter 5. Requirements are different for the mock tank facility and the 216-B-8 tile field. The distance and angle needed to attain the depth and hole orientation are machine specific and not detailed here.

6.1 MOCK TANK FACILITY

The borehole will be directed in an east-west orientation. The borehole is to be directed so that it passes adjacent to the center of the mock tank (Figure 1) at a depth of 7 m (22 ft) below the ground surface (Figure 2). It must move across the tank for at least 20 m (65 ft). The borehole must be maintained in a near-horizontal plane (follow planned drill path).

6.2 216-B-8 TILE FIELD

The borehole at the 216-B-8 tile field will be extended from southwest to northeast parallel to the orientation of the tiles (Figure 3). The bore is to be extended parallel to the base of the tiles at a depth of 10 m (33 ft) below the projected depth of the tiles (Figure 4). The penetration is to extend a minimum of 30 m (100 ft) along the axis of the tile field.

6.3 BOREHOLE DECOMMISSIONING (ABANDONMENT)

On completion, each test bore is to be decommissioned. Decommissioning is to consist of injection grouting of the bore as the drill string is withdrawn. Grout is to consist of neat cement (bentonite may be used at the 216-B-8 Site).

Criterion	Success	Partial Success	Failure
Does Directional Drilling Work in the Hanford Environment and can bit be located with sufficient accuracy?			
Versatility	Drills all formations to distance required	Drills Hanford formation to distance required	Cannot penetrate Hanford formation
Bit Location	Follows planned path, and bit location known at all times	Location more than 5-ft off path, but known	Unable to locate bit
Hole Reentry	Reenter without casing	Reenters with casing	Cannot reenter or case hole
Fluid Use and Return	Limited fluids returned to surface, all fluids retained and controlled, no abnormal exposure.	Fluids returned but contained and no abnormal exposure	Fluids returned, but cannot be contained or abnormal exposure results
Decontamination	Drill string decontaminated as withdrawn	Drill string can be isolated so that no other equipment is contaminated, or rig can be decontaminated	Rig cannot be decontaminated
Mud/Additives	No additives needed	Additives needed	N/A
Rig Size	Penetrates formations and accommodates EMWD and sampling	Penetrates formations with EMWD or sampling	Cannot penetrate formations
Can On-Board Sensors map vadose zone contaminant plumes?			
KUT Concentrations	*Identifies and quantifies natural radionuclides within specified detection limits*	*Identifies and quantifies natural radionuclides, but not within specified limits*	*Unable to detect natural radionuclides*
Geologic Features	Identifies narrow width features	Can identify only features with width of 3 ft or more	N/A
Rugosity	Operates in Hanford environment	Software problems only	System unable to withstand drilling environment
Cs-137	Detects 10 to 10E04 pCi/g	Detects 10E02 to 10E04 pCi/g	Cannot detect less than 10E03 pCi/g
Location	Known to +/- 0.6 m (2 ft)	Known to +/- 1.5 m (5 ft)	Cannot reconcile location
Can directional drilling support sample collection?			
Sampling	Samples returned from known location	No samples returned, but cause is sampler design	No samples returned, or handling results in excessive dose
How "good" are samples and is sampled location known?			
Sample Size	500 + grams of sample	500 g>sample>100 g	Sample < 100 g

Recovery (moist)	95% sand and clay 50% sand and gravel any gravel	N/A	Does not meet success criterion
Recovery (dry)	85% sand and clay 40% sand and gravel any gravel	N/A	Does not meet success criterion
Representativeness	Samples can be used for all analyses	Samples can be used only for radiological analyses	Samples cannot be used
How well can drilling machine be decontaminated?			
Equipment Exposure	Potential of contamination is low and rig can be readily decontaminated.	Engineering work needed to protect rig	Extraordinary actions required to protect rig
Fluid Containment	No drilling fluids returned to surface	Fluids returned to surface but contained and no/low exposure to radiation	Extraordinary actions required to prevent exposure
Worker Exposure	Worker protected from exposure (distance, time, shielding)	Moderate engineering measures required to protect operator.	Extraordinary actions required to prevent exposure
Rig/Site Released	Rig and site released for subsequent activities	Site requires signage or protective measures	Rig requires radiation controls

7.0 DATA ACQUISITION AND ANALYSIS

7.1 PHYSICAL SOIL SAMPLES

One objective of the directional drilling test is to collect location-specific physical samples suitable for analyzing radiological, physical, hydrological, and geochemical constituents and parameters. Up to four samples are to be collected. Coring activities are to be initially limited to the cold test site to assess the equipment's capability to handle potentially contaminated samples in a manner consistent with ALARA principals. If the sampling activity meets the safety requirements, the 216-B-8 tile field site may be sampled.

Any core removed from the 216-B-8 site will be retained for possible future analysis. Samples will be contained in airtight sample containers after their initial screening by the HPT. This process is to retain soil moisture in as close to field condition as possible. All cores will be transported to the Pacific Northwest National Laboratory under refrigeration to further limit alteration of water balance.

A geologist will describe each retrieved core. All physical samples will be handled under chain-of-custody procedures (WMNW 1998).

7.2 LABORATORY ANALYSES

No laboratory analyses will be run on samples, assessment of the usability of the samples will be based on visual examination by site personnel. If the 216-B-8 site is sampled, those samples may be subjected to more comprehensive analyses.

7.3 GEOPHYSICAL LOGGING

Spectral gamma logging will be conducted using the EMWD as the borehole is advanced. Repeat logs will be run any time the EMWD is retracted from or reenters the bore. These logs will be analyzed to provide any indications of contaminated soil having been carried along the drill path. Temperature logging of the bore may be done coincidental with the spectral gamma logging.

7.4 COST EFFECTIVENESS

Time and costs associated with site characterization activities are subject of much scrutiny and the most cost effective means of acquiring needed information will be used as the TWRS Vadose Zone Program advances. To this end, all operating times and costs will be tracked to ascertain the true costs associated with this technology. It is recognized that this AP describes a test procedure and that costs developed may be greater than those which would be experienced in a full scale job.

8.0 RESPONSIBILITIES

This activity plan covers multiple participants, each of which has specific responsibilities associated with the tasks described above. This section defines the general areas of responsibility for each participating entity. The division of responsibilities is provided in Table 3.

8.1 SANDIA NATIONAL LABORATORY

Sandia National Laboratory (SNL) has responsibility for contracting and managing directional drilling services and ensuring that they are compatible with the EMWD instrumentation package and meet LMHC (Hanford) performance requirements. SNL is also responsible for providing, calibrating, and operating the EMWD instrumentation and interpreting the EMWD data. Because the drilling subcontract is placed through SNL, the laboratory will assure that the drilling subcontractor operates in conformance with the site health and safety plans and any site-specific requirements identified by either Bechtel Hanford Incorporated or Lockheed Martin Hanford Corporation. Sandia National Laboratory will provide detailed plans for meeting the performance requirements for drilling as well as for testing of the EMWD (Sections 5 and 6).

8.2 BECHTEL HANFORD INCORPORATED

Bechtel Hanford Inc. (BHI) is the responsible entity for field activities associated with the 216-B-8 tile field site. BHI is to identify site-specific requirements for all project personnel that will have access to the 216-B-8 tile field drill site. Use of this site requires BHI approval, which is pending. Either BHI or LMHC will provide on-site health and safety, health physics, and operational support, pending a BHI decision to participate. Operational support includes the all activities associated with obtaining an excavation permit, notice of construction, and notifications to Ecology.

8.3 LOCKHEED MARTIN HANFORD CORPORATION

Lockheed Martin Hanford Corporation (LMHC) is the technical lead and has general project management responsibility. In addition, LMHC is the responsible entity for field activities associated with drilling at the Mock Tank Leak Test Facility. LMHC will provide all on-site health and safety and operating support. Operating support includes all the activities associated with obtaining an excavation permit and notifications to Ecology, as well as site services.

LMHC will provide the necessary Hanford-specific training identified in either of the site health and safety plans, as well as Hanford General Employee Training.

LMHC has the reponsibility for developing any sampling procedure(s) that will be needed to deploy directional drilling with sampling within the 200 Area Tank Farms.

8.4 PACIFIC NORTHWEST NATIONAL LABORATORY

Pacific Northwest National Laboratory (PNNL) is the recipient of any samples collected from the 216-B-8 site. All samples received by PNNL from the drilling operation will be maintained in refrigerated storage pending decisions on analysis. If analyses are not to be run, PNNL will open the sample containers and make visual inspection of the sampled soils to assess their suitability for hydraulic, chemical, or radiological analysis.

Table 3. Responsibility Matrix

Activity	Mock Tank Leak Test Site Responsibility	216-B-8 Tile Field Site Responsibility
Project Lead	LMHC	LMHC
Engineering	LMHC/SNL/BHI	BHI/LMHC/SNL
Notice of Construction	N/A	BHI or LMHC
Field Lead	LMHC	BHI or LMHC
Training (Cold and Hot)	LMHC	BHI/LMHC
Ground Penetrating Radar	LMHC	LMHC
USQ/Safety	LMHC	BHI or LMHC
Work Package	LMHC	BHI or LMHC
Portable Power	LMHC	LMHC
Work Trailer	LMHC	LMHC
Site Preparation	N/A	BHI or LMHC (if required)
Toilet facility	LMHC	LMHC
Misc. Materials	LMHC	LMHC
HPT	LMHC (training only)	BHI or LMHC
SNL/Contractor mobilize	SNL/Subcontractor	SNL/Subcontractor
Directional Drilling	SNL/Subcontractor	SNL/Subcontractor
Gyroscopic Survey (if needed)	SNL/Subcontractor	SNL/Subcontractor
Sample Retrieval/Handling	LMHC	LMHC/WMNW/PNNL
EMWD Deployment	SNL/Subcontractor	SNL/Subcontractor
Decontamination/Disposal	LMHC	BHI/LMHC

9.0 SCHEDULE

Testing of directional drilling and EMWD equipment beneath the mock tank facility is to commence by September 1, 1998. Testing beneath the 216-B-8 tile field is to be completed by September 30, 1998. Figure 5 depicts the detailed schedule of activities.

10.0 REFERENCES

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Figure 1. Plan View of Mock Tank Site Drill Path

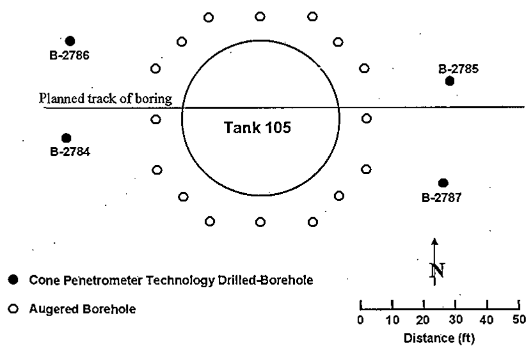


Figure 2. Cross-Section view of Mock Tank Site

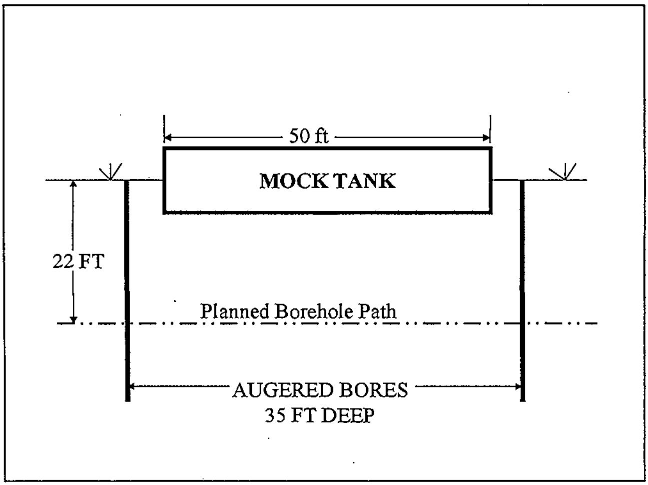


Figure 3. Plan View of 216-B-8 Tile Field

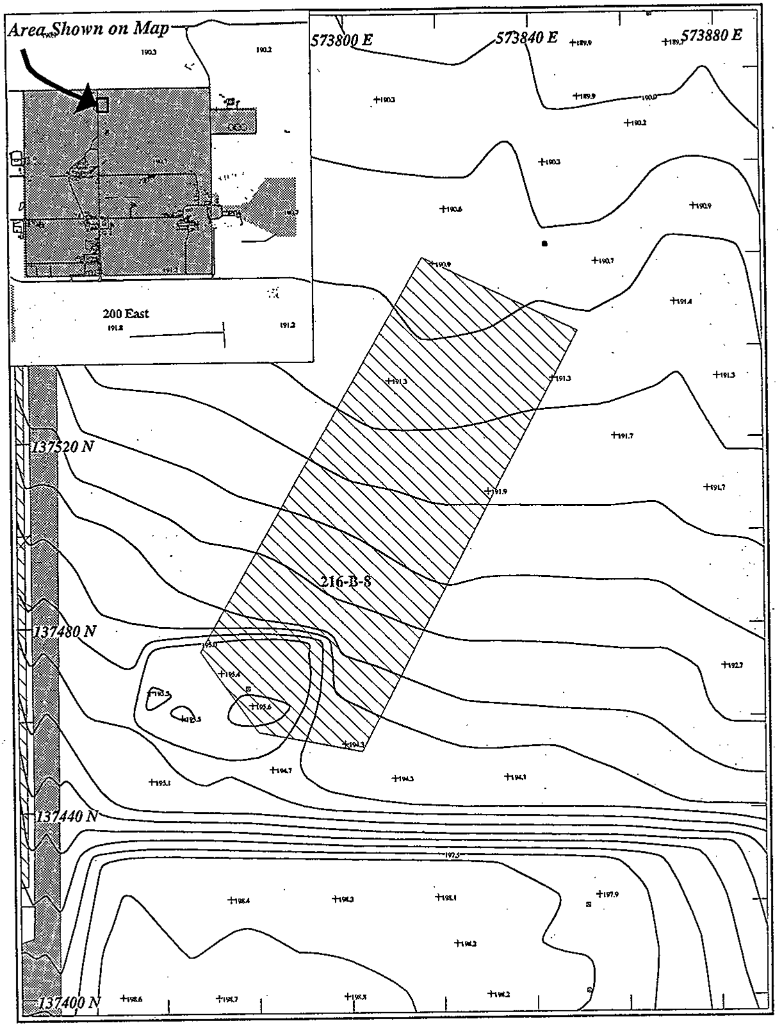


Figure 4. Cross-Section View of 216-B-8 Tile Field

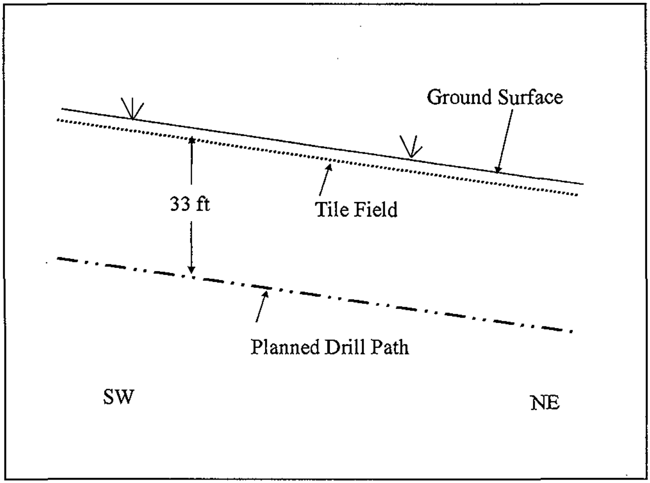
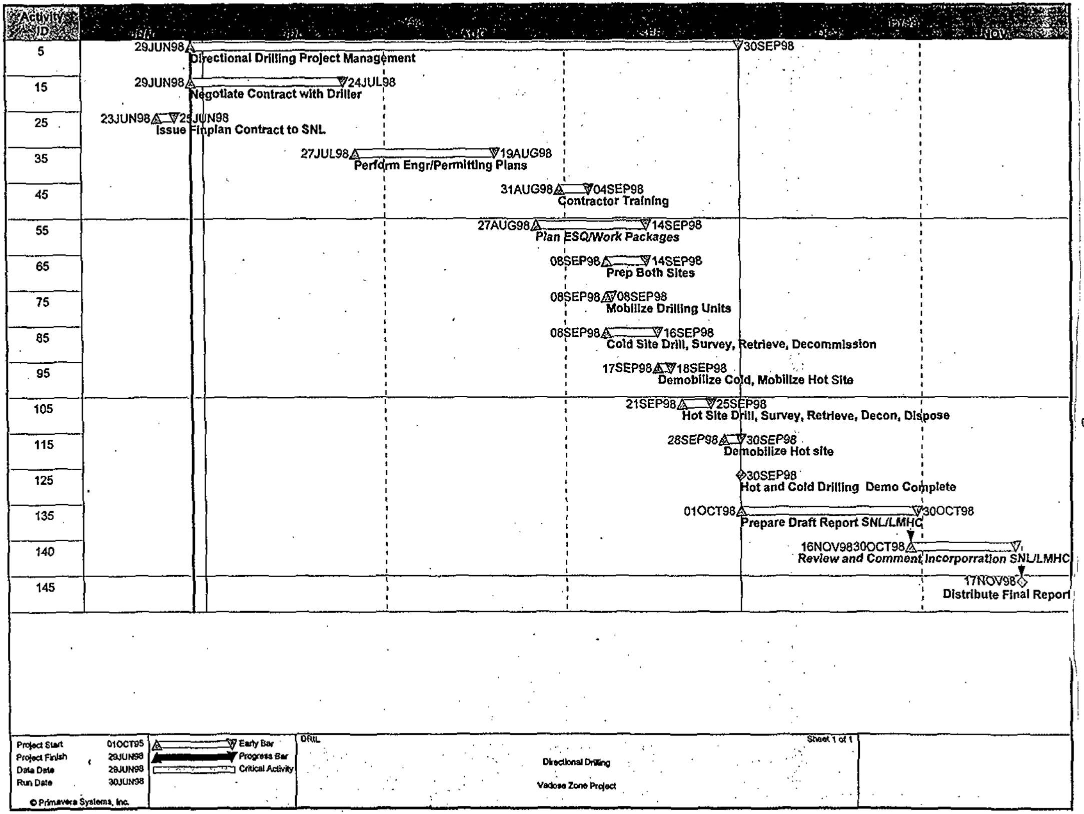


Figure 5. Schedule of Activities, Directional Drilling and Environmental Measurements While Drilling



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