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Pacific Northwest
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Monitoring Plan for Borehole Logging at 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-12 Crib

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1.0 Introduction

This plan describes the fiscal year 1998 vadose monitoring of three inactive, liquid waste disposal facilities associated with the Plutonium Finishing Plant (Z-Plant): the 216-Z-1A Tile Field, the 216-Z-9 Trench, and the 216-Z-12 Crib. Monitoring will consist of spectral gamma-ray logging of twenty-one boreholes. This plan describes the physical characteristics of the facilities, their operational histories, the subsurface geology and known contamination distribution at each facility. The plan then describes the specific monitoring to be done including the boreholes to be logged, the methods of data acquisition, data reduction, and data evaluation, and finally, the quality control, data management and data reporting for this effort.

The three liquid waste disposal facilities at the Z Plant were chosen to be monitored because they were identified by Johnson (in Hartman and Dresel 1997) as containing some of the most significant sources of radioactive contamination in the Hanford vadose zone. Johnson's analysis was based on the relative hazard obtained by combining curie quantities disposed to the facilities with appropriate health/ risk standards (Johnson, in Hartman and Dresel 1997).

The basic question to be addressed by this logging activity is "Has the configuration of subsurface contamination changed since it was last measured?" Historical data from the 216-Z-1A Tile Field, the 216-Z-9 Trench, and the 216-Z-12 Crib form the baseline for comparisons to answer this question.

1.1 Previous Studies of Subsurface Radionuclides at 216-Z-1A, 216-Z-9, and 216-Z-12 Facilities

The results from previous studies are available to serve as a baseline for this monitoring effort. Those results include gross gamma-ray profiles, spectral gamma profiles, and laboratory analytical data.

The latest comprehensive collection and discussion of scintillation probe profiles at the Z Plant area is included in Fecht et al. (1977). They interpreted the scintillation probe profiles for about 100 crib facilities including the 216-Z-1A, 216-Z-9, and 216-Z-12 facilities. They compared the most current profiles available at that time with previous profiles to interpret changes in subsurface distribution of gamma emitting radionuclides.

At 216-Z-1A, Fecht et al. (1977) identified gamma contamination in three wells. Wells 299-W18-57 and 299-W18-58 showed increased activity above background between 6.1 meters and 16.8 meters and between 13.7 meters and about 28 meters, respectively. Gamma intensity increased in both boreholes between 1965 and 1968. Borehole 299-W18-56 showed a zone between 11 meters and 21 meters depth with gamma activity above background but the intensity of the activity decreased between 1965 and 1973. All other logged boreholes at 216-Z-1A had no gamma intensity above background levels.

Fecht et al. (1977) found contamination in two boreholes (299-W15-8 and 299-W15-86) between 15.2 meters and 38.1 meters depth at the 216-Z-9 Trench. The remainder of the boreholes showed near background levels of radiation. They concluded that gamma intensity decreased due to radioactivity decay since the previous logging.

At the 216-Z-12 Crib, Fecht et al. (1977) found contamination near the head end of the crib had persisted in four boreholes (299-W18-5, 299-W18-8, 299-W18-69, and 299-W18-71) at 6.7 meters depth since the beginning of logging in 1967. They concluded that minor redistribution of contaminants had occurred from operations.

Scintillation probe data have been collected subsequent to Fecht et al. (1977) (see Additon et al. 1978a,b) but no comparable discussion or presentation of the data has been made.

In 1991 Chamness et al. (1991) compiled a database of all known geophysical logging done in the Z Plant Operable Unit. That compilation was used, as well as results from the few subsequent and unpublished spectral gamma logging events (Brodeur et al. 1991a,b) in the Z Plant Source Aggregate Area Management Study to delineate subsurface contamination in the Z Plant Source Operable Unit (DOE 1992). The Z Plant Source AAMS Report included isopac maps of elevated gamma activities beneath 216-Z-1A, 216-Z-9, and 216-Z-12.

Brodeur et al. (1993) reported on gross-gamma and spectral gamma logging done in 1992 for the 200 Areas Aggregate Area Management Study. In 1993 Schlumberger and DOE Grand Junction logged several boreholes at Z Plant waste disposal facilities for the DOE Arid Site Integrated Demonstration Project. Schlumberger produced gross gamma logs from four boreholes at 216-Z-9 and from one borehole at 216-Z-12 (as well as other "oil field" type logs such as Reservoir Saturation and porosity logs) but their results have not been described or published. At about the same time, the Grand Junction logging team produced prompt fission neutron (PFN) logs of ten boreholes including four at 216-Z-1A and one each at 216-Z-9 and 216-Z-12. Those results have not been published but a draft report (George and Wilson 1994) states that all the holes at 216-Z-1A and one hole in the 216-Z-12 Crib showed large concentrations of ^{239}Pu. Two of the boreholes in the 216-Z-1A Tile Field had been logged with the PFN tool in 1978 and again in 1984 prior to the 1993 logging. The distribution of contaminants as shown in the logs from the 1993 Grand Junction activity agreed well with the previous logs indicating that the plutonium did not substantially move over the span of fifteen years. A list of all logging in most boreholes at 216-Z-1A, 216-Z-9, and 216-Z-12 is given in Appendix A.

In addition to geophysical borehole logging, some laboratory, analytical results exist from drilling and sampling activities at each of 216-Z-1A Tile Field, 216-Z-9 Trench, and 216-Z-12 Crib. Ridgway et al. (1971) reviewed previous soil sampling at 216-Z-9 Trench and present laboratory results for plutonium concentrations from their "third sampling" from split tube samples. Their samples were all obtained from less than about 3 meters depth so they add little information to contaminant distribution beneath the Trench. Smith (1973) reported results of a gamma survey, an infrared temperature survey, and a neutron survey of the surface (top 13 cm in the case of the neutron survey) of the 216-Z-9 Trench in support of nuclear reactivity evaluations. He also reported results of laboratory analyses for plutonium and americium from shallow (less than 3 meters) boreholes drilled through the Trench floor.

Price et al. (1979) drilled and sampled 16 boreholes at the 216-Z-1A Tile Field for the purpose of delineating the distribution of subsurface contamination at that facility. About 400 samples from those boreholes were analyzed for plutonium and americium activity. Price et al. (1979) summarized their results as cross sections thorough the Tile Field showing plutonium and americium distributions. Their cross sections have been the basis for subsequent visualizations of contamination at that facility.

Kasper (1982) did much the same at 216-Z-12 that Price et al. did at 216-Z-1A. Kasper reviewed existing data and sampled seven new boreholes. His analysis resulted in cross sections of the 216-Z-12 Crib with contours of the plutonium distribution down to the 1 pCi/g level. Also, Buelt et al. (1989) reported laboratory analyses for ^{241}Am, ^{239}Pu, ^{238}U, ^{154}Eu, and ^{137}Cs obtained from three 3 meter cores sampled during drilling of four new wells in support of a large-scale, *in situ* vitrification project at 216-Z-12 Crib. They present both tables of results and cross-sections of concentration versus depth.

All of the previous geophysical logging results and the laboratory analytical results serve as a baseline against which results collected for this monitoring effort can be compared.

2.0 Facility Descriptions

This section presents the physical descriptions of 216-Z-1A, 216-Z-9, and 216-Z-12, their operational histories, and the inventories and characteristics of the waste streams disposed therein. Unless otherwise noted, the information presented in this section is taken from DOE (1992).

2.1 Physical Descriptions

The 216-Z-1A Tile Field is located south of the 234-5Z Building in 200 West Area and immediately south of the 216-Z-1 and 216-Z-2 Cribs (Figure 2.1). The 216-Z-1A Tile Field is approximately 60 m wide by 110 m long. It is excavated to 5.8 m depth with inward sloping side walls resulting in a central floor dimension of about 35 m by 84 m (Price et al. 1979). The floor of the excavation was covered by a 1.2 m thick cobble layer before placing a herringbone pattern of 20 cm diameter clay pipe for waste distribution (Price et al. 1979). The 85.4 m long central distribution pipe runs north-south and has seven pairs of 21.4 m long laterals spaced 10.7 meters apart. The distribution pipe was then covered by 15 cm of cobbles and 1.5 m of sand and gravel. Prior to reactivation of the Tile Field in 1964, a sheet of polyethylene covered by 30 cm of sand and gravel was added to the top of the facility (Price et al. 1979). Figure 2.2, taken from Wood (1958) shows the construction of the 216-Z-1A Tile Field; specific construction details differ among sources.

Figure 2.3 shows the construction of the 216-Z-9 Trench. The trench is located about 213 meters east of the 234-5Z Building and 152 meters south of 19th Street in the 200 West Area (Figure 2.1). The trench consists of a 6.4 m deep excavation with a 36.6 m by 22.5 m concrete cover over what was an active floor area of 9.1 meters by 18.3 meters (Ridgway et al. 1971). The 23 cm thick concrete slab cover is supported by six concrete columns. The 216-Z-9 Trench remains an open excavation beneath the slab.

The 216-Z-12 Crib is about 122 meters southwest of the 234-5Z Building in 200 West Area (Figure 2.1). It was constructed in 1958 to replace the 216-Z-3 Crib. 216-Z-12 has a surface dimension of 25 m by 110 m and was excavated to 6.1 m depth. The Crib has inward sloping sides resulting in a 6.1 m by 91.4 m floor dimension (Kasper 1982). The bottom of the crib was covered with 0.6 m to 1.2 m (inconsistent information in the literature) of clean gravel. A single, 30 cm diameter, vitreous clay, distribution pipe was placed on the gravel layer with no slope. Forty centimeters of gravel were laid over the pipe, followed by a 0.05 cm polyethylene sheet. The excavation was backfilled to grade (Kasper 1982). Figure 2.4 shows the crib construction.

2.2 Operational History

Table 2.1 summarizes the operational history of the 216-Z-1A Tile Field from construction in 1949 to final retirement in 1969. Initially the tile field received overflow from the 216-Z-1 and 216-Z-2 Cribs. Later, liquid waste was routed directly to the tile field. The 216-Z-1A Tile Field received approximately 6.2 million liters (1,640,000 gal) of liquid waste although other sources site other volumes (DOE 1992).

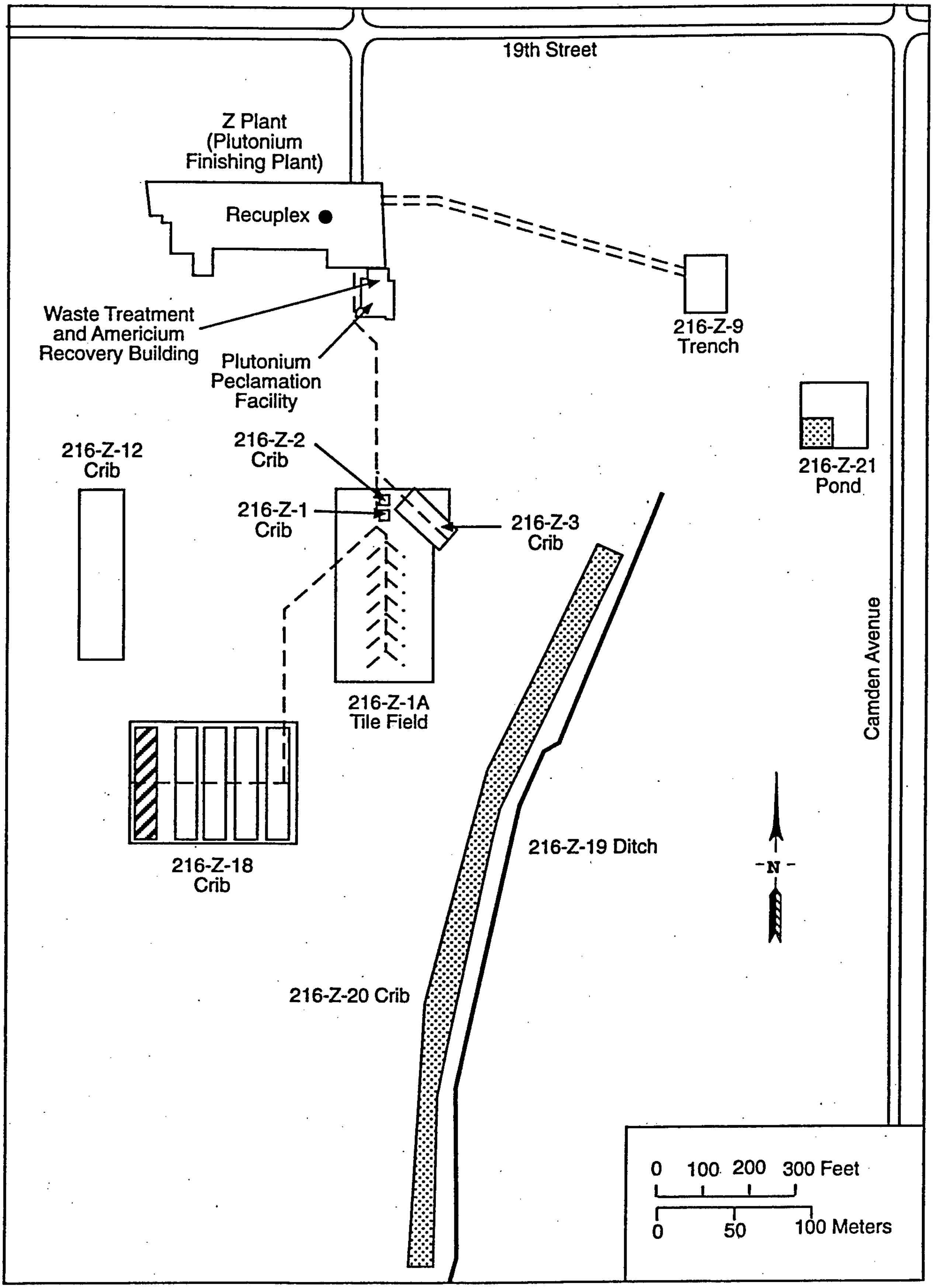

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Figure 2.1. Map Showing the Locations of the 216-Z-1A Tile Field, the 215-Z-9 Trench, and the 216-Z-12 Crib in the 200 West Area, Hanford Site (modified from Rohay et al. 1994)

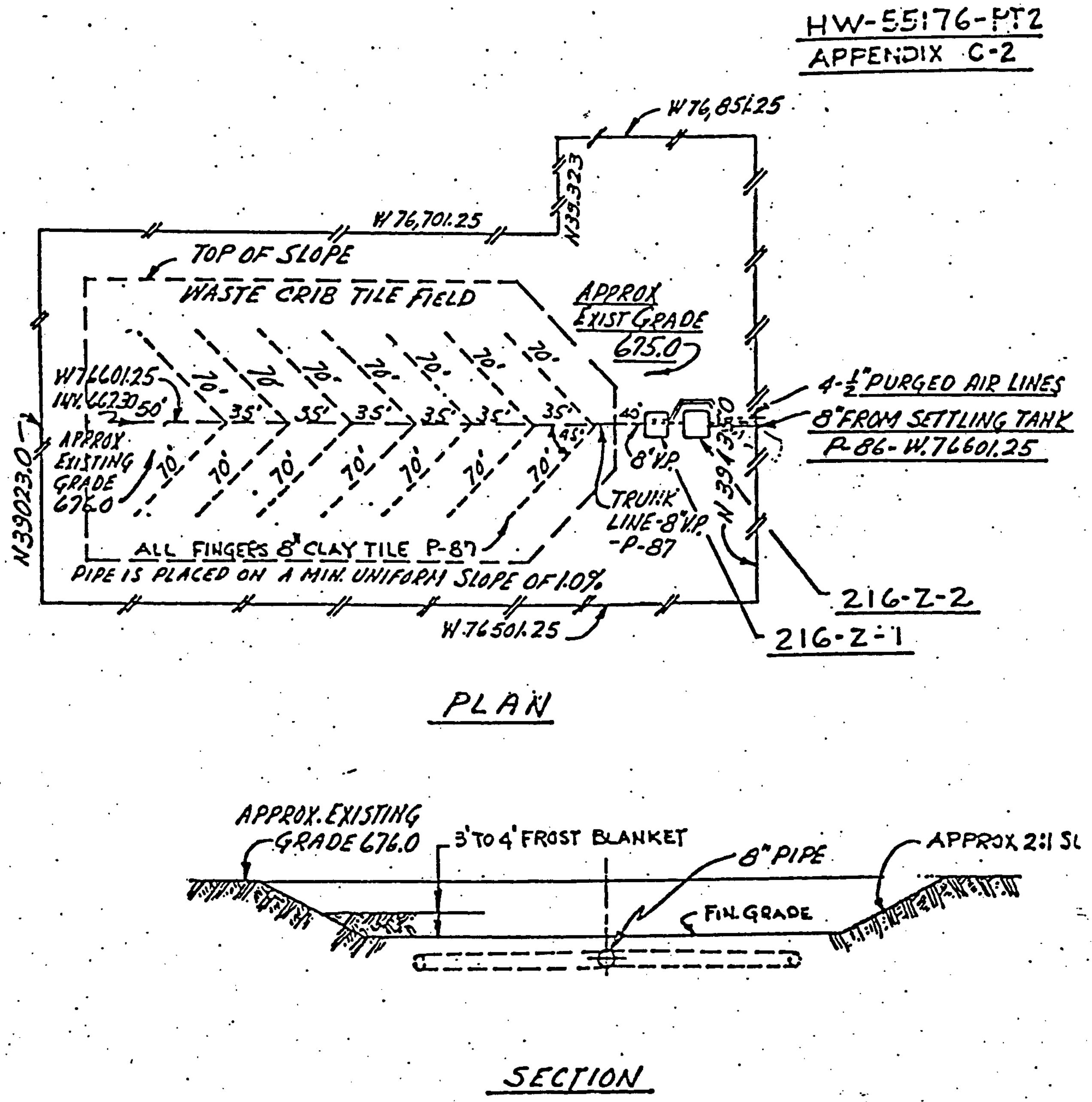

Figure 2.2. Construction Details of the 216-Z-1A Tile Field (from Wood 1958)

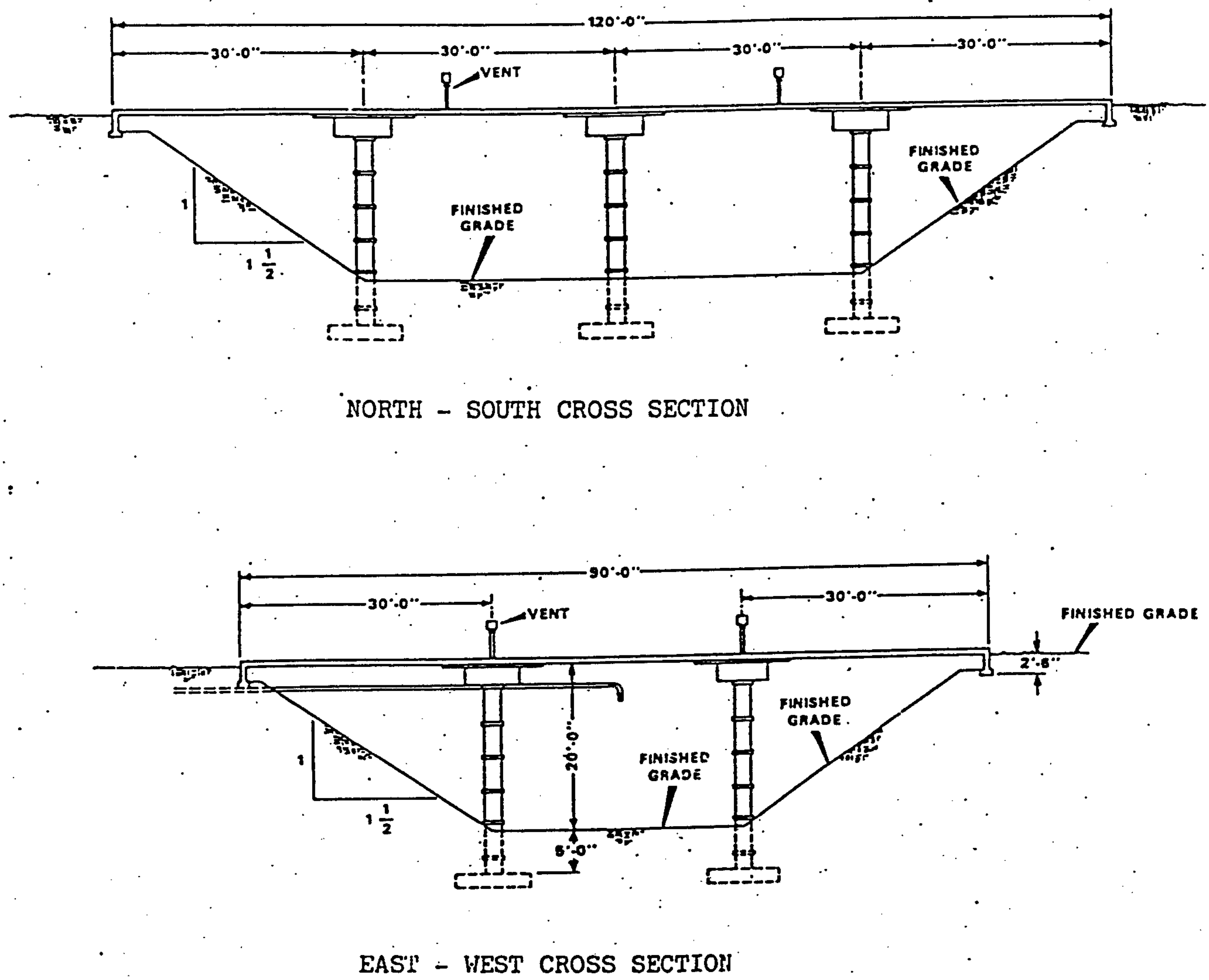

Figure 2.3. Construction Details for the 216-Z-9 Trench (modified from Ridgway et al. 1971)

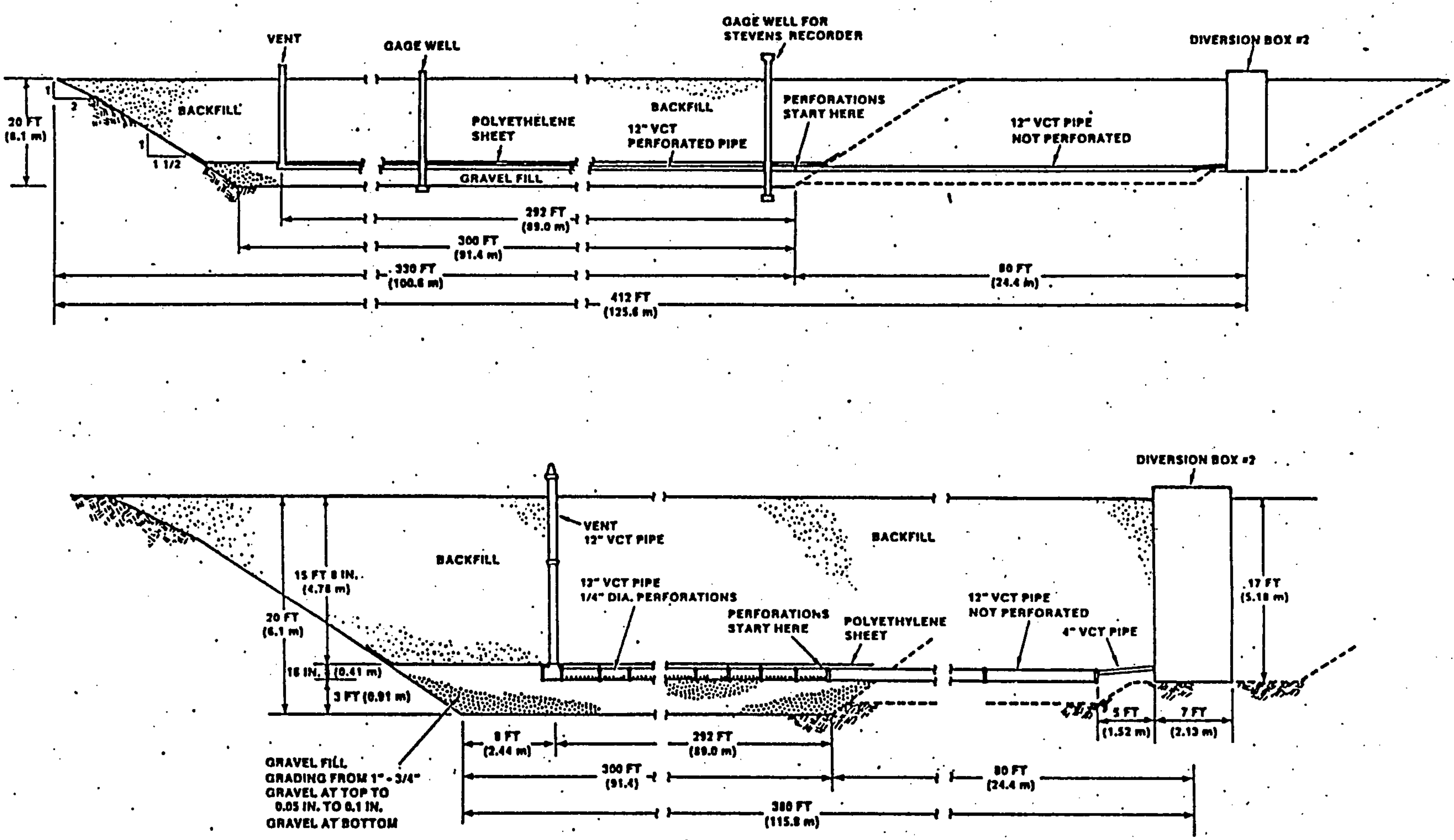

Figure 2.4. Construction Details for the 216-Z-12 Crib (modified from Kasper 1982)

Table 2.1. Operational History for the 216-Z-1A Tile Field (modified from DOE 1992)

Service Dates		Operations
From	To	
6/49	6/52	216-Z-1 and 216-Z-2 Cribs and the 216-Z-1A received process, analytical, and development lab wastes from 234-5Z Building via the 241-Z-361 Settling Tank.
6/52	3/59	216-Z-1 and 216-Z-2 Cribs were bypassed. 216-Z-1A Tile Field received the above wastes via overflow from 216-Z-3 Crib.
3/59	5/64	216-Z-1A was inactive.
5/64	8/64	216-Z-1A received aqueous waste and organic waste from PRF (235-Z Building).
8/64	5/66	216-Z-1A received 242-Z Building Waste and Americium Recovery (242-Z) waste in addition to the above.
5/66	6/66	216-Z-1 and 216-Z-2 Cribs and 216-Z-1A Tile Field received 236-Z Building aqueous and organic waste and 242-Z Building waste and the distribution point in 216-Z-1A Tile Field was moved from the A section 30.5 m (100 ft) down the main trunk to the B section.
6/66	10/67	216-Z-1 and 216-Z-2 Cribs were inactive; section B of the 216-Z-1A Tile Field received aqueous and organic waste from 236-Z Building and from the 242-Z Building, and the discharge point on 216-Z-1A was moved 23 m (75 ft) further down the main trunk.
10/67	10/67	216-Z-1 and 216-Z-2 Cribs received 236-Z and 242-Z Building wastes while the discharge point in the 216-Z-1A Tile Field was moved 23 (75 ft) further down the main trunk from the B section to the C section.
10/67	3/68	216-Z-1 and 216-Z-2 Cribs were inactive; 216-Z-1A Tile Field received 236-Z and 242-Z Building wastes.
3/68	4/69	216-Z-1A Tile Field continued to received the above wastes; 216-Z-1 and 216-Z-2 Cribs received uranium wastes from 236-Z Building.
4/69		All portions of the 216-Z-1, 216-Z-2, 216-Z-3 Cribs and 216-Z-1A Tile Field were retired.

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 reportedly received 4.04 million liters of low salt, acidic, aqueous, and organic liquid waste from the RECUPLEX facility. In 1973 it was decided to actively mine the 216-Z-9 Trench to remove plutonium so as to reduce the risk of environmental contamination and reduce the criticality potential. Between August 1976 and January 1977, the top 30 cm of soil containing an estimated 58 kg of plutonium was removed from the Trench with remote mechanical equipment (Rohay et al. 1994; DOE 1992).

The 216-Z-12 Crib received PFP process waste and analytical and development laboratory waste from the 234-5Z Building via the 241-Z-361 Settling Tank. The Crib was active from 1959 to 1973. The 216-Z-12 Crib received 2.81 million liters of slightly acidic, low salt waste that was adjusted to a pH between 8 and 10 before disposal (DOE 1992). In 1987 a portion of the Crib was used as a demonstration for large-scale *in situ* vitrification. The test resulted in vitrification of the upper 5 meters of the Crib and therefore did not encompass most of the contamination (Buelt 1989).

2.3 Waste Description

Table 2.2 lists the inventories of what is known to have been disposed to the 216-Z-1A Tile Field, 216-Z-9 Trench and 216-Z-12 Crib. All information in the table is from DOE (1992).

Table 2.2. Waste Inventories for the 216-Z-1A, 216-Z-9, and 216-Z-12 Facilities (DOE 1992)[a]

	216-Z-1A	216-Z-9	216-Z-12
Pu (gm)	57,000	48,000	25,000
^{238}U		3.7×10^{-5}	1.7×10^{-5}
^{137}Cs	0.16	0.052	0.053
^{106}Ru	5.2×10^{-6}	1.9×10^{-8}	9.3×10^{-7}
^{90}Sr	0.15	0.049	0.051
^{60}Co		0.00395	0.00515
^{241}Am	3,432	8,580	
^{239}Pu	137	2.19	1.43
^{240}Pu	37	590	386
CCl_4	268,000	131,140 to 471,000	
Tributylphosphate	30,000		
DBBP	20,300		
Nitrate	3,000	500,000	900,000
Sodium	900	200,000	600,000
Fluoride	900		300,000
$Ca(NO_3)_2$		130,000	
$Mg(NO_3)_2$		180,000	
Nitric Acid		39,000	
Aluminum Fluoride Nitrate		210,000	
$Al(NO_3)_3$		190,000	
$Fe(NO_3)_3$		40,000	
Sulfate		10,000	

(a) All radionuclide quantities are reported in Ci unless otherwise noted. Curies are decayed through 1989. Chemical quantities are reported in kilograms unless otherwise noted.

The 216-Z-1A and 216-Z-9 facilities essentially received the same type of waste: high salt, acidic, aqueous and organic liquid waste. Kasper (1982) describes the waste as 5M to 6M, acidic (pH about 1.0), sodium nitrate solution. Organic liquids consisted of carbon tetrachloride (CCl_4), tributylphosphate (TBP), and dibutylbutylphosphonate (DBBP) as both saturation amounts in the aqueous phase and as separately discharged batches.

Waste disposed to the 216-Z-12 facility differed from that sent to the other two facilities. The 216-Z-12 Crib received PFP waste which was low salt, aqueous phases that were typically dilute (about 0.15M), adjusted to be slightly basic (pH about 8), sodium, fluoride, and nitrate solution (Kasper 1982). Also, the PFP process did not use organic extraction so that the large amounts of organic-radionuclide complexes disposed to 216-Z-1A and 216-Z-9 were not disposed to the 216-Z-12 Crib. Kasper (1982) says that 216-Z-12 did receive minor amounts of CCl_4 as part of laboratory waste. There is sufficient CCl_4 associated with the 215-Z-12 Crib to include the Crib in the CCl_4 Soil Vapor Extraction project.

The behavior of plutonium in the two different waste types is expected to be different and, in fact, earlier studies show much wider distribution of subsurface plutonium contamination associated with the acidic, organic waste streams than with the basic waste stream (compare the plume maps in Price et al. 1979 with those in Kasper 1982). One goal of this logging effort is to compare any subsequent changes in subsurface contamination between the two different wastes.

3.0 Site Descriptions

3.1 Site Hydrogeology

The latest update to the hydrogeology of the Z Plant area is in the *1994 Conceptual Model of the Carbon Tetrachloride Contamination in the 200 West Area at the Hanford Site* (Rohay et al. 1994). The brief description of the hydrogeology presented in this section is limited to the vadose portion of the hydrogeologic section beneath the facilities and is taken from Rohay et al. (1994) unless cited otherwise.

The vadose zone beneath the Z Plant liquid waste disposal facilities is 50 meters to 65 meters thick and consists of the Hanford formation, the Plio-Pleistocene unit, and the upper parts of the Ringold Formation (Figure 3.1). Natural recharge near these facilities has been estimated at near zero (0.1 cm/yr) in areas with established vegetation and fine-grained soils (Gee 1987; Routson and Johnson 1990; Murphy et al. 1991). The surface of the 216-Z-1A Tile Field, however, is not vegetated and was covered with gravel in the mid 1990s to reduce risk of contamination to workers. Also, the surface of the 216-Z-12 Crib is sparsely vegetated and covered with backfill material and wind blown soil. These sites may experience recharge near that of annual precipitation (up to 10 cm/yr). In addition, 216-Z-1A is a depression (see Facility Description, Section 2.0) such that rain and snow adjacent to the Tile Field will probably drain into the Tile Field.

216-Z-9 is covered by concrete and experiences no natural recharge. However, runoff from the cover may enhance recharge adjacent to the facility. Waste streams to all three facilities have been discontinued so that no man made recharge contributes to recharge immediately at the facilities although there may be some contribution at depth from other facilities. (See discussion of perched water later in this section.)

The vadose zone beneath 216-Z-1A and 216-Z-9 has been subdivided by Rohay et al. (1994) into seven hydrogeologic units. Each unit is discussed in detail in the Appendix B of their report. The units are

- H_{uf} - Hanford gravelly sand and sand (upper fine unit)
- H_{uc} - Hanford gravels (upper coarse unit)
- H_f - Hanford sand (fine unit)
- H_{lc} - Hanford sandy gravel (lower coarse unit)
- H_{lf} - Hanford interbedded silt and fine sand (lower fine unit)
- PP - Plio-Pleistocene unit (caliche among other sediment)
- R_{ge} - Ringold gravel unit E (unsaturated).

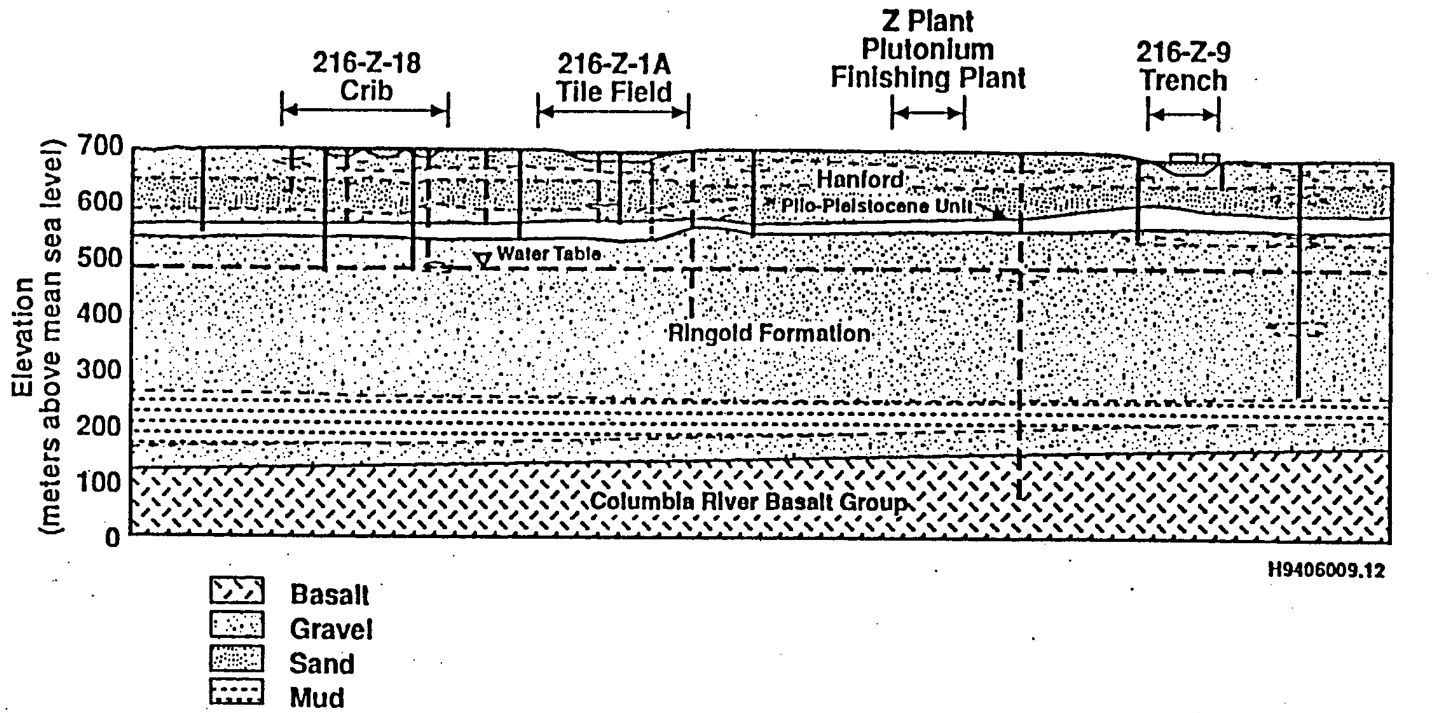

Figure 3.1. Generalized Stratigraphy Beneath the Z Plant Liquid Waste Disposal Facilities, 200 West Area, Hanford Site (from Rohay et al. 1994)

The thickness and configuration of these units vary beneath the 216-Z-1A Tile Field, the 216-Z-9 Trench, and the 216-Z-12 Crib. Figure 3.2 shows the thickness and configuration of these hydrogeologic units beneath the facilities

Perched water was found near the 216-Z-9 Trench at 28 meters to 33 meters depth in two wells in 1992 and 1993 (Rohay et al. 1992, 1993). The water was perched on the Plio-Pleistocene Unit. They postulated that the source of the water was the 216-Z-21 Pond about 40 meters southeast of the wells.

3.2 Contaminant Distributions

The extent of plutonium and americium contamination at the 216-Z-1A Tile Field is shown in Figure 3.3. That figure is from DOE (1992) but is primarily based on data in Price et al. (1979) who constructed six cross-sections showing the plutonium and americium distribution beneath the Tile Field. Their cross-sections show that contamination reached about 20 meters to 30 meters depth below the center of the Tile Field for almost the entire length of the Tile Field.

Figure 3.4 shows two cross-sections illustrating the distribution of subsurface plutonium contamination found by Kasper (1982). Kasper's results show that contamination beneath 216-Z-12 was distributed beneath the northern two-thirds of the Crib and reached approximately 17 meters depth in 1982.

Ridgway et al. (1971) collected and analyzed samples from beneath the 216-Z-9 Trench. The distribution of their samples were all within 3 meters of the crib floor. They did not plot their results on maps or cross sections but their data show significant contamination in almost all of their samples. Smith (1973) does present cross-section of ^{239}Pu and ^{241}Am analyses versus depth in several shallow (less than 3 meters) boreholes in the Trench floor. His results show significant plutonium and americium activity throughout the profiles.

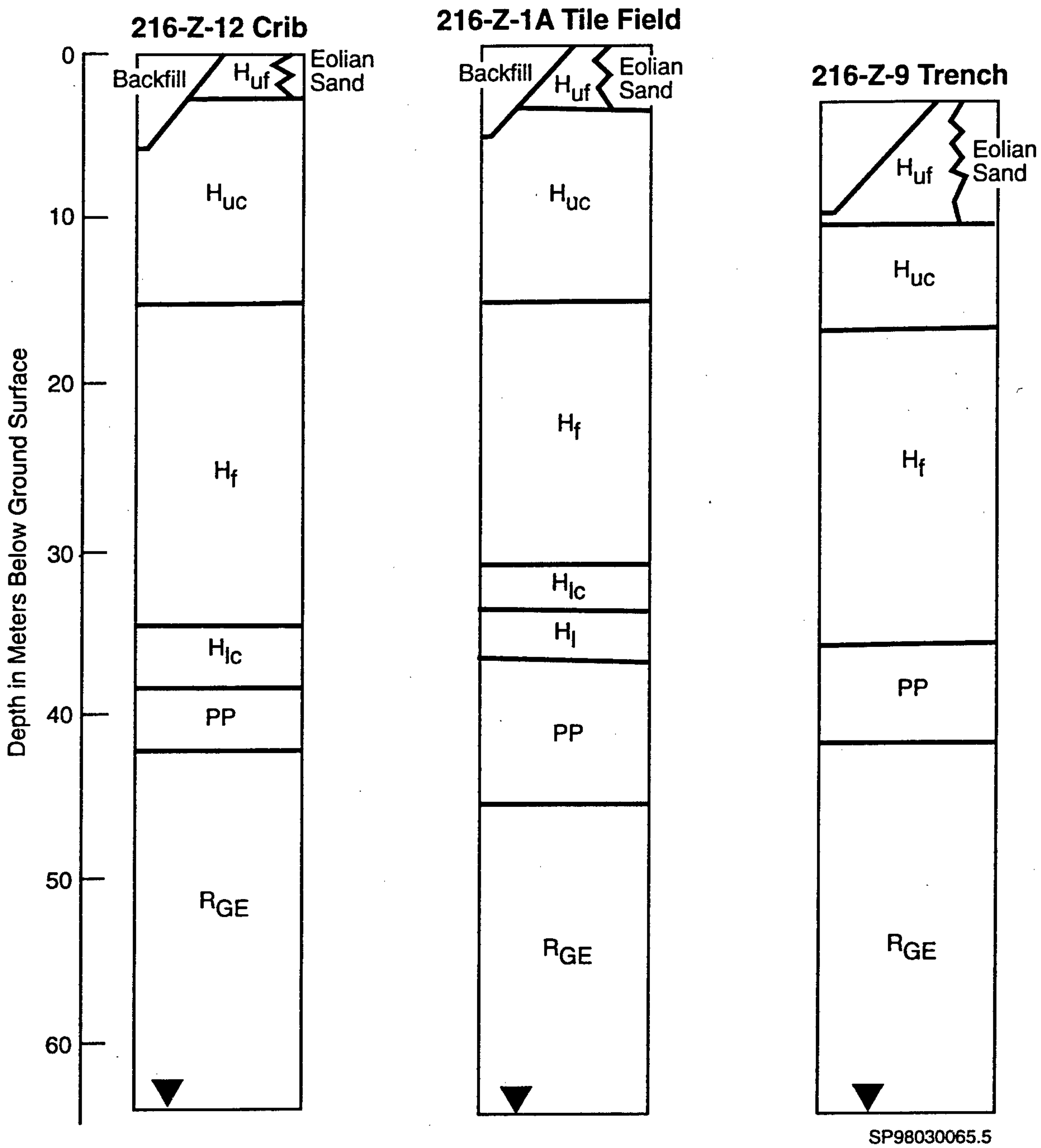

Figure 3.2. Hydrogeologic Units Beneath the 216-Z-1A Tile Field and the 216-Z-9 Trench (modified from Rohay et al. 1994) and Beneath the 216-Z-12 Crib (stratigraphy interpreted from data in Kasper 1982)

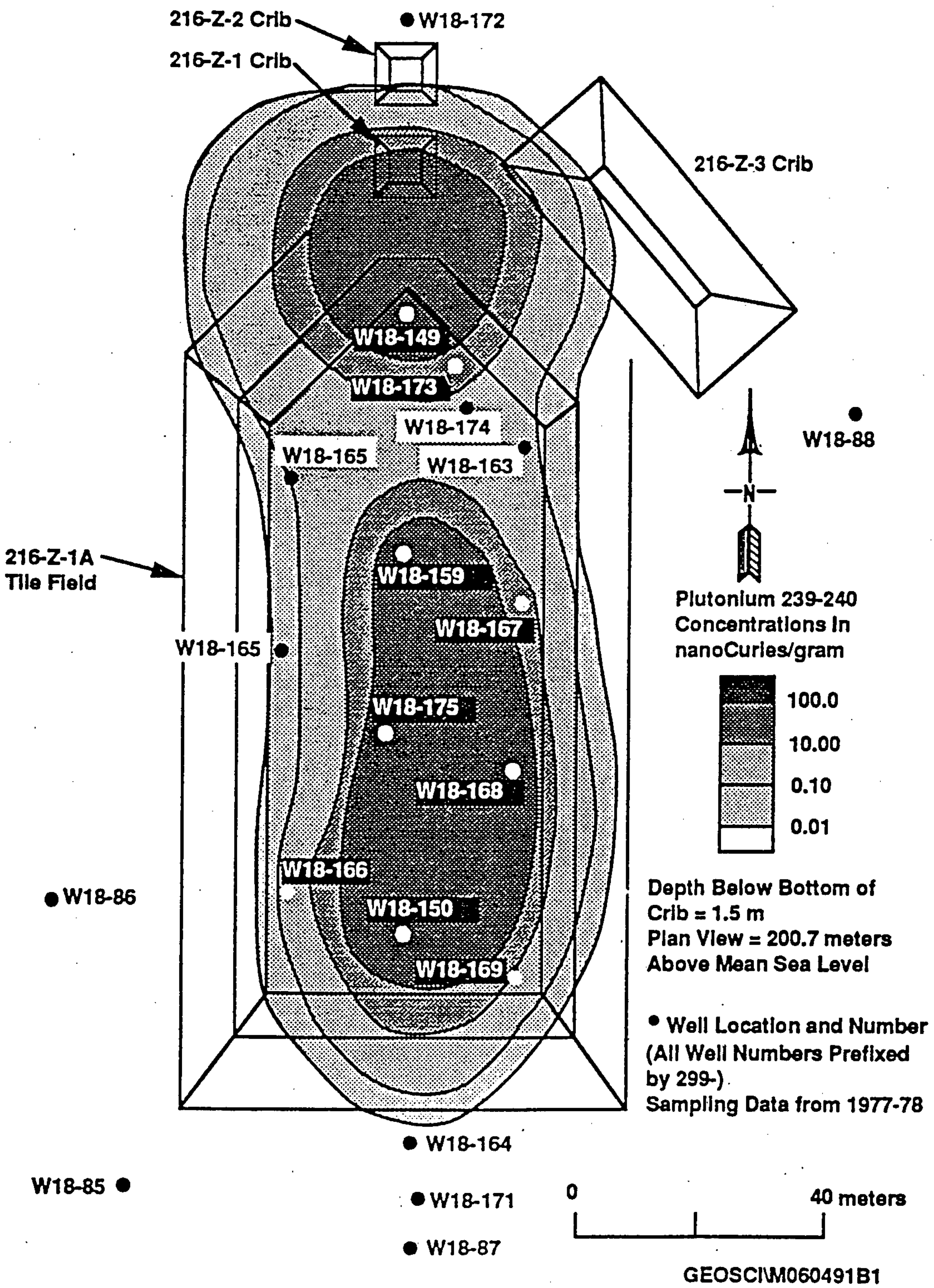

Figure 3.3. Map of Plutonium Distribution Beneath the 216-Z-1A Tile Field (modified from DOE 1992)

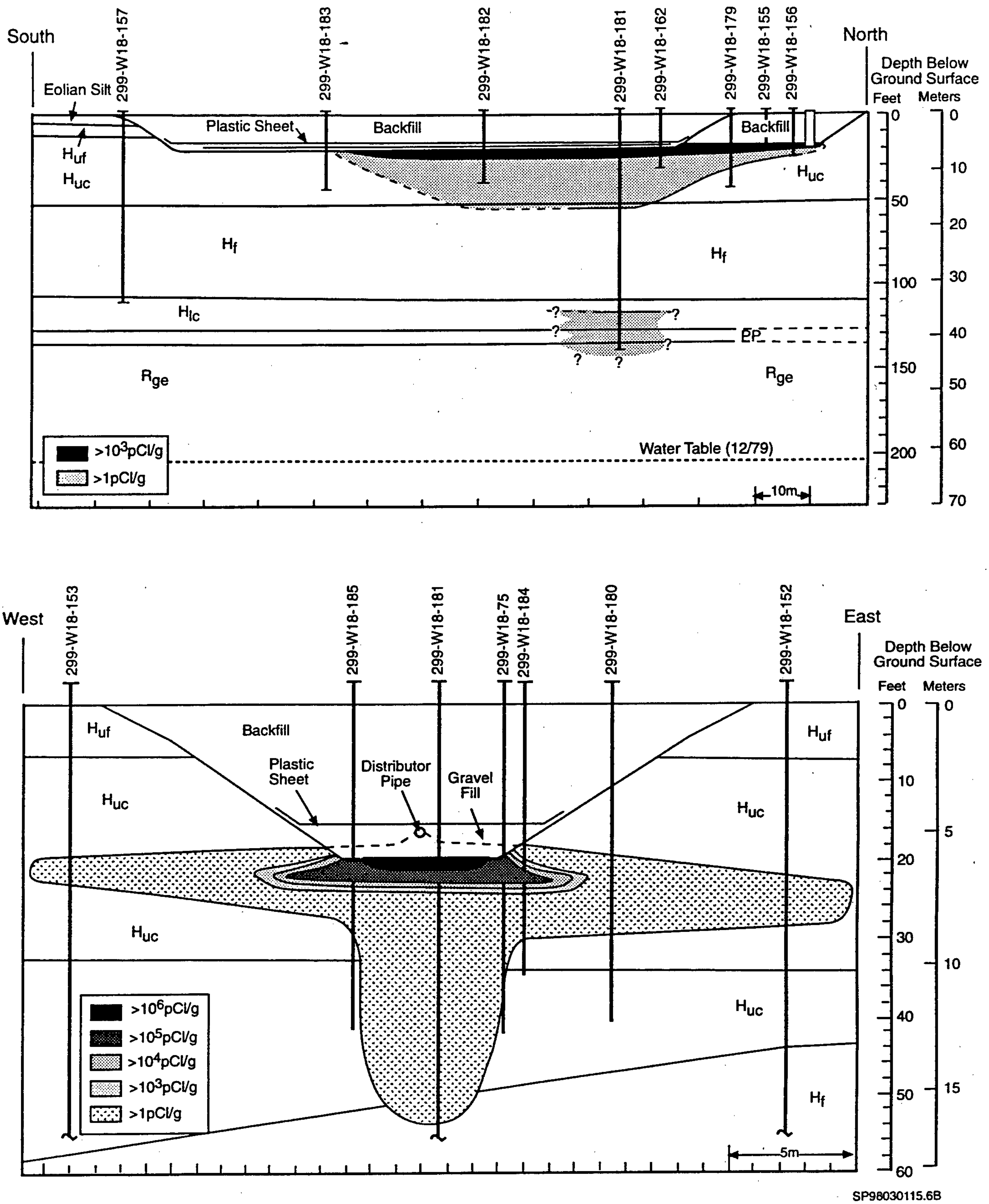

Figure 3.4. Cross Sections Through the Waste Plume Beneath the 216-Z-12 Crib (modified from Kasper 1982)

4.0 Vadose Monitoring

This section describes the specifics of the vadose monitoring to be applied to the 216-Z-1A Tile Field, the 216-Z-9 Trench and the 216-Z-12 Crib in fiscal year 1998. In summary, twenty-one boreholes are scheduled to be logged using spectral gamma methods. The logging is to be competed in March and April 1998. The Bechtel Hanford Company's Soil Vapor Extraction System is scheduled to restart at 216-Z-1A and 216-Z-12 on April 1, 1998 and at 216-Z-9 in July 1998. Borehole logging must be completed prior to the vapor extraction startup.

4.1 Objectives of Monitoring

There are three objectives of this monitoring effort. First, describe the current, subsurface configuration of gamma emitting contaminants. Second, document changes in the distribution of subsurface contaminants that have occurred since the most previous logging (or drilling, sampling and laboratory analysis) events. Third, compare differences in subsurface contaminant distribution between the 216-Z-1A and 216-Z-9 facilities, which received acidic and organic wastes, and the 216-Z-12 Crib which received basic waste.

4.2 Constituents of Interest and Detection Limits

The constituents of interest for this monitoring project are the gamma emitting radionuclides disposed to the facilities and listed on Table 2.2; namely, ^{137}Cs, ^{106}Ru, ^{60}Co, ^{241}Am, and ^{239}Pu. Of particular interest are plutonium and americium because these are by far the most abundant contaminant, with the longest half-lives of the gamma emitters (except for uranium), and they pose the potentially most significant hazard associated with the Z Plant liquid waste disposal facilities.

Table 4.1 lists the gamma emitting radionuclides that can be detected with the current spectral gamma system to be used for this logging effort. Also shown on the table is the half-life for each isotope, the energy of the major isotope-specific gamma-ray, the intensity of the major gamma-ray, and the detection limit. The detection limits in Table 4.1 are for gamma-ray emitting radionuclides in the Hanford subsurface detected through a 0.64 cm (0.25 inch) thick steel casing with a 40 second spectra collection time, a 35% HPGe detector, and full-width-at-half-maximum resolution of 2.2 KeV at 1332 KeV.

Price et al. (1979) mapped plutonium and americium distribution beneath the 216-Z-1A Tile Field down to the 10 pCi/g level and Kasper (1982) mapped plutonium distribution beneath the 216-Z-12 Crib down to the 1 pCi/g level. Although both of those studies used laboratory analyses to achieve the low detection limits, it is a goal of this project to map changes in subsurface contamination that have occurred since those studies.

Table 4.1. Detectable Radionuclides

Radionuclide	Half-Life (yr)	Major Gamma-Ray (KeV)	Gamma-Ray Intensity (percent)	Detection Threshold[(a)] (pCi/g)
K-40	1.3×10^9	1460.8	10.7	2.0
Nat. Uranium	4.5×10^9	609.3	46.1	0.4
Nat. Thorium	14.1×10^9	2614.5	35.8[(b)]	0.7
Co-60	5.3	1332.5	100	0.2
Ru-106	1.02	622.0	9.8	1.8
Sb-125	2.7	428.0	29.6	0.6
Sb-126 (Sn-126)	10,000	695.1	99.7	0.2
Cs-134	2.06	604.7	97.6	0.2
Cs-137	30.2	661.6	84.6	0.2
Eu-152	12.7	1408.1	21.1	1.0
Eu-154	8.5	1274.8	35.5	0.6
U-235	0.7×10^9	185.7	54.0	0.5
U-238	4.5×10^9	1001.0	0.8	24.
Pa-233 (Np-237)	2.1×10^6	311.9	33.7	0.5
Pu-239	24,000	413.7	0.00151	4950.0
Pu-241	15.2	98.4	0.0022	26,000.0
Am-241	433	59.5	36.3	40.0

(a) Detection threshold for 0.25 inch steel casing, 35% HPGe detector and 40 second sample time.
(b) Branching ratio: 35.8% from Bi-212 to Tl-208 included.

To improve the detection limits shown in Table 4.1, three alternative logging schemes were considered. The first option involved simultaneous use of a NaI and a HPGe detectors. This array would be used to log each borehole at a relatively high count rate of about 100 seconds/foot. The HPGe generated spectra would be used to identify specific isotopes but could only quantify them to about the levels on Table 4.1. The NaI spectra would generate a gross gamma spectra that would be sensitive to total activities less than the capabilities of the HPGe detector but would not have the isotopic specific resolution of the HPGe detector.

The second option involved logging each borehole with the 35% HPGe detector at the relatively fast logging speed of about 50 seconds/foot. The resulting spectra would identify the specific isotopes present and the depths in the boreholes where the relatively high detection limit (resulting from the fast count times) was exceeded. A second logging run would be made, at a much slower logging speed of about 400 seconds/foot over those depths that were below the detection limit of the first logging run.

The third option is to log each borehole once using the 35% HPGe detector at the fairly slow logging speed of 100 seconds/foot. This is essentially the same as the first option without the NaI spectra.

After considering the above options it was decided that a modified version of the second option will yield the optimum data to determine changes in subsurface contamination while remaining within the time and budget constraints for the project. The modified logging scheme is described in Section 4.5. The final detection limits achieved for plutonium and americium will not equal those obtained by the laboratory studies (Price et al. 1979; Kasper 1982) but will be lower than those shown in Table 4.1 by about a factor of 2. The magnitude of the detection limits are a function of environmental variables, such as casing thickness, and the counting times (as well as being isotope specific). Specific detection limits will be determined at the time of logging and reported with the logging results.

One additional action will be taken to reduce detection limits. The casing thickness for each well will be measured in the field by caliper (and by an ultrasonic wall thickness tester if one can be located) to determine the exact casing correction that needs to be applied to the results from each specific borehole. This will ensure that too large of a casing correction will not be applied such that detection limits are increased and results are biased as smaller than reality.

In addition to isotope specific activities, gross gamma activity is a parameter of interest. The gross gamma activity will be obtained by summing the intensity of each separate photon energy. The gross gamma logs can be qualitatively compared to previously obtained gross gamma logs to help discern any movement by subsurface contamination.

4.3 Monitoring Points (Boreholes)

Thirty-two primary and fifteen alternate boreholes were initially chosen to evaluate for gamma logging at 216-Z-1A, 216-Z-9, and 216-Z-12. These initial boreholes were chosen based on

- Location relative to the facility

- Location relative to subsurface contamination

- Availability of historical gamma ray spectra and laboratory data for comparison.

- Superficial evaluation of well construction

Each well on the initial list was then evaluated for logging quality by reviewing information found in driller's logs, borehole construction reports, as-builts, and documentation of alterations made to the well subsequent to their its original construction. Based on the results of these evaluations, twenty-one boreholes were selected for logging (Table 4.2). Figures 4.1, 4.2, and 4.3 show their locations. The reason for most of the rejected boreholes was unknown construction characteristics such as unknown details concerning seals or the number of well casings which could render the logging results unquantifiable. A few boreholes were rejected because of packers or other obstructions in the boreholes and a few were rejected

Table 4.2. Wells to be Logged at Z Plant Waste Disposal Facilities

Well Number	Comments
216-Z-1A Tile Field	
299-W18-149	***Scheduled for logging***, requires Field Inspection Report (FIR)
299-W18-150	Internal contamination, well used for vapor extraction
299-W18-158	***Scheduled for logging***, well used for vapor extraction, packer in the well will be pulled and replaced
299-W18-159	***Scheduled for logging***, well used for vapor extraction
299-W18-163	Downhole packer in well, well used for vapor extraction
299-W18-164	Type and depth of seal, and existence of filler between casings not documented.
299-W18-165	Two strings of casing with cement grout filler to 122 feet, well used for vapor extraction
299-W18-166	Two strings of casing with cement grout filler to 124 feet, well used for vapor extraction
299-W18-167	***Scheduled for logging***, well used for vapor extraction
299-W18-168	***Scheduled for logging***, well used for vapor extraction
299-W18-169	***Scheduled for logging***, well used for vapor extraction
299-W18-172	Well is in area marked "Cave-in-potential"
299-W18-173	***Scheduled for logging***, requires RCT support, alpha contaminated borehole
299-W18-175	***Scheduled for logging***, requires RCT support, alpha contaminated borehole, well used for vapor extraction
216-Z-9 Trench	
299-W15-6	Three strings of casing to 164 feet, well used for vapor extraction, well is to be decommissioned
299-W15-8	Multiple casing strings with cement grout filler, well used for vapor extraction
299-W15-9	Multiple casing strings with cement grout filler, well used for vapor extraction
299-W15-82	***Scheduled for logging***, well used for vapor extraction
299-W15-84	***Scheduled for logging***, well used for vapor extraction
299-W15-85	***Scheduled for logging***, well used for vapor extraction
299-W15-86	Three strings of casing, well used for vapor extraction
299-W15-95	***Scheduled for logging***, well used for vapor extraction
216-Z-12 Crib	
299-W18-8	***Scheduled for logging***, requires FIR and swabbing to establish contamination levels
299-W18-152	***Scheduled for logging***, requires FIR, well used for vapor extraction
299-W18-153	***Scheduled for logging***, well used for vapor extraction
299-W18-156	***Scheduled for logging***, borehole is under the PFP fence, requires FIR and swabbing to establish contamination levels
299-W18-179	***Scheduled for logging***, requires FIR and swabbing to establish contamination levels
299-W18-180	No well construction and summary information
299-W18-181	***Scheduled for logging***, requires FIR and swabbing to establish contamination levels
299-W18-182	***Scheduled for logging***, requires FIR and swabbing to establish contamination levels
299-W18-183	***Scheduled for logging***, requires FIR and swabbing to establish contamination levels
299-W18-184	No well construction and summary information
299-W18-185	***Scheduled for logging***, requires FIR and swabbing to establish contamination levels

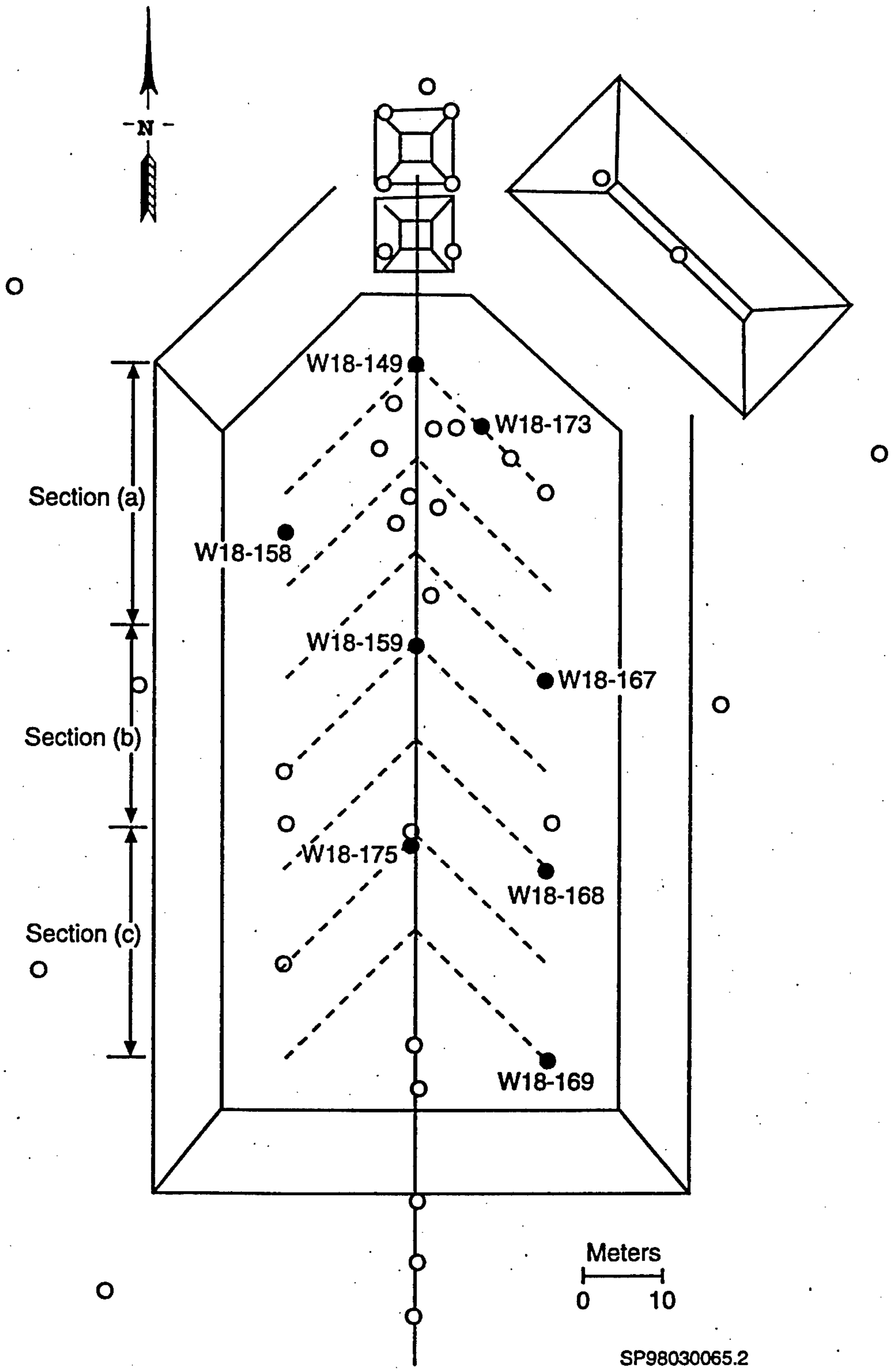

Figure 4.1. Map Showing the Location of Boreholes at the 216-Z-1A Tile Field that are Scheduled for Logging (modified from Price et al. 1979)

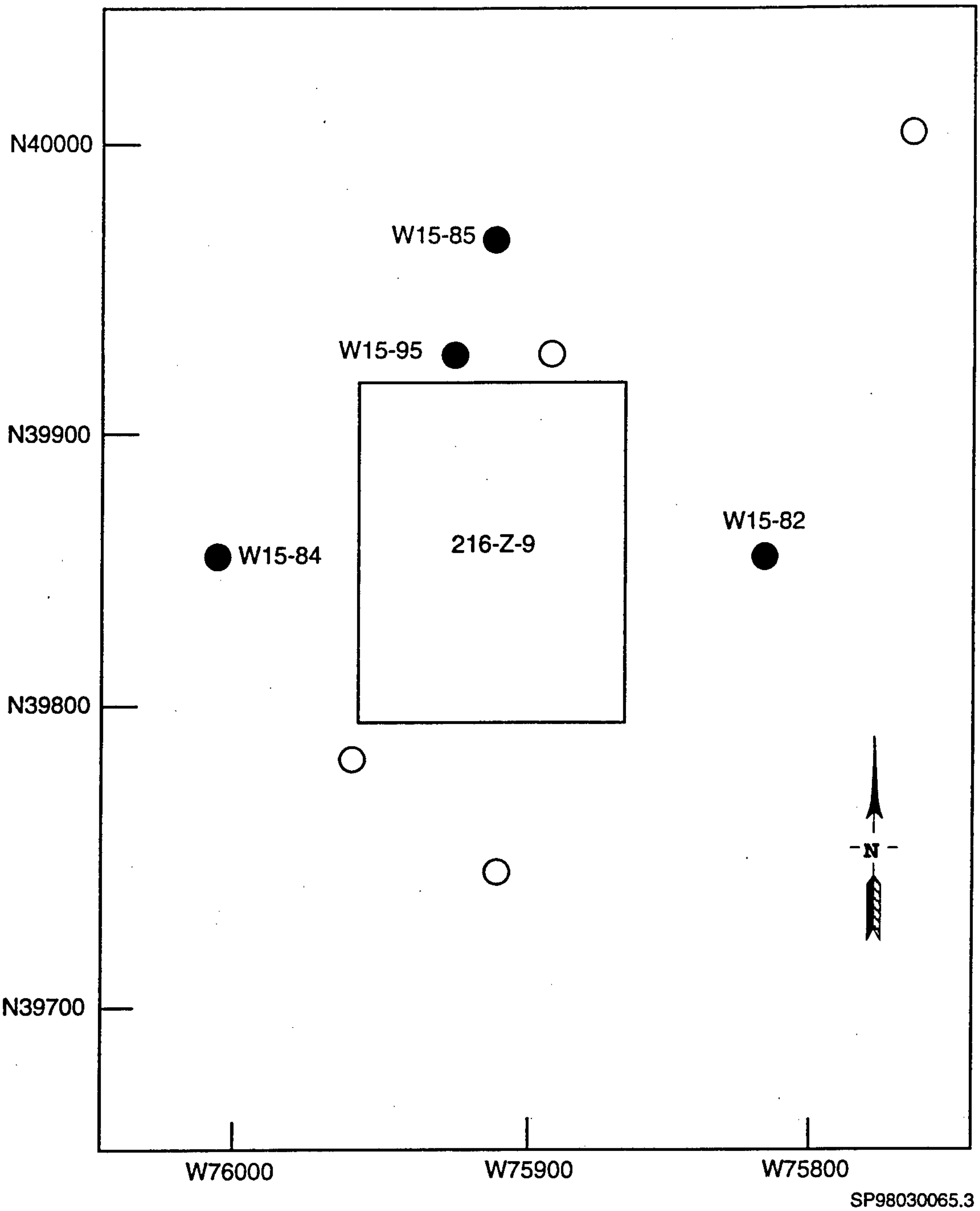

Figure 4.2. Map Showing the Location of Boreholes at the 216-Z-9 Trench that are Scheduled for Logging (modified from Fecht et al. 1977)

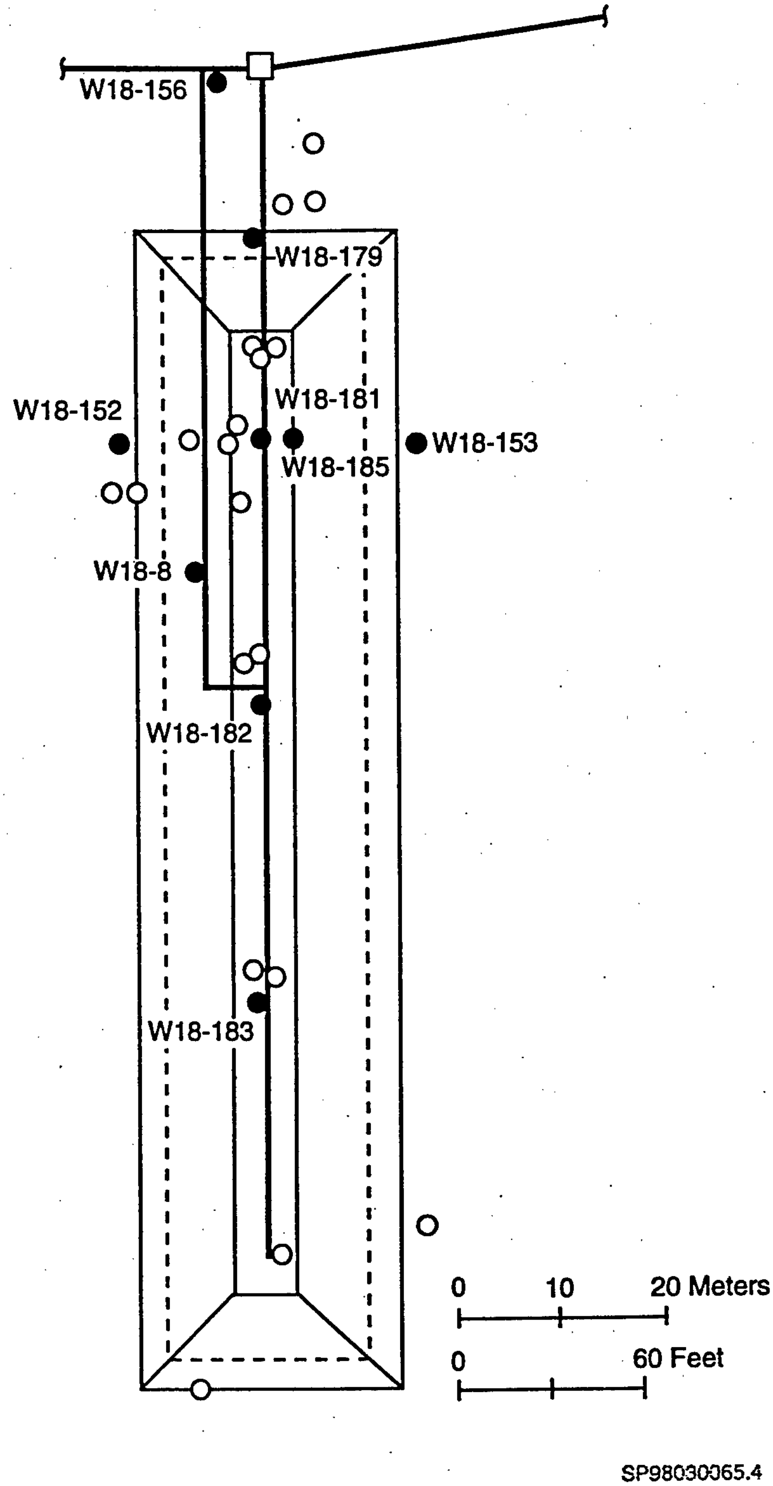

Figure 4.3. Map Showing the Location of Boreholes at the 216-Z-12 Crib that are Scheduled for Logging (modified from Kasper 1982)

because they have been decommissioned. Well Construction and Summary Reports are in Appendix B of this document for boreholes scheduled to be logged except for boreholes 299-W18-179, 299-W18-181 through -183, and 299-W18-185 for which no Well Summary Reports can be found.

4.4 Pre-Logging Field Activities

Several activities need to be accomplished before geophysical logging can begin. Field operations in preparation for logging will be done by WMNW under PNNL direction. The following activities must be completed.

- The boreholes to be logged are to be temporarily transferred to PNNL custody from the custody of the BHI Soil Vapor Extraction operation. The transfer will take place as per BHI Field Support Administration Procedure No. 1.15. The same procedure also documents the need for RCT support and the RWP number covering the work. The boreholes will be transferred back to BHI custody after logging.

- Radiation Control Technologist (RCT) support is needed for the following activities.

  - Generate an RWP for the project
  - Swabbing of wells for check of internal contamination
  - Removal of packer in well 299-W18-158
  - Check surface of casing and tagging tools as wells are unbolted
  - Check wipes and logging cable between logging events
  - Uncap, log, and recap of wells 299-W18-173 and 299-W18-175.

- Support from PFP Security is needed for well 299-W18-156. The well is directly underneath the outside PFP perimeter fence.

- Boreholes that are part of the Soil Vapor Extraction operation will need the cap on the boreholes unbolted and removed. The boreholes must be returned to their pre-logging configuration after logging is complete.

- Boreholes that have not been entered recently must have a completed Field Inspection Report and must be swabbed for internal contamination.

- Borehole 299-W18-152, 299-W18-167, and 299-W18-168 must be prepared and logged first to avoid conflicts with the Soil Vapor Extraction project.

4.5 Monitoring Method - Spectral Gamma-Ray Logging

The Radionuclide Logging System (RLS) will use a 35% efficient high purity germanium (HPGe) gamma-ray detector. A winch on the back of the RLS vehicle will move the tool through the borehole for data collection. Detector depth will be monitored and controlled by computer. A multichannel analyzer and a computer in the RLS vehicle will receive the spectra from the detector and store the data along with the depth from which it was acquired for future data processing.

Boreholes that have a total depth of 50 feet or less will be logged with the 35% HPGe tool at a rate of 400 seconds/foot. A screening approach will be used for boreholes greater than 50 feet total depth. Screening will consist of a high speed log run of 100 seconds/foot with the 35% HPGe tool. At the conclusion of the logging run, the technician will review the log and select the lowest depth high-count zone in the borehole. The zone will be selected as the zone below which count rates for the isotopes of concern appear to fall below the detection limits of the current logging mode. The logging tool will be repositioned in this zone and a long count time (800 seconds) will be executed at this precise depth. This point will serve as the start point for relogging.

Subsequent log analysis of the data from the first run will be conducted for identification of 1) the gamma emitting isotopes in the borehole, 2) the detection limits for each isotope based on counting times, casing thickness and logging tool used, 3) depths in the borehole where the identified isotopes fall below detection limits, and 4) isotopes present, concentrations and depths for the 800 second count point. This data will provide the basis for the overlap/repeat logging below the long count zone. Repeat logging for extended counting times is for the purpose of lowering the detection limits and accurately identifying the deepest points of gamma emitting radionuclides in the well.

The overlap/repeat logging will be conducted with the 35% HPGe tool at 400 seconds/foot (or with the 70% HPGe tool, if available, at count times specified by the log analyst). The total length and number of overlap/repeat logging runs will be based on the analyst's review of the screening pass. The time required to relog and the number of zones will be controlled with considerations for budget, schedule, and defensible resolution of the detection limits and depth of detectable contamination. At the conclusion of the extended count time log runs, the log analyst will conduct data reduction and provide a well report consisting of 1) the gamma emitting isotopes identified in the borehole, 2) the detection limits for each isotope based on count times, casing thickness and logging tool used, 3) depths in the borehole where the detected isotopes fall below detection limits, 4) a graphic display of data by depth (well log), and 5) standard analytical summary report for the individual borehole including results of the long count time run.

4.5.1 Detector Calibration

The HPGe detector used for this logging effort will have a current Calibration Certificate documenting that it has been calibrated according to the methods in Randall (1994). Measurements for the calibration are acquired in the borehole calibration models located east of the 200 West Area. The construction of those models is documented in Stromswold (1994b). Four calibration models are available for calibrating spectral gamma-ray detectors. The models contain varying mixtures of the natural radionuclides potassium, uranium, and thorium. The borehole size is 4.5 in. The boreholes are uncased and calibration measurements are made with the borehole air-filled.

4.5.2 Detector Verification

Pre- and post-logging calibration/verification will be done for each logging event and the results will be documented on the log header sheet. The measurements are made by attaching a sealed and unregulated quantity of radioactive material to the outside of the logging probe at a repeatable position. After collecting a spectra, the field verification assembly is removed to a remote location and a background spectra is collected. The difference between the two spectra represents the contribution from the verification assembly. The field verification spectra are analyzed during data processing to confirm that the equipment performance was within specifications. If calibration/verification results fall outside of the established acceptance criteria any deficiencies with the detector will be corrected, and if necessary the detector will be recalibrated, prior to continued logging. The acceptance criteria are documented at WMNW (WMNW-CM-004, Attachment D).

4.5.3 Replicate Logging

A minimum of ten feet in each borehole will be relogged as a replicate analysis. As nearly as practicable, the replicate logging runs will be measured and analyzed in the same manner as associated data. The start and stop depth intervals of the repeat will be selected from the response identified on the main log. The replicate logs are a quality control check on precision and stability of the detector and electronics.

4.6 Data Reduction and Analysis

The LGCALC software and associated subroutines will be used to read the digital data, analyze the spectrum (locate peaks and correct for background), identify radionuclides, correct for casing thickness, calculate radionuclide activity, sum all channels for "gross gamma" values, and generate borehole log plot, and analyst's findings and comments. The main LGCALC program and it's subroutines were tecnically reviewed by Stromswold (1994a) for appropriateness, correctness, completeness and coding accuracy. Stromswold ran the programs with test data and confirmed that the programs operate correctly.

Analysis of each raw survey spectra will be as follows (Price 1998):

1. A check of the gamma-ray energy conversion coefficient of each spectra is made by identifying the gamma-ray photo-peaks from the natural radionuclides and adjusting the channel-to-energy conversion coefficient.

2. The HPGe spectra is scanned for all gamma-ray peaks present and the net area (gross counts less background counts) of each peak is computed.

3. The gamma-ray peaks are matched with peaks in a processing library to identify the radionuclide and compute the concentration. The library contains the radionuclide names, gamma-ray energies, and gamma-ray intensities.

4. Gamma-ray peaks that were not matched in the processing library are reexamined first by the algorithm and then, if they are still not matched, by the analyst.

5. The areas of identified gamma-ray peaks are corrected for casing thickness and borehole fluid (water or air) and the concentration is computed. The water depth, borehole size, and casing thickness are input by the analyst. Uncertainties from counting statistics are computed and reported with the radionuclide concentration.

   If an identified radionuclide has multiple gamma-rays, the concentration from each gamma-ray in the spectra is computed and recorded in a file. The concentration reported in the results file is the concentration with the lowest uncertainty.

5.0 Quality Assurance and Quality Control

5.1 Organization and Responsibilities

The Applied Geology and Geochemistry Group of PNNL has primary responsibility for overseeing this monitoring activity. Field work and geophysical logging will be subcontracted to WMNW. Health Physics support will be provided by BHI. Support from PFP Security is needed to log well 216-W18-156 which is located under the PFP perimeter fence.

5.2 Data Collection and Data Reduction

The quality assurance requirements in WMNW-CM-004, Section 17.0 and in WMNW-QAPP-001 will govern all aspects of data collection and data reduction for this monitoring effort. Specific Standard Operating procedures covering the work are

- Data acquisition - WMNW-CM-004, 17.0, Attachment A
- Data storage and security - WMNW-CM-004, 17.0 Attachment C
- Data reduction, verification, and reporting - WMNW-CM-004, 18.0
- Quality control and acceptance criteria - WMNW-CM-004, 17.0, Attachment D
- Document control - WMNW-CM-004, 17.0
- Calibration practices and standards - WMNW-CM-004, 17.0, Attachment E
- Equipment maintenance - WMNW-CM-004, 17.0
- Qualifications of personnel and training - WMNW-CM-004, 17.0.

Deviations from documented procedures may be necessary due to field conditions or other unplanned situations. Any deviations will be documented.

5.3 Performance and System Audits and Corrective Actions

All activities addressed by this monitoring plan are subject to surveillances of project performance and systems adequacy. Surveillances shall be conducted in accordance with appropriate PNNL or WMNW procedures.

Corrective action requests required as a result of surveillance reports shall be documented and dispositioned as required by standard PNNL and WMNW corrective action procedures. Primary responsibilities for corrective action resolution are assigned to the technical lead.

6.0 Data Interpretation and Reporting

The basic question of whether or not the subsurface distribution of contaminants has changed since they were last measured will be addressed in several ways. First, comparisons will be made between the logs collected by this effort with logs collected during past efforts. Data will be adjusted to the same scale for comparisons. Detection limits and analytical errors will be available for the more recent data. Where this information is available for past logs quantitative or semi-quantitative comparisons may be made. Quantitative comparisons probably will not be able to be made using older data because associated errors, calibration information, and detection limits are generally not available.

A similar approach using historic laboratory analytical data will be done as with the older logging data. Analytical error values are associated with the past laboratory data so that more quantitative comparisons can be made. The detection limits that were achievable during past laboratory studies are much less than those achievable for this logging effort, however. This will limit the comparisons that can be made.

The results of the data evaluation and interpretation will be a series of cross-sections and maps depicting the current distribution of contamination at each of the logged facilities and, if possible, a series of maps and cross-sections depicting changes in subsurface contamination.

7.0 Data Management

The data resulting from this data collection effort will be assimilated in two ways. First, a hard copy data package containing all Log Header Files, work sheets, control charts, Borehole Survey Data Sheets, and pertinent pages of log notebooks will be assembled and transmitted to PNNL. Logging results will be included in the hard copy data package and will include 1) references to associated electronic data files for both the raw data and the processed data, 2) interpretative data plots of activities or concentrations versus depth for each borehole logged, and 3) summary narratives discussing pertinent activities associated with the logging effort.

Repeat logs (including associated references to electronic files, interpretive plots, and summary narratives) will be included in the data packages as well as all associated calibration and QC information pertinent to the logging events.

In addition to hard copy data, electronic files of Log Header Files, raw data, processed data, QC data (if available), and Summary narratives will be placed on CD-ROM media for archive and for transmittal to PNNL. Copies of both the hard copy data package and the CD-ROMs will be incorporated in the PNNL geophysical data library.

The following document control requirements are applicable to this monitoring effort.

- All data supporting this Monitoring Plan and ensuing results will be maintained in a safe and secured manner such that reconstruction of processed data from raw data, reconstruction of interpretive data from processed data, and reconstruction of interpretations of subsurface contamination will be possible.

- All preprinted forms and log book entries shall be signed and dated by the person responsible for the activity at the time it was performed. All entries will be made in ink and any corrections will be made such that no information is rendered unreadable.

- The original of all data will be kept by WMNW and copies kept in the PNNL Geophysical Logging Library.

8.0 References

Additon, M. K., K. R. Fecht, T. L. Jones, and G. V. Last. 1978a. *Scintillation Probe Profiles 200 East Area Crib Monitoring Wells.* RHO-LD-28, Rockwell Hanford Operations, Richland, Washington.

Additon, M. K., K. R. Fecht, T. L. Jones, and G. V. Last. 1978b. *Scintillation Probe Profiles 200 West Area Crib Monitoring Wells.* RHO-LD-29, Rockwell Hanford Operations, Richland, Washington.

Brodeur, J. R., C. J. Koizumi, and K. R. Price. 1991a. *Borehole Logging Activity Report for Interim Response Action: Carbon-Tetrachloride Vapor Extraction.* Internal Memo 81232-91-021, Westinghouse Hanford Company, Richland, Washington.

Brodeur, J. R., C. J. Koizumi, and K. R. Price. 1991b. *Borehole Logging Activity Report for Crib Z-20.* Internal Memo 81232-91-028, Westinghouse Hanford Company, Richland, Washington.

Brodeur, J. R., R. K. Price, R. D. Wilson, and C. J. Koizumi. 1993. *Results of Spectral Gamma-Ray Logging of Select Boreholes for the Aggregate Area Management Study.* WHC-SD-EN-TI-021, Westinghouse Hanford Company, Richland, Washington.

Buelt, J. L, C. L. Timmerman, and J. G. Carter. 1989. *Results of Large-Scale In Situ Vitrification at Transuranic-Contaminated 216-Z-12 Crib.* Draft Letter Report, Pacific Northwest Laboratory, Richland, Washington.

Chamness, M. A, S. S. Teel, D. L. McAlister, A. W. Pearson, K.R.O. Barton, R. W. Fruland, and R. E. Lewis. 1991. *Z Plant Geologic and Geophysics Data Package for the 200 Aggregate Area Management Study.* WHC-SD-EN-DP-020, Westinghouse Hanford Company, Richland, Washington.

DOE. 1992. *Z Plant Source Aggregate Area Management Study Report.* DOE/RL-91-58, Department of Energy, Richland Operations Office, Richland, Washington.

Fecht, K. R., G. V. Last, and K. R. Price. 1977. *Evaluation of Scintillation Probe Profiles From 200 Area Crib Monitoring Wells.* ARH-ST-156, Atlantic Richfield Hanford Company, Richland, Washington.

Gee, G. W. 1987. *Recharge at the Hanford Site: Status Report.* PNL-6403, Pacific Northwest Laboratory, Richland, Washington.

George, D.C., and R. D. Wilson. 1994. *Demonstration of Prompt Fission Neutron Logging Tool Response to Fissile Elements.* Unpublished manuscript.

Kasper, R. B. 1981. *216-Z-12 Crib Status Report.* RHO-LD-166, Rockwell Hanford Operations, Richland, Washington.

Kasper, R. B. 1982. *216-Z-12 Transuranic Crib Characterization: Operational History and Distribution of Plutonium and Americium.* RHO-ST-44, Rockwell Hanford Operations, Richland, Washington.

Murphy, E. M., J. E. Szecsody, and S. J. Phillips. 1991. *Moisture Content and Recharge Estimates at the Yakima Barricade Borehole.* PNL-SA-20155, Pacific Northwest Laboratory, Richland, Washington.

Price, S. M, R. B. Kasper, M. K. Addition, R. M. Smith, and G. V. Last. 1979. *Distribution of Plutonium and Americium Beneath the 216-Z-1A Crib: A Status Report.* RHO-ST-17, Rockwell Hanford Operations, Richland, Washington.

Price, R. K. 1998. *In Situ Spectral Gamma-Ray Survey Results of Selected Boreholes Associated with B-BX-BY Tank Farm Reassessment.* Attachment to letter WMNW-9759114, from Waste Management Federal Services, Inc. Northwest Operations to Pacific Northwest National Laboratory.

Randall, R. R. 1994. *Calibration of the Radionuclide Logging System Germanium Detector.* WHC-SD-EN-TI-292, Westinghouse Hanford Company, Richland, Washington.

Ridgway, K. R., M. D. Veatch, and D. T. Crawley. 1971. *216-Z-9 Crib History and Safety Analysis.* ARH-2207, Atlantic Richfield Hanford Company, Richland, Washington.

Rohay, V. J., G. V. Last, V. L. King, and L. A. Doremus. 1992. *FY92 Site Characterization Status Report and Data Package for the Carbon Tetrachloride Site.* WHC-SD-EN-TI-063, Rev.0, Westinghouse Hanford Company, Richland, Washington.

Rohay, V. J., K. J. Swett, V. M. Johnson, G. V. Last, D. C. Lanigan, and L. A. Doremus. 1993. *FY93 Site Characterization Status Report and Data Package for the Carbon Tetrachloride Site.* WHC-SD-EN-TI-202, Westinghouse Hanford Company, Richland, Washington.

Rohay, V. J., K. J. Swett, and G. V. Last. 1994. *1994 Conceptual Model of the Carbon Tetrachloride Contamination in the 200 West Area at the Hanford Site.* WHC-SD-EN-TI-248, Westinghouse Hanford Company, Richland, Washington.

Routson, R. C., and V. G. Johnson. 1990. *Recharge Estimates for the Hanford Site 200 Areas Plateau.* Northwest Science, v. 64, no. 3, pp. 150-158.

Smith, A. E. 1973. *Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench.* ARH-2915, Atlantic Richfield Hanford Company, Richland, Washington.

Stromswold, D. C. 1994a. *Technical Evaluation of Software for Gamma-Ray Logging System.* PNL-9807, Pacific Northwest Laboratory, Richland, Washington.

Stromswold, D. C. 1994b. *Calibration Facilities at Hanford for Gamma-Ray and Fission-Neutron Well Logging.* PNL-9958, Pacific Northwest Laboratory, Richland, Washington.

WMNW. 1997. *Operational Environmental Monitoring*, WMNW-CM-004, Section 17.0, Geophysical Logging.

WMNW. 1997. *Quality Assurance Program Plan for Project Hanford Management Contract Work*, WMNW-QAPP-001.

WMNW. 1998. *Operational Environmental Monitoring,* WMNW-CM-004, Section 18.0, Geophysical Log Data Analysis.

Wood, V. W. 1958. *Index of CPD Crib Building Numbers - Designs of CPD Radioactive Liquid Wastes Disposal Sites, Part II, Z Plant.* HW-55176- Part II, General Electric Hanford Atomic Products Operation, Richland, Washington.

Appendix A

BOREHOLE	LOG RUN	DATE	TOP	BOTTOM	LOGGED BY
216-Z-1A					
299-W18-6	NAT. GAMMA	2/25/66	0	205	PNL
299-W18-6	NAT. GAMMA	5/11/72	5	188	PNL
299-W18-6	DENSITY	6/21/72	3	188	PNL
299-W18-6	NEUTRON	2/23/73	4	187	PNL
299-W18-6	NAT. GAMMA	2/11/83	2	200	PNL
299-W18-7	NAT. GAMMA	3/18/60	0	268	PNL
299-W18-7	NEUTRON	6/7/61	0	198	PNL
299-W18-7	NAT. GAMMA	10/14/61	0	220	PNL
299-W18-7	NEUTRON	10/14/61	0	195	PNL
299-W18-7	NAT. GAMMA	2/22/64	0	232	PNL
299-W18-7	NEUTRON	1/19/66	0	197	PNL
299-W18-7	NAT. GAMMA	2/25/66	0	207	PNL
299-W18-7	NEUTRON	4/22/69	0	202	PNL
299-W18-7	NAT. GAMMA	4/26/69	0	212	PNL
299-W18-7	NAT. GAMMA	5/11/72	4	212	PNL
299-W18-7	DENSITY	6/21/72	3	212	PNL
299-W18-7	NEUTRON	2/23/73	4	212	PNL
299-W18-7	NAT. GAMMA	9/22/82	2	206	PNL
299-W18-7	NAT. GAMMA	7/20/83	0	273	PNL
299-W18-7	GROSS GAMMA	3/8/88	2.6	202.2	PNL
299-W18-7	CALIPER	3/8/88	3.8	200	PNL
299-W18-56	NAT. GAMMA	8/18/59	0	148	PNL
299-W18-56	NAT. GAMMA	10/14/61	0	149	PNL
299-W18-56	NAT. GAMMA	4/30/69	0	149	PNL
299-W18-56	NEUTRON	4/30/69	0	149	PNL
299-W18-57	NAT. GAMMA	8/18/59	0	149	PNL
299-W18-57	NAT. GAMMA	10/14/61	0	149	PNL
299-W18-57	NAT. GAMMA	12/11/61	0	149	PNL
299-W18-57	NAT. GAMMA	1/30/62	0	123	PNL
299-W18-57	NEUTRON	4/30/69	0	144	PNL
299-W18-58	NAT. GAMMA	8/18/59	0	150	PNL
299-W18-58	NAT. GAMMA	10/14/61	0	150	PNL
299-W18-58	NEUTRON	10/14/61	0	148	PNL
299-W18-58	NAT. GAMMA	1/12/62	2	152	PNL
299-W18-58	NAT. GAMMA	9/14/63	0	99	PNL
299-W18-59	NAT. GAMMA	8/18/59	0	148	PNL
299-W18-59	NAT. GAMMA	10/14/61	0	148	PNL
299-W18-59	NEUTRON	10/14/61	0	146	PNL
299-W18-59	NAT. GAMMA	9/21/63	0	90	PNL
299-W18-59	NAT. GAMMA	4/30/69	0	148	PNL
299-W18-59	NEUTRON	4/30/69	0	146	PNL
299-W18-66	NEUTRON	10/14/61	0	148	PNL
299-W18-66	NAT. GAMMA	7/20/82	4	149	PNL
299-W18-76	NAT. GAMMA	4/30/69	0	16	PNL
299-W18-76	NEUTRON	4/30/69	0	16	PNL
299-W18-77	NOT LOGGED				
299-W18-78	NAT. GAMMA	4/30/69	0	13	PNL
299-W18-78	NEUTRON	4/30/69	0	12	PNL

BOREHOLE	LOG RUN	DATE	TOP	BOTTOM	LOGGED BY
299-W18-79	NOT LOGGED				
299-W18-80	NOT LOGGED				
299-W18-81	NAT. GAMMA	4/30/69	0	37	PNL
299-W18-81	NEUTRON	4/30/69	0	35	PNL
299-W18-85	NEUTRON	1/19/66	0	149	PNL
299-W18-85	NAT. GAMMA	2/25/66	0	150	PNL
299-W18-85	NEUTRON	1/13/68	0	149	PNL
299-W18-85	NEUTRON	4/22/69	0	149	PNL
299-W18-85	NAT. GAMMA	4/26/69	0	149	PNL
299-W18-85	NAT. GAMMA	5/11/72	4	151	PNL
299-W18-85	DENSITY	6/21/72	3	150	PNL
299-W18-85	NEUTRON	2/23/73	4	151	PNL
299-W18-85	NAT. GAMMA	7/21/83	1	148	PNL
299-W18-86	NEUTRON	1/19/66	0	148	PNL
299-W18-86	NAT. GAMMA	2/25/66	0	149	PNL
299-W18-86	NEUTRON	1/13/68	0	148	PNL
299-W18-86	NEUTRON	4/22/69	0	148	PNL
299-W18-86	NAT. GAMMA	4/26/69	0	148	PNL
299-W18-86	NAT. GAMMA	5/11/72	5	159	PNL
299-W18-86	DENSITY	6/21/72	4	150	PNL
299-W18-86	NEUTRON	2/23/73	3	147	PNL
299-W18-86	NAT. GAMMA	7/21/83	1	148	PNL
299-W18-87	NEUTRON	1/19/66	0	148	PNL
299-W18-87	NAT. GAMMA	2/25/66	0	149	PNL
299-W18-87	NEUTRON	1/13/68	0	148	PNL
299-W18-87	NEUTRON	4/22/69	0	148	PNL
299-W18-87	NAT. GAMMA	4/26/69	0	149	PNL
299-W18-87	NAT. GAMMA	5/11/72	0	149	PNL
299-W18-87	DENSITY	6/21/72	3	150	PNL
299-W18-87	NEUTRON	2/23/73	4	150	PNL
299-W18-87	NAT. GAMMA	7/22/83	2	148	PNL
299-W18-88	NEUTRON	1/18/66	0	145	PNL
299-W18-88	NEUTRON	4/22/69	0	145	PNL
299-W18-88	NAT. GAMMA	4/26/69	0	146	PNL
299-W18-88	NAT. GAMMA	5/11/72	5	147	PNL
299-W18-88	DENSITY	6/21/72	3	148	PNL
299-W18-88	NEUTRON	2/23/73	4	148	PNL
299-W18-88	NAT. GAMMA	9/22/82	2	145	PNL
299-W18-149	PFN	9/20/93	3	22	GRAND JUNCTION
299-W18-150	NAT. GAMMA	7/20/82	1	117	PNL
299-W18-158	NAT. GAMMA	7/20/82	1	124	PNL
299-W18-159	NAT. GAMMA	7/20/82	3	119	PNL
299-W18-159	SPECTRAL GAMMA	3/19/91	0	60	WHC
299-W18-159	PFN	9/20/93	3	118	GRAND JUNCTION
299-W18-163	NAT. GAMMA	7/20/82	1	127	PNL
299-W18-165	NAT. GAMMA	7/20/82	1	124	PNL

BOREHOLE	LOG RUN	DATE	TOP	BOTTOM	LOGGED BY
299-W18-166	NAT. GAMMA	7/20/82	1	127	PNL
299-W18-167	NAT. GAMMA	7/21/82	1	124	PNL
299-W18-168	NAT. GAMMA	7/21/82	1	123	PNL
299-W18-169	NAT. GAMMA	7/20/82	1	124	PNL
299-W18-170	NAT. GAMMA	7/20/82	0	25	PNL
299-W18-170	PFN	9/17/93	3	26	GRAND JUNCTION
299-W18-171	NAT. GAMMA	7/16/82	1	126	PNL
299-W18-171	NAT. GAMMA	7/22/83	3	127	PNL
299-W18-171	GROSS GAMMA	2/20/87	3.7	129.5	PNL
299-W18-171	SPECTRAL GAMMA	2/13/91	0	124	WHC
299-W18-172	NAT. GAMMA	7/21/82	1	126	PNL
299-W18-173	NAT. GAMMA	7/20/82	1	42	PNL
299-W18-174	NAT. GAMMA	7/20/82	2	45	PNL
299-W18-174	GROSS GAMMA	4/8/89	3.1	130.8	PNL
299-W18-175	NAT. GAMMA	7/20/82	2	120	PNL
299-W18-175	PFN	9/20/93	3	118	GRAND JUNCTION

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299-W15-6	NAT. GAMMA	7/14/55	0	218	PNL
299-W15-6	TEMP	3/4/58	190	350	PNL
299-W15-6	TEMP	4/30/58	192	370	PNL
299-W15-6	NAT. GAMMA	5/1/59	0	316	PNL
299-W15-6	NEUTRON	6/7/61	0	187	PNL
299-W15-6	TEMP	5/9/63	186	296	PNL
299-W15-6	NAT. GAMMA	2/22/64	0	304	PNL
299-W15-6	NEUTRON	1/18/66	7	182	PNL
299-W15-6	NEUTRON	4/24/69	0	187	PNL
299-W15-6	TEMP	3/3/70	190	304	PNL
299-W15-6	NAT. GAMMA	5/17/72	4	372	PNL
299-W15-6	DENSITY	6/21/72	5	369	PNL
299-W15-6	NEUTRON	2/23/73			PNL
299-W15-6	NAT. GAMMA	3/2/83	4	370	PNL
299-W15-6	NEUTRON	3/2/83	5	370	PNL
299-W15-6	DENSITY	3/2/83	3	368	PNL
299-W15-6	NAT. GAMMA	3/22/83	3	366	PNL
299-W15-6	GROSS GAMMA	10/12/88	3.1	303.2	PNL
299-W15-6	GROSS GAMMA	9/6/89	3.2	357.2	PNL
299-W15-6	ELEMENTAL CAPTURE	9/6/93	29	330	SCHLUMBERGER
299-W15-6	RESERVOIR SATURATION	9/16/93	39.5	365	SCHLUMBERGER
299-W15-6	THERM NEUTRON DECAY	9/16/93	58	360.5	SCHLUMBERGER
299-W15-6	ASP LOG	9/16/93	35.5	330	SCHLUMBERGER
299-W15-6	PFN	9/20/93	6	353	GRAND JUNCTION
299-W15-8	NAT. GAMMA	10/9/64	0	201	PNL
299-W15-8	NEUTRON	10/9/64	0	188	PNL
299-W15-8	NEUTRON	1/18/66	0	188	PNL
299-W15-8	NAT. GAMMA	2/25/66	0	201	PNL
299-W15-8	NAT. GAMMA	4/25/69	4	202	PNL
299-W15-8	NEUTRON	4/25/69	5	202	PNL
299-W15-8	NAT. GAMMA	3/2/83	4	202	PNL

BOREHOLE	LOG RUN	DATE	TOP	BOTTOM	LOGGED BY
299-W15-8	NEUTRON	3/2/83	5	202	PNL
299-W15-8	DENSITY	3/2/83	4	202	PNL
299-W15-8	NAT. GAMMA	3/22/83	3	202	PNL
299-W15-8	GROSS GAMMA	3/3/88	3	201.6	PNL
299-W15-8	CALIPER	3/3/88	4.2	200	PNL
299-W15-8	GROSS GAMMA	3/4/92	3	201	PNL
299-W15-8	SPECTRAL GAMMA	7/1/92	0	199	WHC
299-W15-8	THERM NEUTRON DECAY	9/20/93	0	205	SCHLUMBERGER
299-W15-8	RESERVOIR SATURATION	9/20/93	66.5	205	SCHLUMBERGER
299-W15-9	NAT. GAMMA	2/7/63	0	191	PNL
299-W15-9	NEUTRON	2/7/63	0	181	PNL
299-W15-9	NEUTRON	1/18/66	0	184	PNL
299-W15-9	NAT. GAMMA	2/25/66	0	190	PNL
299-W15-9	NEUTRON	4/24/69	0	186	PNL
299-W15-9	NAT. GAMMA	4/25/69	0	190	PNL
299-W15-9	NAT. GAMMA	5/17/72	4	190	PNL
299-W15-9	DENSITY	6/21/72	4	190	PNL
299-W15-9	NEUTRON	2/23/73	4	190	PNL
299-W15-9	NAT. GAMMA	2/25/83	4	189	PNL
299-W15-9	NEUTRON	2/25/83	4	189	PNL
299-W15-9	DENSITY	2/25/83	2	189	PNL
299-W15-9	NAT. GAMMA	3/22/83	3	190	PNL
299-W15-9	CALIPER	8/8/88	4.6	189.5	PNL
299-W15-9	GROSS GAMMA	8/8/88	3.4	190.1	PNL
299-W15-9	GROSS GAMMA	9/6/89	3.4	190.2	PNL
299-W15-9	GROSS GAMMA	8/9/92	3.1	190.1	PNL
299-W15-9	RESERVOIR SATURATION	9/14/93	1	195.5	SCHLUMBERGER
299-W15-9	THERM NEUTRON DECAY	9/14/93	73.5	193.5	SCHLUMBERGER
299-W15-82	NAT. GAMMA	5/2/59	0	99	PNL
299-W15-82	NEUTRON	1/18/66	0	97	PNL
299-W15-82	NAT. GAMMA	5/17/72	3	97	PNL
299-W15-82	DENSITY	6/21/72	4	99	PNL
299-W15-82	NEUTRON	2/23/73	4	98	PNL
299-W15-82	NAT. GAMMA	2/25/83	4	98	PNL
299-W15-82	GROSS GAMMA	9/7/89	3.8	97.9	PNL
299-W15-82	ELEMENTAL CAPTURE	9/20/93	0	97.5	SCHLUMBERGER
299-W15-82	NAT GAMMA	9/20/93	0	97.5	SCHLUMBERGER
299-W15-82	RESERVOIR SATURATION	9/20/93	0	102	SCHLUMBERGER
299-W15-82	THERM NEUTRON DECAY	9/20/93	0	102	SCHLUMBERGER
299-W15-84	NAT. GAMMA	5/1/59	0	109	PNL
299-W15-84	NEUTRON	1/18/66	0	105	PNL
299-W15-84	NAT. GAMMA	4/25/69	0	106	PNL
299-W15-84	NEUTRON	4/25/69	0	105	PNL
299-W15-84	NAT. GAMMA	5/17/72	3	106	PNL
299-W15-84	DENSITY	6/21/72	2	106	PNL
299-W15-84	NEUTRON	2/23/73	5	107	PNL
299-W15-84	NAT. GAMMA	3/4/83	5	106	PNL
299-W15-84	GROSS GAMMA	3/9/88	3.6	105.6	PNL
299-W15-84	CALIPER	3/11/88	4.8	105.2	PNL
299-W15-84	GROSS GAMMA	9/7/89	4.6	105.4	PNL
299-W15-84	GROSS GAMMA	3/10/92	3.6	105.6	PNL
299-W15-84	NAT. GAMMA	9/15/93	0	105	SCHLUMBERGER
299-W15-84	THERM NEUTRON DECAY	9/15/93	0	108.5	SCHLUMBERGER
299-W15-84	ELEMENTAL CAPTURE	9/15/93	0	105	SCHLUMBERGER
299-W15-84	RESERVOIR SATURATION	9/15/93	0	107.5	SCHLUMBERGER
299-W15-84	ASP LOG	9/15/93	0	105	SCHLUMBERGER

BOREHOLE	LOG RUN	DATE	TOP	BOTTOM	LOGGED BY
299-W15-85	NAT. GAMMA	5/1/59	0	105	PNL
299-W15-85	NEUTRON	1/18/66	0	103	PNL
299-W15-85	NAT. GAMMA	4/25/69	0	106	PNL
299-W15-85	NEUTRON	4/25/69	0	102	PNL
299-W15-85	NAT. GAMMA	5/17/72	4	103	PNL
299-W15-85	DENSITY	6/21/72	3	104	PNL
299-W15-85	NEUTRON	2/23/73	4	104	PNL
299-W15-85	NAT. GAMMA	2/25/83	4	103	PNL
299-W15-85	GROSS GAMMA	9/7/89	4.6	101.7	PNL
299-W15-86	NAT. GAMMA	5/1/59	0	142	PNL
299-W15-86	NEUTRON	1/18/66	0	142	PNL
299-W15-86	NAT. GAMMA	4/25/69	0	142	PNL
299-W15-86	NEUTRON	4/25/69	0	142	PNL
299-W15-86	NAT. GAMMA	3/2/83	4	142	PNL
299-W15-86	NAT. GAMMA	3/22/83	1	136	PNL
299-W15-86	GROSS GAMMA	2/21/88	2.1	138.9	PNL
299-W15-86	CALIPER	3/11/88	3.3	138.3	PNL
299-W15-86	MAGNETIC	3/11/88	2.2	138.3	PNL
299-W15-86	GROSS GAMMA	2/22/92	2.1	138.9	PNL
299-W15-95	NAT. GAMMA	5/2/59	0	100	PNL
299-W15-95	NEUTRON	1/18/66	0	98	PNL
299-W15-95	NAT. GAMMA	4/25/69	0	100	PNL
299-W15-95	NEUTRON	4/25/69	0	98	PNL
299-W15-95	NAT. GAMMA	5/17/72	3	98	PNL
299-W15-95	DENSITY	6/21/72	3	100	PNL
299-W15-95	NEUTRON	2/23/73	4	104	PNL
299-W15-95	NAT. GAMMA	2/25/83	4	100	PNL

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299-W18-2	NAT. GAMMA	7/21/55	0	195	PNL
299-W18-2	NAT. GAMMA	5/6/59	0	208	PNL
299-W18-2	NEUTRON	6/8/61	0	204	PNL
299-W18-2	NAT. GAMMA	2/22/64	0	249	PNL
299-W18-2	NEUTRON	4/22/69	0	206	PNL
299-W18-2	NAT. GAMMA	5/1/69	0	146	PNL
299-W18-2	NAT. GAMMA	5/6/72	5	246	PNL
299-W18-2	DENSITY	6/21/72	3	246	PNL
299-W18-2	NEUTRON	2/23/73	5	246	PNL
299-W18-2	NAT. GAMMA	7/21/83	3	244	PNL
299-W18-5	NAT. GAMMA	7/22/55	0	200	PNL
299-W18-5	TEMP.	5/2/58	211	272	PNL
299-W18-5	TEMP.	11/5/58	211	272	PNL
299-W18-5	TEMP.	1/16/59	210	274	PNL
299-W18-5	NAT. GAMMA	5/6/59	0	274	PNL
299-W18-5	NEUTRON	6/8/61	0	205	PNL
299-W18-5	NEUTRON	2/7/63	0	205	PNL
299-W18-5	NAT. GAMMA	2/7/63	0	274	PNL
299-W18-5	NAT. GAMMA	2/27/63	0	205	PNL
299-W18-5	NEUTRON	2/27/63	0	202	PNL
299-W18-5	NAT. GAMMA	2/22/64	0	273	PNL
299-W18-5	NEUTRON	5/22/65	0	202	PNL
299-W18-5	NAT. GAMMA	2/25/66	0	272	PNL
299-W18-5	NEUTRON	4/22/69	0	208	PNL
299-W18-5	NAT.GAMMA	5/1/69	0	273	PNL
299-W18-5	GROSS GAMMA	5/4/88	3.3	272.1	PNL
299-W18-5	GROSS GAMMA	5/5/92	3.3	272.1	PNL

BOREHOLE	LOG RUN	DATE	TOP	BOTTOM	LOGGED BY
299-W18-5	SPECTRAL GAMMA	4/5/92	0	268.5	WHC
299-W18-8	NAT. GAMMA	2/7/63	0	209	PNL
299-W18-8	NEUTRON	2/7/63	0	204	PNL
299-W18-8	NAT. GAMMA	2/25/66	0	76	PNL
299-W18-8	NAT. GAMMA	4/30/69	0	76	PNL
299-W18-8	NEUTRON	4/30/69	0	74	PNL
299-W18-8	NAT. GAMMA	5/18/72	0	76	PNL
299-W18-8	DENSITY	6/21/72	4	76	PNL
299-W18-8	NEUTRON	2/23/73	5	76	PNL
299-W18-8	NAT. GAMMA	8/23/94	0	45	SCHLUMBERGER
299-W18-8	NAT. GAMMA	8/2/94			HALLIBURTON
299-W18-8	EPITERMAL NEURTON	8/2/94			HALLIBURTON
299-W18-69	NAT. GAMMA	2/7/63	0	46	PNL
299-W18-69	NEUTRON	2/7/63	0	46	PNL
299-W18-69	NAT. GAMMA	2/22/64	0	46	PNL
299-W18-70	NOT LOGGED				
299-W18-71	NAT. GAMMA	2/25/66	0	48	PNL
299-W18-71	NAT. GAMMA	4/30/69	0	46	PNL
299-W18-71	NEUTRON	4/30/69	0	46	PNL
299-W18-71	NAT. GAMMA	8/19/83	4	20	PNL
299-W18-72	NAT. GAMMA	7/14/82	2	20	PNL
299-W18-72	NAT. GAMMA	8/19/83	3	20	PNL
299-W18-73	NAT. GAMMA	4/30/69	0	18	PNL
299-W18-73	NEUTRON	4/30/69	0	18	PNL
299-W18-73	NAT. GAMMA	8/19/83	3	15	PNL
299-W18-74	NEUTRON	4/30/69	0	18	PNL
299-W18-74	NAT. GAMMA	4/30/69	0	18	PNL
299-W18-74	NAT. GAMMA	8/19/83	4	18	PNL
299-W18-75	NAT. GAMMA	7/7/82	3	38	PNL
299-W18-151	NAT. GAMMA	7/14/82	4	11	PNL
299-W18-152	NAT. GAMMA	7/7/82	1	113	PNL
299-W18-153	NAT. GAMMA 104-2	7/14/82	2	104	PNL
299-W18-154	NAT. GAMMA	7/14/82	3	18	PNL
299-W18-155	NAT. GAMMA	7/14/82	3	12	PNL
299-W18-156	NOT LOGGED				
299-W18-157	NAT. GAMMA	7/14/82	2	106	PNL
299-W18-162	NOT LOGGED				
299-W18-179	NOT LOGGED				
299-W18-180	NOT LOGGED				
299-W18-181	NOT LOGGED				

BOREHOLE	LOG RUN	DATE	TOP	BOTTOM	LOGGED BY
299-W18-182	PFN	9/21/93	4	35	GRAND JUNCTION
299-W18-183	NOT LOGGED				
299-W18-184	NOT LOGGED				
299-W18-185	NOT LOGGED				

Appendix B

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Drilling Fluid Used: Not documented
Driller's Name: Hatch
Drilling Company: Hatch Drilling Co
Date Started: 21Jan74

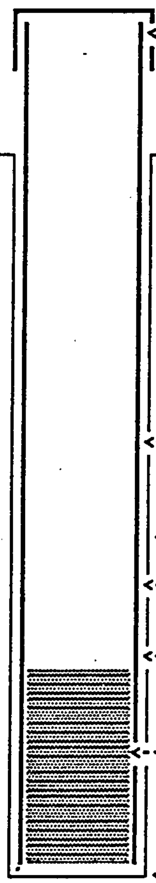
Sample Method: Hard tools Drive barrel
Additives Used: Not documented
WA State Lic Nr: Not documented
Company Location: Pasco, WA
Date Complete: 12Apr74

WELL NUMBER: 299-W18-149
TEMPORARY WELL NO: ______
Hanford Coordinates: N/S N 39,329 E/W W 76,602
State Coordinates: N 444,434 E 2,218,622
Start Card #: Not documented T___ R___ S______
Elevation Ground surface (ft): Not documented

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY	Driller/Geologist Log w/notes

0-7: No recovery
7-12: Dry SAND & GRAVEL (2-5 mr, 25-60,000 c/m)
12-14: Dry SAND (2-5 mr, 25-50,000 c/m)
14-15: Dry SAND, sparse ROCK (20,000 c/m)
15-17: Dry coarse SAND (8,000 c/m)
17-18.5: Moist coarse SAND (7,500-3,500 c/m)
18.5-22: Coarse SAND and very fine GRAVEL (~1,500 c/m)
22-24: Coarse to med SAND (1,800 c/m)
24-27: Med SAND (850 c/m)
27-29: Sandy SILT
29-31: Coarse SAND and SILT (1,350-2,500 c/m)
31-34: Not documented, reduced casing size
34-46: Broken ROCK
46-62: Brown hard packed SILT
62-ND Broken ROCK
ND-79 Fine brown SILT
79-80 Grey SAND
80-82 GRAVEL
82-92 SAND



Elevation of reference point: (top of casing) [672.56 ft]
Height of reference point above ground surface [~ 1 ft]
Depth of surface seal [ND]
Type of surface seal: None documented
I.D. of surface casing (If present) [ND]
I.D. of riser pipe: [6-in]
Type of riser pipe: PVC
Diameter of borehole: [7-in nom]
Type of filler: Not documented
Elevation/depth top of seal
Type of seal: Not documented
Cement plug?, 75-92 ft
Placement not documented
Depth bottom of casing
Depth bottom of borehole: [92 ft]

Drawing By: RKL/2W18-149.ASB Date: 06Dec90
Reference: ______

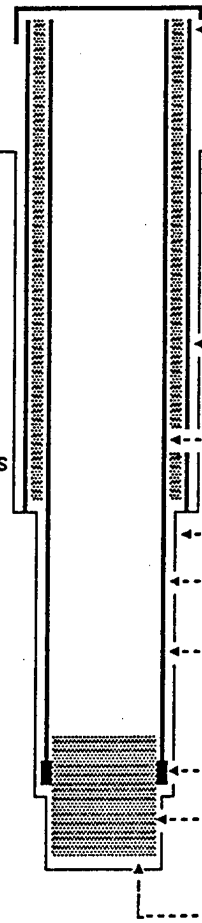
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 299-W18-158	TEMPORARY WELL NO:
Drilling Fluid Used: None	Additives Used: Not documented	Hanford Coordinates: N/S N 39,266	E/W W 76,650
Driller's Name: Evans/Baker	WA State Lic Nr: Not documented	State Coordinates: N 444,371	E 2,218,574
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented	T____ R____ S____
Date Started: 30Aug76/06Sep77	Date Complete: 30Sep76/08Sep77	Elevation Ground surface (ft): 670.0 Estimated	

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Geologist/Driller Log

0-7: Medium-fine sandy SILT w/trace of fine GRAVEL
7-13: Coarse-medium sand fine-medium GRAVEL w/some COBBLES
13-13: 1/2 in SILT lens
13-18: Coarse-medium sand GRAVEL some small COBBLES
18-20: Fine gravelly coarse-medium SAND to small COBBLES
20-25: Very coarse sand fine-medium GRAVEL (85% basalt gravel)
25-35: Medium-very coarse SAND, some PEBBLES, GRAVEL & BOULDERS
35-47: Fine-coarse SAND w/PEBBLES, GRAVEL and COBBLES (broken)
47-48: About 9 in SILTY layer with a little fine GRAVEL
48-50: Medium-fine sandy SILT
50-51: Silty very fine-medium SAND
NOTE: Contamination encountered at 51 ft
51-90: Not documented
90-93: Medium-fine SAND
93-94: SILT stringer
94-95: Medium-fine SAND
95-96: Medium SAND, slightly pebbly w/trace of small COBBLES
▲ First phase of drilling
▼ Second phase of drilling
96-100: GRAVEL & COBBLES
100-107: Silty very fine to medium SAND, 60% GRAVEL few COBBLES
107-111: Fine to medium SAND, 20% GRAVE;, few COBBLES
111-112: Very fine SAND
112-118: Fine to medium SAND, few coarse particles
118-119: SILT layer
119-121: Very fine to fine SAND
121-123: SILT
123-125: Fine SAND and SILT
125-128: Silty very fine SAND
128-131.5: SILT



Elevation of reference point: (top of casing) [672.61 ft]
Height of reference point above ground surface [2.6 ft]
Depth of surface seal [ND]
Type of surface seal: Grouted around top
I.D. of surface casing (If present) [ND]
8 in casing 0-94 ft
I.D. of riser pipe: [6-in]
Type of riser pipe: Carbon steel
Diameter of borehole: [7-in nom]
Type of filler: Not documented
Elevation/depth top of seal
Type of seal: Grouted
No perforations documented
Depth bottom of casing: [127.5 ft]
Bottom cement plugged
Depth to bottom Feb91 125.2 ft (128.2 ft from top-of-casing)
Bottom borehole [131 ft]

Drawing By: RKL/2W18-158.ASB Date: 18Mar91

Reference: ____________________

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Dual wall & Drive barrel	WELL NUMBER: 299-W18-159 A7642 TEMPORARY WELL NO:
Drilling Fluid Used: None	Additives Used: Not documented	Hanford Coordinates: N/S N 39,228 E/W W 76,602
Driller's Name: Baker	WA State Lic Nr: Not documented	State Coordinates: N 444,333 E 2,218,622
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented T___ R___ S___
Date Started: 09Dec77	Date Complete: 11Jan78	Elevation Ground surface: 669.7-ft estimated

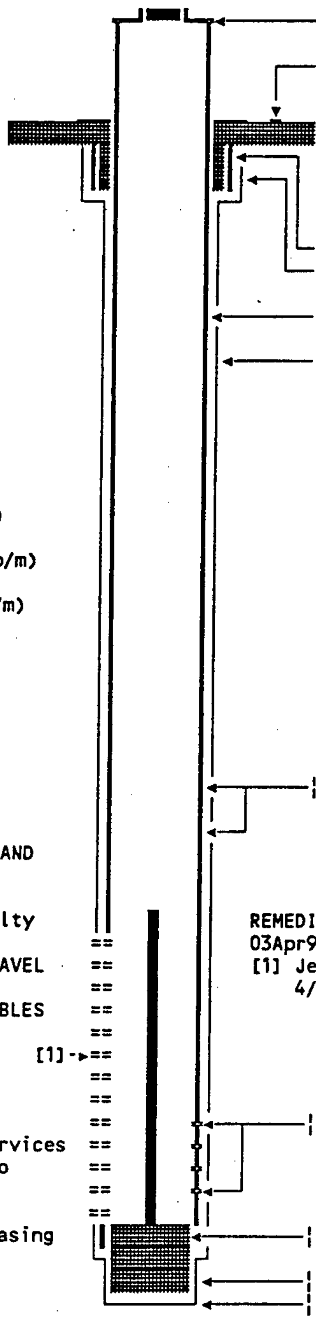
Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Driller's Log

Dual Wall Sample Descriptions:
11: Fine SAND, few PEBBLES
13: Med↔cse SAND, few PEBBLES
15.5: Med↔cse SAND, few PEBBLES
18: Cse SAND, few PEBBLES
21: Fine to medium SAND
23.5: Med↔cse SAND
26: Fine↔med SAND
28.5: Cse SAND
32; 34.5; 37; Cse↔very cse SAND
39.5: Cse SAND
42: Fine SAND

Drive barrel sample descriptions:
42↔47: Fine↔med SAND (Contamination 20,000-dp/m)
47↔50.5: Very fine↔fine SAND (Contamination 40↔70,000-dp/m)
50.5↔57: Fine↔med SAND (Contamination 5↔30,000-dp/m)
57↔62: Fine↔med SAND (Contamination 500-dp/m)
62↔69: Fine↔med SAND (Contamination <500-dp/m)
69↔75: Very fine↔med SAND
75↔76: SILT
76↔78: SILT↔cse SAND
78↔81: Med↔cse SAND
81↔82: Fine↔med SAND, imbedded SILT
82↔82.5: SILT stringer, fine↔cse SAND
82.5↔85: Fine↔med SAND, some SILT
85↔88.5: Fine↔cse SAND
88.5↔93: Fine↔cse SAND, GRAVEL, silty
93↔98: Silty GRAVEL, fine↔cse SAND
98↔103: Silty, fine↔v cse SAND, GRAVEL
103↔106: Fine↔med SAND, PEBBLES
106↔116: V fine↔fine SAND, few PEBBLES
116↔120: SILT↔v fine SAND
120↔125: SILT [1]
125↔127: V fine↔fine SAND, SILT
127↔130: SILT

REMEDIATIONS:
25↔26Feb92/13Mar91 by WHC Well Services Perforated 113↔120-ft, unable to perforate 73↔78-ft (TOC).
13Mar92 by WHC Well Services Welded plate w/4-in nipple to casing



- Elevation of reference point: (top of casing) [670.77-ft]
- Height of reference point above ground surface [1.1-ft]
- Depth of surface seal [7-ft]
- Type of surface seal: Concrete pad 20-ft by 30-ft w/2-ft sq rubber mat around casing
- 8-in ID carbon steel casing, 0↔7-ft
- 9-in nominal hole, 0↔7-ft
- 6-in ID carbon steel casing, +1.1↔126.0-ft
- 7-in nominal hole, 7↔126-ft
- Apparent hardened casing zone, 72↔77-ft, unable to perforate

REMEDIATION ACTIVITIES:
03Apr95,
[1] Jet Shot Perforated 120↔90-ft.(TOC) 4/ft x ½" spiraled

- 6-in casing perforations, 112↔119-ft, cuts indeterminate
- Cement plug, not well documented
- 6-in nominal hole, 126↔130-ft
- Borehole drilled depth: [130.0-ft]
- DTB=Depth to bottom, 120.9-ft, 01Feb91

Drawing By: TJW/2W18-159.ASB
Date : 26May95
Reference : HANFORD WELLS

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 299-W18-167 A7649 TEMPORARY WELL NO:
Drilling Fluid Used: None	Additives Used: Not documented	Hanford Coordinates: N/S N 39,214 E/W W 76,552
Driller's Name: Baker	WA State Lic Nr: Not documented	State Coordinates: N 444,319 E 2,218,672
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented T___ R___ S___
Date Started: 20Apr77	Date Complete: 17May77	Elevation Ground surface: 665.7-ft Estimated

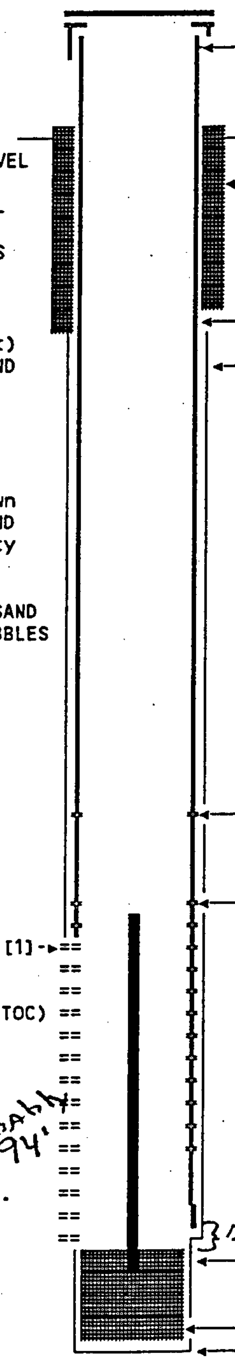
Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Driller's Log

0↔15: Backfill, very fine SAND/GRAVEL
15↔20: Fine SAND, GRAVEL
20↔25: Silty, fine↔cse SAND, GRAVEL
25↔37: Med↔cse SAND
37↔38.5: Cse SAND, PEBBLES, COBBLES
38.5↔44: Med↔v cse SAND, GRAVEL
44↔48.5: V fine↔fine SAND
48.5↔53: V fine SAND, sl silty
53↔55: V fine SAND; med SAND (moist)
55↔58: Silty, v fine SAND; fine SAND
58↔60: SILT, fine↔med SAND
60↔64: Fine↔med SAND
64↔67: Fine, med, cse SAND
67↔71: V fine↔fine SAND & silty
71↔76: Fine↔med SAND
76↔78: SILT, some v fine SAND, brown
78↔83: Silty, v fine↔fine brown SAND
83↔90: Fine↔med SAND, sl silty↔silty
90↔92: Small GRAVEL, fine↔med SAND some SILT
92↔97: All sizes GRAVEL, SILT/cse SAND
97↔103: Med silty SAND, PEBBLES/COBBLES
103↔108: Silty, v fine↔fine SAND
108↔118: Fine, med & cse SAND
118↔121: V fine↔fine silty SAND
121↔124: SILT
124↔134: Silty & v fine SAND (Layer of pure SILT)
134↔ : CALICHE

DRILLER'S NOTES:
CCl4 odor encountered @ 10-ft
55-ft=2,000dpm & 51,000dpm. 7,500↔8,000cpm
56-ft=<500dpm

REMEDIATIONS:
19Mar91 by WHC Well Services
Perforated 79↔81 and 114↔119-ft (TOC)
03Jan92 by WHC Well Services
Welded lid on casing
28Feb94 by WHC Well Services
Welded 8-in slip flange on casing
02May94 by WHC Well Services
Perforated 89↔114-ft (TOC) probably 94'
24Mar95
[1] Jet Shot Perforated 119↔89-ft. (TOC) 4/ft x ½" spiraled



Elevation of reference point: [669.00-ft] (top of casing)
Height of reference point above ground surface [3.3-ft]
Depth of surface seal [ND]
Type of surface seal: Cement grout outside 8-in casing
Depth and hole diameter not documented
8-in ID carbon steel casing, +3.3↔~124-ft
9-in nominal hole, ND↔~124-ft
8-in casing perforations, 75.7↔77.7-ft, 4 rows/6 cuts/ft
8-in casing perforations, 85.7↔115.7-ft, 4 rows/6 cuts/ft
8-in nominal hole, ~124↔134-ft
DTB=Depth to bottom, 126.5-ft, 01Feb91
Cement plug, not well documented
Borehole drilled depth: [134.0-ft]

Drawing By: TJW/2W18-167.ASB
Date : 26May95
Reference : HANFORD WELLS

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 299-W18-168 A7650 TEMPORARY WELL NO:
Drilling Fluid Used: None	Additives Used: Not documented	Hanford Coordinates: N/S N 39,143 E/W W 76,552
Driller's Name: Baker	WA State Lic Nr: Not documented	State Coordinates: N 444,248 E 2,218,673
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented T___ R___ S___
Date Started: 29May77	Date Complete: 16Jun77	Elevation Ground surface: 665.7-ft Estimated

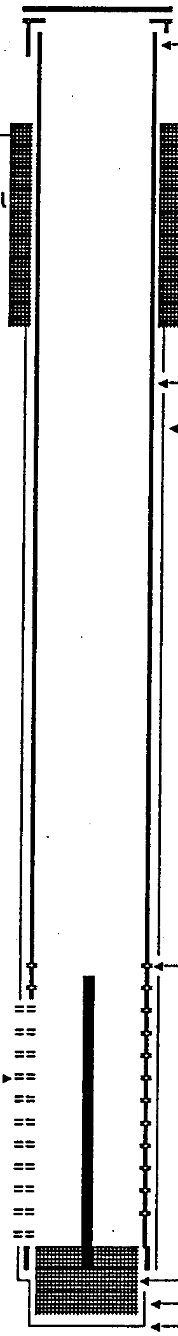
Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Driller's Log

0-5: Not documented
5-10: Med-fine SAND, sparse GRAVEL
10-12: Cse SAND, GRAVEL/COBBLE backfill
12-16: 30%cse, 30%med, 30%fine SAND
16-22: V cse-med SAND
22-41: Med-v cse SAND/PEBBLES/COBBLES
41-45: Silty, PEBBLES & COBBLES
45-48.5: Sl amt SILT, v fine-fine SAND
48.5-49: Med-cse SAND at top, SILT & v fine SAND bottom
49-51: V fine SAND & SILT
51-53: SILT-v fine SAND
53-55: V fine-fine SAND
55-59: Fine-med SAND
59-60: V fine-fine SAND
60-63: V fine-med SAND
63-70: V fine-fine SAND
70-74: Fine-med SAND
74-75: Silty, v fine SAND, w/mica
75-80: V fine-med SAND
80-85: Fine-med SAND
85-89: Med-cse SAND
89-93: Fine-med SAND, some cse
93-95: SILT-v fine SAND
95-97.5: Med-fine SAND
97.5-101.5: Med-fine SAND
101.5-104: Med-fine silty SAND w/small-med GRAVEL
104-105: Med-v fine silty SAND
105-111.5: Med-cse SAND
111.5-114: Fine-med SAND
114-117: Med-cse SAND
117-119: V fine-fine SAND w/SILT
119-122: Fine-med SAND, tr cse SAND
122-131: SILT

DRILLER'S NOTES: CCl4 odor 10&12-ft
48.5-49-ft=>40,000dpm;
51-ft=<500dpm; 55-ft+18,000dpm;
56-ft=12,000dpm; 58-ft=>40,000dpm;
59-ft=30,000dpm; 60&61-ft=20,000dpm;
62-ft=20,00dpm; 63-ft=10,000dpm;
65-ft=>500dpm [1]

REMEDIATIONS:
19Dec91 by WHC Well Services
Perforated 118-123-ft (TOC).
30Mar94 by WHC Well Services
Welded 8-in slip flange on casing.
03May94 by WHC Well Services
Perforated 97-127-ft (TOC).



Elevation of reference point: [669.00-ft] (top of casing)
Height of reference point above ground surface [3.3-ft]
Depth of surface seal [ND]
Type of surface seal: Cement grout outside 8-in casing
Depth and hole diameter not documented
11-in nominal hole, 0-ND-ft
8-in ID carbon steel casing, +3.3-~127-ft
9-in nominal hole, ND-~127-ft
8-in casing perforations, 93.7-123.7-ft, 6 rows/6 cuts/ft
114.7-119.7-ft, 4 rows/6 cuts/ft

REMEDIATION ACTIVITIES:
28Mar95
[1] Jet Shot Perforated, 127-97-ft.(TOC) 4/ft x ½" spiraled

Cement plug, not well documented
DTB=Depth to bottom, 124.1-ft, 01Feb91
8-in nominal hole, ~127-131-ft
Borehole drilled depth: [131.0-ft]

Drawing By: TJW/2W18-168.ASB
Date : 26May95
Reference : HANFORD WELLS

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 299-W18-169 A7651 TEMPORARY WELL NO:
Drilling Fluid Used: None	Additives Used: Not documented	Hanford Coordinates: N/S N 39,073 E/W W 76,552
Driller's Name: Baker	WA State Lic Nr: Not documented	State Coordinates: N 444,178 E 2,218,673
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented T__ R__ S__
Date Started: 16Jun77	Date Complete: 05Sep77	Elevation Ground surface: 665.9-ft Estimated

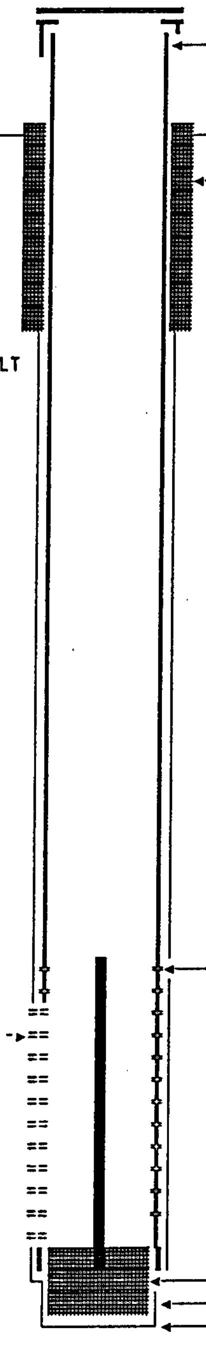
Depth to water: Not applicable

GENERALIZED STRATIGRAPHY   Driller's Log

0↔10: Backfill, no sample
10↔12.5: CseSAND, COBBLES
12.5↔23: M↔cseSAND, COBBLES
23↔28: M↔fSAND
28↔36: F↔mSAND
36↔37.5: M, f↔cseSAND, PEBBLES
37.5↔47: Silty, m↔v cseSAND, PEBBLES & COBBLES
47↔48: Vf↔mSAND & COBBLES
48↔49: Vf↔fSAND w/mSAND matrix, tr SILT
49↔53.5: Vf↔m SAND, PEBBLES & SILT
53.5↔58: Vf↔cse SAND, SILT stringers
58↔66: Vf↔vcse SAND
66↔71: SILT, f↔cseSAND, PEBBLES
71↔72: F↔vcseSAND, some SILT/PEBBLES
72↔73.5: F↔cseSAND
73.5↔78: SILT, f↔mSAND
78↔82: F↔mSAND, tr cseSAND
82↔83: F↔vcseSAND, few COBBLES
83↔86: F↔mSAND, tr cseSAND/PEBBLES
86↔88: Vf↔fSAND
88↔90: F↔cseSAND
90↔93: F↔vcseSAND w/SILT/GRAVEL
93↔99: M↔vcseSAND w/SILT/PEBBS/COBBS
99↔103: M↔vcseSAND, pea GRAVEL/COBBS
103↔104: VfSAND
104↔108: F↔cseSAND
108↔110: MSAND
110↔113: Vf↔cse↔vcseSAND
113↔117: F↔vcseSAND w/SILT stringers
117↔120: Silty↔vfSAND
120↔122.5: SILT↔vfSAND
122.5↔132: SILT

DRILLER'S NOTES:
34.5-ft=5,00dpm;
36-ft=1,000dpm, 5,00cpm;
37.5-ft=15,000dpm, 2,000cpm;
38-ft=15,000dpm, 900cpm;
39-ft=600dpm; 40-ft=<500dpm
43.5=ft=600dpm; 45-ft=500dpm;
47-ft=<500dpm
CCl4 odor= 93-ft, 113↔115-ft

REMEDIATIONS:
03May94 by WHC Well Services Perforated 96↔126-ft (TOC).
13May94 by WHC Well Services Welded 8-in slip flange on casing.



Elevation of reference point: [669.00-ft] (top of casing)
Height of reference point above ground surface [3.1-ft]
Depth of surface seal [ND]
Type of surface seal:
Cement grout outside 8-in casing
Depth and hole ~~diameter not documneted~~

8-in casing perforations, 92.9↔122.9-ft, 6 rows/6 cuts/ft

REMEDIATION ACTIVITIES:
30Mar95,
[1] Jet Shot Perforated, 126↔96-ft.(TOC) 4/ft x ½" spiraled

Cement plug, not well documented
DTB=Depth to bottom, 125.6-ft, 02Feb91

8-in nominal hole, ~128↔132-ft
Borehole drilled depth: [132.0-ft]

Drawing By: TJW/2W18-169.ASB
Date : 26May95
Reference : HANFORD WELLS

WELL CONSTRUCTION AND COMPLETION SUMMARY

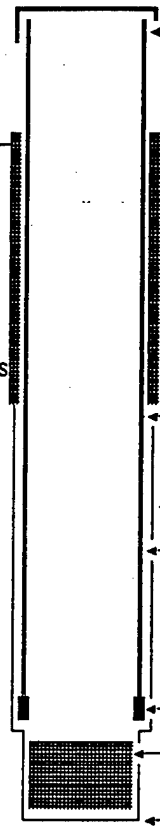
Drilling Method: Cable tool
Sample Method: Drive barrel
Drilling Fluid Used: None
Additives Used: Not documented
Driller's Name: Baker
WA State Lic Nr: Not documented
Drilling Company: Not documented
Company Location: ND
Date Started: 12Oct77
Date Complete: 24Oct77

WELL NUMBER: 299-W18-173
TEMPORARY WELL NO: ____
Hanford Coordinates: N/S N 39,307 E/W W 76,574
State Coordinates: N 444,412 E 2,218,650
Start Card #: Not documented T___ R___ S___
Elevation Ground surface (ft): Not documented

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Driller's Log

0-15: Not documented
15-16.5: Med-coarse SAND
16.5-18: Med SAND
18-30: Med-very coarse SAND
30-31.5: Fine-coarse SAND
31.5-33: Med-coarse SAND
33-34.5: Med-very coarse SAND, GRAVEL
34.5-36: Med-very coarse SAND, GRAVEL COBBLES
36-39: Fine-coarse SAND, GRAVEL, COBBLES
39-40: Med-coarse SAND, GRAVEL, COBBLES
40-43: Med-very coarse SAND, GRAVEL
43-45: Fine-coarse SAND, GRAVEL
45-47: Very fine-fine SAND, SILT stringers
47-48: Fine-med SAND
48-51: Very fine-fine SAND



Elevation of reference point: (top of casing) [673.31-ft]
Height of reference point above ground surface [ND] 3.29'
Depth of surface seal [ND]
Type of surface seal: Cement grout
I.D. of surface casing (If present) [ND]
I.D. of riser pipe: [8-in]
Type of riser pipe: Carbon steel
Diameter of borehole: [9-in nom]
Type of filler: Not documented

DTB - 44.5 BLS

8-in casing to ~47-ft
Cement plug not well documented
Depth bottom of borehole: [51-ft]

DRILLER'S NOTES:
Contamination encountered:
15-ft=40,000-dp/m
16.5-ft=4,000-dp/m
18-ft=<500-dp/m
24-ft=20,000-dp/m
30-ft=20,000-dp/m
31-ft=90,000-dp/m
31.5-ft=35,000-dp/m
33-ft=35,000-dp/m
34.5-ft=35,000-dp/m
36-ft=20,000-dp/m
37-ft=30,000-dp/m
39-ft=500-1,000-dp/m
40-ft=20,000-dp/m
41-ft=500-dp/m
42-ft=2,000-dp/m
43 and 45-ft=<500 dp/m
46-ft=20,000-dp/m
47-ft=5,200-dp/m
48-ft=<500-dp/m

Drawing By: RKL/2W18-173.ASB Date: 10Dec92

Reference: ____

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Dual wall CB & Drive barrel	WELL NUMBER: 299-W18-175 A7657 TEMPORARY WELL NO:
Drilling Fluid Used: None	Additives Used: Not documented	Hanford Coordinates: N/S N 39,147 E/W W 76,600
Driller's Name: Baker	WA State Lic Nr: Not documented	State Coordinates: N 444,252 E 2,218,625
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented T12N R 25E S 12
Date Started: 28Oct77	Date Complete: 07Dec77	Elevation Ground surface: 667.1-ft Estimated

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY   Driller's Log

0↔26: Not documented, sampled by dual wall core barrel
26↔33.5: Cse↔vcseSAND
35.5↔40: Med↔cseSAND, GRAVEL, COBBLES
40↔41: Sample lost
41↔43.5: Silty↔f↔cseSAND, GRAVEL
43.5↔48: Med↔vcseSAND, GRAVEL
48↔53: F↔mSAND (49↔50: sample lost)
53↔58: Vf↔fSAND   58↔59: VFSAND
59↔60: Silty fSAND   60↔63: F↔mSAND
63↔69.5: Vf↔mSAND   69.5↔71: SILT&vfSAND
71↔77: Vf↔mSAND   77↔78: silty vf↔fSAND
78↔79: SILT&vfSAND   79↔84.5: Vf↔mSAND
84.5↔87: MedSAND, few PEBBLES
87↔89: Med↔cseSAND   89↔95: F↔mSAND
95↔96.5: SILT&vfSAND 96.6↔98: SILT
98↔105: F↔mSAND   105↔109: VF↔fSAND
109↔112: F↔mSAND
112↔115: SILT stringer & vfSAND
115↔118: Vf↔fSAND

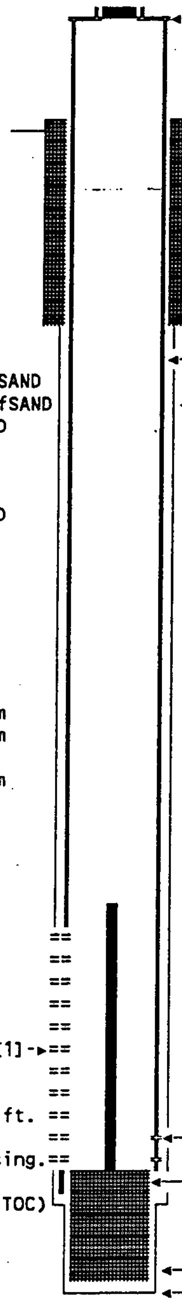
DRILLER'S NOTES: Contamination found
Dual wall core barrel GM readings

13.5-ft=300cpm	14-ft=3,000cpm
14.5-ft=1,500cpm	15-ft: 6↔700cpm

Sample readings:

26-ft=15,000dpm	28.5-ft=30,000dpm
30-ft=20,000dpm	51.5-ft=51,000dpm
32-ft=20,000dpm	53-ft=40,000dpm
33.5-ft=12,500dpm	55.5-ft=24,000dpm
35.5-ft=12,500dpm	58-ft=8,000dpm
37.5-ft=1,000dpm	59-ft=3,000dpm
38.5-ft=10,000dpm	60-ft=500dpm
41-ft=2,000dpm	61-ft=<500dpm
41.5-ft=10,000dpm	77-ft=2,500dpm
43.5-ft=20,000dpm	78-ft=5,000dpm
46-ft=40,000dpm	79-ft=<500dpm
48-ft=20,000dpm	93-ft=10,000dpm
49-ft=30,000dpm	95-ft=70,000dpm
50-ft=27,000dpm	98↔100-ft=500dpm

REMEDIATIONS: [1]
10Feb92 by WHC Well Services
Perforated 115↔120-ft (TOC).
Unable to perforate 71↔78 or 90↔97-ft.
13Mar92 by WHC Well Services
Welded plate and 4-in nipple to casing.
24Apr95
[1] Jet Shot Perforated 90↔120-ft (TOC) 4/ft x ½" spiraled



Elevation of reference point: [670.00-ft] (top of casing)
Height of reference point above ground surface [2.9-ft]
Depth of surface seal [0↔7-ft]
Type of surace seal:
Cement grout outside 6-in casing
Depth and hole diameter not documented
6-in ID carbon steel casing, +2.9↔121-ft
7-in nominal hole, ND↔121-ft
6-in casing perforations, 112.1↔117.1-ft, 4 rows/6 cuts/ft
Cement plug, not well documented
DTB=Depth to bottom, 118.4-ft, 29Jan91
6-oin nominal hole, 121↔130-ft
Borehole drilled depth: [130.0-ft]

Drawing By: TJW/2W18-175.ASB
Date : 13Jun95
Reference : HANFORD WELLS

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool
Sample Method: Hard tool (nom)
Drilling Fluid Used: Water
Additives Used: Not documented
Driller's Name: D. Bigham
WA State Lic Nr: Not documented
Drilling Company: Hatch Drilling Co.
Company Location: Pasco, WA
Date Started: 14Dec66
Date Complete: 12Jan67

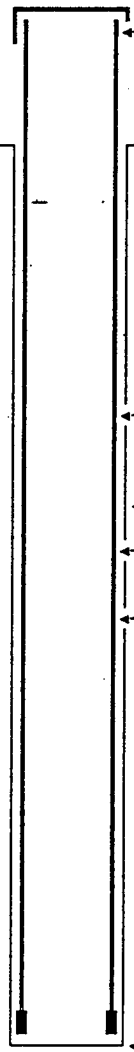
WELL NUMBER: 299-W18-8
TEMPORARY WELL NO: 299-W18-5A
Hanford Coordinates: N/S N 39,327 E/W W 77,221
State Coordinates: N 444,431 E 2,218,093
Start Card #: Not documented T____ R____ S______
Elevation Ground surface (ft): Not documented

Depth to water: 202-ft Jan67
(Ground surface) Dry 03May91

GENERALIZED STRATIGRAPHY — Geologist's Log (?)

5: SILT, fine SAND, dry
14: Coarse SAND and pea GRAVEL, dry
15: Fine SAND, damp
20: Coarse black & white SAND
25: Coarse black & white SAND, wet
29: Fine SAND & SILT, saturated
30: Fine SAND, some SILT, very moist
35: Coarse SAND & GRAVEL, less moisture
40: Coarse GRAVEL, SAND & SILT, dry
44: SILT, moist (Variable)
45-65: Fine SAND & SILT (Moisture)
65-70: Fine SAND, some SILT
70-75: Fine SAND, little SILT
75-79: Fine SAND and SILT
79-87: Fine SAND, some SILT
87-88: SILT
90: Med-fine SAND
95: Fine SAND & SILT
100-108: Med-fine SAND & SILT
108-109: SILT
109-114: Fine SAND and SILT
114-115: GRAVEL, SAND & SILT
115-120: Coarse SAND, GRAVEL & SILT, wet
120-130: GRAVEL, SAND & SILT
130-138: SILT
138-142: CALICHE and GRAVEL
142-150: COBBLES
150-167 COBBLES, SAND & SILT
167-168: SILT
169-205: GRAVEL, SAND & SILT
205-212: Fine SAND, SILT & small GRAVEL

DTB on
8/2/94 48.54'



Elevation of reference point: (top of casing) [683.00-ft]
Height of reference point above ground surface [ND]
Depth of surface seal [ND]
Type of surface seal: None documented
I.D. of surface casing (If present) [ND]
I.D. of riser pipe: [6-in]
Type of riser pipe: Carbon steel
Diameter of borehole: [7-in nom]
Type of filler: Not documented
Elevation/depth top of seal
Type of seal: Not documented
Depth top of perforations: [ND]
Description of perforations: None documented
Depth bottom of perforations: [ND]
Depth bottom of casing
Depth bottom of borehole: [212-ft]

Drawing By: RKL/2W18-08.ASB Date: 27Apr93
Reference: HANFORD WELLS

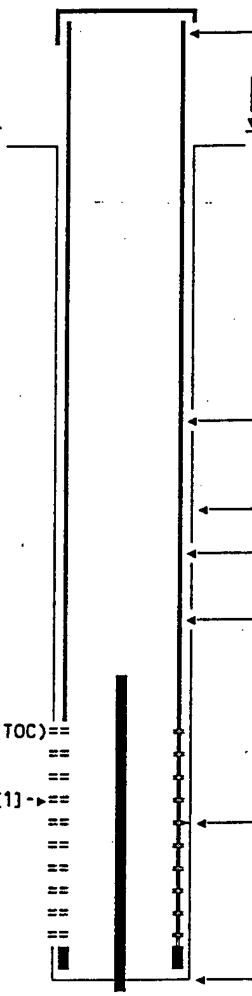
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 299-W18-152 A7635 TEMPORARY WELL NO: ____
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 39,368 E/W W 77,247
Driller's Name: J. Evans	WA State Lic Nr: Not documented	State Coordinates: N 444,473 E 2,218,163
Drilling Company: Hatch Drilling Co	Company Location: Pasco, WA	Start Card #: Not documented T____ R____ S____
Date Started: 13Jul76	Date Complete: 23Jul76	Elevation Ground surface (ft): 684.0 Estimated

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Driller's Log

0-118-ft: Not documented



Elevation of reference point: (top of casing) [685.80-ft]

Height of reference point above ground surface [1.8-ft]

Depth of surface seal [ND]

Type of surface seal: None documented

I.D. of surface casing (If present) [ND]

I.D. of riser pipe: [8-in]
Type of riser pipe: Carbon steel

Diameter of borehole: [9-in nom]

Type of filler: Not documented

Elevation/depth top of seal
Type of seal: Not documented

8-in. casing perforations 88-118-ft, 4 rows/6 cuts/ft

Depth to bottom [118-ft]

REMEDIATION:
16Mar95
[1] Jet Shot Perforated 118-88-ft.(TOC) [1]
4/ft x ½" spiraled

10" csg to 35.5'?
(7/19/76) - unclear
8' - to 118'

Swabbed
5/4/94 No det.

Perf 5/4/94 - PerfHawk
118-88' - No det. - sl. increase in CCl_4

Perf JetShot 3/16/95
118-88 - No det.

Drawing By: TJW/2W18-152.ASB Date: 25May95

Reference: HANFORD WELLS

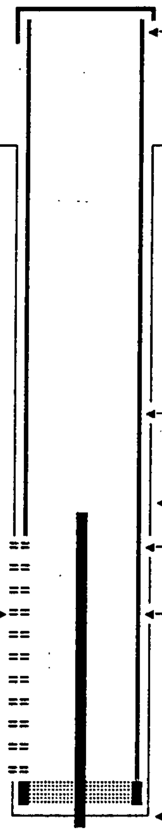
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Drive barrel	WELL NUMBER: 299-W18-153 A7636 TEMPORARY WELL NO:
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 39,365 E/W W 77,154
Driller's Name: J. Evans	WA State Lic Nr: Not documented	State Coordinates: N 444,469 E 2,218,070
Drilling Company: Hatch Drilling Co	Company Location: Pasco, WA	Start Card #: Not documented T___ R___ S___
Date Started: 27Jul76	Date Complete: 06Aug76	Elevation Ground surface (ft): 682.0 Estimated

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Geologist Log

5: Silty cse↔med SAND w/some GRAVEL
8: Med↔cse sandy GRAVEL (1-ft thick)
9: Silty cse↔med SAND w/some GRAVEL
10,13: Cse↔med sandy GRAVEL w/few PEBs
14: Cse↔med slightly silty sandy GRAVEL w/few PEBBLES
15,18.5,19: Very cse↔med SAND, GRAVEL-w/few PEBBLES
20,21.5,22.5,24: Very cse↔med SAND
25: Cse↔med SAND
27: Slightly silty cse↔med SAND some PEBBLES
30,34: Sandy SILT
36: Silty SAND
38: Slightly silty SAND
40: Fine SAND
41,44,45: Cse SAND, PEBBLES & COBBLES
50: Mostly small COBBLES w/fine silty SAND (Hit carbon tet)
55: Slightly gravelly sandy SILT
57: SILT [1]→
59: Very fine SAND & SILT with few small PEBBLES
60: Poorly sorted very fine↔med fine and cse SAND, some SILT
63: Sandy SILT
64: Cse↔med SAND
65,67,69: Med↔very fine SAND
70,74: Med↔very fine SAND, trace SILT (2↔3-in SILT lens @ 73-ft)
75: Med↔very fine SAND
77: Fine↔very fine SAND w/SILT
80,84: SILT w/some very fine SAND
85: Med↔fine SAND w/some SILT
87: Silty very fine SAND
88: Med fine↔med SAND w/some SILT
90: Med SAND w/some med cse SAND
94: Very silty very fine SAND (Hit layer ~93-ft)
95: Med cse SAND w/some very cse & some very fine SAND
100: Med fine↔cse SAND w/little SILT
104: SILT layer
105: Med↔fine SAND (some cse grains-few)
107: SILT layer
109: Cse↔med SAND w/some PEBBLES (Some $CaCO_3$ tested with acid)
110: Cse↔med sandy GRAVEL (Ringold)
Some $CaCO_3$ tested with acid
Strong Carbon Tet (?) smell from casing. Smell not in soil - no contamination



- Elevation of reference point: (top of casing) [683.76-ft]
- Height of reference point above ground surface [1.8-ft]
- Depth of surface seal [ND]
- Type of surface seal: None documented
- I.D. of surface casing (If present) [ND]
- I.D. of riser pipe: [8-in]
- Type of riser pipe: Carbon steel
- Diameter of borehole: [9-in nom]
- Type of filler: Not documented
- Elevation/depth top of seal
- Type of seal: Not documented
- Depth to bottom 17Mar95 [107-ft]
- Depth bottom of casing
- Depth bottom of borehole: [110-ft]

10" to ≈27'
8" to 110'
Swab 5/4/94 - No det.
Perf Hawk perf. 5/4/94 110-80 No det

REMEDIATION ACTIVITIES:
17Mar95 [1] Jet Shot Perforated 107↔77-ft.(TOC) 4/ft x ½" spiraled

Jet Shot 77-107 (TOC) No cont.

Drawing By: TJW/2W18-153.ASB Date: 12Jun95

Reference: HANFORD WELLS

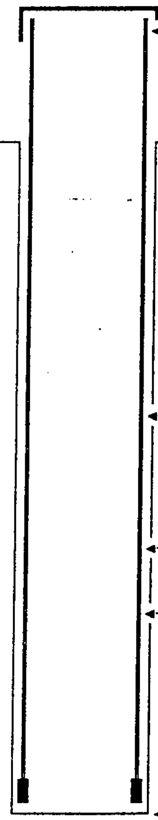
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-W15-82 — TEMPORARY WELL NO: 2904 #1
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 39,860 E/W W 75,810
Driller's Name: Row/Gentz	WA State Lic Nr: Not documented	State Coordinates: N 444,967 E 2,219,333
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented T___ R___ S___
Date Started: 30Sep54	Date Complete: 04Oct54	Elevation Ground surface (ft): Not documented

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Driller's Log

0↔15: BACKFILL
15↔44: GRAVEL
44↔80: SAND & SILT
80↔100: Sandy SILT



- Elevation of reference point: (top of casing) [660.09-ft]
- Height of reference point above ground surface [ND]
- Depth of surface seal [ND]
- Type of surface seal: None documented
- I.D. of surface casing (If present) [ND]
- I.D. of riser pipe: [8-in]
- Type of riser pipe: Carbon steel
- Diameter of borehole: [9-in nom]
- Type of filler: Not documented
- Elevation/depth top of seal
- Type of seal: Not documented
- No perforations documented:
- Depth bottom of casing [101-ft]
- Depth bottom of borehole: [101-ft]

101.5 Ft of csg

Add 2' of csg 1/18/92

Perfed 76.5' - 90.5' TOC 4/27/93

Swabbed 2/4/94 - No cont.
#157063

Stickup on 1/25/91 6¼"

+ 2' on 1/18/92

Total csg = 103.5' w/stickup of
2.5 = DTB of csg = 101'

Tag 1/25/91 = 99.6' TOC = 97' DTB
Stickup 2.6?

Drawing By: RKL/2W15-82.ASB Date: 09Dec92

Reference: HANFORD WELLS

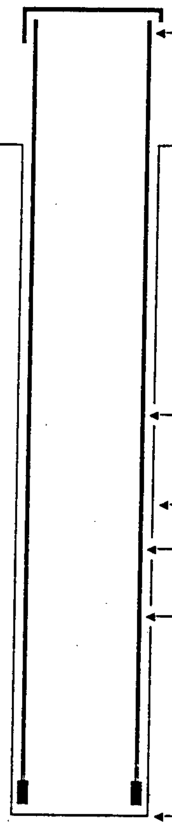
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-W15-84
Drilling Fluid Used: Water	Additives Used: Not documented	TEMPORARY WELL NO: 2904 #3
Driller's Name: Row/Jahnke	WA State Lic Nr: Not documented	Hanford Coordinates: N/S N 39,860 E/W W 76,000
Drilling Company: Not documented	Company Location: ND	State Coordinates: N 444,967 E 2,219,223
Date Started: 06Oct54	Date Complete: 10Oct54	Start Card #: Not documented T____ R____ S____
		Elevation Ground surface (ft): Not documented

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Driller's Log

0-20: Not documented
20-25: Blow SAND, GRAVEL
25-54: GRAVEL
54-110: SAND & SILT



Elevation of reference point: (top of casing) [669.82-ft]

Height of reference point above ground surface [ND]

Depth of surface seal [ND]

Type of surface seal: None documented

I.D. of surface casing (If present) [ND]

I.D. of riser pipe: [8-in]
Type of riser pipe: Carbon steel

Diameter of borehole: [9-in nom]

Type of filler: Not documented

Elevation/depth top of seal
Type of seal: Not documented

No perforations documented:

Depth bottom of casing [110-ft]
Depth bottom of borehole: [110-ft]

110'3" Total csg   Oct 10, 1954
Stickup 1.5'
108.75' BLS bttm csg

Perfed 4/27/93 - PerfHawk
(91.5 (TOC) to 76.50') = 15'
Swab csg 2/4/94 - No cont.

Drawing By: RKL/2W15-84.ASB   Date: 09Dec92

Reference: HANFORD WELLS

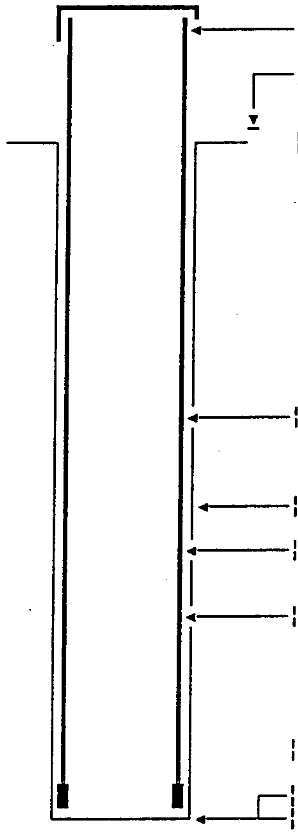
WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-W15-85 TEMPORARY WELL NO: 2904 #4
Drilling Fluid Used: Water	Additives Used: Not documented	Hanford Coordinates: N/S N 39,970 E/W W 75,910
Driller's Name: Row/Jahnke	WA State Lic Nr: Not documented	State Coordinates: N 445,077 E 2,219,313
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented T____ R____ S______
Date Started: 11Oct54	Date Complete: 12Oct54	Elevation Ground surface (ft): Not documented

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY — Driller's Log

0–15: Backfill, SAND & SILT
15–20: SAND-SILT-GRAVEL
20–35: GRAVEL-SAND
35–45: Black SAND-fine GRAVEL
45–48: GRAVEL
48–55: SAND-very little SILT
55–90: SAND-some SILT
90–105: Sandy SILT



Elevation of reference point: (top of casing) [664.11-ft]
Height of reference point above ground surface [ND]
Depth of surface seal [ND]
Type of surface seal: None documented
I.D. of surface casing (If present) [ND]
I.D. of riser pipe: [8-in]
Type of riser pipe: Carbon steel
Diameter of borehole: [9-in nom]
Type of filler: Not documented
Elevation/depth top of seal
Type of seal: Not documented
No perforations documented:
Depth bottom of casing [106-ft]
Depth bottom of borehole: [106-ft]

106'8" Total csg
1.5' Stickup = 105.25' BOC
Perf 99.5' – 84.5' (Below TOC) 4/27/(
15'
Swab 2/4/94 – No det

Drawing By: RKL/2W15-85.ASB Date: 09Dec92

Reference: HANFORD WELLS

WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method: Cable tool	Sample Method: Hard tool (nom)	WELL NUMBER: 299-W15-95 A7394 TEMPORARY WELL NO:
Drilling Fluid Used: Not documented	Additives Used: Not documented	Hanford Coordinates: N/S N 39,930 E/W W 75,925
Driller's Name: Osburn	WA State Lic Nr: Not documented	State Coordinates: N 445,037 E 2,219,298
Drilling Company: Not documented	Company Location: ND	Start Card #: Not documented T___ R___ S___
Date Started: 19Jan59	Date Complete: 21Jan59	Elevation Ground surface: 663.0-ft

Depth to water: Not applicable

GENERALIZED STRATIGRAPHY   Driller's Log

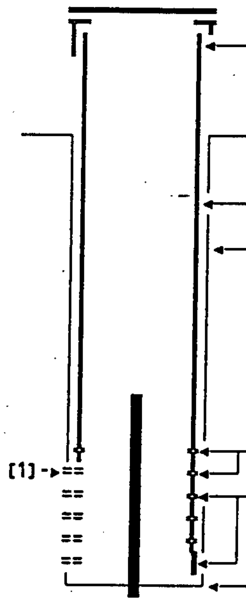
0↔5: SAND & DIRT
5↔13: SAND-GRAVEL
13↔18: Pea GRAVEL
18↔30: SAND-GRAVEL
30↔38: SAND-GRAVEL & COBBLE
38↔43: SAND
43↔80: SAND & SILT
80↔91: Sandy SILT
91↔100: SAND & SILT

REMEDIATIONS:
10Feb93 by WHC Well Services
Repaired holes in casing and welded on 8-in slip flange

27Apr93 by WHC Well Services
Perforated 85.5↔100-ft-ft.
4 rows @ 6 holes/ft.

05May94 by WHC Well Services
Perforated 73↔83-ft.
4 rows @ 6 holes/ft.

15Mar95:
[1] Shot Perforated 100.5↔75.5-ft (TOC)
4/ft x ½" spiraled



Elevation of reference point: [665.65-ft]
(top of casing)
Height of reference point above ground surface [2.65-ft]
Depth of surface seal [ND]
No surface seal documented
8-in ID carbon steel casing, 0↔100-ft
9-in nominal hole, 0↔100-ft
8-in casing perforations,
73↔83-ft, 4 rows/6 holes/ft
85.5↔100.5-ft, 4 rows/ 6 holes/ft
Borehole drilled depth: [100-ft]
DTB=Depth to bottom,
99.3-ft, 25Jan91

① 10' of 12"
103' of 8" csg (Stickup 2.5')
② Perf 100.5 – 85.5 – TOC
98 – 83 (4-27-93)
③ Swab 2/4/94 No Cont
④ Camera
⑤ Jet Shot – 3/15/95 – No det.

Drawing By: TJW/2W15-95.ASB
Date : 23May95
Reference : HANFORD WELLS

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