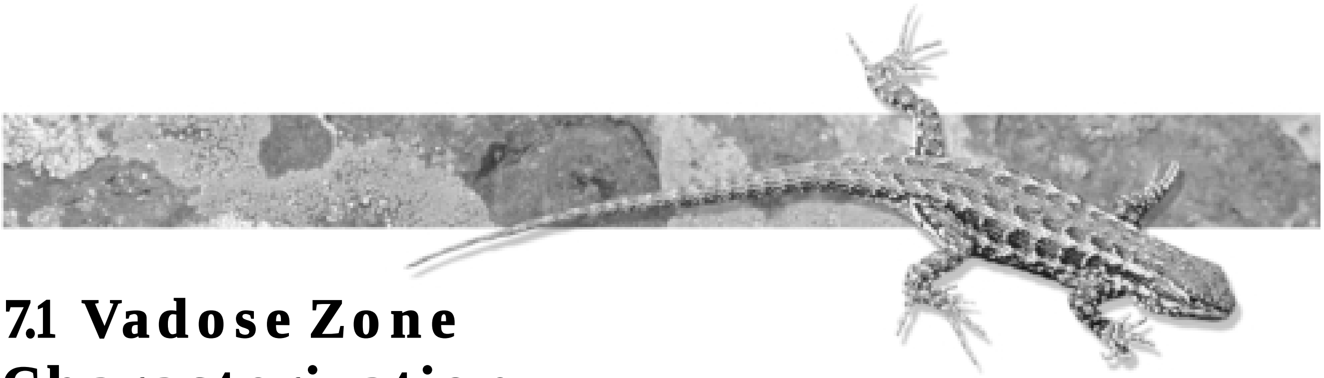


7.1 Vadose Zone Characterization

D. G. Horton

This section describes significant vadose zone characterization activities that occurred during fiscal year 2001. These characterization activities were done to further the understanding of physical and chemical properties of the vadose zone and vadose zone contamination. Vadose zone characterization activities at single-shell tank farms in fiscal year 2001 were concentrated at the B, BX, and BY tank farms in the 200-East Area and the S and SX, tank farms in the 200-West Area. Two new boreholes were drilled at Waste Management Area B-BX-BY through subsurface contaminant plumes. A third borehole was drilled immediately outside the tank farms to obtain uncontaminated core for comparison with the contaminated material obtained in the tank farms. Interim measures (Section 7.1.7) were completed at single-shell tank farms in fiscal year 2001 to minimize the subsurface movement of contaminants by preventing surface water from encroaching onto the tank farms. Although these efforts are not strictly characterization efforts, they are important and related because they help minimize the spread of contamination beyond existing contaminated regions.

During fiscal year 2001, baseline spectral gamma logging of selected wells at past-practice, liquid waste disposal facilities began. The results will be a baseline against which future monitoring results can be compared.

Vadose zone characterization activities were completed at one site in the 100-H Area to support remediation in the reactor areas.

Finally, characterization activities were completed at two burial grounds in the 600 Area, north of the city of Richland. The results of these activities provide a clearer picture of the distribution of subsurface contaminants in this area.

7.1.1 Drilling, Sampling, and Analysis of Soil at Waste Management Area B-BX-BY, 200-East Area

D. A. Myers

Two boreholes were drilled in single-shell tank farms at Waste Management Area B-BX-BY to obtain drill cores from contaminated sediment. Analysis of the samples will further our knowledge about contaminant distribution in this area and about migration of subsurface contaminants.

BX Tank Farm. Borehole 299-E33-45 was drilled in the BX tank farm east of single-shell tank BX-102 (RPP-7921). The location of the borehole is shown in Figure 7.1.1. The site for this borehole was selected based on information from spectral gamma logging of many drywells in the vicinity. The drywell logs indicated numerous radionuclides dispersed through the vadose zone to the full depth of the wells. The borehole was planned and constructed to characterize those radionuclides and collect samples for chemical and radiochemical analysis to determine the extent of non-gamma emitting radioisotopes in the soil around the wells.

A perched water zone, i.e., a local zone of saturation in the vadose zone caused by an impermeable sediment layer stopping the downward movement of water, was encountered ~69.2 meters (~227 feet) below ground surface. Water samples from the perched zone were collected for chemical and radiological analysis. Groundwater was encountered at a depth of 77.4 meters (254 feet) below ground surface, and the borehole was advanced to a total depth of 79.6 meters (261 feet). Groundwater was sampled to ascertain the technetium-99 concentration and to determine whether or not the borehole should be completed as a *Resource Conservation and Recovery Act of 1976* (RCRA)-compliant monitoring well. The technetium-99 concentration (~1,500 pCi/L [~55.5 Bq/L])

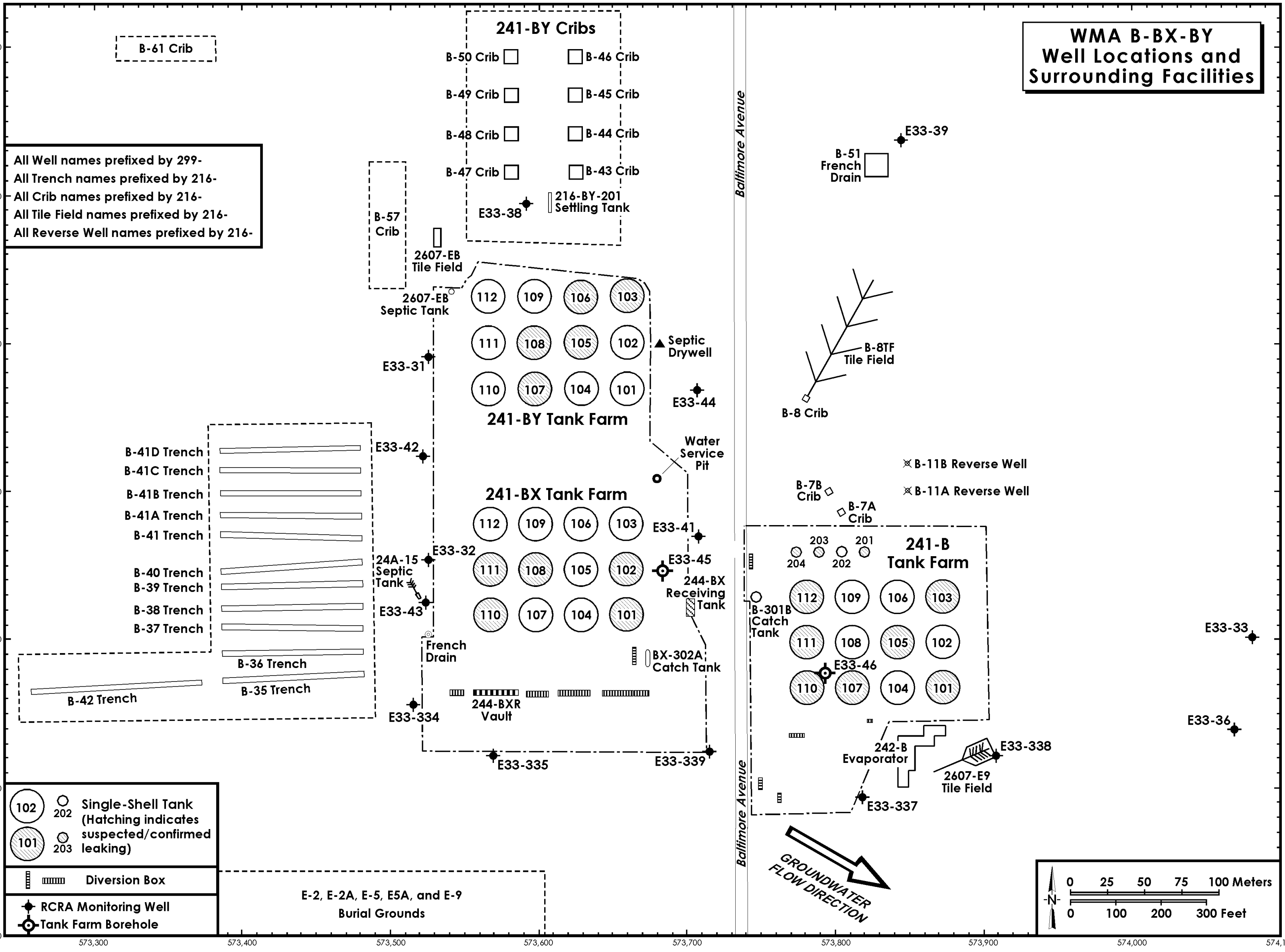


Figure 7.1.1. Locations of New Boreholes 299-E33-45 and 299-E33-46 at Waste Management Area B-BX-BY

was below the agreed-upon criterion of 4,000 pCi/L (148 Bq/L) for completion as a monitoring well. Sediment samples also were collected at depth intervals within the borehole. The borehole was geophysically logged using gross and spectral gamma tools and a neutron tool to measure soil moisture.

Some difficulty was experienced in decommissioning the borehole as portions of the hole collapsed as the casing was removed. An agreement with the Washington State Department of Ecology was reached to assure that abandonment of the borehole was consistent with the guidelines and intent of WAC 173-160. The borehole was decommissioned in accordance with the agreed-upon plan.

Analytical data are being collected from the samples obtained in the borehole. The results of those tests will be available in fiscal year 2002 and will be reported in a field investigation report for Waste Management Area B-BX-BY.

B Tank Farm. Borehole 299-E33-46 was drilled in the B tank farm adjacent to the B-110 single-shell tank. The location of the borehole is shown in Figure 7.1.1. The site for this borehole was selected based on data that indicated the possible presence of strontium-90. Initial identification of strontium-90 was based on spectral gamma logging that pointed to a potential source between 21 and 25 meters (69 and 82 feet) below ground surface in nearby drywells. Whereas strontium-90 has a relatively short half-life (29.1 years) and is not very mobile in soil, other longer-lived and more mobile radionuclides were likely to be present.

The borehole was advanced using the cable-tool technique. Thirty-three split-spoon samples were collected. In addition, 102 composite samples were collected every 0.6 meter (2 feet), through intervals from which split-spoon samples were not collected, starting from immediately below the first split-spoon sample at ~3.7 meters (~12 feet) and continuing to 80 meters (262 feet) below ground surface.

Groundwater was encountered at a depth of 78 meters (256 feet) below ground surface, and the borehole was drilled to a total depth of 80.5 meters (264 feet). A temporary screen was installed and groundwater was sampled to ascertain the technetium-99 concentration and to determine whether or not the borehole should be completed as a RCRA-compliant monitoring well. The technetium-99 concentration was below the agreed-upon criterion of 4,000 pCi/L (148 Bq/L) for completion as a groundwater monitoring well. The borehole was geophysically logged using gross and spectral gamma tools and a neutron tool to measure soil moisture.

Borehole 299-E33-46 was completed as a vadose zone monitoring structure (see Section 7.2.5).

7.1.2 Characterization of Single-Shell Tank Waste Management Area S-SX, 200-West Area

Compiled by D. G. Horton

Characterization activities continued at the S-SX tank farms in the 200-West Area in fiscal year 2001.

A series of four reports were issued in fiscal year 2001 describing the sampling and analysis associated with five boreholes drilled in or adjacent to the S-SX tank farms. The boreholes are: 299-W22-48 and 299-W22-50 (PNNL-13757-1), 299-W23-234 also known as 41-09-39 (PNNL-13757-3), 299-W23-19 (PNNL-13757-2), and C3082 (PNNL-13757-4). The work described in these reports occurred in 1998, 1999, and 2000; preliminary results were reported in previous Hanford Site environmental reports (PNNL-12088; PNNL-13230; PNNL-13487). This section summarizes and compares the final results from analyses of samples from the five boreholes. Complete discussions of the sampling, analytical techniques, and results are found in the reports cited above.

Boreholes 299-W22-48 and 299-W22-50 were drilled and completed as RCRA groundwater monitoring wells in fiscal year 2000 east of the SX tank farm (see Figure 6.1.24). They were drilled in uncontaminated sediment and serve as baseline wells to compare with those drilled in contaminated areas of the tank farm. Continuous core samples were collected from both boreholes during drilling.

Borehole 41-09-39 was originally drilled in December 1996 adjacent to the southeastern edge of tank SX-109 to a depth of 40 meters (131 feet). The purpose of the borehole was to determine the presence of cesium-137 at depths of 20 to 40 meters (65 to 131 feet). The borehole was deepened in 1997 to 68.6 meters (225 feet), and sediment samples were collected wherever possible. The borehole was decommissioned in 1999 at which time samples were obtained from portions of the borehole that were previously unsampled.

In 1999, borehole 299-W23-19 was drilled 3 meters (10 feet) from the southwestern edge of tank SX-115. The purpose of the borehole was to characterize the vadose zone sediment in the area of a 189,000-liter (49,900-gallon) leak that occurred in the mid-1960s. Near-continuous sediment samples were collected down to a depth of ~62.5 meters (~205 feet). The borehole was completed as a groundwater monitoring well in 2000.

Borehole C3082 was installed adjacent to tank SX-108 in 2000. Tank SX-108 had leaked between 9,084 and 132,475 liters (2,400 and 35,000 gallons) in 1962 (HNF-EP-0182). Borehole C3082 was drilled at an angle and aligned to pass beneath the tank, through a zone of high contamination, and terminate at a depth of 45 meters (147 feet). Sediment samples were obtained from 16 zones in the borehole.

Borehole 299-W23-19 encountered essentially the same stratigraphy and lithologies as the aforementioned boreholes except that the upper Ringold Formation is missing in borehole 299-W23-19. Borehole C3082 penetrated backfill and the Hanford formation and terminated in the upper Plio-Pleistocene unit.

Borehole samples were analyzed for anions, electrical conductivity, metals, pH, radionuclides, and water content. Differences in the analytical results between tank farm boreholes and the baseline boreholes were considered to be indicators of contamination from tank waste.

Anions and Metals (Nitrate and Sodium). Nitrate is the most concentrated anion in tank liquors. Its high concentration and mobility in the vadose zone make nitrate one of the most sensitive indicators of tank waste migrating through the vadose zone. Also, sodium is the dominant cation in tank fluids and is mobile in the vadose zone environment. Both nitrate and sodium profiles closely resemble the electrical conductivity profiles.

In borehole 41-09-39, elevated nitrate was encountered to a depth of 38.7 meters (127 feet) and sodium was elevated to a depth of 38.7 meters (127 feet), though moderate sodium values existed to ~47 meters (~154 feet). These deeper sodium concentrations may have been due to contaminants carried down on the drilling equipment during the drilling process (PNNL-13757-3). Nitrate in samples from C3082 was elevated throughout the total depth of the borehole, and sodium concentrations were high to a depth of ~39.6 meters (~130 feet).

Nitrate in borehole 299-W23-19 was elevated from 19.8 to ~47.6 meters (65 to ~156 feet). Nitrate concentrations were generally within natural range in samples deeper than 47.6 meters (156 feet) except for the two deepest samples. The two deepest samples were collected below the highest water-table level recorded during the time that tank SX-115 was suspected to have leaked. Thus, the deepest nitrate concentrations may have resulted from nitrate in a water table that was higher than the current water table. In general, the distribution of nitrate with depth in borehole 299-W23-19 suggests that the leading edge of the nitrate plume is 47.6 meters (156 feet) deep.

Elevated sodium concentrations began abruptly at 22.3 meters (73 feet) below ground surface in borehole 299-W23-19 and extended to ~48.3 meters (~158 feet) below ground surface. The bottom of the sodium profile was not sharp, but gradually decreases until natural concentrations were attained at ~39.6 meters (~130 feet) below ground surface.

In boreholes 41-09-39 and C3082, sodium was slightly elevated throughout the upper part of the boreholes but did not greatly increase until 23.1 to 25.3 meters (76 to 83 feet) below ground surface. In borehole 41-09-39, sodium concentration decreased to natural levels at 40.6 meters (133 feet) below ground surface; sodium remained above natural levels in borehole C3082 to total depth.

Evidence for ion exchange reactions in the vadose zone was seen in the boreholes impacted by tank waste. This was especially evident for sodium, calcium, and magnesium. The sediment samples showed that the sodium in the leaked tank fluids had replaced the other major cations on exchange sites in the native sediment. The displaced cations were effectively pushed ahead of the sodium bearing fluids as they migrated downward.

Electrical Conductivity. The natural, dilution corrected, electrical conductivity in boreholes 200-W22-48 and 299-W22-50 was between ~200 and 6,000 µS/cm. Because the 1:1 water extract values are diluted with respect to the natural porewater, the diluted value is multiplied by the dilution factor, i.e., the amount of water added, to obtain the natural value for the sediment (PNNL-13757-1). One sample in borehole 299-W22-50 showed pH and electrical conductivity values greater than the other samples from the two uncontaminated boreholes. The electrical conductivity of that sample was considered natural and resulted from dissolved minerals in the sample (PNNL-13757-1).

The electrical conductivity versus depth profiles for boreholes 41-09-39 and C3082 were similar, although the electrical conductivity of the sediment beneath tank SX-108 (C3082) was an order of magnitude greater than the conductivity of the sediment adjacent to tank SX-109 (41-09-39). The data from these two boreholes suggested that contamination had reached 40.3 meters (132 feet) in borehole 41-09-39 and was below 44 meters (144 feet) in borehole C3082. For both boreholes, however, the bulk of the contamination was higher, between 24.4 and 39.6 meters (80 and 130 feet) in borehole 41-09-39 and between 22.9 and 32 meters (75 and 105 feet) in borehole C3082.

The electrical conductivity profile from borehole 299-W23-19 was somewhat different than the profile of the other two boreholes. The profile showed that the contaminant plume had reached the bottom of a silt-rich sediment at 47.6 meters (156 feet) and the bulk of contamination was within the silt unit between ~36.6 and 47.6 meters (~120 and 156 feet). This was deeper than the bulk of contamination shown by electrical conductivity from boreholes 41-09-39 and C3082 where the bulk of the contamination was in the geologic unit above the silt unit.

pH. The pH from 1:1 sediment:water extracts versus depth for all five boreholes indicated that natural pH values of uncontaminated sediment were between ~7.0 and 8.5 with a few samples extending to near 9.0.

In none of the contaminated boreholes was the pH as high as might be expected where tank fluids completely saturate sediment (pH > 13; PNNL-11495). This may have resulted from neutralizing reactions with the sediment and/or carbon dioxide in the vadose zone. Because of these possible neutralizing reactions, pH is not considered a good indicator of the extent of contamination, although it is essential to understand contaminant behavior in the vadose zone.

Radionuclides. Concentrations of technetium-99, a contaminant from leaked waste tank fluids, were found to be elevated in sediment from the three contaminated boreholes at the SX tank farm. Technetium-99 is thought to be extremely mobile in the vadose zone (PNL-10379). The distribution of elevated technetium-99 generally mimics that of electrical conductivity and nitrate. Using the distribution of technetium-99, the leading edge of the contaminant plume was at depths of 41.2 and 42 meters (135 and 138 feet) in boreholes 41-09-39 and C3082. In borehole 299-W23-19, the bulk of technetium-99 contamination was above 47.6 meters (156 feet) below ground surface, but elevated technetium-99 concentrations (between 6 and 68 pCi/mL) extended to the deepest sample. The deepest sediment sample contained 176 pCi/mL of technetium-99, which may be a result of past interactions with groundwater containing technetium-99.

In summary, the pH of sediment samples did not identify the leading edge of contaminant plumes in the SX tank farm. However, the more mobile indicators, such as electrical conductivity, nitrate, sodium, and technetium, suggested that the leading edge of the contaminant plume was at a depth of 38.7 to 41.2 meters (127 to 135 feet) in borehole 41-09-39 and 42 meters to >44.2 meters (138 to >145 feet) (i.e., deeper than the bottom of the borehole) in borehole C3082. In these two boreholes, the bulk of contamination appeared to be significantly shallower than the leading edge of the plume. In borehole 299-W23-19, the bulk of contamination was between a depth of 37.2 and 47.6 meters (122 and 156 feet), but some contamination extended to groundwater.

Water Content. Although there was some correlation between moisture content and the presence of contamination, the relationship was not straightforward because the moisture content also reflects changes in the physical characteristics of the sediment. Fine-grained sediment tended to have a higher moisture content than coarse-grained sediment, and those differences were mixed with moisture differences due to leaked fluids. Therefore, moisture by itself was not considered a good indicator of contamination, though moisture content tended to be higher in contaminated zones.

7.1.3 Geophysical Logging at Former Liquid Waste Disposal Facilities

S. M. Sobczyk, P. D. Henwood, R. G. McCain, and S. E. Kos

Geophysical logging was conducted in fiscal year 2001 to support

- the 200 Areas Vadose Zone Characterization
- the 200-TW-1 Scavenged Waste Group Operable Unit
- the 200-TW-2 Tank Waste Group Operable Unit Remedial Investigation/Feasibility Study
- installation of new RCRA groundwater monitoring wells.

Spectral gamma logging in existing boreholes near the liquid waste disposal sites and solid waste burial grounds in the Hanford Site 200 Areas began during fiscal year 2001. The purpose of this work was to detect and quantify naturally occurring and manmade gamma-emitting radionuclides in the vadose zone. This was an extension of the baseline characterization work completed in the Hanford Site single-shell tank farms in previous years (e.g., PNNL-13230; PNNL-13487). The newly acquired spectral gamma logs will establish a baseline for comparison of future logs identifying gamma-emitting contaminants and tracking the rate of contaminant movement in the vadose zone.

The spectral gamma logs provided information regarding the nature and extent of vadose zone radiological contamination associated with former liquid waste disposal facilities. Data from each borehole were analyzed to determine concentrations of naturally occurring radionuclides such as potassium-40, uranium-238, thorium-232, and associated decay progeny, as well as manmade gamma-emitting radionuclides such as cesium-137, cobalt-60, and europium-152 and -154. Variations in concentrations of naturally occurring radionuclides are used to correlate geologic layers. The presence of manmade gamma emitters helps define the extent of the contaminated areas under the disposal facilities.

The logging system, the logging methods, and the data collection and analysis procedures are described in documents available on the worldwide web at http://www.gjo.doe.gov/programs/hanf/HTFVZ.html.

During fiscal year 2001, data from spectral gamma logging were collected in 30 boreholes in or near waste sites in the 200 Areas. Fifteen existing boreholes were logged for the 200 Areas Vadose Zone Characterization Project. Eight new characterization boreholes were logged for the 200-TW-1 Scavenged Waste Group Operable Unit and the 200-TW-2 Tank Waste Group Operable Unit Remedial Investigation/Feasibility Study. In addition, seven new RCRA groundwater monitoring wells, which were installed during fiscal year 2001, were logged. Results of the 200 Areas Vadose Zone Characterization Project are posted on the worldwide web at: http://www.gjo.doe.gov/programs/hanf/HTFVZ.html.

In 2001, the 200 Areas Vadose Zone Characterization Project was in full operation. Gamma spectra were collected in boreholes and monitoring wells located within and near waste disposal sites (e.g., ponds, ditches, cribs, and burial grounds) in the 200-East and 200-West Areas. Priority for logging existing boreholes was determined by the data needs of ongoing investigation efforts of the Groundwater/Vadose Zone Integration Project.

The logging done for the 200 Areas Vadose Zone Characterization Project identified deep contamination in borehole 299-E33-20 near the 216-B-11B injection well (see Figure 7.1.1 for location of well 216-B-11B). In this borehole, cesium-137 and cobalt-60 were detected at depths below 73.2 meters (240 feet). These depths coincided with historical water levels; the depth to water was reported at 74.1 meters (243 feet) in July 1956, 71.4 meters (234 feet) in November 1989, and 76.5 meters (251 feet) in April 2000. The increased water levels in the late 1980s were probably due to the 216-B-3 pond system (B Pond), but the cesium-137 and cobalt-60 concentrations may have come from the 216-B-11A and 216-B-11B injection wells located ~4.6 meters (~15 feet) northeast of the logged borehole. The discharges to the B Pond system caused a groundwater mound in this area that has since receded, leaving contaminated soil in the vicinity.

Logging for the 200-TW-1 Scavenged Waste Group Operable Unit and 200-TW-2 Tank Waste Group Operable Unit was done at the 216-B-38 specific retention trench (see Figure 7.1.1 for location of the trench). The maximum concentration of cesium-137 measured to date in any borehole logged outside of tank farms is 300,000 pCi/g (11,100 Bq/g) of cesium-137 between ~6 and 10 meters (~20 and 35 feet) depth in a characterization borehole (C3104) located near the 216-B-38 trench. This cesium-137 concentration level is about three orders of magnitude less than the maximum cesium-137 concentration detected in the single-shell tank farms.

Seven RCRA groundwater monitoring wells installed during fiscal year 2001 were logged. Four of those wells (299-E33-339, 299-W19-45, 299-W18-40, and 299-W15-765) showed indications of naturally occurring radon in groundwater. Radon in a borehole may increase the observed gamma counts so that, if the gross gamma log is being used for geologic correlations, the presence of radon must be considered.

7.1.4 Trench 116-H-1 Characterization

J. J. Kious

Bechtel Hanford, Inc. remediated the 116-H-1 trench in spring 2000. Characterization for site closeout was subsequently completed and documented in fiscal year 2001. Characterization consisted of determining the vertical distribution of contaminants of concern in the vadose zone between the base of the 116-H-1 trench and the water table. This section summarizes the characterization activities and results. A complete description of the characterization work can be found in BHI-01541.

The 116-H-1 trench, located in the 100-H Area, received ~90 million liters (~2.4 million gallons) of reactor cooling water and an unknown volume of water and sludge from the operation and deactivation of the 107-H retention basin. The waste contained 90 kilograms (198 pounds) of sodium dichromate.

Borehole C3048 was drilled at the northern end of the trench ~5 meters (~16 feet) from the inlet pipe. The borehole was drilled to a total depth of 9.76 meters (32 feet) below the bottom of the trench. The bottom of the trench is 4.9 meters (16 feet) below grade. The sediment encountered during drilling was pebble-cobble gravel with thin interbeds of sand and silt. The water table was encountered at a depth of 8.01 meters (26.3 feet).

Eight sediment samples were collected at 1-meter (3.28-feet) intervals between 0.76 and 7.8 meters (2.5 and 25.6 feet) drilled depth. Samples were sent to the laboratory to measure concentrations of constituents of concern (arsenic, carbon-14, cesium-137, cobalt-60, europium-152, -154, and -155, hexavalent chromium, mercury, plutonium-239/240, total strontium, and uranium-238).

Analytical results showed that the concentrations of most constituents decreased with increasing depth. For several constituents, there was a sharp decrease in concentration at a depth of 2 meters (6.5 feet) below the trench bottom. This was most dramatic for cesium-137 and europium-152 (Figure 7.1.2). Cobalt-60 and mercury were detected only above a borehole depth of 2 meters (6.5 feet) with maximums of 1.4 pCi/g (0.052 Bq/g) and 0.12 mg/kg at 1 meter (3.28 feet), respectively. Arsenic, europium-154, plutonium-239/240, strontium-90, and uranium-238 showed slight decreases in concentrations with depth. All results for carbon-14 and europium-155 were below minimum detectable levels. Unlike the other constituents, hexavalent chromium showed a maximum concentration below a depth of 2 meters (6.5 feet) below the trench bottom. The maximum hexavalent chromium concentration was 0.47 to 0.59 mg/kg at 4.1 to 5.2 meters (13.5 to 17.1 feet), which is 2.8 to 3.9 meters (9 to 13 feet) above the water table. The deepest sample, from a depth of 6.1 meters (20 feet), contained no detectable hexavalent chromium.

Finally, the moisture content of all samples was below ~10%, which is within the normal range of Hanford Site sediment. This indicates that water used for dust control during remediation activities has not driven contaminants deeper into the soil column.

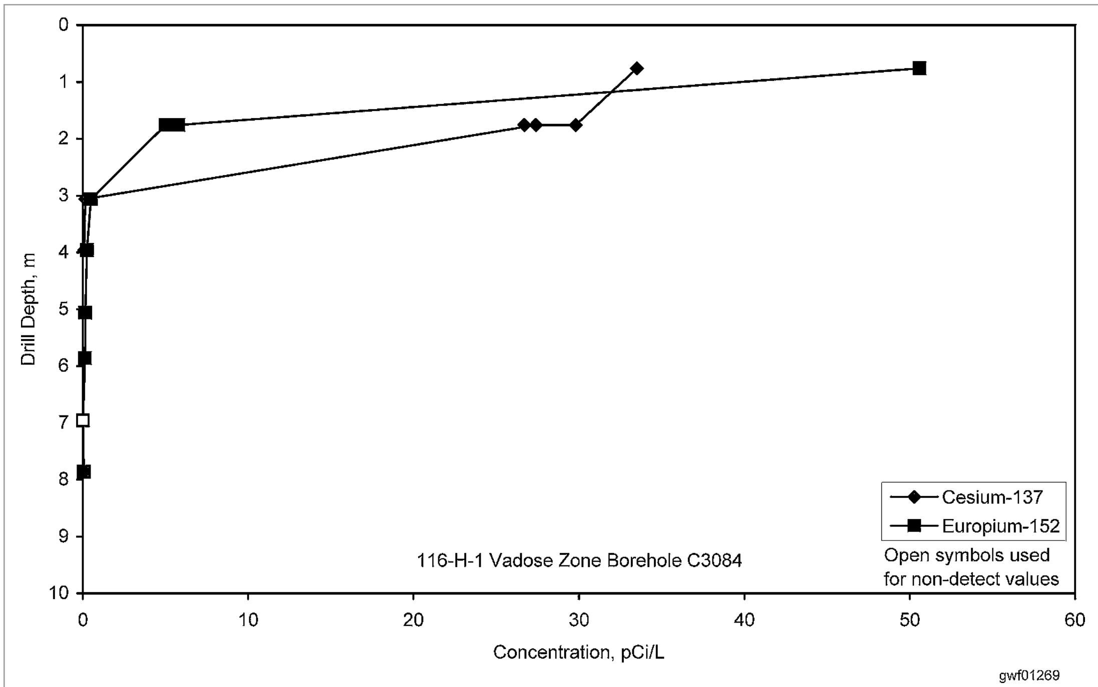


Figure 7.1.2. Concentrations versus Depth for Cesium-137 and Europium-152 in Borehole Samples at the 116-H-1 Trench

7.1.5 Helium-3/Helium-4 Ratios in Soil Gas as an Indicator of Subsurface Tritium Contamination at the 618-11 Burial Ground Site

P. E. Dresel and K. B. Olsen

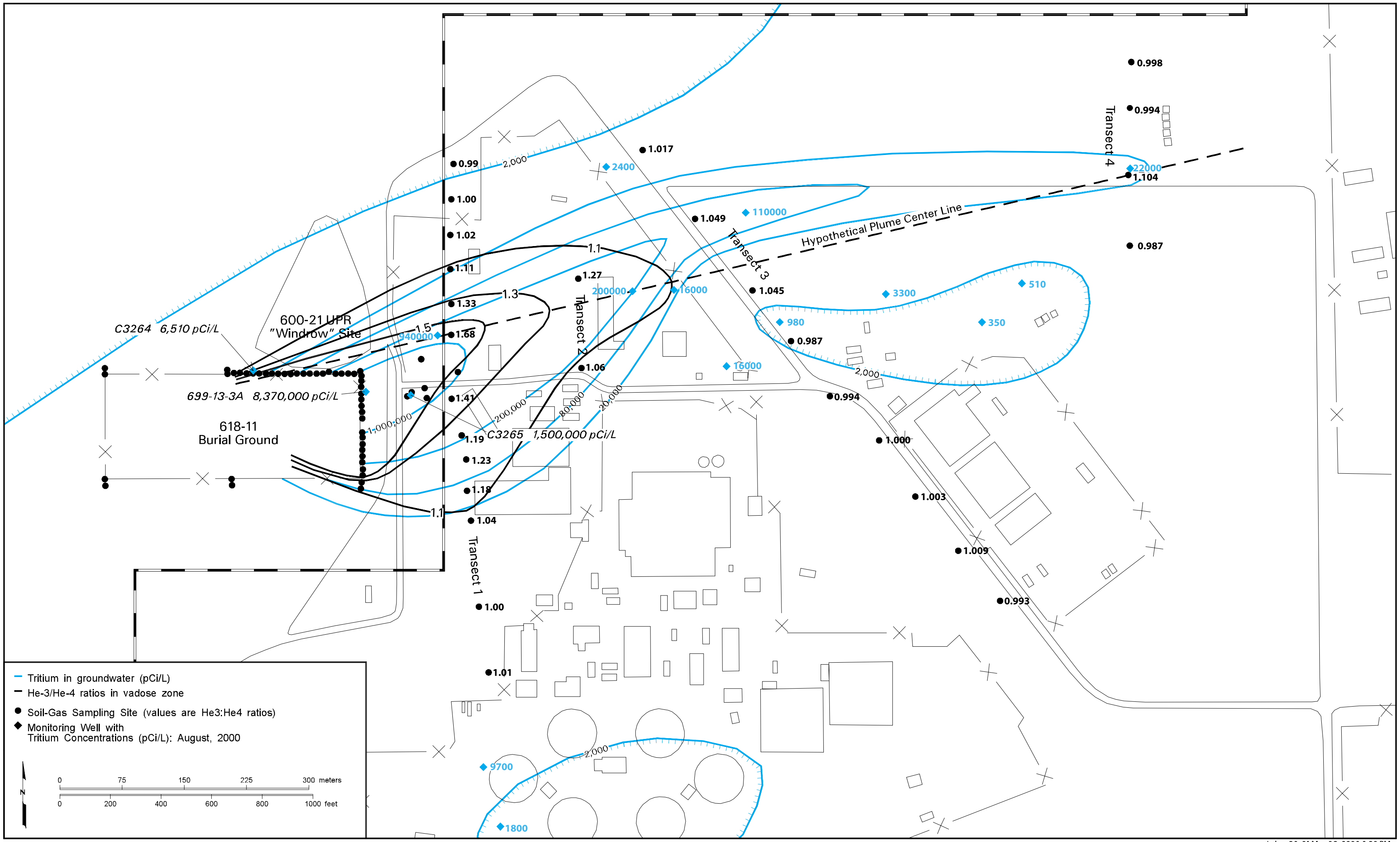
A groundwater sample collected in January 2000 from well 699-13-3A, located along the eastern fence line of the 618-11 burial ground (Figure 7.1.3), contained 8.1 million pCi/L (299,700 Bq/L) of tritium. This was the highest concentration of tritium detected at the Hanford Site in recent years. To determine the extent of the groundwater contamination, investigators used helium-3 in the vadose zone as a surrogate tracer for tritium in groundwater. The investigation began in fiscal year 2000 and continued through fiscal year 2001. The fiscal year 2000 investigation established the burial ground as the source of tritium in groundwater and showed that the contamination extended east (downgradient) of the burial ground. A soil gas survey was performed in summer 2001 to determine the direction and extent of tritium groundwater contamination downgradient of the burial ground. The results of the soil gas survey were used to define locations for groundwater sampling and monitoring well installation. Section 6.1 discusses the results of the groundwater investigation at the 618-11 burial ground and contains a plume map for tritium in the area. This section summarizes the soil gas investigation results.

Samples of soil gas collected at the 618-11 burial ground were analyzed for helium isotopes (helium-3 and helium-4) to determine helium-3/helium-4 ratios. The technique is based on the decay of tritium, with a half-life of 12.32 years. Tritium decays to the stable, inert isotope helium-3. As tritium decays, its daughter isotope, helium-3, begins to build up in the vadose zone and groundwater at the rate of tritium decay. The helium-3 then diffuses away from the source and toward the surface. Soil gas monitoring at the 618-11 burial ground was based on the measurement of helium-3 in the soil gas to identify vadose and/or groundwater sources of tritium in the subsurface environment. The results are expressed as the ratio of helium-3 to helium-4, normalized to the ratio in the atmosphere. Thus, the background value for soil gas that has not been affected by tritium contamination is expected to be close to 1.00.

Fifty-four soil gas sampling points were installed north and east of the 618-11 burial ground in fiscal year 2000. Twenty-seven new soil gas sampling points were installed in fiscal year 2001 east (downgradient) of the 618-11 burial ground (see Figure 7.1.3). All sampling points were completed at 6 meters (20 feet) below ground surface. Each sampling location was allowed to equilibrate for at least 24 hours before soil gas samples were collected. Several of the fiscal year 2000 sample points were re-sampled in fiscal year 2001 to complete the spatial coverage and to look at temporal changes.

The results of analyses of the soil gas samples from the fiscal year 2001 sampling are shown in Figure 7.1.3. Helium-3/helium-4 ratios from samples from the northern and southern ends of the area approached background levels (1.0). The helium-3/helium-4 ratios reached a maximum of 1.65 in transect 1, closest to the burial ground. The plume is narrower and helium-3/helium-4 ratios were smaller in transect 3, to the east. Only one soil gas sampling point in transect 4 showed a signal greater than background. The value at that point was higher than the maximum seen in transect 3, though transect 4 was farther from the source. The higher ratio seen in transect 4 was believed to be because transect 4 is topographically low compared to the other transects; so the soil gas points in transect 4 are closer to the water table and the source of helium-3. The soil gas helium results indicate the centerline of the tritium plume and bound the lateral extent.

Six locations for groundwater samples were chosen, based on the results of the soil gas monitoring. Four of the boreholes drilled for the groundwater sampling were completed as monitoring wells for ongoing sampling of the tritium plume. The results of the groundwater sampling were in agreement with the extent of contamination defined by the soil gas study (see Figure 7.1.3).



can kolsen02 01 May 06, 2002 2:02 PM

Figure 7.1.3. Locations of Monitoring Points and Results of Fiscal Year 2001 Helium Ratio Analyses at the 618-11 Burial Ground

7.1.6 Geophysical and Statistical Investigation of the 618-4 Burial Ground

C. J. Murray, G. V. Last, and Y. Chien

A geophysical and statistical investigation of the 618-4 burial ground was completed in fiscal year 2001. The objective was to use the Enhanced Site Characterization System to analyze previously collected geophysical data and new geophysical data to map the distribution of buried waste. The Enhanced Site Characterization System is a set of geostatistical techniques to simultaneously analyze multiple data sets. This section provides a brief summary of the characterization work at the 618-4 burial ground. A full description of the work is given in PNNL-13656.

The 618-4 burial ground is located north of the 300 Area, ~1.6 kilometers (~1 mile) north of the city of Richland and 340 meters (1,120 feet) west of the Columbia River. The burial ground consists of a single pit that is 160 meters (525 feet) long, 32 meters (105 feet) wide, and 6 meters (20 feet) deep (DOE/RL-88-31). The burial ground received trash and debris contaminated with uranium from nuclear fuel manufacturing processes in the 300 Area between 1955 and 1961.

Geophysical surveys using ground penetrating radar, magnetometer, and metal detectors were conducted over the burial ground in 1991 (WHC-SD-EN-TI-061) revealing metallic waste in the main part of the pit. The burial ground was partly excavated during 1997 and 1998 as part of the environmental restoration at the 300-FF-1 Operable Unit. In April 1998, excavation was stopped after 338 drums containing depleted uranium metal shavings and uranium-oxide powder were exposed.

A re-interpretation of the 1991 ground penetrating radar data in 1999 showed the presence of two anomalies; one coincided with the location of known, buried drums adjacent to the 338 exposed drums, and the second was located ~20 to 30 meters (~65 to 98 feet) southwest of the buried drums. A detailed geophysical investigation was conducted over the central, unexcavated portion of the burial ground in 2001 to better define the boundaries of the two anomalies identified in 1999.

Five variables were incorporated into the Enhanced Site Characterization System analysis: time domain electromagnetic data, magnetic field strength, the thickness of the fill overlying the buried waste (from ground penetrating radar data), the slope of the top of the buried waste (from ground penetrating radar data and surface elevation measurements), and the amplitude of the ground penetrating radar reflection.

The newly acquired geophysical data allowed estimates of the number of drums remaining in the unexcavated parts of the 618-4 burial ground. The number of remaining drums was estimated to be between ~770 and 850 depending on their stacking arrangement and size.

A combination of box plots and discriminant function analysis showed that the area of known drums and the southwest anomaly are similar to one another and different from the rest of the study area. The major differences between the two anomalies and the rest of the study area are that the two anomalies have a higher magnetic field strength, indicating the presence of ferric metals, and a greater thickness of overlying fill material

The results of the study showed that analyses using the Enhanced Site Characterization System could successfully integrate multiple geophysical variables and group observations into clusters that are relevant for planning the excavation of buried waste. The deployment of the Enhanced Site Characterization System and use of multivariate geostatistical methods allowed construction of a conceptual model of the distribution of buried waste at the 618-4 burial ground. The conceptual model provided information that can increase the efficiency of remediating the burial ground.

7.1.7 Interim Measures at 200-West Area Tank Farms

D. A. Myers

The River Protection Project's Vadose Zone Project is finding ways to reduce the movement of tank farm contaminants in the vadose zone. Infiltration of water through the vadose zone has been identified as the primary means by which contaminants are displaced beneath the farms. Two interim measures were taken during fiscal year 2001: placing surface water controls adjacent to tank farms in the 200-West Area, and testing and capping water lines associated with S, SX, and U tank farms in the 200-West Area.

Surface Water Controls. The tank farms in the 200-West Area were originally located in areas that would allow gravity flow of intertank transfer liquids to the farms and minimize the need for supplemental pumping to transfer waste from the point of origin to the storage tanks. Because of this, the tank farms are situated in areas of relatively low elevation. Placement of the farms at a lower elevation was helpful in filling the tanks, but it resulted in the tank farms being potential accumulation points for surface water run-on from major meteorological events or from breaks in waterlines supplying facilities in the 200 Areas. One notable instance of a natural meteorological event occurred in 1978 when a Chinook wind melted a substantial snow pack and water flooded Waste Management Area T tank farm. An example of a failed waterline occurred in 1993 when a 35-centimeter (13.8-inch) water main failed during construction activities and released an estimated 2.2 liters (580,051 gallons) that ultimately reached the S and SY tank farms.

During fiscal year 2001, berms and other diversion structures were placed in the 200-West Area to redirect run-on away from the tank farms. Whereas precipitation falling directly on the tank farm surfaces remains as a source of recharge, surface water run-on from land adjacent to these farms has been effectively redirected and eliminated from the tank farm. Plans are presently being implemented to construct similar controls in the 200-East Area during fiscal year 2002.

Testing and Capping of Waterlines. Aging water-supply pipelines in the 200-West Area have been used for up to 2.5 times their design life. These lines that service the tank farms are a major potential source of water that could mobilize contaminants present in the vadose zone. The ongoing water requirements of the single-shell tank farms were assessed to ascertain which lines were essential for operations. Those lines that were determined to be unnecessary are being isolated, cut, and capped near the large diameter trunk lines that supply water throughout the 200 Areas. Those lines that were found to be necessary for continued operations are being leak tested; lines found to be leaking will be removed from service and replacement lines constructed.

During fiscal year 2001, two lines leading to the S, SX, and SY tank farms were abandoned by capping. Lines servicing the U tank farm and the 242-S evaporator were tested for leakage. The three lines tested showed no measurable losses when tested for 24 hours.