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Westinghouse Hanford Company Operational Environmental Monitoring Annual Report, Calendar Year 1995

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Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management



Westinghouse
Hanford Company Richland, Washington

Management and Operations Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

Approved for Public Release

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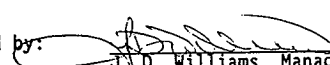
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RECOGNITION

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WESTINGHOUSE HANFORD COMPANY OPERATIONAL ENVIRONMENTAL
MONITORING ANNUAL REPORT

Calendar Year 1995

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ABSTRACT

This document summarizes the results of the Westinghouse Hanford Company near-facility operational environmental monitoring for 1995 in the 100, 200/600, and 300/400 Areas of the Hanford Site, in south-central Washington State. Surveillance activities included sampling and analyses of ambient air, surface water, groundwater, soil, sediments, and biota. Also, external radiation measurements and radiological surveys were taken at waste disposal sites, radiologically controlled areas, and roads. These activities were conducted to assess and control the effects of nuclear facilities and waste sites on the local environment. In addition, diffuse sources were monitored to determine compliance with Federal, State, and/or local regulations. In general, although effects from nuclear facilities can still be observed on the Hanford Site and radiation levels are slightly elevated when compared to offsite locations, the differences are less than in previous years.

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EXECUTIVE SUMMARY

NEAR-FACILITY ENVIRONMENTAL MONITORING

The near-facility environmental monitoring program operated by Westinghouse Hanford Company provides environmental monitoring as a means to measure the impacts of operations, waste management, and remediation activities on the environment adjacent to facilities and ensure compliance with local, State, and Federal environmental regulations.

Specifically, the near-facility environmental monitoring program monitors new and existing sites, processes, and facilities for potential impacts and releases, fugitive emissions and diffuse sources from contaminated areas, and surplus facilities before decontaminating or decommissioning. External radiation, ambient air particulates, ground and surface water, soil, vadose zone, sediment, and biota (plants and animals) were sampled or monitored. Parameters included, as appropriate, radionuclides; radiation fields; chemical or physical constituents, such as nitrates; pH; and water temperature.

While the analytical results showed a high degree of variability, in general, the samples collected from media located on or directly adjacent to the waste disposal and other nuclear facilities had significantly higher concentrations than those farther away. As expected, certain radionuclides were found in higher concentrations within different operational areas. Generally speaking, the predominant radionuclides were activation products/gamma emitters (e.g., ^{60}Co , ^{137}Cs , etc.) in the 100 Areas, fission products (e.g., ^{90}Sr , etc.) in the 200/600 Areas, and uranium in the 300 Area.

Air Monitoring. Radioactivity in air was sampled by a network of continuously operated samplers at 47 locations near facilities: 4 in the 100-N Area, 4 in the 100-K Area, 37 in the 200/600 Areas, 1 near the 300 Area Treated Effluent Disposal Facility, and 1 station collocated with the Surface Environmental Surveillance Project and the Washington State Department of Health at the Wye Barricade. Air samplers were primarily located at or near sites and/or facilities having the potential for or history of release, with an emphasis on the prevailing downwind directions. Of the radionuclide analyses performed, ^{90}Sr , ^{137}Cs , $^{239,240}\text{Pu}$, and uranium were consistently detectable in the 200 Areas and ^{60}Co was consistently detectable in the 100-N Area. Air concentrations for these radionuclides were elevated near facilities when compared to the concentrations measured off site by the Surface Environmental Surveillance Project, but were well below the applicable derived concentration guides used to indicate performance.

Monitoring of Surface-Water Disposal Units and Seeps. Sampling of surface-water disposal units included water, sediment, and aquatic vegetation. Samples collected at river shoreline seeps consisted of water only. Radiological analysis included total alpha, total beta, ^3H , $^{239,240}\text{Pu}$, and gamma-emitting radionuclides. Nonradiological analyses performed on water samples included pH, temperature, and nitrates.

Radionuclide concentrations in surface-water disposal units were below the applicable Derived Concentration Guides used as indices of performance and, in most cases, were at or below the analytical detection limit. Although some slightly elevated levels were seen in both aquatic vegetation and sediment, in all cases the radiological analytical results were well below the standards for radiological control. The results for pH were well within the

range of 2.0 to 12.5, the standard for liquid effluent discharges required by the *Resource Conservation and Recovery Act of 1976*. The analytical results for nitrates were all below the 45-mg/L Drinking Water Standard.

Groundwater seeps along the 100-N Area shoreline are sampled to verify the reported radionuclide releases to the Columbia River from past operations of the N Reactor. By characterizing the radionuclide concentrations in the seeps along the shoreline, the results can be compared to the concentrations measured in the facility effluent monitoring well.

In 1995, the concentrations detected in the seep samples were highest in those seeps nearest the facility effluent monitoring well, although the seep concentrations were considerably lower than those measured in the well.

Vadose Zone Monitoring. The inactive liquid effluent facilities vadose monitoring program tracks the movement of radioactive contaminants discharged to the soils. The Hanford Site has more than 300 liquid waste disposal sites that have received over 53 billion liters of waste, excluding the 1,620 billion liters discharged at the surface to ponds and ditches. During calendar year 1995 approximately 75 boreholes were logged around these facilities. They will be used to identify and track radioactive plumes. In addition, approximately 35 wells scheduled for decommissioning on Site were surveyed for gamma-ray radiation to ensure that the wells were not contaminated and for moisture and geologic data to help determine moisture migration pathways. Vadose Zone Monitoring also supported the environmental restoration program by collecting approximately 40 borehole logs for delineating subsurface radioactive contamination.

Groundwater Monitoring. Groundwater monitoring to assess changes in water quality is conducted at *Resource Conservation and Recovery Act of 1976* (RCRA) and non-RCRA operational facilities as part of the RCRA/Operational Monitoring (ROM) activity. The ROM's primary purposes are to comply with interim- and final-status state and federal RCRA requirements, assess the potential impact of facilities on groundwater quality and movement, and provide an early warning of unusual occurrences and trends. During calendar year 1995, more than 300 RCRA-compliant wells were sampled quarterly or semiannually (about 900 sampling events).

The non-RCRA monitoring network currently includes approximately 50 wells, as described in the *Hanford Site Environmental Monitoring Plan* (DOE-RL 1994). Samples are collected quarterly at active discharge sites and semiannually or annually at other sites. Up to 100 additional wells have been sampled annually to supplement available data for defining near-field plume distribution patterns.

Groundwater monitoring wells are sampled for site-specific chemical and radiological constituents, and for general contamination indicator parameters. Water-table elevations in selected wells are measured to determine the direction of groundwater movement in the vicinity of waste disposal and storage sites. Most of the monitoring wells are located immediately adjacent to the monitored facility, but some are located further away to help define plume boundaries. Data from upgradient and downgradient wells are compared to assess the impact from a specific facility. The direction of groundwater movement is inferred from water-table elevation maps based on area-wide and facility-specific water-level measurements.

Groundwater Protection Issues. Four major changes or trends were identified by the ROM groundwater program during calendar year 1995.

- Specific conductance of groundwater and mobile co-contaminants (e.g., ^{99}Tc , nitrate, and chromate) increased beneath the B-BX-BY and S-SX Waste Management Areas. Plans are being made for additional assessment monitoring to determine if these TSDs are responsible for the observed changes in groundwater quality.
- Elevated ^{90}Sr in groundwater immediately downgradient of the 100-KE basin reached concentrations well above the DCG (1,000 pCi/L). Concentrations declined sharply following repair of a leaking water line above an adjacent past-practice disposal site.
- Concentrations of ^{14}C and tritium in groundwater near the 100-KE/KW reactor buildings remain elevated. Cleanup priorities and jurisdictional uncertainties have hindered corrective measures at the past-practice disposal sites assumed responsible.
- More than 200 older monitoring wells were identified that could be preferential pathways for contaminant transport to deeper portions of the unconfined and upper confined aquifers. The most critical is well 2-W15-5, near the center of the carbon tetrachloride plume in the 200 West Area. Although work began on well 2-W15-5, issues of jurisdiction and unavailable equipment have hindered progress on decommissioning these older wells.

Long-Term Trends and Changing Monitoring Needs. Terminating disposal of untreated waste water to the ground in 1995 eliminated most active sources of groundwater contamination. However, residual contaminants continue to migrate from the soil column beneath certain disposal sites.

As declines in waste water disposal volumes and changes in discharge locations cause shifts in groundwater flow direction, regional monitoring networks may be more appropriate than unit-specific ones. An area-based groundwater monitoring plan covering the PUREX cribs (216-A-37-1, 216-A-36B, 216-A-10 and 216-A-45) was prepared during 1995. However, the continuing presence of mobile single-shell tank-related constituents in groundwater beneath tank farms and at other disposal sites suggests that contaminant transport through the vadose zone to groundwater continues. At critical TSD sites, site-specific vadose and groundwater monitoring must be used to provide early warning of contaminant movement.

Radiological Surveys. Approximately 2,531 ha (6,254 acres) of outdoor contamination/soil contamination and 1,025 ha (2,532 acres) of underground radioactive material were posted sitewide in 1995. These areas were typically associated with cribs, burial grounds, tank farms, and covered ponds, trenches, and ditches. The number of posted contamination/soil contamination areas varied because of an ongoing effort to clean, stabilize, and remediate areas of known contamination while new areas of contamination were being identified. New areas may have been identified because of either contaminant migration or the increased effort being made to investigate outdoor areas for radiological contamination. It was estimated that the external dose rate for 80 percent of the identified outdoor surface contamination areas was less than 1 mrem/h, although isolated radioactive specks [smaller than 0.6 cm

(0.25 in.)] could be considerably higher. Contamination levels of this type would not significantly add to external dose rate calculations for the public or Site employees.

Soil and Vegetation Monitoring. Soil and vegetation samples were also collected on, or adjacent to, waste disposal units and from locations downwind and within the operating environment of facilities. Special samples were collected where physical or biological transport problems were identified. Soil and vegetation sample concentrations for some radionuclides were elevated near facilities, when compared to the concentrations measured off site. The concentrations show a large degree of variability; in general, samples collected on, or directly adjacent to, waste disposal facilities had significantly higher concentrations than those collected farther away.

External Radiation. External radiation fields were surveyed near facilities and waste-handling, storage, and disposal sites to measure, assess, and control the effects of operations.

A hand-held meter (to measure low-level radiation fields) was used in the 100-N Area to survey points near and in the N Springs area. The levels measured in the N Springs area continued to decline in 1995, reflecting the continuing decay of the radionuclide inventory in the nearby 1301-N Liquid Waste Disposal Facility.

Radiation levels measured with thermoluminescent dosimeters were highest near facilities that had contained or received liquid effluent from N Reactor, primarily the 1325-N and the 1301-N Liquid Waste Disposal Facilities. Dose

rates for 1995 for these two facilities decreased approximately 12 percent from 1994.

The highest dose rates measured in the 200/600 Areas were near waste-handling facilities, such as tank farms. The average annual dose rate for 1995 in the 200/600 Areas was 120 mrem/yr, a 10-percent decrease from the average dose rate of 133 mrem/yr measured in 1994.

The highest dose rates in the 300 Area were measured near waste handling facilities such as the 340 Waste Handling Facility. The average annual dose rate measured in the 300 Area in 1995 was 130 mrem/yr. This represents a 17-percent decrease from the average dose rate of 170 mrem/yr measured in 1994. The average annual dose rate at the 300 Area Treated Effluent Disposal Facility was 80 mrem/yr, which represents a 28-percent decrease from the average dose rate of 110 mrem/yr measured in 1994.

The average annual dose rate for 1995 in the 400 Area was 80 mrem/yr, a 31-percent decrease from the average annual dose rate of 110 mrem/yr in 1994.

Investigative Sampling

Investigative sampling was conducted in the operations areas to help resolve questions about radiological status of the facilities and waste sites. Such special samples were collected in 1995 where physical or biotic radionuclide transport was suspected or identified and included air, rain water runoff, soil, ant mounds, cryptogams, Russian thistle (tumbleweeds), a wasp nest, a rattlesnake, gopher snakes, rock doves (pigeon), a house finch, deer mice, a bat, a coyote jawbone, and coyote feces. Predominant

radionuclides identified were activation products and ^{90}Sr in the 100 Areas and fission products in the 200 Areas. No investigative samples were collected from the 300 or 400 Area in 1995. Maximum concentrations of radionuclides in 1995 were in a 200 West Area gopher snake (^{90}Sr and ^{137}Cs), and a 100-D Area bat (^{60}Co). Isotopes of plutonium or uranium, although occasionally above background, were below concentration guidelines.

Suspect waste site investigations were conducted before a location was entered into the Environmental Surveillance Database (formerly known as the Waste Information Database or WIDS), which is administered for the U.S. Department of Energy by the Environmental Restoration Contractor. Nine sites were investigated in 1995; seven of the nine qualified for inclusion as waste management units.

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SUMMARY

OPERATIONAL (NEAR-FACILITY) ENVIRONMENTAL MONITORING

Several types of environmental media are sampled near nuclear facilities to monitor the effectiveness of waste management and restoration activities and effluent treatment and control practices. These media include air, surface water and springs, groundwater, vadose zone, surface contamination, soil, vegetation, sediments, biota, and external radiation. Sampling and analysis information and analytical results for 1995 for each of these media are summarized in the following section.

Near-Facility Environmental Monitoring at the Hanford Site

Near-facility environmental monitoring is defined as routine monitoring near facilities that have potential to discharge, or have discharged, stored, or disposed of radioactive or hazardous contaminants. Monitoring locations are associated mostly with major nuclear facilities, such as the Plutonium-Uranium Extraction Plant and N Reactor, and waste storage or disposal facilities such as burial grounds, tank farms, ponds, cribs, trenches, and ditches.

Much of the work of the monitoring program consists of collecting and analyzing environmental samples and methodically surveying areas near facilities releasing effluents and waste streams. The program also evaluates acquired analytical data, determines the effectiveness of facility effluent monitoring and controls, measures the adequacy of containment at waste disposal units, and detects and monitors unusual conditions. The program implements applicable portions of DOE Orders 5400.1 (DOE 1988a), 5400.5 (DOE 1990), and 5820.2A (DOE 1988b); *Washington Administrative Code* (WAC) 246-247; and Title 40 *Code of Federal Regulations* (CFR) Part 61, Subpart H (EPA 1989).

Routine monitoring activities include sampling and monitoring ambient air, water from surface-water disposal units, external radiation, vadose zone, soil, sediment, vegetation, and animals. Some of the parameters typically monitored are pH, radionuclide concentrations, radiation fields, and concentrations of selected hazardous chemicals. Samples are collected from known or expected effluent pathways. These pathways are generally downwind of potential or actual airborne releases and downgradient of liquid discharges. The routine activities of near-facility monitoring in 1995 are summarized in Table S-1, which shows the type, quantity, and location of samples collected.

Waste disposal sites and the terrain surrounding them are surveyed to detect and characterize any radioactive surface contamination. Routine survey locations include cribs, trenches, retention basin perimeters, pond perimeters, ditch banks, solid waste disposal sites (for example, burial grounds or trenches), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around the Site operational areas.

Table S-1. Near-Facility Routine Environmental Samples and Locations, 1995.

Sample Type	No. of sampling locations	100-K Area	100-N Area	200/600 Areas	300/400 Areas
Air	47	4	4	38 ^a	1
Surface Water	13	0	8	5	0
External Radiation	199	11	104 ^b	63	21
Soil	80	0	12	53	15
Vegetation	86	0	20	50	16

^aIncludes one station located at the Wye Barricade.

^bThirty thermoluminescent dosimeters and 74 survey points.

Air Monitoring

Near-facility air sampling systems monitor the effectiveness of waste management and effluent treatment and controls in reducing effluents and emissions; these systems also monitor diffuse source emissions.

Sample Collection and Analysis

Radioactivity in the air was sampled by a network of continuously operating samplers at 47 locations near nuclear facilities: 4 were located in the 100-N Area, 4 were in the 100-K Area, 37 were in the 200 Areas, 1 was located near the 300 Area Treated Effluent Disposal Facility, and 1 station was collocated with samplers operated by the Pacific Northwest National Laboratory and the Washington State Department of Health at the Wye Barricade. To avoid duplicate sampling, the near-facility environmental monitoring program used existing Pacific Northwest National Laboratory air samplers in the 300 and 400 Areas. Air samplers were primarily located within approximately 500 m (1,500 ft) of sites and/or facilities having the potential for, or history of, environmental releases, with an emphasis on the prevailing downwind directions.

Samples were collected according to a schedule established before the monitoring year (Schmidt et al. 1994). Airborne particles were sampled at each station by drawing air through a glass-fiber filter. The filters were collected biweekly, field-surveyed for gross radioactivity to detect any unusual trends or off-normal occurrences, held for at least 7 days, then analyzed for total alpha and beta activity. The 7-day holding period was necessary to allow for the decay of naturally occurring radionuclides that would otherwise obscure detection of longer lived radionuclides associated

with emissions from nuclear facilities. The total radioactivity measurements were used to indicate changes in trends in the near-facility environment.

For most radionuclides, the amount of radioactive material collected on a single filter during a 2-week sampling period was too small to be measured accurately. The accuracy of the sample analysis was increased by compositing the samples into biannual samples for each location. Each composite sample was then sent to Quanterra Inc. (Richland, Washington) to be analyzed for ^{238}Pu , $^{239, 240}\text{Pu}$, ^{90}Sr , ^{234}U , ^{235}U , ^{238}U , and gamma-emitting (e.g., ^{137}Cs , ^{60}Co) radionuclides.

Results

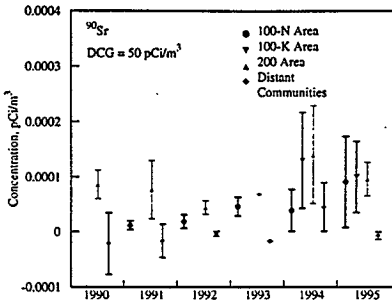
Of the radionuclide analyses performed, ^{137}Cs , $^{239, 240}\text{Pu}$, ^{90}Sr , and uranium were consistently detectable in the 200 Areas. ^{60}Co and, infrequently, $^{239, 240}\text{Pu}$ were detectable in the 100-N Area. Air concentrations for these radionuclides were elevated near facilities compared to the concentrations measured off site. Figure S-1 shows average values for 1995 and the preceding 5 years for selected radionuclides compared to Derived Concentration Guides, DOE Order 5400.5, and the background air concentration as measured by the Pacific Northwest National Laboratory. The Derived Concentration Guides are reference values that are used to indicate performance. The data indicate a large degree of variability. In general, samples collected from air samplers located at or directly adjacent to nuclear facilities had significantly higher concentrations than did those samples collected farther away. The data also show, as expected, that concentrations of certain radionuclides were higher in different operational areas. Generally, the predominant radionuclides are activation products (i.e., gamma emitters) in the 100 Areas and fission products in the 200 Areas.

In 1995, ^{241}Pu was included as an analyte for the first time to more completely account for the dose to the public. This also made the monitoring consistent with the facility effluent monitoring analytes. Section 2 describes the analytical results in more detail.

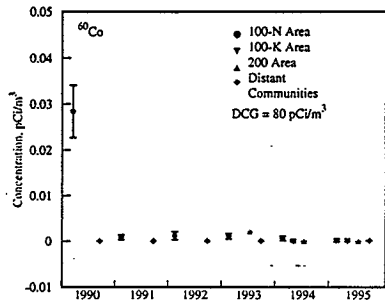
100-N Area. Analytical results from air samples collected in the 100-N Area continued to be at or near background concentrations for most radionuclides as a result of facility shutdowns and improved effluent controls and waste management practices. Concentrations were much less than the Derived Concentration Guides; however, they were greater than levels measured off site. Section 2 describes the 100-N Area ambient air monitoring program in more detail.

100-K Area. Analytical results from air samples show quantities of $^{239, 240}\text{Pu}$, ^{241}Pu , ^{241}Am , and ^{137}Cs that were slightly above detection levels. These levels were much less than the Derived Concentration Guides; however, they were greater than levels measured off site. The results are slightly elevated over 1994 values. This is expected based on higher facility emissions in 1995. Facility emissions have increased as the basins are changing from only storing spent nuclear fuel to prepare to move the fuel from the basins. Section 2 describes the 100-K Area ambient air monitoring program in more detail.

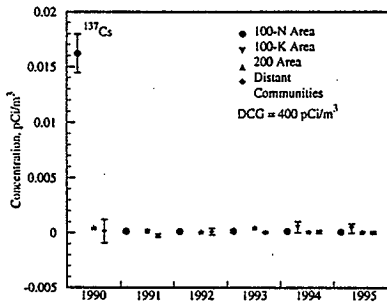
Figure S-1. Concentrations (± 2 standard error of the mean) of Selected Radionuclides in Near Facility Air Samples Compared to Those in Distant Communities, 1990 through 1995. As a result of figure scale, some uncertainties (error bars) are concealed by point symbol.



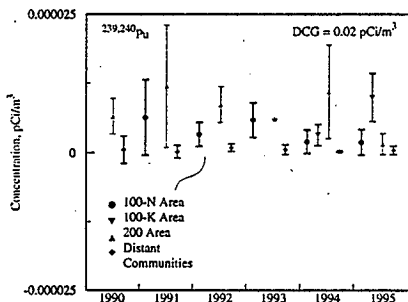
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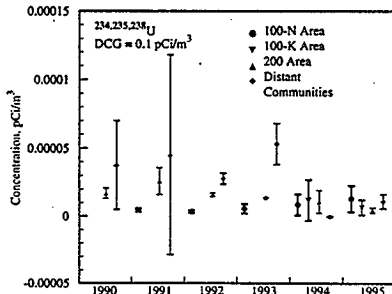
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SGW020215.101

200 Areas. Analytical results from air samples collected in the 200 Areas showed levels on a downward trend for most radionuclides as a result of facility shutdowns, better effluent controls, and improved waste management practices (Figure S-1). These levels, although much less than the DOE Derived Concentration Guides, were greater than levels measured off site and were higher for $^{239, 240}\text{Pu}$, ^{90}Sr , and uranium than levels measured in the 100-N Area. Section 2 describes the 200 Areas ambient air monitoring program in more detail.

SURFACE-WATER DISPOSAL UNITS AND RIVERBANK SPRINGS MONITORING

Surface-water disposal units (open ponds and ditches) used by the operating facilities and springs located along the Columbia River shoreline in the 100-N Area are monitored to assess the effectiveness of effluent and contamination controls. Surface water disposal units declined from a maximum of 5 to 2 during 1995. These are the 200 East Area Powerhouse Ditch and the 216-B-3C Pond, east of the 200 East Area. Sampling in the 216-T-4 Ditch, located in the 200 West Area, was resumed from mid-January through March of 1995. Section 6 describes surface-water disposal units and riverbank springs monitoring in more detail.

Sample Collection and Analysis

Samples from surface-water disposal units were collected from various locations in the operational areas. Samples also were collected from Columbia River shoreline springs in the 100-N Area. Section 6.0 describes the sampling locations in more detail. Samples collected from surface-water disposal units included water, sediment, and aquatic vegetation. Water and vegetation samples were collected at the 100-N river shoreline springs. The sampling methods are discussed in detail in *Operational Environmental Monitoring* (WHC-CM-7-4). To avoid duplicate sampling, the near-facility environmental monitoring program used surface-water sample data collected by the Surface Environmental Surveillance Project for the 400 Area. Results for the 400 Area sampling may be found in Section 4.2, "Surface-Water and Sediment Surveillance," of the *Hanford Site Environmental Report, 1995* (Dirkes and Hanf 1996).

Radiological analyses of water samples from surface-water disposal units were performed on site by the Waste Sampling and Characterization Facility (WSCF) in 1995. Analyses included ^{238}Pu ; $^{239, 240}\text{Pu}$; uranium; tritium; ^{90}Sr ; and gamma-emitting radionuclides. Radiological analyses of sediment and aquatic vegetation samples were performed for $^{239, 240}\text{Pu}$; ^{90}Sr ; uranium; and gamma-emitting radionuclides. Nonradiological analyses were performed for pH, temperature, and nitrates. Analytes of interest were selected based on their presence in effluent discharges and their importance in verifying effluent control and determining compliance with applicable effluent discharge standards. Surface-water disposal units that received potentially radioactively contaminated effluents were within posted radiological control areas.

Radiological Results

Surface-Water Disposal Units. Results of radiological analyses for liquid samples from surface-water disposal units (ponds and ditches) located in the 200 Areas are summarized in Table S-2. In all cases, radionuclide concentrations in surface-water disposal units were less than the DOE Derived Concentration Guides and in most cases were equal to or less than the analytical detection limit.

Radiological analytical results for aquatic vegetation and sediment samples collected from surface-water disposal units located in the 200 Areas are summarized in Tables S-3 and S-4, respectively. Although both aquatic vegetation and sediment showed some elevated levels compared to the Derived Concentration Guide for water and the accessible soil concentration limits, in all cases the radiological analytical results were much less than the Westinghouse Hanford Company standards used for radiological control. Section 6.0 provides a more detailed data summary of samples collected to monitor surface-water disposal units.

Riverbank Springs. In the past, radioactive effluent streams sent to the 1301-N and 1325-N Liquid Waste Disposal Facilities in the 100-N Area contributed to the release of radionuclides to the Columbia River through their migration with the groundwater. Radionuclides enter the Columbia River along the riverbank region known as the N Springs. Releases into the river at N Springs are calculated based on analysis of weekly samples collected from a monitoring well (well 199-N-46) located near the shoreline. *Environmental Releases for Calendar Year 1995* (Gleckler 1996) discusses the release calculations in more detail.

Groundwater springs along the 100-N Area shoreline are sampled annually to verify that the reported radionuclide releases to the Columbia River are conservative (i.e., not under reported). Release reporting uses conservatively high radionuclide concentrations in samples collected from well 199-N-46, multiplied by the estimated groundwater discharge into the river. The N Springs groundwater flow rate was estimated using a computer model developed by Gilmore et al. (1992). The estimated groundwater flow rate used to calculate 1995 releases from N Springs was 38 liters per minute (10 gallons per minute). By characterizing the radionuclide concentrations in the springs along the shoreline, these results can then be compared to the concentrations measured in well 199-N-46 ensuring that the well is located in the groundwater migration route that contains the highest concentrations of radionuclides.

In 1995, except for tritium, the concentrations detected in shoreline springs samples were highest in the springs nearest well 199-N-46. Concentrations of tritium were highest in the two farthest downstream sampling locations. The data from shoreline springs sampling are summarized in Table S-5. Section 6.0 covers these data in more detail.

Nonradiological Results for Surface-Water Disposal Units

Nonradiological analytical results for water samples collected from surface-water disposal units located in the 200 Areas are summarized in Table S-6. The results for pH were well within the *Resource Conservation and*

Table S-2. Radiological Results for Liquid Samples from Surface-Water Disposal Units,
200 Areas, 1995 (pCi/L).

Sample Location ^a	No. of Samples		²³⁸ Pu	^{239, 240} Pu	Total U	³ H ^b	⁹⁰ Sr	¹³⁷ Cs
200 West Area Ditch	3	Mean Maximum	1.7 E-02 6.0 E-02	3.6 E-03 4.1 E-02	2.1 E-05 8.2 E-05	<4.5 E+02 <4.5 E+02	1.9 E+01 2.7 E+01	1.4 E+01 1.8 E+01
200 West Area Ponds	10	Mean Maximum	3.1 E-04 3.2 E-02	7.4 E-02 1.8 E-01	6.0 E-05 1.7 E-04	<4.5 E+02 <4.5 E+02	7.7 E+01 6.0 E+00	-1.8 E-01 1.3 E+00
200 East Area Ditch	12	Mean Maximum	1.4 E-02 2.3 E-01	4.2 E-02 1.5 E-01	1.9 E-04 2.6 E-04	<4.5 E+02 <4.5 E+02	9.0 E-01 1.9 E+01	-9.7 E-01 2.8 E+00
200 East Area Pond	12	Mean Maximum	1.2 E-01 1.1 E+00	1.1 E+00 1.3 E+01	2.2 E-04 2.7 E-04	<4.5 E+02 <4.5 E+02	-6.8 E-01 2.3 E+00	1.5 E-01 3.0 E+00
DCG			4.0 E+01	3.0 E+01	5.0 E+02 ^c	2.0 E+06	1.0 E+03	3.0 E+03

^a200 West Area Ditch: 216-T-4 Pond

200 West Area Ponds: 216-Z-21 Basin, 200 West Powerhouse Pond

200 East Area Ditch: 200 East Powerhouse Ditch

200 East Area Pond: 216-B-3C Pond

^bThe detection limit for ³H is 450 pCi/L.

^cUsing ²³⁸U as the most limiting DCG

Negative values indicate results at or below background levels of radioactivity.

DCG = Derived Concentration Guide

Table S-3. Radiological Results for Aquatic Vegetation Samples from Surface Water Units, 200 Areas, 1995 (pCi/g).

Sample Locations ^a	No. of Samples		⁹⁰ Sr	¹³⁷ Cs	^{239,240} Pu	U Total (g/g)
200 West Area Ponds	2	Mean	2.4 E+00	2.0 E+00	2.1 E+00	4.4 E-08
		Maximum	3.6 E+00	3.7 E+00	4.2 E+00	8.6 E-08
200 East Area Pond	1	Maximum	5.6 E-01	4.0 E+00	9.1 E-01	1.0 E-08
200 East Area Ditch	1	Maximum	1.6 E+00	2.3 E+00	2.9 E+00	4.9 E-09

^a200-West Area Ponds: 216-Z-21 Basin, Powerhouse Pond

200-East Area Pond: 216-B-3C Pond

200-East Area Ditch: Powerhouse Ditch

Table S-4. Radiological Results for Sediment Samples from Surface Water Disposal Units, 200 Areas, 1995 (pCi/g).

Sample Locations ^a	No. of Samples		¹³⁷ Cs	^{239, 240} Pu	⁹⁰ Sr	U Total (g/g)
200 West Area Ponds	2	Mean	8.0 E-02 ^b	2.8 E-01	7.8 E-01	1.7 E-07
		Maximum	8.0 E-02	3.9 E-01	1.2 E+00	3.2 E-07
200 East Area Pond	1	Maximum	6.6 E+00	2.0 E+00	5.7 E-01	1.6 E-07
200 East Area Ditch	1	Maximum	NR ^c	5.2 E-01	4.1 E-01	3.8 E-08

^a200-West Area Ponds: 216-Z-21 Basin, Powerhouse Pond

200-East Area Pond: 216-B-3C Pond

200-East Area Ditch: Powerhouse Ditch

^bOnly one ¹³⁷Cs analysis was reported^cNR - not reported

Table S-5. Concentration of Radionuclides in 100-N Area Columbia River Shoreline Springs, 1995 (pCi/L).

Radionuclide	Facility Effluent Monitoring Well (09/27/95)	Springs		
		Maximum	Mean	DCG
^3H	517.17	5.0 E+02	9.0 E+01	2.0 E+06
^{90}Sr	Data not available	3.0 E+02	5.4 E+01	1.0 E+03

DCG = Derived Concentration Guide

Recovery Act of 1976 corrosivity designation limits of 2.0 to 12.5. The analytical results for nitrates were all less than the 45-mg/L Drinking Water Standard for public water supplies.

Radiological Surveys

Radiological surveys are used to monitor and detect radiological contamination on the Hanford Site. The two main types of posted radiological controlled areas are underground radioactive materials and contamination areas. Contamination areas include contamination areas, soil contamination areas, and high contamination areas.

Underground radioactive material areas are posted areas with contamination contained below the soil surface. These areas are typically "stabilized" cribs, burial grounds, and covered ponds, trenches, and ditches. Barriers over the contamination sources are used to inhibit radionuclide transport to the surface environs. These areas are surveyed at least annually to document the current radiological status.

Contamination/soil contamination areas may or may not be associated with an underground radioactive material structure. A breach in the barrier of an underground radioactive materials area may result in the growth of contaminated vegetation. Insects or animals may burrow into an underground radioactive materials area and bring contamination to the surface. Vent pipes or risers from an underground structure may be a source of speck contamination. Fallout from stacks or unplanned releases from previously operating facilities may cause an area of contamination that is not related to a subsurface structure. All types of contamination areas may be susceptible to contamination migration. All known contamination areas were surveyed at least annually to document the current radiological status.

Table S-6. Nonradiological Results for Liquid Samples from Surface-Water Disposal Units,
200 Areas, 1995.

Sample Locations ^a	pH			Nitrate (NO ₃), mg/L			
	No. of Samples	Mean	Maximum	Minimum	No. of Samples	Mean	Maximum
200 West Area Ditch	12	6.3	6.7	5.9	1	NA	1.3 E+00
200 West Area Ponds	40	8.0	9.0	7.3	2	3.6 E-01	6.0 E-01
200 East Area Ditch	52	8.5	9.6	6.7	4	6.2 E-01	1.3 E+00
200 East Area Pond	52	7.4	8.0	6.4	4	3.4 E-01	9.1 E-01

^a200 West Area Ditch: 216-T-4 Ditch
 200 West Area Ponds: 216-Z-21 Basin, 200 West Powerhouse Pond
 200 East Area Ditch: 200 East Powerhouse Ditch
 200 East Area Pond: 216-B-3C Pond
 NA = Not applicable

In 1995 the Hanford Site had approximately 2,531 ha (6,254 acres) of posted outdoor contamination areas and 1,025 ha (2,532 acres) of posted underground radioactive materials areas not including active facilities. The number of hectares (acres) of contamination areas is three times larger than the underground radioactive materials areas. This is primarily because of the BC Controlled Area located south of the 200 East Area. This area was posted as a Radiologically Controlled Area in 1958 because of widespread speck contamination and currently encompasses approximately 1,000 ha (2,500 acres). Table S-7 lists the acreage for contamination areas and underground radioactive material areas, showing the net change from 1994 to 1995. A global positioning system was used in 1995 to measure the surface areas more accurately than in past years. Area measurements for 1995 have been entered into the Hanford Geographical Information System, maintained by the Environmental Restoration Contractor.

The posted contamination areas vary between years because of an ongoing effort to clean, stabilize, and remediate areas of known contamination. During this time, new areas of contamination are also being identified. Table S-8 indicates the changes resulting from stabilization activities during 1995. Approximately 50 ha (124 acres) were reclassified from contamination/soil contamination areas to underground radioactive materials areas and 6 ha (15 acres) were posted as soil contamination areas. Newly identified areas may have resulted from contaminant migration or an increased effort to investigate outdoor areas for radiological contamination. Vehicles equipped with radiation detection devices and an ultrasonic ranging and data system have identified areas of contamination that were previously undetected.

The external dose rate at 80 percent of the identified outdoor contamination areas was estimated at less than 1 mrem/h, although direct dose rate readings from isolated radioactive specks (a diameter less than 0.6 cm or [0.25 in.]) could have been considerably higher. Contamination levels of this magnitude did not significantly add to dose rates for the public or Hanford Site workers in 1995.

Vadose Zone Monitoring

The inactive liquid effluent facilities vadose monitoring program tracks the movement of radioactive contaminants discharged to the soils. The Hanford Site has more than 300 liquid waste disposal sites that have received over 14 billion liters of waste, excluding the 430 billion liters discharged at the surface to ponds and ditches. During calendar year 1995 approximately 70 boreholes were logged around these facilities to identify and track radioactive plumes. The logging surveys of the boreholes identifies gamma-ray-emitting radionuclides in the soils and quantifies the concentration of contaminant plumes as a function of depth. These survey data will become the baseline for any further vadose zone monitoring at these facilities. In addition, the staff and equipment have supported the Environmental Restoration contractor in characterizing subsurface radiological conditions at such sites as the 1301-N Trench. The sites of their new boreholes and cone penetrometer emplacements were also surveyed to help delineate the subsurface wastes.

Table S-7. Outdoor Contamination Status, 1995 [approximate surface area in hectares (acres)].

Hanford Site Area	Contamination Area ^a	Net Change ^b	Underground Radioactive Material ^c	Net Change
100-B/C	8 (20)	0	39 (96)	0
100-KE/KW	3 (7)	-8 (19)	60 (148)	8 (19)
100-N	29 (73)	0	.3 (1)	0
100-D/DR	3 (8)	-3 (8)	36 (89)	3 (8)
100-H	0.4 (1)	0	13 (33)	0
100-F	8 (20)	0	30 (74)	0
200 East ^d	2,258 (5,580)	-12 (30)	151 (373)	12 (30)
200 West ^e	201 (497)	-21 (52)	677 (1,673)	21 (52)
300	21 (52)	0	13 (32)	0
400	0	0	0	0
600	0	0	6 (14)	0
Totals	2,531 (6,254)	-44 (109)	1,025 (2,532)	44 (109)

^aIncludes areas posted as "contamination/soil contamination" or as "Radiologically Controlled" and areas that had both underground and contamination/soil contamination.

^b- = decreases.

^cIncludes areas with only underground contamination. Does not include areas that had contamination/soil contamination as well as underground radioactive material.

^dIncludes tank farms, BC controlled zone, and waste disposal facilities outside the 200 East Area boundary which received waste from 200 East facilities (e.g., 216-A-25, 216-B-3).

^eIncludes tank farms, and waste disposal facilities outside the 200 West Area boundary which received waste from 200 West facilities (e.g., 216-S-19, 216-U-11).

Table S-8. Zone Status Change of Posted Contamination Areas, 1995.

Location	Zone change	Area, hectares (acres)
100 Areas	CA to URM	11 (27)
200 East Area	CA to URM	18 (45)
200 East Area	URM to CA	6 (15)
200 West Area	CA to URM	21 (52)
300 Area	CA to URM	0
400 Area	CA to URM	0
600 Area	CA to URM	0

CA = Contamination/Soil Contamination Area

URM = Underground Radioactive Materials Area

Wells that are scheduled for decommissioning on Site are surveyed with the high-resolution (laboratory quality) gamma-ray and moisture-gauge logging equipment to ensure that no radioactivity exists in the wells before they are filled in. These data add to the geologic database used for determining the moisture migration pathways in the vadose and groundwater zones.

All boreholes associated with the 216-T-6 Crib, located to the west of T Plant in the 200 West Area, have been surveyed for radionuclide identification and contaminant plume definition. The preliminary assessment of the subsurface plume from spectral gamma-ray log surveys of the 15 boreholes associated with this crib confirms that the contaminant concentration exceeds 10,000 pCi/g (picocuries per gram) in the soils near the crib structure, then slowly decreases to 1,000 pCi/g at several meters from the crib. Finally, at a concentration level of 10 pCi/g, the contamination plume extends over 30 m (100 ft) beyond the crib structures and to 15 m (50 ft) below the ground surface.

⁶⁰Co has been found to be migrating laterally below the BY cribs 40 years after the liquid waste discharges were terminated. In well 299-E33-5, a 20-percent decrease in activity caused by the migration has been identified. The activity decreased from 19 pCi/g to 10 pCi/g over 3 years, with 6.3 pCi/g that would have been expected from natural decay, and the remaining 2.6 pCi/g from the migration.

Section 3 summarizes the subsurface radionuclide logging surveys in more detail.

SOIL AND VEGETATION SAMPLING FROM OPERATIONAL AREAS

Soil and vegetation samples were collected on or adjacent to waste disposal units and from locations downwind and near or within the boundaries of the operating facilities. Samples were collected to detect potential migration and deposition of facility effluents. Special samples were also collected where physical or biological transport problems were identified. Migration can occur as the result of resuspension from radioactively contaminated surface areas, absorption of radionuclides by the roots of vegetation growing on or near underground and surface-water disposal units, or by waste-site intrusion by animals.

In 1993, routine annual soil and vegetation sampling was eliminated in the 100 Areas except for the 100-N Area. Historical data indicated that the 100 Area sites previously monitored exhibited no signs of contamination migration and continued monitoring would not be cost effective. Soil sampling in the 200 Areas also was modified in 1994 to be more cost effective. Fifty-five soil samples will be collected at alternating locations each year. In 1995, 53 samples were collected. Two samples were not collected because the sample locations were destroyed by construction activity. The results of the sampling effort are discussed in the following paragraphs.

Sample Collection and Analysis

The sampling methods and locations used are discussed in detail in *Operational Environmental Monitoring* (WHC-CM-7-4). Radiological analyses of

soil and vegetation samples included ^{239} , ^{240}Pu , ^{90}Sr , uranium, and gamma-emitting radionuclides.

Soil Results

Of the radionuclide analyses performed, ^{137}Cs , ^{60}Co , ^{239} , ^{240}Pu , ^{90}Sr , and uranium were consistently detectable. Soil concentrations for these radionuclides were elevated near and within facility boundaries when compared to the concentrations measured off site. Figure S-2 shows average values for 1995 and the preceding 5 years. The concentrations show a large degree of variability. In general, concentrations in samples collected on or directly adjacent to waste disposal facilities were significantly higher than concentrations in samples collected farther away. The data also show, as expected, that concentrations of certain radionuclides were higher within different operational areas. Generally, the predominant radionuclides were activation products and ^{90}Sr in the 100-N Area, fission products in the 200 Areas, and uranium in the 300 Area. Section 4 summarizes these data in more detail.

100-N Area. Analytical results from soil samples collected in the 100-N Area in 1995 generally exhibited concentrations at or near background levels, as a result of the shutdown of the 105-N Reactor, and associated facilities, and the implementation of more effective effluent controls. However, contamination levels were greater than those measured off site, and the concentrations of ^{60}Co were greater than those measured in the 200 and 300/400 Areas. The ^{60}Co in the 100-N Area soils resulted from past discharges to waste disposal structures, primarily the 1301-N Liquid Waste Disposal Facility.

200 Areas. Analytical results from soil samples collected in the 200 Areas were on a downward trend for most radionuclides because of facility shutdowns and improved effluent controls and waste management practices. However, the results were higher than those for samples collected off site and were shown to be higher for ^{137}Cs , ^{239} , ^{240}Pu , and ^{90}Sr when compared to values from the 100 and 300/400 Areas.

300/400 Areas. Analytical results from soil samples collected in the 300/400 Areas were compared to results for other operational areas and to those from samples collected off site. The levels of uranium for the 300/400 Areas were higher than those measured from the 100 Area and the 200 Areas. Uranium was expected in these samples because it was used during past fuel fabrication operations conducted in the 300 Area.

Vegetation Results

Of the radionuclide analyses performed for vegetation, ^{137}Cs , ^{60}Co , ^{239} , ^{240}Pu , ^{90}Sr , and uranium were consistently detectable. Concentrations of these radionuclides in vegetation were elevated near and within facility boundaries compared to the concentrations measured in samples collected off site. Figure S-3 shows average values for 1995 and the preceding 5 years. The concentrations show a large degree of variability. In general, concentrations in samples collected on or directly adjacent to the waste disposal facilities were higher than concentrations in samples collected

Figure S-2. Average Concentrations (± 2 standard error of the mean) of Selected Radionuclides in Near-Facility Soil Samples Compared to Those in Samples in Distant Communities, 1990 through 1995. As a result of figure scale, some uncertainties (error bars) are concealed by point symbols. The 1994 and 1995 100 Areas data include the 100-N Area only.

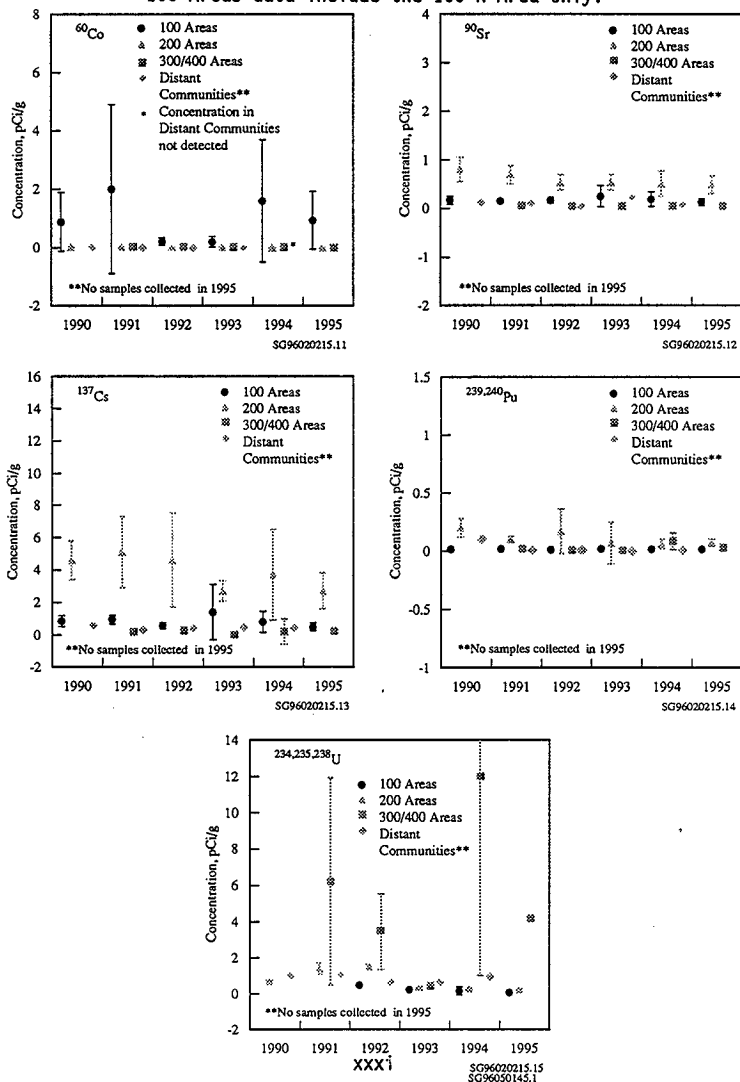
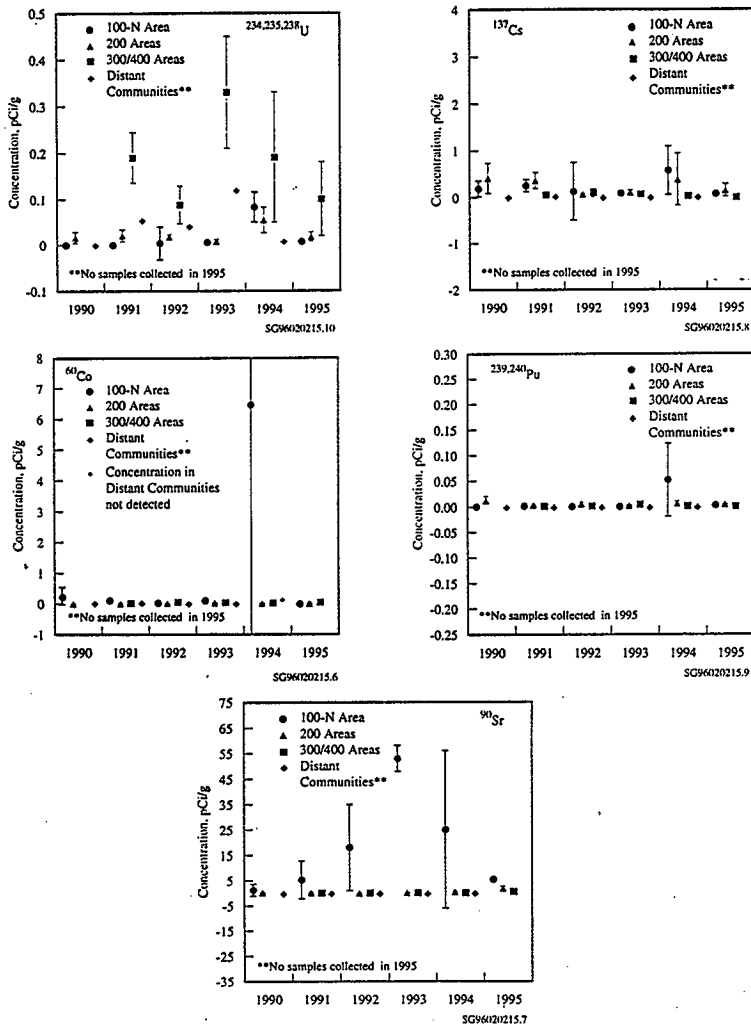


Figure S-3. Average Concentrations (± 2 standard error of the mean) of Selected Radionuclides in Near-Facilities Vegetation Samples Compared to Those in Samples in Distant Communities, 1990 through 1995. As a result of figure scale, some uncertainties (error bars) are concealed by point symbols. The 1994 and 1995 100 Areas data include the 100-N Area only.



waste disposal facilities were higher than concentrations in samples collected farther away. As with the soil samples, the data show that certain radionuclides were found in higher concentrations in vegetation in different operational areas. The predominant radionuclides are activation and fission products in the 100 Areas, fission products in the 200 Areas, and uranium in the 300 Area. Section 4.0 summarizes the data in more detail.

100-N Area. Analytical results from vegetation samples collected in the 100-N Area in 1995 were generally lower than those seen in 1994. The maximum values observed were for ^{90}Sr in samples collected near the N Springs. The 1995 levels were higher than those measured in samples collected off site and levels for ^{60}Co and ^{90}Sr were similar to those collected in the 200 and 300/400 Areas.

200 Areas. Analytical results from vegetation samples collected in the 200 Areas have been on a downward trend for most radionuclides because of facility shutdowns, better effluent controls, and improved waste management practices. Before 1992, radionuclide levels in these areas were higher than those measured in samples collected off site and were higher for ^{137}Cs and plutonium-239 than in the 100 and 300/400 Areas. During 1995, the average concentrations for ^{137}Cs and plutonium-239 were similar on site, off site, and in the operational areas.

300/400 Areas. Generally, the levels of most radionuclides measured in the 300 Area were higher than those measured in samples collected off site and levels for uranium were higher than in the 100 and 200 Areas. The higher uranium levels were expected because uranium was released during past fuel fabrication operations in the 300 Area. The levels measured in the 400 Area were at or near those measured off site.

EXTERNAL RADIATION

External radiation fields were measured near facilities and waste handling, storage, and disposal sites to measure, assess, and control the impacts of operations.

Field Measurements and Analysis

Two methods are used to measure external radiation fields. Hand-held meters are used at individual points of interest to give real-time assessments. Thermoluminescent dosimeters are used at numerous fixed locations over longer periods of time. Thermoluminescent dosimeter results can be used individually or averaged to determine dose rates in a given area for a particular sampling period. Specific information about external radiation sampling methods and locations can be found in *Operational Environmental Monitoring* (WHC-CM-7-4).

Results

Radiation Measurements

A hand-held micro-rem meter was used to survey points along the N Springs Area. These radiation measurements were taken at a height of approximately 1 m (3.28 ft).

In previous years, the instrument used for this survey was a micro-R meter. This instrument is known to over respond to low-energy gamma radiation. In 1995, a micro-rem meter, which more accurately measures the true dose rate, was used.

The overall shape of the curve shown on the graph (Figure S-4) for 1995 indicates that the area along the N Springs shoreline with the highest dose rate is still along the area juxtapositional with the 1301-N Liquid Waste Disposal Facility.

Surveys conducted in previous years at the 1301-N and 1325-N Liquid Waste Disposal Facilities were discontinued this year. Data obtained from the thermoluminescent dosimeter stations located around the perimeters of these facilities provide adequate radiation assessment because neither facility is active. Section 7.0 covers radiation surveys in more detail.

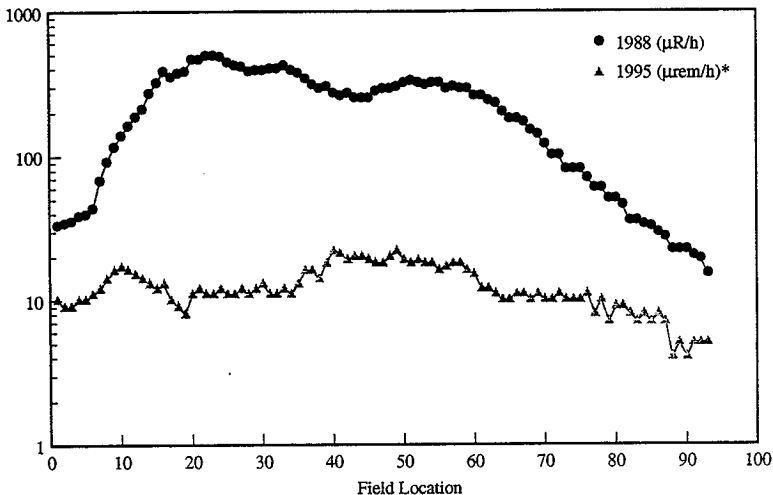
Thermoluminescent Dosimeters

A decrease of up to 65 percent was noted in near-facility thermoluminescent dosimeter readings between 1994 and 1995. This may be partially attributed to a difference in response between the old Hanford thermoluminescent dosimeter and reader system used in 1994 and the Harshaw 8807 dosimeter and the Harshaw 8800 reader system used in 1995. This difference is believed to be the result of dissimilarities in readout methodologies and dosimeter designs between the two systems. With the old system, the dosimeters located in the field were not as well protected from light, heat, moisture, and dirt as the new system. The Harshaw dosimeters are packaged in a more opaque holder with an "O ring" seal. Also, the signal-to-noise ratio in the Harshaw system reader is much better than in the old system reader. Although the preissue 16-hour oven anneal has been retained for the Harshaw dosimeters, the new reader system provides the capability for various preread, read, and anneal options. These options are being used to improve the low-dose performance of the new dosimeters (Endres 1995).^a This system is discussed in more detail in Section 5.

100-N Area. The results from the 100-N thermoluminescent dosimeters are presented in Table S-9. The 1995 results indicated that direct radiation levels are highest near facilities that had contained or received liquid effluent from the N Reactor. These facilities primarily included the 1301-N and 1325-N Liquid Waste Disposal Facilities. While the results for

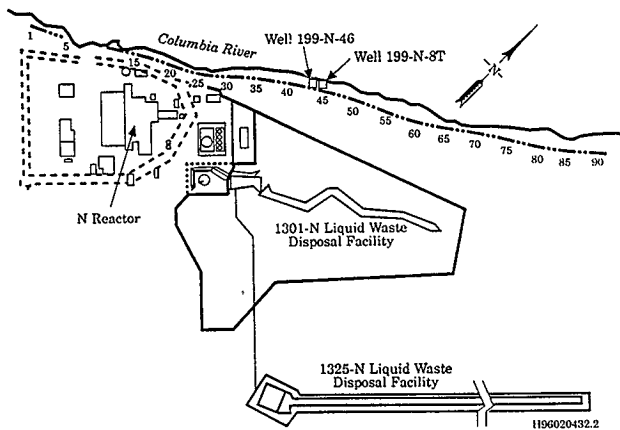
^aPersonal communication April 4, 1995, Alan W. Endres Research Scientist, Health Protection Department, Pacific Northwest National Laboratory, Richland, Washington.

Figure S-4. Radiation Survey Measurement Locations at the 100-N Area Shoreline.



* Surveys in 1995 utilized a micro-rem/h meter, as opposed to a micro-R/h meter used in previous surveys.

SG96020215.72a
 SG96050145.4DG



these two facilities were noticeably higher than those for other 100-N Area dosimeter locations, they were approximately 12 percent lower than exposure levels measured at these locations in 1994. Section 5.0 contains a historical summary of the dose rates measured around the liquid waste disposal facilities. Decreases are attributable to the decay of the radionuclide inventories in the facilities.

Table S-9. Thermoluminescent Dosimeter (TLD) Results for Waste-Handling Facilities in the Operations Areas, 1994 and 1995 (mrem/yr based on 24 hours/day).

Area	No. of Sites, 1995	1994 Annual Average		1995 Annual Average		% Change ^a
		Maximum	Mean	Maximum	Mean	
100-K	11	14,700	1,100	2,800	390	-65
100-N	30	15,800	1,560	10,900	1,290	-17
200/600	63 (60) ^b	770	130	700	120	-8
300	8	540	170	310	140	-18
300 TEDF	6	120	110	84	81	-28
400	7	210	110	81	77	-32

^aNumbers indicate a decrease (-) or increase (+) from 1994.

^bIndicates that 60 of 63 data points were applicable to this table.
TEDF = Treated Effluent Disposal Facility.

Two projects performed by the Environmental Restoration Contractor had a temporary, yet noticeable impact on radiation dose rates in the 100-N Area in 1995. Work to remove irradiated fuel spacers from the 1303-N Spacer Silo occurred in August 1995. Dose rates around the 105-N Reactor building were elevated during this period. The third-quarter average for selected thermoluminescent dosimeters located near the silo reflected this increase. During the fourth quarter, the source term that was previously present in the 1304-N Emergency Dump Tank was reduced. This facility was decontaminated during August and September of 1995. The overall affect of these two clean-up projects around the 105-N Reactor building was a decrease in dose rates to a level lower than those measured before the projects began.

100-K Area. This is the third year that thermoluminescent dosimeters have been placed in the 100-K Area; surrounding the 105-K East and West fuel storage basins and adjacent reactor buildings. Three of the dosimeters have consistently shown elevated readings because of their proximity to radioactive waste storage areas or stored radioactive rail equipment. Section 5 describes these data in more detail.

200 Areas. Three new thermoluminescent monitoring sites were established in the 200 Area network to better measure exposures at the Central Waste Complex, the Solid Waste Operations Complex, and the Waste Receiving and Packaging

1995 in the 200/600 Areas. The highest dose rates were measured near waste-handling facilities such as tank farms. The highest dose rate was measured at the 241-A Tank Farm complex located in the 200 East Area. The average annual dose rate measured in 1995 by thermoluminescent dosimeters was 120 mrem/yr, which was 8 percent lower than the average dose rate of 130 mrem/yr measured in 1994. Section 5 summarizes these data in more detail.

300/300 Treated Effluent Disposal Facility/400 Areas. Table S-9 compares 1995 dosimeter results to those of 1994 for the 300 and 400 Areas. The highest dose rates in the 300 Area were measured near waste-handling facilities such as the 340 Waste Handling Facility. The average annual dose rate measured in the 300 Area in 1995 was 140 mrem/yr. This represents a 18-percent decrease from the average dose rate of 170 mrem/yr measured in 1994. The average annual dose rate at the 300 Area Treated Effluent Disposal Facility in 1995 was 81 mrem/year, which is 28 percent less than the average dose rate of 110 mrem/yr measured in 1994. The average annual dose rate measured in the 400 Area in 1995 was 70 mrem/yr, which is 32 percent less than the average dose rate of 110 mrem/yr measured in 1994.

INVESTIGATIVE SAMPLING

Investigative sampling was conducted in the operations areas to confirm the absence or presence of radioactive or chemical contaminants. Investigative sampling took place near facilities, such as storage and disposal sites, for at least one of the following reasons:

- To follow up radiological surface surveys that indicated that radioactive contamination was present
- To conduct preoperational surveys to quantify the radiological/chemical contaminants at a site before facility construction or operation
- To quantify the radiological condition of a site before remediation
- To determine if biotic intrusion (e.g., animal burrows or deep-rooted vegetation) has created a potential for the spread of contaminants.
- To determine the integrity of waste containment systems.

The maximum concentrations of radioactive isotopes from samples collected during these investigations are included in this report. Complete data results for these investigations, including field instrument and dose readings where appropriate, are provided in Section 8.0.

Generally, the predominant radionuclides discovered during these efforts were activation and fission products and ⁹⁰Sr in the 100 Areas, fission products in the 200 Areas, and uranium in the 300 Area. Hazardous chemicals have not generally been identified above background levels in preoperational environmental monitoring samples.

Sample Collection and Analysis

Investigative samples collected in 1995 included air, water, soil (including sediment and radioactive specks), vegetation (e.g., cryptogams and tumbleweeds), a wasp's nest, bull snakes, a western rattlesnake, rock doves (domestic pigeons), a house finch, deer mice, a bat, coyote feces, and a coyote jawbone.

Methods for collecting or otherwise obtaining investigative samples are found in *Operational Environmental Monitoring* (WHC-CM-7-4). Field monitoring was conducted to detect radioactivity before samples are collected. Field monitoring results are expressed as counts per minute (cpm) when a Geiger-Mueller detector is used or as mrad/h when an "ion chamber" is used. Laboratory sample analysis results are generally expressed in pCi/g. Analysis results for air and liquid samples are measured in pCi/m³ and pCi/L, respectively. Maximum concentrations, rather than averages, are presented in this summary (Table S-10).

Results

Investigative samples were collected where known or suspected radioactive contamination was present, or to verify radiological conditions at project sites. In 1995, 51 samples were analyzed for radionuclides and 34 showed some level of contamination higher than 10 pCi/g. Also, 112 contamination incidents were reported and disposed of without isotopic analyses. Field instrument readings were recorded for most material during cleanup operations. Section 8 summarizes these data in detail.

A 200 Areas baseline investigation was initiated in 1995 to use vegetation and wildlife as indicators of radiological conditions in and around waste sites. Cryptogams (i.e., mosses and lichens) (37 samples), deer feces, and coyote feces (39 samples) were collected using a random block method and analyzed for gamma-emitting radionuclides.

Air. Investigative air samples were collected in 1995 to determine the fugitive and diffuse air emissions from four stabilization or operations sites using 10 samplers. These sites included Environmental Restoration Contractor stabilization projects in the 100 Areas and the area downwind of Westinghouse Hanford Company operations in the 200 East Area. Radionuclides monitored included the gamma-emitting isotopes (e.g., ¹³⁷Cs, ⁶⁰Co), ⁹⁰Sr, ²³⁹Pu, ²⁴⁰Pu, and total uranium. All analytical results for these nuclides were below the Derived Concentration Guide values.

Table S-10. Investigative Samples Collected from the Operations Areas, 1995. (2 sheets)

Sample Type	Location (No. of Samples)	Radionuclides	Maximum Concentrations
Air	100 Area (10)	^{60}Co ^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ Total U	1.4 E-04 pCi/m ³ 3.2 E-04 pCi/m ³ 5.6 E-04 pCi/m ³ 1.5 E-05 pCi/m ³ 2.2 E-04 pCi/m ³
Water	200 East (2)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ Total U	4.7 E+01 pCi/L <5.9 E+01 pCi/L <5.9 E+00 pCi/L 5.0 E-01 pCi/L
Soil	100 Areas (4)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{212}Pb ^{214}Pb ^{228}Ac ^{228}Ra ^{212}Bi Total U	2.1 E+01 pCi/g 2.1 E+01 pCi/g <3.7 E-01 pCi/g 1.0 E+00 pCi/g 1.4 E+00 pCi/g 1.1 E+00 pCi/g 2.4 E+00 pCi/g 1.2 E+00 pCi/g 9.7 E-07 pCi/g
Soil	200 Areas (4)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{228}Ac ^{241}Bi Total U	1.9 E+03 pCi/g 6.3 E+02 pCi/g 2.4 E+00 pCi/g 6.7 E-01 pCi/g 6.5 E-01 pCi/g 4.6 E-07 pCi/g
Soil (sediment - greenish coloration)	200 East (1)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ Total U	2.9 E+02 pCi/g 6.8 E+01 pCi/g 3.6 E-01 pCi/g 1.3 E-07 pCi/g
Ant Mounds	200 Areas (2)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ Total U	8.0 E+02 pCi/g 7.9 E+03 pCi/g 2.2 E+03 pCi/g 3.0 E-04 pCi/g
Cryptogams (baseline study)	200 Areas (37)	^{137}Cs	2.9 E+01 pCi/g
Tumbleweeds	200 Areas (3)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{214}Pb Total U	3.9 E+02 pCi/g 1.4 E+01 pCi/g 2.0 E+01 pCi/g 4.5 E+00 pCi/g 1.1 E-07 pCi/g
Wasp Nest	100-N (1)	^{137}Cs ^{60}Co	4.8 E+02 pCi/g 2.5 E+03 pCi/g
Reptiles	200 Areas (4)	^{90}Sr ^{137}Cs ^{134}Cs $^{239}, ^{240}\text{Pu}$ Total U	3.5 E+04 pCi/g 9.6 E+05 pCi/g 1.4 E+02 pCi/g <2.8 E+00 pCi/g 2.4 E-08 pCi/g

Table S-10. Investigative Samples Collected from the Operations Areas, 1995. (2 sheets)

Sample Type	Location (No. of Samples)	Radionuclides	Maximum Concentrations
Pigeons	100-N (1)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ Total U	5.1 E-02 pCi/g <3.2 E-02 pCi/g <5.0 E-02 pCi/g 9.3 E-08 pCi/g
Pigeons	200 West (2)	^{90}Sr ^{137}Cs ^{234}Th $^{239}, ^{240}\text{Pu}$ Total U	<3.1 E-01 pCi/g 3.4 E-01 pCi/g 9.4 E+00 pCi/g <1.4 E-01 pCi/g 5.4 E-04 pCi/g
House Finch	200 East (1)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$	2.3 E+02 pCi/g 5.4 E+00 pCi/g <3.5 E+01 pCi/g
Deer Mouse	100-K (1)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ Total U	2.2 E+02 pCi/g 3.7 E+02 pCi/g 1.3 E+00 pCi/g 1.2 E-08 pCi/g
Deer Mice	200 Areas (11)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ Total U	4.8 E+03 pCi/g 1.2 E+03 pCi/g 7.5 E+00 pCi/g 1.0 E-02 pCi/g
Bat	100-D (1)	^{90}Sr ^{137}Cs ^{60}Co $^{239}, ^{240}\text{Pu}$ Total U	1.1 E+04 pCi/g 2.2 E+02 pCi/g 1.6 E+03 pCi/g <7.6 E+00 pCi/g 6.8 E-06 pCi/g
Coyote Jawbone	200 East (1)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ Total U	1.3 E+02 pCi/g <1.2 E+01 pCi/g <1.0 E+01 pCi/g 2.2 E-08 pCi/g
Coyote Feces	200 East (2)	^{90}Sr ^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{60}Co ^{154}Eu ^{159}Eu Total U	5.0 E+02 pCi/g 1.6 E+02 pCi/g <5.7 E-01 pCi/g 1.3 E+00 pCi/g 1.5 E+01 pCi/g 1.5 E+01 pCi/g 8.9 E-02 pCi/g
Coyote Feces (baseline study)	200 Areas (39)	^{137}Cs	1.3 E+03 pCi/g

pCi/m³ = picocuries per cubic meter

pCi/L = picocuries per liter

pCi/g = picocuries per gram

Water. Investigative samples were collected from runoff water at two tank farms in the 200 East Area in 1995. Maximum concentrations of radionuclides are reported in Table S-10 and included ^{90}Sr (47 pCi/L), ^{137}Cs (<59 pCi/L), $^{239,240}\text{Pu}$ (<5.9 pCi/L), and total uranium (0.5 pCi/L).

Soil. In 1995, 11 investigative soil samples, including specks, sediment and ant mounds, were collected. The highest ^{137}Cs concentrations (7,900 pCi/g) were found in ant mounds near the 241-C Tank Farm; the highest $^{239,240}\text{Pu}$ concentrations (2,200 pCi/g) were also found near the 241-C Tank Farm; and the highest ^{90}Sr concentrations (1,900 pCi/g) were found near Unplanned Release Site UN-216-E-6 in the 200 East Area. Analytical results are provided in Table S-10. In addition, 62 incidents of contaminated soil or specks were found during cleanup operations and disposed of in low-level burial grounds.

In 1995, the number of contamination incidents, the range of radiation dose levels, and radionuclide concentrations were generally within historical limits. Areas of special soil sampling that were outside radiological control areas and had radiation levels greater than WHC radiological control limits (HSRCM-1) were posted as surface contamination areas.

Vegetation. In 1995 three tumbleweeds were analyzed for gamma-emitting radionuclides, ^{90}Sr , $^{239,240}\text{Pu}$, and total uranium (Table S-10). Maximum radionuclide concentrations for the tumbleweeds are listed in Table S-10 and include ^{137}Cs (14 pCi/g), $^{239,240}\text{Pu}$ (20 pCi/g), and ^{90}Sr (390 pCi/g). Analytical results were below WHC radiological control limits (HSRCM-1). In addition, 36 instances of contaminated vegetation (mostly tumbleweeds) were recorded in the operational areas in 1995. This vegetation was discovered during remedial operations, surveyed with field instruments, and disposed of to low-level burial grounds. The field-instrument readings for this vegetation ranged from less than 1 mrad/h (100 cpm) to 50 mrad/h (>1,000,000 cpm), which were within the ranges reported for the past few years (Schmidt et al. 1995).

During 1995 the incidents of contaminated vegetation, the radioactivity levels, and the range of radionuclide concentrations were all within historical limits. The greatest number of contaminated vegetation samples (42) were submitted for analyses in 1978 (Johnson et al. 1994).

As part of a baseline investigation in the 200 Areas, 37 cryptogam (e.g., mosses and lichens) samples were collected and analyzed for gamma-emitting radionuclides (Table S-10). Cryptogams were selected because of their ability to act as highly sensitive indicators of environmental quality (Landeon et al. 1994), particularly for radionuclide contamination.

Wildlife. In 1995 wildlife and wildlife-related samples (e.g., feces, nests) were collected either as part of the Integrated Pest Management program designed to limit the exposure and potential contamination of animals to radioactive material or as a result of finding a radiologically contaminated animal. Animals were collected directly from or near facilities to identify potential problems and preventive measures designed to inhibit animal intrusion were subsequently taken. Surveys were performed after collection to determine whether an animal was radioactively contaminated. If a live animal was found free of contamination, it was taken to an area of suitable habitat and released. If an animal was contaminated, a decision based on the level of contamination, sampling facility, and frequency of occurrence was made to

either collect the animal as a sample or to dispose of the animal in a low-level burial ground.

Twenty-two of the 25 special animal samples (including nests and feces) analyzed in 1995 showed detectable levels of contamination. The number of incidents increased slightly in 1995 compared to 16 in 1994; but decreased when compared to 32 incidents in 1993. The greatest number of contaminated animals (44, mostly pigeons) submitted for analysis occurred in 1982 (Johnson et al. 1994).

In 1995, the maximum radionuclide concentrations were for ^{137}Cs (960,000 pCi/g) and ^{90}Sr (35,000 pCi/g) in a gopher snake from the 200 West Area and ^{60}Co (2,500 pCi/g) in a wasp's nest from the 100-N Area (Table S-10). In addition, 14 cases of contaminated wildlife or related samples were found during cleanup operations, which were disposed of without being analyzed. The numbers of animals found to be contaminated with radioactivity, the radioactivity levels, and the range of radionuclide concentrations were within historical limits (Johnson et al. 1994).

As part of a baseline investigation in the 200 Areas, 39 fecal samples (37 coyote and 2 deer) were collected and analyzed for gamma-emitting radionuclides. The feces were selected as an indicator of transport pathways for radionuclide contamination from waste sites into the environment. The maximum radionuclide concentration, ^{137}Cs (1,330 pCi/g) in a coyote fecal sample, was higher than expected for a randomly selected sample (Table S-10).

The practical uses of these data, in addition to those mentioned previously were to identify locations where pest control, waste containment, or biotic barriers needed to be improved or added, and to use vegetation and wildlife as indicators of radiological environmental quality. Benefits derived from this sampling included improved worker health and safety, reduced potential exposures, and reduced cleanup costs by early identification of loss of contaminant control.

Special Characterization Sampling

Special characterization projects were conducted or completed in 1995 to verify the radiological, and in some cases, hazardous chemical status of several operations. These included the following:

- Conducted ambient air monitoring to determine the levels of diffuse and fugitive air emissions at 116-B-1, 116-B-4, 116-B-5, 116-C-1, 183-H Solar Evaporation Basin, all in the 100 Areas, and the area downwind of WHC operations in the 200 Area. Analytical data indicate that all radionuclides were below the DOE Derived Concentration Guide air values. The analytical data for the samples collected downwind from the 200 East Area operations are being evaluated and the study is ongoing.
- Issued the *Preoperational Environmental Survey Report: 200 Areas Effluent Treatment Facility, State Approved Land Disposal Site, and Liquid Effluent Retention Facility (C-018H)* (Johnson et al. 1995) completing the 2-year preoperational environmental monitoring survey for those projects. The analytical data did not

identify any environmental concerns that would delay startup of those facilities.

- Submitted the *Preoperational Environmental Survey Report: 200 Areas Cross-Site Transfer Line Replacement (W-058)* (Johnson et al. 1996), completing the 2-year preoperational environmental monitoring survey for this project. The analytical data did not identify any environmental concerns that would delay startup of this project.
- Completed ambient air monitoring and issued a letter report (Johnson 1996) for the Transuranic Waste Retrieval Pilot Project. The analytical data indicated elevated levels of ^{241}Pu at one location, however the concentrations were below the DOE Derived Concentration Guides.
- Continued preoperational monitoring in support of Solid Waste Operations Complex projects (Waste Receiving and Packaging and the Central Waste Complex) in the 200 West Area. Preoperational monitoring in 1995 included collection of surface soil, vegetation, and small mammal samples. Sampling in 1996 will include vadose zone soil samples and verification sampling at selected sample locations. A final report of these activities is scheduled to be issued near the end of calendar year 1996.
- Four soil and two vegetation samples were collected and analyzed for chemical contaminants from a vegetation kill area west of the 221-T facility in the 200 West Area. A radiological survey did not detect any elevated activity. Analysis indicated that the vegetation was killed by elevated concentrations of phosphate, nitrates, and sulfate, all constituents of fertilizer that was used as a parking-lot deicer and had been stockpiled on a conterminous parking lot and spread into the immediate environment during a spring thaw and warm rains.

Suspect Waste Sites. In 1995, nine suspect waste site investigations were completed. Seven of these sites met the criteria for waste management units in the Waste Information Data System. The other two sites were investigated, but not included in the Waste Management Data System because the waste was removed.

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TERMS

2SEM	Two Standard Error of the Mean
ACV	administrative control value
AEC	U.S. Atomic Energy Commission
ALARA	as low as reasonably achievable
AMU	aqueous make-up
APHA	American Public Health Association
ASTM	American Society for Testing and Materials
CAM	continuous air monitor
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
cpm	counts per minute
CRADA	cooperative research and development agreement
CWC	Central Waste Complex
D&D	decontamination and decommissioning
DCG	derived concentration guides
DCRT	double-contained receiver tanks
DOE	U.S. Department of Energy
DST	double-shell tank
DWS	drinking water standard
Ecology	Washington State Department of Ecology
EDE	effective dose equivalent
EDP	electronic data processing
EDT	effluent discharge trench
EML	Environmental Measurements Laboratory
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
ESD	Environmental Sites Database
ETF	effluent treatment facility
FFTF	Fast Flux Test Facility
GJPO	U.S. Department of Energy, Grand Junction Project Office
HEHF	Hanford Environmental Health Foundation
HEPA	high-efficiency particulate air
HGP	Hanford Generation Plant
HPGe	high-purity germanium
HPT	health physics technician
HSWMUR	<i>Hanford Site Waste Management Units Report</i>
HVAC	heating, ventilation, and air conditioning
ICF-KH	ICF Kaiser Hanford Company
ITAS-RL	International Technologies Analytical Services-Richland
LWDF	liquid waste disposal facility
MEI	maximally exposed individual
MSCM	mobile surface contamination monitor
MW	mixed waste
NaI	sodium iodide
NCRPM	National Council on Radiation Protection and Measurements
NFM	Near-Field Monitoring
OEC	Operations and Engineering Contractor
PCB	polychlorinated biphenyl
PEDF	Protective Equipment Decontamination Facility
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory

TERMS (cont.)

PPF	Plutonium Processing Facility
PRF	Plutonium Reclamation Facility
PUREX	Plutonium/Uranium Extraction (Plant)
PWR	pressurized water reactor
QA	quality assurance
RCA	radiological control areas
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RL	U.S. Department of Energy, Richland Operations Office
RLS	Radionuclide Logging System
RMA	Remote Mechanical A
RMC	Remote Mechanical C
RPS	retention process sewer
RWC	radioactive waste container
SALDS	state-approved land disposal structure
SCA	surface contamination area
SEM	standard error of the mean
SNM	special nuclear material
SST	single-shell tank
SWOL	Solid Waste Operations Complex
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeters
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
TRU	transuranic
TRUSAF	Transuranic Waste Storage and Assay Facility
TSD	treatment, storage, and disposal (sites)
UNH	uranyl-nitrate-hexahydrate
UO ₂	uranium trioxide
URM	underground radioactive material
USRADS	Ultrasonic Ranging and Data System
UST	United States Testing Company
WAC	waste acceptance criteria
WESF	Waste Encapsulation and Storage Facility
WDOH	Washington State Department of Health
WHC	Westinghouse Hanford Company
WIDS	Waste Information Data System
WIPP	Waste Isolation Pilot Plant

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1.0 INTRODUCTION

1.1 BACKGROUND

The Hanford Site, consisting of 1,450 km² (560 mi²), is located within the Pasco Basin in south-central Washington State, approximately 270 km (170 mi) southeast of Seattle and 200 km (120 mi) southwest of Spokane. As shown in Figure 1-1, the 100 Areas are located in the north-central part of the Site, along the southern (right) bank of the Columbia River. The locations of facilities within the 100 Areas are shown in Figure 1-2. The 200 Areas are almost in the center of the Site, 11 km (7 mi) south of the Columbia River. The locations of facilities, tank farms, solid waste burial grounds, and liquid waste disposal sites in the 200 Areas are shown in Figures 1-3 and 1-4. The 300 and 400 Areas are located in the southwestern part of the Site, as shown in Figure 1-5. The areas not associated with any of the listed areas are considered the 600 Area.

Westinghouse Hanford Company (WHC) conducts the Operational Environmental Monitoring Program in the 100, 200, 300, 400 and 600 Areas to monitor diffuse sources and the impact of effluent releases and waste management practices at and near the facilities and waste disposal sites.

1.2 NEAR-FACILITY MONITORING PROGRAM OBJECTIVES

The objectives of the near-facility monitoring program are to evaluate the following:

- Compliance with the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), Washington State Department of Health (WDOH), and internal environmental protection requirements and guidelines
- Performance of radioactive waste confinement systems
- Trends of radioactive materials in the environment at and adjacent to nuclear facilities, waste disposal units, and restoration units so that appropriate control actions can be taken in a timely manner.

This report presents and interprets the results of the near-facility monitoring activities performed at the Hanford Site during 1995.

1.3 NEAR-FACILITY TRANSPORT PATHWAYS

The Hanford Site consists of semiarid shrub-steppe land, of which approximately 6 percent has been disturbed and actively used for processing nuclear material. This disturbed land, about 82.9 km² (32 mi²) is divided into large operational areas: the 100, 200, 300, 400, and 1100 Areas. Radioactive emissions from the Site are grouped into three broad categories for regulatory purposes: point, diffuse, and fugitive source emissions. Point sources are easily defined and recognized as facilities with effluent

Figure 1-1. The Hanford Site.

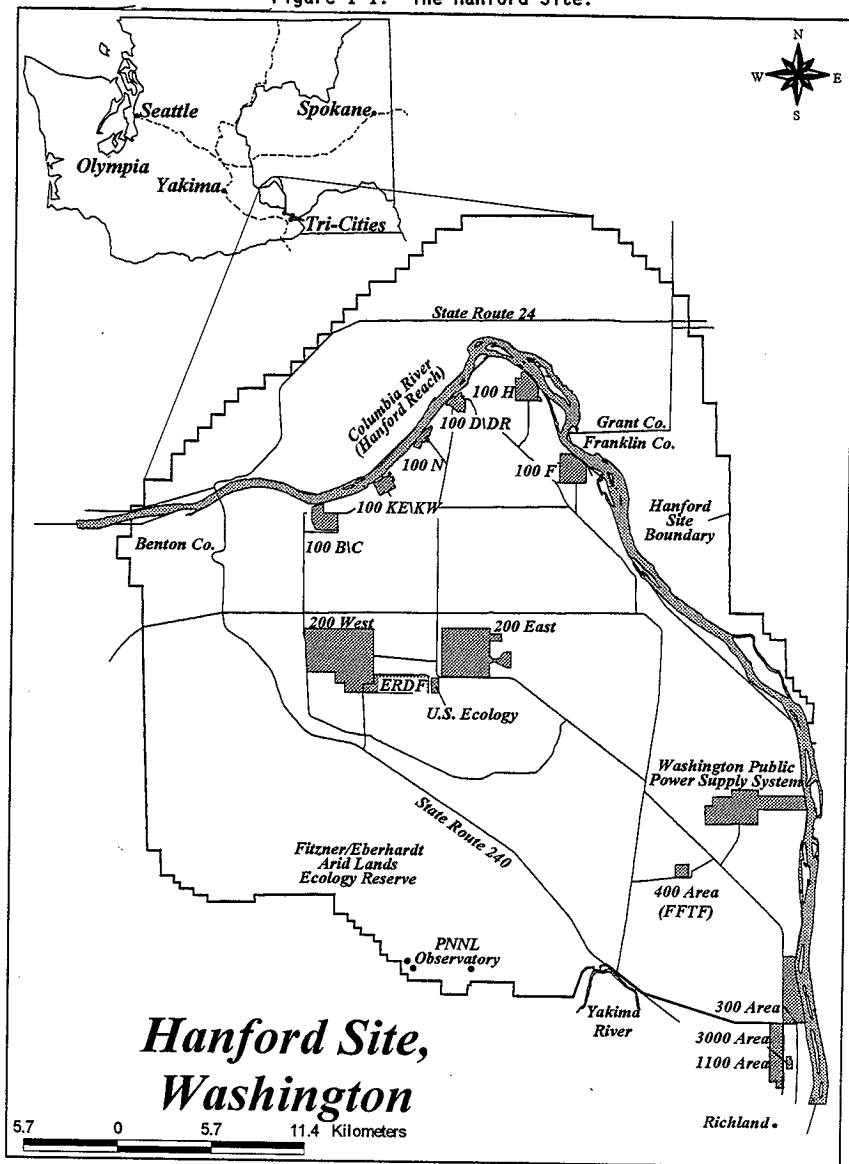


Figure 1-2. 100 Areas.

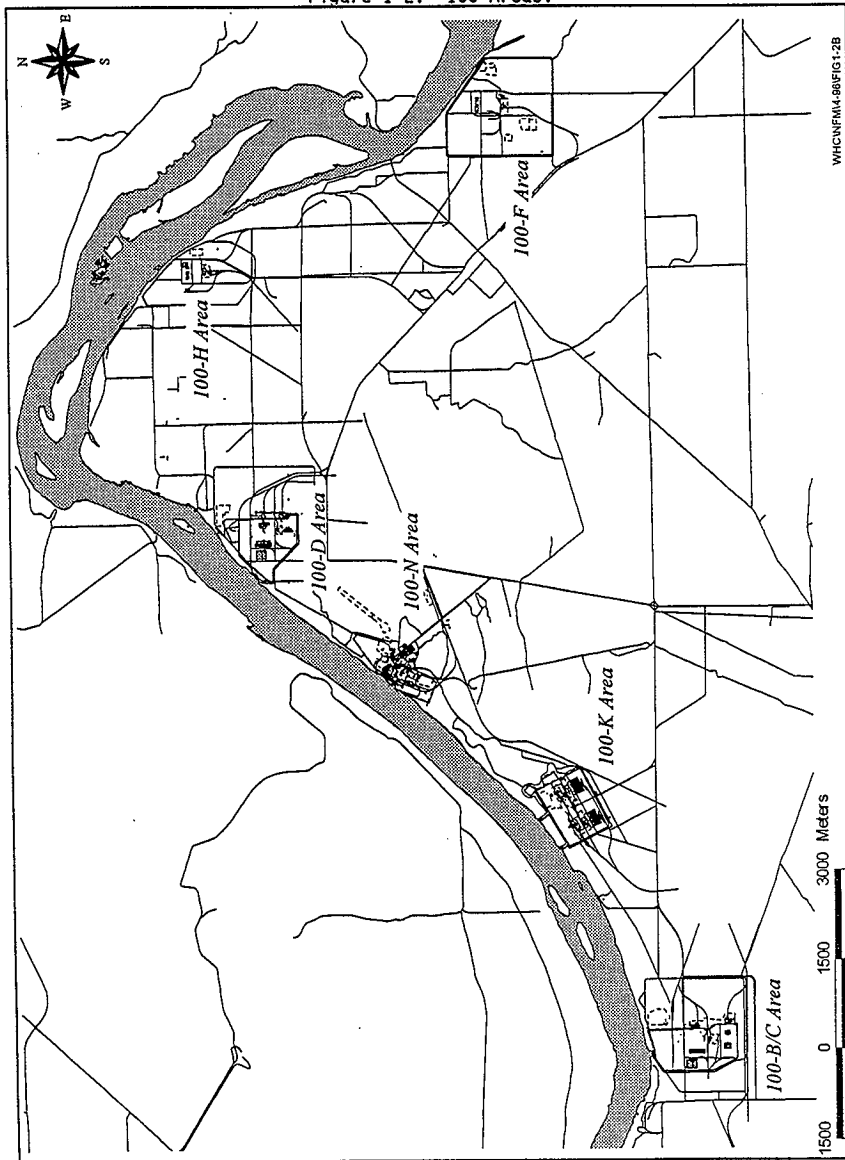


Figure 1-3. 200 East Area.

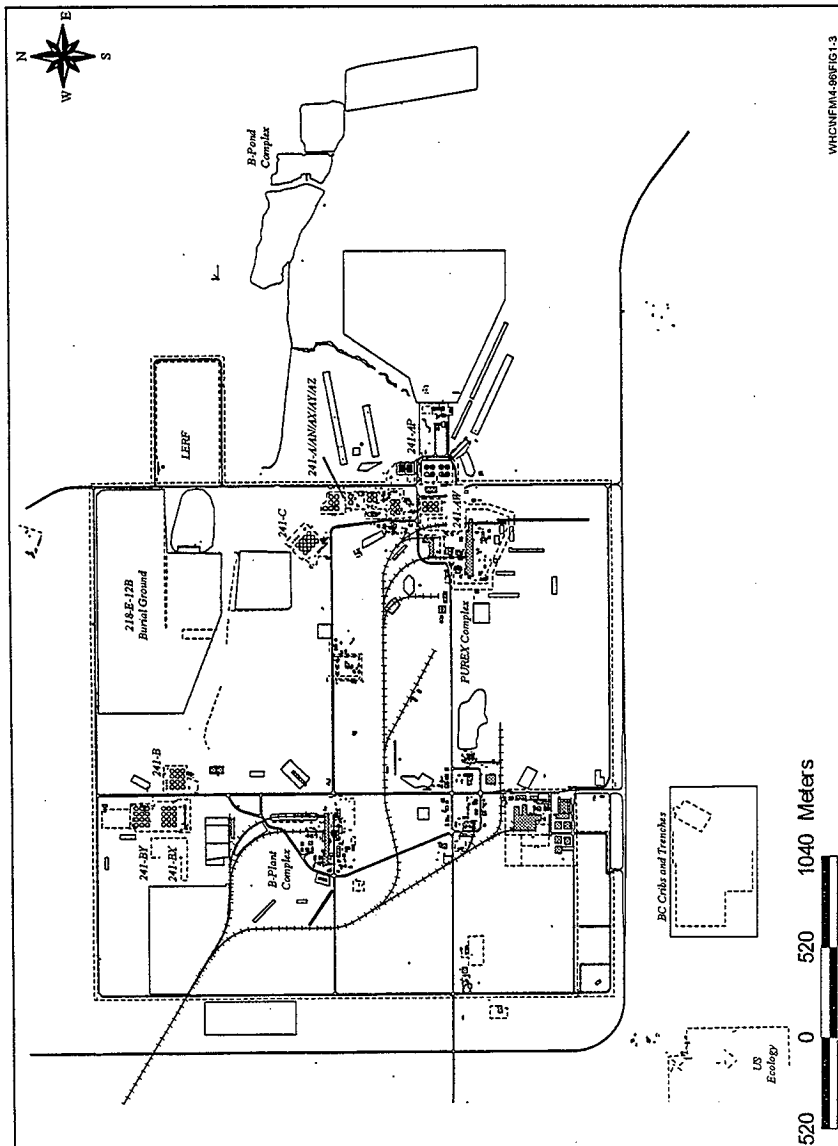
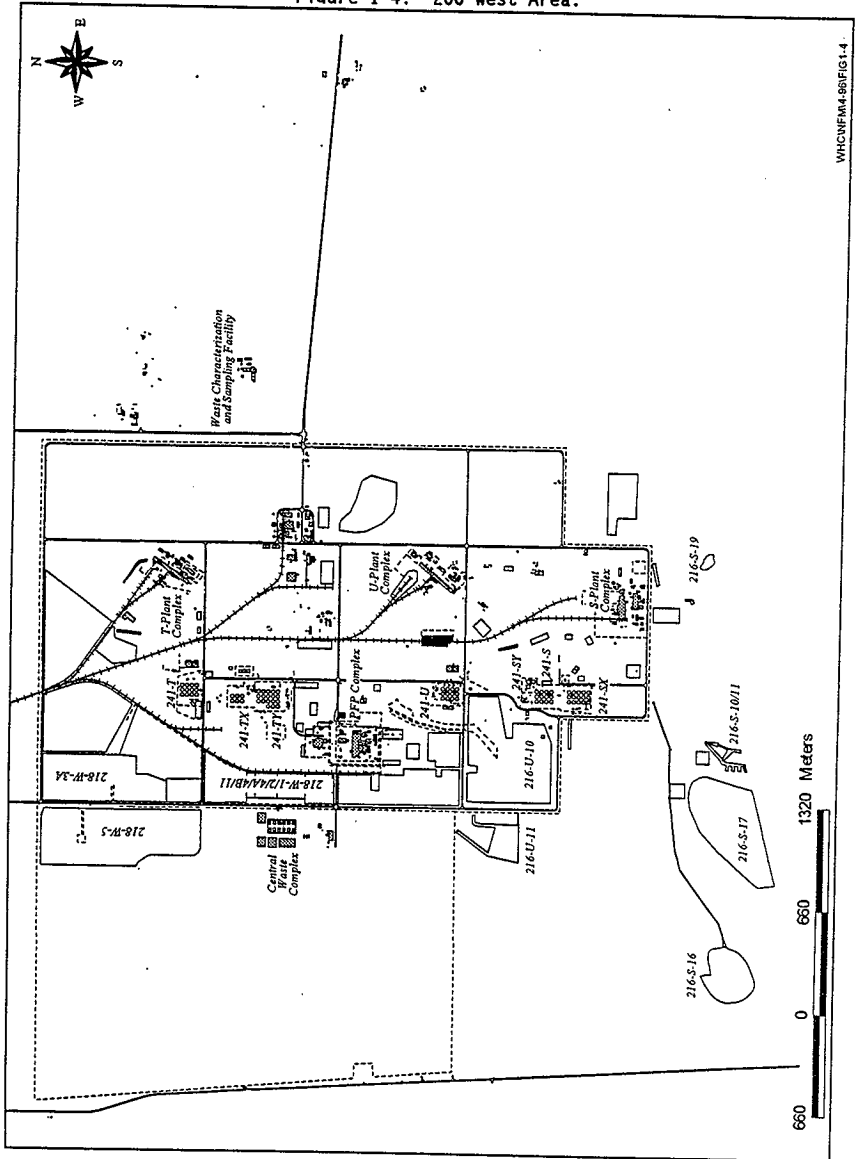
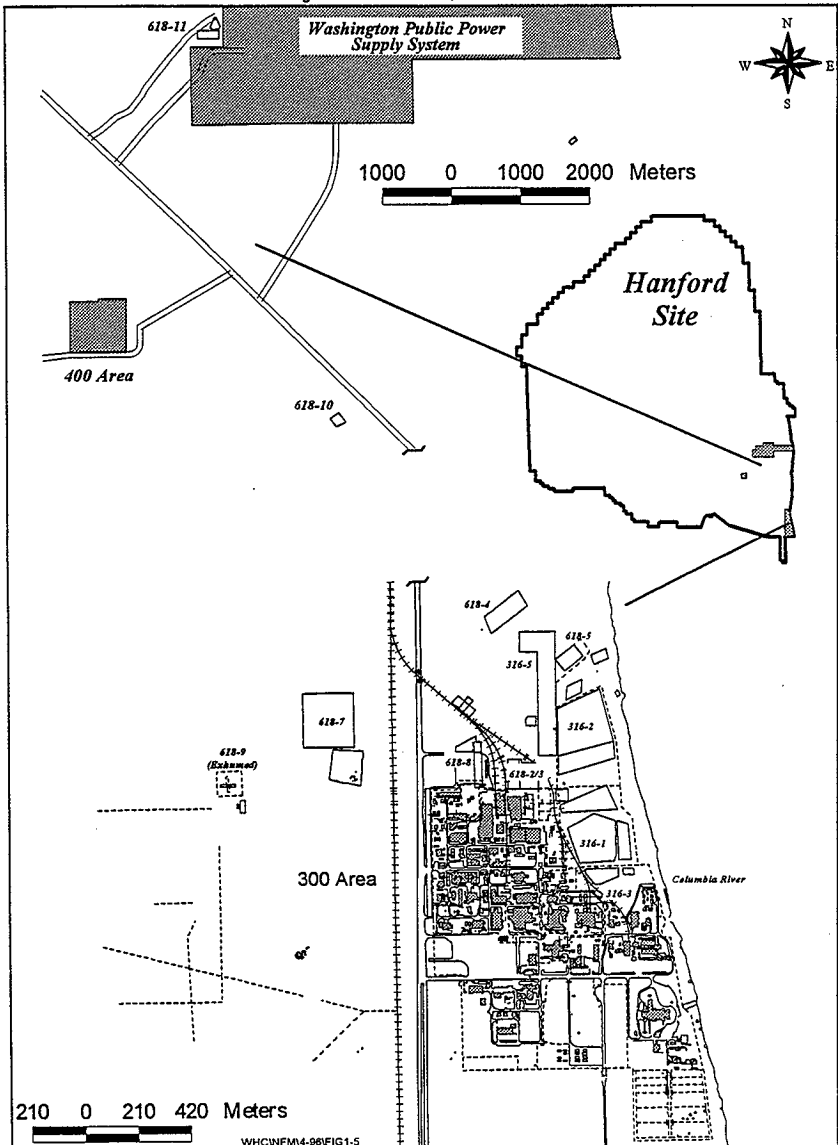


Figure 1-4. 200 West Area.



WHC-NF-M4-95FIG1-4

Figure 1-5. 300/400 Areas.



emission structures such as stacks and are typically equipped with filtering and monitoring systems. Diffuse sources are extremely varied, do not have or cannot have direct monitoring systems, and are measured through the near-facility environmental monitoring systems. Fugitive emissions may occur from doors, vents, or seams in facilities. A facility may be considered a point source and still contribute to fugitive emissions. The 600 Area designates the Site land outside the operational areas. Almost all sources of radionuclide emissions are within the five operational areas; three minor point sources are in the 600 Area. Emissions from point sources, such as stacks and vents, are measured directly or calculated from process knowledge. Diffuse emissions are measured through a network of monitoring systems near and/or adjacent to active and inactive waste sites.

The Hanford Site was acquired in 1943 and dedicated to producing plutonium for national defense and managing the resulting production wastes. Restoring the Hanford Site environment is the current mission that has largely supplanted the previous operational objectives. The environmental restoration effort will entail activities such as decontaminating and decommissioning more than 100 facilities and cleaning up and restoring more than 2,000 waste sites. Until the restoration and cleanup work is completed, diffuse and fugitive radioactive emissions potentially may be released from hundreds of sources besides the 121 point-sources (e.g., stacks and vents) registered with the WDOH. Emissions and offsite doses to the public are reported annually to the EPA and WDOH (see DOE-RL 1996).

1.3.1 Environmental Transport Sources

The presently identified actual or potential sources of diffuse and fugitive radionuclide emissions and biotic transport to the environment at the Hanford Site are described in this section. Among the sources that could contribute to biotic transport and diffuse radionuclide emissions are several kinds of waste handling and disposal facilities, such as cribs, ponds, ditches, trenches, retention basins, valve pits, French drains, reverse wells, tanks, and burial grounds. Operating facilities or facilities on standby, that are inactive, or that are being remediated also could contribute diffuse emissions. Each site or facility usually has one or more unique features or characteristics that may influence the contribution to diffuse and fugitive emissions. Features may include structures such as passive vents, risers, equipment access doors, and personnel access doors. Exhausters on facilities are point sources that are monitored at the stack or main point of effluent release in accordance with state and federal regulations. Characteristics may include an undetected leak, unburied waste, or an absence of intrusion barriers.

Various environmental conditions such as changing atmospheric pressures, wind speed, erosion, evaporation, percolation, biotic intrusion, and/or resuspension influence rates of diffuse and fugitive emissions.

1.3.2 General Types of Facilities

Sections 1.3.2.1 through 1.3.2.12 briefly describe general types of sites and facilities and the potential primary sources of diffuse emissions and environmental transport pathways from each.

1.3.2.1 Crib. Low-level liquid waste is discharged to the ground via structures called cribs. These are generally subsurface systems, similar to sanitary drain fields, that allow the liquid component of the waste to percolate into the soil. The adsorptive properties of the soil are used to remove radioactive material from the effluent through filtration, ion-exchange, precipitation reactions, absorption, and adsorption.

Many cribs are vented to the atmosphere through vents and pipe risers. These engineered structures promote downward flow of liquids disposed of in the cribs, but also provide a pathway to the surface and atmosphere. Secondary routes for diffuse emissions include erosion, biotic uptake, and intrusion followed by wind-caused resuspension.

1.3.2.2 Pond. Ponds were used to manage the large quantities of water (i.e., cooling water and chemical-sewer waste water) associated with chemical processing operations. Normally, these liquid effluents are nonradioactive. The ponds allow percolation of the liquid effluent into the soil column. Diffuse emissions from ponds are primarily by wind-caused resuspension.

1.3.2.3 Ditch. A ditch is an open, unlined excavation that was used for disposing of liquid effluents or for transporting liquid effluents to ponds for disposal. Diffuse emissions from ditches are materials resuspended by the wind.

1.3.2.4 Trench. Early disposal practices included disposing of liquid effluents into unlined trenches, then filling the trenches with soil over time. These trenches were replaced with cribs, such as the BC cribs where both cribs and trenches can be found. Diffuse emissions from trenches are primarily the result of erosion, biotic uptake, or intrusion, followed by wind-caused resuspension.

1.3.2.5 Retention Basin. Similar to trenches, retention basins generally were lined with concrete and used to hold liquids before they were routed to ditches or ponds. Diffuse and fugitive emissions from retention basins are primarily wind-caused resuspension.

1.3.2.6 Diversion Box. A diversion box is usually an underground, concrete structure formed around a junction of transfer lines carrying liquid effluent. When diversion boxes are accessed for operation or maintenance, radioactively contaminated material may be released in the form of diffuse and/or fugitive emissions.

1.3.2.7 Valve Pit. A valve pit is similar in structure to a diversion box, but contains piping valves. When valve pits are accessed for operations or maintenance, radioactively contaminated material may be released in the form of diffuse and/or fugitive emissions.

1.3.2.8 French Drain and Reverse or Injection Well. A French drain is a rock-filled encasement inserted into the ground. A reverse or injection well is an ordinary well used for mixing liquid waste with groundwater. These subsurface systems manage potentially contaminated liquid waste by promoting percolation into the soil. The natural filtration properties of the soil remove radionuclide material from effluent water. Diffuse airborne emissions from French drains and reverse wells could occur from erosion, biotic uptake, or intrusion, followed by wind-caused resuspension.

1.3.2.9 Tank. A tank generally is a large, reinforced, metal structure that receives liquid effluent for storage. Examples are the double-shell tanks (DSTs) and single-shell tanks (SSTs) in the 200 Areas, which typically are arrayed in clusters called tank farms. Sources of diffuse and fugitive emissions from tanks include vents and exhausters open to the atmosphere plus deposition and resuspension from surface soil contamination.

1.3.2.10 Burial Ground. Burial grounds are shallow trenches in which contaminated solid waste is buried. This waste is generated by various activities on the Hanford Site. Waste packaging procedures and burial practices depend on the type of waste. Diffuse and fugitive emissions occur at burial grounds through direct release to the atmosphere before the waste is buried, followed by erosion, biotic uptake and intrusion, and wind-caused resuspension.

1.3.2.11 Decontamination and Decommissioning Activities. WHC and the Environmental Restoration Contractor (ERC) activities also involve decontaminating and decommissioning (D&D) retired facilities, equipment, and waste disposal sites. These activities are aimed at preventing the release or spread of contamination and reducing the number of acres of surface contamination. In some cases, contaminated material may be exposed to the atmosphere, but, as contamination is identified, steps are taken to isolate it and reduce its spread. Diffuse and fugitive emissions may be caused by exposing contaminated surfaces, such as the insides of contaminated structures. Proper planning and controls minimize these exposures. In addition, monitors around demolition sites confirm that controls are effective. To date no significant increases at demolition sites have been observed. The majority of these activities have been transferred to the ERC.

1.3.2.12 Radioactively Contaminated Surface Areas. All radioactive burial grounds, cribs, trenches, retention basins, and unplanned release sites are surveyed routinely. The surveys are performed at least annually, but may be done more frequently when needed. The number of surface-contaminated acres varies. The number is not fixed because a continuing effort to clean, stabilize, or remediate known contaminated areas is under way, while new areas of contamination continue to be identified. Newly identified contamination may be caused by resuspension or biological intrusion to previously uncontaminated areas, or because the radiological criteria have become more stringent. Approximately 80 percent of all areas of surface contamination are estimated to have dose rates of less than 1 mrem/h.

The radiologically contaminated areas have been reposted to meet the new requirements outlined in the *Hanford Site Radiological Control Manual*, HSRCM-1. The postings include "Contamination," "High Contamination" (activity of $>100,000$ dpm/100 cm^2 beta/gamma or $>10,000$ dpm/100 cm^2 alpha), "Soil Contamination," "Underground Radioactive Material," "Radiological Buffer," and "Radiation/High Radiation" areas. For continuity between annual reports issued in 1994 and 1995, the use of "Surface Contamination Area" (SCA) in this report includes contamination, high contamination, and soil contamination areas. If an area has surface and underground contamination, such as the surface above a crib, it will have both postings. Table 1-1 shows the general location (by area), the approximate area of surface contamination, and the volume of underground contamination. Sources of diffuse emissions from surface-contamination areas include erosion, biotic uptake, or intrusion followed by wind-caused resuspension.

A more detailed description of specific sites and facilities can be found in *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 1995* (DOE-RL 1996), and in the facility effluent monitoring plans for major facilities, which are referenced in this report.

Table 1-1. Hanford Site Surface and Underground Contamination.

Hanford Site Area	Surface Contamination, ^a ha (acres)	Underground Radioactive Material, ^b ha (acres)
100 Areas	51 (126)	178 (440)
200 Areas ^c	2,459 (6,076)	828 (2,040)
300 Area (north)	21 (52)	13 (32)
600 Area	0	6 (14)
Total	2,531 (6,254)	1,025 (2,532)

^aIncludes areas posted as "contamination/soil contamination" or as "radiologically controlled" and areas that had both underground and surface/soil contamination.

^bIncludes areas with only underground contamination. Does not include areas that had surface and underground radioactive material.

^cIncludes tank farms, BC Controlled Area, and waste disposal facilities outside the 200 East Area boundary that received waste from 200 East Area facilities (e.g., 216-A-25, 216-B-3), and waste disposal facilities outside the 200 West Area boundary that received waste from 200 West Area facilities (e.g., 216-S-19, 216-U-11).

2.0 AMBIENT AIR MONITORING

2.1 INTRODUCTION

Ambient air monitoring is conducted to determine baseline concentrations of radionuclides in the operations areas, to assess the impact of operations on the local environment, and to monitor diffuse emissions from sources located within the operations area. These measurements also provide an indication of the WHC-and ERC-managed facilities' performance and are used to demonstrate compliance with environmental protection criteria. The WHC air monitoring program in the 100 and 200 Areas, as illustrated in Figures C-1, C-2, C-3, and C-4 (Appendix C) takes into consideration the directions of prevailing and high winds, as well as potential source terms. Air monitoring within the 300 and 400 Areas is performed by Pacific Northwest National Laboratory (PNNL) as part of the Site Surface Environmental Surveillance Project, with one exception. WHC operates one ambient air sampler near the 300 Area Treated Effluent Disposal Facility (TEDF) (Figure C-5). The results for ambient air monitoring in these areas are summarized in this report. A more detailed discussion of the ambient air monitoring results for the 300 and 400 Areas can be found in the *Hanford Site Environmental Report for Calendar Year 1995* (Dirkes and Hanf 1996). Meteorological conditions are monitored continuously by PNNL meteorology stations, which are strategically positioned on and around the Hanford Site.

Hanford Site air samplers in the 100, 200/600, and 300 Areas operate at a flow rate of $0.056 \text{ m}^3/\text{min}$ ($2 \text{ ft}^3/\text{min}$), drawing a sample through a 47-mm (2-in.), open-faced filter about 2 m (6 ft) above ground. All sample filters are exchanged biweekly, held one week (to allow for decay of the short-lived natural radioactivity), and then sent to the WSCF for initial analysis of total alpha and total beta activity. These initial analyses serve as an indicator of potential environmental problems.

The filters are stored until the end of the 6-month sampling period, then segregated and composited by sample location (or as deemed appropriate) and sent to an offsite laboratory for specific radionuclide analysis. Segregating and compositing air filters by site provides a larger sample size and, thus, a more sensitive and accurate measurement of the concentration of airborne radionuclides.

To help assess the impact of Site operations, the results obtained are compared to DOE Derived Concentration Guides (DCGs) and results from the distant communities of Yakima and Sunnyside as reported by the Site Environmental Surveillance Program. WHC has set up a single distant station located on site (Appendix C, Figure C-6) to compare data from samples collected in the operating areas using sampling techniques identical to those used in the rest of the program and to compare with data from samples collected by PNNL, the WDOH, and Washington Public Power Supply System. A split sampling site is used for comparability and precision.

2.2 AIR SAMPLING 1995

2.2.1 100-N Area

The concentrations of airborne radionuclides measured at the 100-N Area were many times less than the applicable DOE DCGs. The 1995 air sampling results were comparable to the 1994 results and are presented in Table C-1. The annual average concentrations of ^{60}Co detected in the 100-N Area ambient air samples since 1981 are presented in Figure 2-1. Annual average concentrations of ^{60}Co detected near the 1301-N Liquid Waste Disposal Facility (LWDF) since 1982 are presented in Figure 2-2. The results of the 1995 isotopic analyses are detailed in the following subsections.

2.2.1.1 ^{60}Co . The highest result for ^{60}Co was at site N103, located southwest of the 105-N facility (Table 2-1). The air concentration was $1.1 \text{ E-03} \pm 36\% \text{ pCi/m}^3$, which was much less (<0.1 percent) than the DCG. This value was 7.9 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Figure 2-1. Average Concentrations of ^{60}Co Detected in 100-N Area Ambient Air from 1982 to 1995.

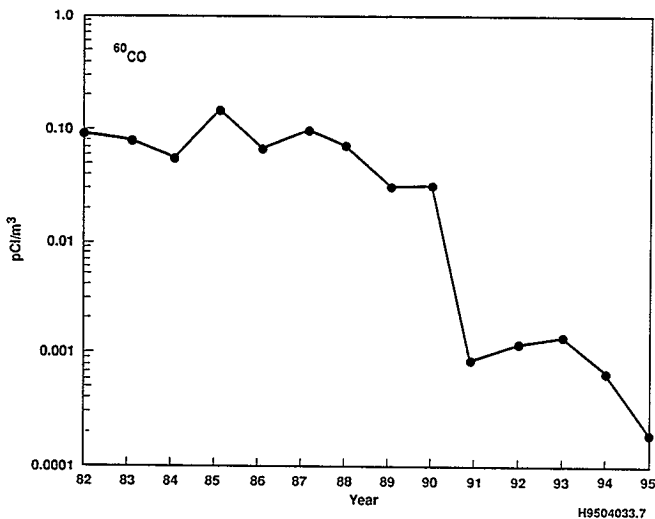


Figure 2-2. Average Concentrations of ^{60}Co Detected in 1301-N Air Samples from 1982 to 1995.

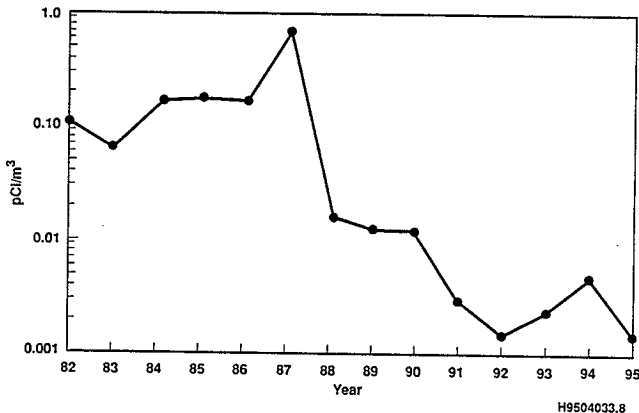


Table 2-1. ^{60}Co in Air, 100-N Area, 1995 (pCi/m³).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
1.1 E-03 $\pm$ 36%	1.9 E-04 $\pm$ 168%	8.0 E+01	1.4 E-04 $\pm$ 93%

2.2.1.2 ^{90}Sr . The highest result for ^{90}Sr was at site N101 at the 1301-N LWDF site (Table 2-2). The air concentration was $3.1 \text{ E-}04 \pm 40\%$ pCi/m³, which was less than 0.1 percent of the DCG. This value was 44 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-2. ^{90}Sr in Air, 100-N Area, 1995 (pCi/m³).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
3.1 E-04 $\pm$ 40%	9.1 E-05 $\pm$ 82%	9.0 E+00	-7.0 E-06 $\pm$ 97%

Negative value indicates results at or near background levels of radioactivity.

2.2.1.3 ^{137}Cs . The highest result for ^{137}Cs was at site N102 at N Springs (Table 2-3). The air concentration was $2.7 \text{ E-}04 \pm 122\% \text{ pCi/m}^3$, which was less than 0.1 percent of the DCG. This value was 84 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-3. ^{137}Cs in Air, 100-N Area, 1995 (pCi/m^3).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant Community $\pm$ 2SEM (%)
$2.7 \text{ E-}04 \pm 122\%$	$8.0 \text{ E-}05 \pm 108\%$	$4.0 \text{ E+}02$	$3.2 \text{ E-}06 \pm 375\%$

2.2.1.4 $^{239}, ^{240}\text{Pu}$. The highest result for $^{239}, ^{240}\text{Pu}$ was at Site N101 at the 1301-N LWDF site (Table 2-4). The air concentration was $9.3 \text{ E-}06 \pm 92\% \text{ pCi/m}^3$, which was less than 0.1 percent of the DCG. This value was 20 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-4. $^{239}, ^{240}\text{Pu}$ in Air, 100-N Area, 1995 (pCi/m^3).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
$9.3 \text{ E-}06 \pm 92\%$	$1.9 \text{ E-}06 \pm 115\%$	$2.0 \text{ E-}02$	$4.6 \text{ E-}07 \pm 167\%$

2.2.2 100-K Area

Sampling at 100-K Area is conducted in an area surrounding the 105-KE Basin. This is the preferred sampling area since the stack emissions from that facility are the largest emissions source in the 100-K Area. (Stack emissions from the 105-KW basin are approximately two orders of magnitude less than 105-KE basin.) In general, the concentrations of airborne radionuclides measured at the 100-KE Area were many times less than the DOE DCGs. Concentrations of many of the isotopes were negative or had large standard errors of the mean, indicating that the result was at or near background levels of radioactivity. Appendix C, Table C-1 lists all of the 1995 air sampling results.

2.2.2.1 ^{90}Sr . The maximum annual result for ^{90}Sr was at Site N-401 (Table 2-5). The air concentration was $2.4 \text{ E-}04 \pm 30\% \text{ pCi/m}^3$, which was less (<0.1 percent) than the DCG. This value was 34 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-5. ^{90}Sr in Air 100-K Area, 1995 (pCi/m^3).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
2.4 E-04 $\pm$ 30%	1.0 E-04 $\pm$ 62%	9.0 E+00	-7.0 E-06 $\pm$ 97%

Negative value indicates results at or near background levels of radioactivity.

2.2.2.2 ^{137}Cs . The maximum annual result for ^{137}Cs was at Site N401 (Table 2-6). The air concentration was $1.5 \text{ E-}03 \pm 27\% \text{ pCi}/\text{m}^3$, which was much less (<0.1 percent) than the applicable DOE DCG. This value was 13 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-6. ^{137}Cs in Air 100-K Area, 1995 (pCi/m^3).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant Community $\pm$ 2SEM (%)
1.5 E-03 $\pm$ 27%	4.1 E-04 $\pm$ 104%	4.0 E+02	1.2 E-04 $\pm$ 375%

2.2.2.3 $^{239}, ^{240}\text{Pu}$. The maximum annual result for $^{239}, ^{240}\text{Pu}$ was at Site N403 (Table 2-7). The air concentration was $1.7 \text{ E-}05 \pm 25\% \text{ pCi}/\text{m}^3$, which was much less (<0.1 percent) than the DOE DCG. This value was 37 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-7. $^{239}, ^{240}\text{Pu}$ in Air 100-K Area, 1995 (pCi/m^3).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
1.7 E-05 $\pm$ 25%	9.9 E-06 $\pm$ 38%	2.0 E-02	4.6 E-07 $\pm$ 167%

2.2.2.4 ^{241}Pu . The maximum annual result for ^{241}Pu was at Site N403 (Table 2-8). The air concentration was $3.4 \text{ E-}04 \pm 72\% \text{ pCi}/\text{m}^3$, which was less (<0.1 percent) than the DOE DCG. This value was not reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-8. ^{241}Pu in Air 100-K Area, 1995 (pCi/m^3).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
3.4 E-04 $\pm$ 72%	2.3 E-04 $\pm$ 38%	1.0 E+00	Not reported

2.2.2.5 ^{241}Am . The maximum annual result for ^{241}Am was at Site N403 (Table 2-9). The air concentration was $1.0 \text{ E-05} \pm 31\% \text{ pCi}/\text{m}^3$, which was less (<0.1 percent) than the DOE DCG. This value was much less than the value reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-9. ^{241}Am in Air 100-K Area, 1995 (pCi/m^3).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
1.0 E-05 $\pm$ 31%	4.6 E-06 $\pm$ 53%	2.0 E-02	-3.4 E-01 $\pm$ 100%

2.2.3 200 Areas

The concentrations of airborne radionuclides measured in 1995 in the 200 Areas were many times less than the DOE DCG. The 1995 air sampling results for the 200 Areas are summarized in Table C-1 (Appendix C). The annual average concentrations since 1979 are illustrated in Figures 2-3 through 2-5. All results were well below the applicable DOE guidelines (see Appendix J) in 1995. Radionuclide concentrations detected in the ambient air continue to decline within the 200 Areas. Increasing trends seen in the past are associated with the operation of nuclear facilities such as the Plutonium/Uranium Extraction (PUREX) Plant. The results of the isotopic analyses are detailed in the following sections.

2.2.3.1 ^{90}Sr . The highest air concentration for ^{90}Sr was at Site N984, east of the 241-C Tank Farm in 200 East Area (Table 2-10). The result was $6.9 \text{ E-04} \pm 23\% \text{ pCi}/\text{m}^3$, which was less than 0.1 percent of the DOE DCG. This value was 98 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-10. ^{90}Sr in Air, 200 Areas, 1995 (pCi/m^3).

Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
6.9 E-04 $\pm$ 23%	9.6 E-05 $\pm$ 33%	9.0 E+00	-7.0 E-06 $\pm$ 97%

Negative value indicates results at or near background levels of radioactivity.

2.2.3.2 ^{137}Cs . The highest air concentration for ^{137}Cs was at Site N155, southeast of the 241-U Tank Farm in the 200 West Area (Table 2-11). The result was 6.6 E-04 $\pm$ 35% pCi/m^3 , which was less than 0.1 percent of the DOE DCG. This value was 206 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-11. ^{137}Cs in Air, 200 Areas, 1995 (pCi/m^3).

Maximum result $\pm$ overall error(%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
6.6 E-04 $\pm$ 35%	1.0 E-04 $\pm$ 54%	4.0 E+02	3.2 E-06 $\pm$ 375%

2.2.3.3 $^{239}, ^{240}\text{Pu}$. The highest air concentration for $^{239}, ^{240}\text{Pu}$ was at Site N165, near the 216-Z-19 Ditch in the 200 West Area (Table 2-12). The result was 1.1 E-04 $\pm$ 14% pCi/m^3 , which was less than 0.1 percent of the DOE DCG. This value was 239 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-12. $^{239}, ^{240}\text{Pu}$ in Air, 200 Areas, 1995 (pCi/m^3).

Maximum Result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
1.1 E-04 $\pm$ 14%	4.5 E-06 $\pm$ 79%	2.0 E-02	4.6 E-07 $\pm$ 167%

2.2.3.4 Uranium. The highest air concentration for uranium was at Site N976, west of the 241-C Tank Farm in the 200 East Area (Table 2-13). The result was 3.0 E-05 pCi/m^3 (the sum of the uranium isotopes), which was less than 0.1 percent of the DOE DCG. This value was three times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-13. Uranium in Air, 200 Areas, 1995 (pCi/m³).

Uranium	Maximum result $\pm$ overall error (%)	Annual average $\pm$ 2SEM (%)	DCG	Distant community $\pm$ 2SEM (%)
²³⁴ U	1.4 E-05 $\pm$ 42%	4.7 E-06 $\pm$ 24%	1.0 E-01	
²³⁵ U	2.3 E-07 $\pm$ 646%	1.7 E-07 $\pm$ 154%	1.0 E-01	
²³⁸ U	1.6 E-05 $\pm$ 39%	4.3 E-06 $\pm$ 20%	1.0 E-01	
Total	3.0 E-05	1.5 E-05	1.0 E-01	1.1 E-05 $\pm$ 48%

2.2.4 300/400 Areas

The concentrations of airborne radionuclides measured during 1995 in the 300 and 400 Areas were many times less than the DOE DCG. Air monitoring near the operating facilities in the 300 (300 Area and 300 Area NE) and 400 Areas is provided by PNNL and the data are transferred to WHC after review and validation. One ambient air sampler, located at the 300 Area Treated Effluent Disposal Facility, is operated and the data reported by Near-Field Monitoring. For a more detailed discussion, refer to the *Hanford Site Environmental Report for Calendar Year 1995* (Dirkes et al. 1996).

2.2.4.1 ⁹⁰Sr. The air concentration for ⁹⁰Sr for the 300 Area was $-9.8 \text{ E-07} \pm 1,000\% \text{ pCi/m}^3$ and for 300NE was $-6.0\text{E-06} \pm 100\% \text{ pCi/m}^3$ as reported by PNNL and $1.4 \text{ E-05} \pm 193\% \text{ pCi/m}^3$ for the 300 Area TEDF (Table 2-14). These concentrations were many times (<0.01 percent) less than the DOE DCG. This value is not significantly different from the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside when compared to the 300 Area and 300NE air concentrations. The 300 Area TEDF concentration was 20 times the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

The air concentration for ⁹⁰Sr for the 400 Area was $1.2 \text{ E-06} \pm 200\% \text{ pCi/m}^3$, which was many times (<0.01 percent) less than the DOE DCG. This value is not significantly different from the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Figure 2-3. Annual Average ^{137}Cs Concentrations in Air for the 200/600 Areas.

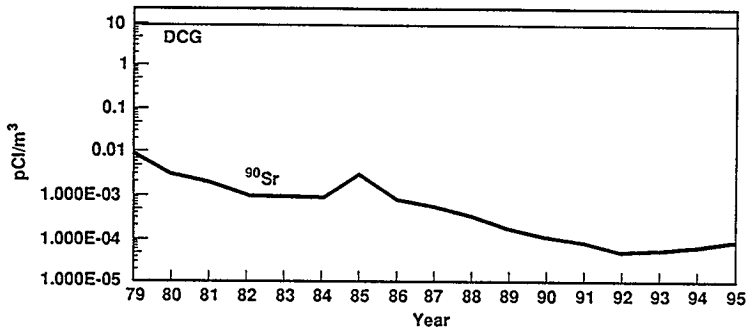


Figure 2-4. Annual Average ^{90}Sr Concentrations in Air for the 200/600 Areas.

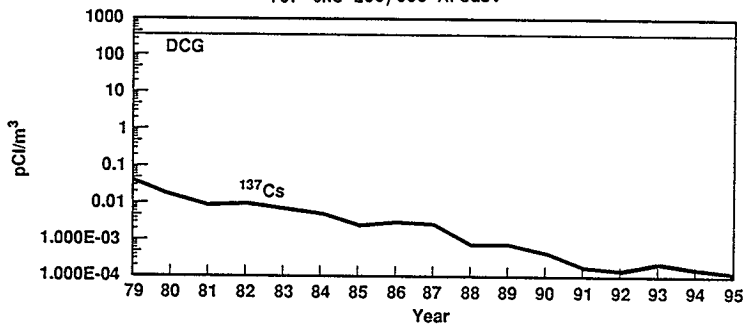


Figure 2-5. Annual Average $^{239,240}\text{Pu}$ Concentrations in Air for the 200/600 Areas.

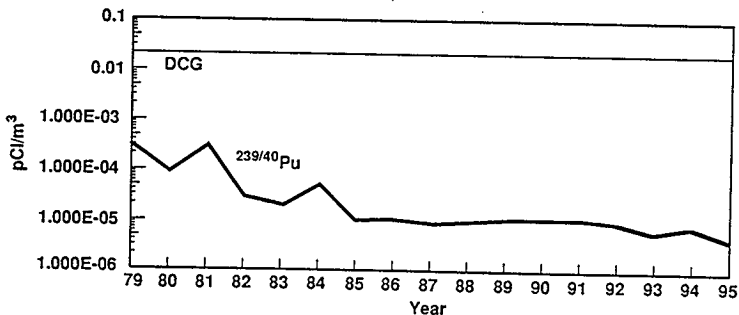


Table 2-14. ^{90}Sr in Air, 300/400 Areas, 1995 (pCi/m^3).

Area	Annual average $\pm$ overall analytical error (%)	DCG	Distant Community $\pm 2\text{SEM}(\%)*$
300 (PNNL)	$-9.8 \text{ E-}07 \pm 1,000\%$	9.0 E+00	$-7.0 \text{ E-}06 \pm 97\%$
300NE (PNNL)	$-6.0 \text{ E-}06 \pm 100\%$		
300 Area TEF N-130	$1.4 \text{ E-}04 \pm 193\%*$		
400	$1.2 \text{ E-}06 \pm 200\%$		

Negative value indicates results at or near background levels of radioactivity.

*2SEM value reported

2.2.4.2 $^{239,240}\text{Pu}$. The air concentration for $^{239,240}\text{Pu}$ for the 300 Area was $1.0 \text{ E-}06 \pm 2,000\% \text{ pCi}/\text{m}^3$ and for 300NE was $3.8 \text{ E-}07 \pm 100\%$ as reported by PNNL and $1.6 \text{ E-}06 \pm 100\% \text{ pCi}/\text{m}^3$ as reported for the 300 Area TEF (Table 2-15). These concentrations were many times ($\ll 0.01$ percent) less than the DOE DCG. This value is not significantly different from the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

The air concentration for $^{239,240}\text{Pu}$ for the 400 Area was $3.2 \text{ E-}07 \pm 33\% \text{ pCi}/\text{m}^3$, which was many times ($\ll 0.01$ percent) less than the DOE DCG. This value is not significantly different from the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

Table 2-15. $^{239,240}\text{Pu}$ in Air, 300/400 Areas, 1995 (pCi/m^3).

Area	Annual average $\pm$ overall analytical error (%)	DCG	Distant Community $\pm 2\text{SEM}(\%)*$
300 (PNNL)	$1.0 \text{ E-}06 \pm 2,000\%$	2.0 E-02	$4.6 \text{ E-}07 \pm 167\%$
300NE (PNNL)	$3.8 \text{ E-}07 \pm 100\%$		
300 Area TEF N-130	$1.6 \text{ E-}06 \pm 100\%*$		
400	$3.2 \text{ E-}07 \pm 33\%$		

Negative value indicates results at or near background levels of radioactivity.

*2SEM value reported

2.2.4.3 Uranium. The air concentration for uranium for the 300 Area was $1.1 \text{ E-}5 \pm 10\% \text{ pCi}/\text{m}^3$ ^{238}U , $7.4 \text{ E-}07 \pm 90\% \text{ pCi}/\text{m}^3$ ^{235}U , and $1.4 \text{ E-}05 \pm 20\% \text{ pCi}/\text{m}^3$ ^{238}U and for 300NE was $2.4 \text{ E-}5 \pm 20\% \text{ pCi}/\text{m}^3$ ^{234}U , $1.4 \text{ E-}06 \pm 90\% \text{ pCi}/\text{m}^3$ ^{235}U , and

1.5 E-06 $\pm$ 206% pCi/m³ ²³⁵U, and 4.0 E-06 $\pm$ 122% pCi/m³ ²³⁸U as reported for the 300 Area TEDF (Table 2-16). These concentrations were many times (<<0.01 percent) less than the DOE DCGs. For comparison purposes, This value is not significantly different from the annual average concentration reported by PNNL for the distant communities of Yakima and Sunnyside (Dirkes and Hanf 1996).

The total uranium for the 400 Area was not reported in 1995.

Table 2-16. Total Uranium in Air, 300/400 Areas, 1994 (pCi/m³).

Area	Annual Average $\pm$ overall analytical error	DCGs	Distant Community $\pm$ 2SEM(%)	
300 (PNNL)	^{234}U , 1.1 E-05 $\pm$ 10%	^{234}U , 9.0 E-02	3.7 E-05 $\pm$ 84%	
	^{235}U , 7.4 E-07 $\pm$ 90%			
	^{238}U , 1.4 E-05 $\pm$ 20%			
300NE (PNNL)	^{234}U , 2.4 E-05 $\pm$ 20%	^{235}U , 1.0E-01		
	^{235}U , 1.4 E-06 $\pm$ 90%			^{238}U , 1.0E-01
	^{238}U , 2.5 E-05 $\pm$ 10%			
300 Area TEDF N-130	^{234}U , 5.8 E-06 $\pm$ 12%*			
	^{235}U , 1.5 E-06 $\pm$ 206%*			
	^{238}U , 4.0 E-06 $\pm$ 122%*			
400	NR			

NR = Not Reported

*2SEM Value Reported

2.3 CONCLUSIONS

Operational activities in the 100, 200/600, and 300/400 Areas contributed to average air radionuclide concentrations that were above background. Over the past 12 years, the average ambient air concentrations generally have decreased because of overall improvement in the operational environmental controls and reduced Site operations. All airborne radionuclide concentrations in air were below the DOE DCGs in 1995.

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3.0 SUBSURFACE MONITORING AND CHARACTERIZATION

Radioactive and hazardous waste in the soil column and stored in underground tanks at the Hanford Site are potential sources of continuing groundwater contamination. Both state and federal groundwater protection regulations require early-warning detection monitoring of such sources. Subsurface monitoring conducted for this purpose at WHC-operated facilities during 1995 consisted of vadose zone (soil column) and groundwater monitoring. Characterization studies were also conducted to evaluate transport and behavior of contaminants in the vadose zone. The primary objective of the subsurface monitoring conducted by WHC was to document the status of radionuclides in the soil column and to identify changes in near-field groundwater quality at waste treatment, storage, and disposal (TSD) facilities.

This chapter summarizes major findings during 1995 and emphasizes the spent nuclear fuel storage basins and SST farm areas where most of the radioactive waste is stored. Emphasis is on integration and interpretation of vadose zone and groundwater data in relation to known or suspected contaminant sources and driving forces. Section 3.1 is a brief review of past waste disposal practices relevant to interpreting monitoring and characterization results discussed in subsequent sections. Section 3.6 is a summary and discussion of the long-term groundwater protection implications of major findings. Appendix L lists project reports that support this interpretive summary.

3.1 SOIL COLUMN DISPOSAL HISTORY

During periods of peak production of nuclear materials, large quantities of liquid waste were discharged to the vadose zone. The liquid waste streams contained varying concentrations of hazardous chemicals and intermediate- to low-level radioactive waste products (Routson 1973). Hazardous and radioactive liquid waste discharged to the vadose zone are the major source of groundwater contamination (Fecht et al. 1977, Lindberg et al. 1993, DOE-RL 1995).

Routson (1973) identified three zones for release of liquid effluent generated from production of nuclear materials and three categories of radioactive effluent liquids. These zones were the upper vadose zone, the lower vadose zone, and the saturated zone (groundwater). The radioactive waste was divided into high-, intermediate-, and low-level categories based on radionuclide content. The intermediate-level classification has been discontinued. Currently, the radioactive waste classifications are high-level, low-level, and transuranic (TRU) waste; spent reactor fuel; and byproduct material (DOE 1988b).

3.1.1 Low-Level Waste in the Upper Vadose Zone

The upper vadose zone is defined as the unsaturated zone from the ground surface to a depth of 6 m (20 ft) (Routson 1973). The upper vadose zone was identified as the least desirable for disposing of radioactive waste because the probability is high for plant or animal intrusion and subsequent

dispersion, possible transport by wind and water, and potential introduction into the food chain. Low-level radioactive waste contained less than 50 pCi/g of beta-emitting mixed fission products (Irish 1962) and was considered safe for discharge to the upper vadose zone through ponds and ditches.

3.1.2 Intermediate-Level Waste in the Lower Vadose Zone

The lower vadose zone is the unsaturated zone from the depth of 6 m (20 ft) to the capillary fringe of the groundwater saturation zone. The thickness of the lower vadose zone varies across the Site from a few meters beneath the 100 Areas to approximately 60 m (190 ft) beneath the 200 Areas. Liquid waste discharges to the lower vadose zone are generally inaccessible to biota and climatic events (e.g., wind, rain) that could disperse radioactive material (Routson 1973). This zone was identified as the most desirable for storage or disposal of waste containing intermediate-level radioactive contaminants. Intermediate-level radioactive waste contained between 50 pCi/g and 100,000,000 pCi/g (100 μ Ci/mL) of beta-emitting mixed fission products. The total documented discharge of radioactive waste to the lower vadose zone is over 3,000,000 Ci at the time of discharge; the largest annual discharge, 834,000 Ci, occurred in 1955 (Hanson et al. 1973).

Discharging intermediate-level radioactive waste into the groundwater was considered to be an unacceptable risk. Therefore, significant efforts were made to contain most of the radioactive materials in the vadose zone and limit the amount that reached the groundwater. Laboratory studies were conducted to estimate the volume of contaminated waste that could be retained in the vadose zone and to adjust effluent chemistry to optimize retention by the soil. However, occasionally contaminant breakthrough to groundwater occurred.

3.1.3 High-Level Liquid Waste

High-level liquid waste contains beta-emitting radionuclides at concentrations higher than 100 μ Ci/mL. The high-level liquid waste was placed in underground tanks. However, over 450 million L (120 million gal) of liquid waste from underground storage tanks was discharged to the lower vadose zone via cribs and French drains (Waite 1991). The estimated total quantity was 65,000 Ci (decayed through December 1989). Past-practice disposal included the following:

- Discharge of concentrate (evaporator bottoms) to cribs after cascading through a series of underground storage tanks.
- Discharge of first-cycle supernatant liquids to cribs after cascading through a series of underground storage tanks.
- Discharge of second-cycle radioactive chemical process liquids to the cribs from the underground storage tanks.

Because of the large volumes discharged, the entire soil column beneath many disposal sites that received this waste became saturated and breakthrough of mobile contaminants to groundwater occurred. The residual saturation (liquid held in soil pore spaces following drainage of free liquid) at these

sites can continue to be a source of groundwater contamination if a driving force is present (enhanced natural infiltration, leaking water lines, etc.). The smaller volume (less than 4,000,000 L), high-activity waste that leaked from SSTs can also become a source of groundwater contamination if a driving force is present to transport the contaminants through the vadose zone to groundwater. Because waste constituents in the liquid waste discharges were similar to the waste that was intended for storage in SSTs, a tank leak is virtually indistinguishable from a tank farm-related crib source. These two major contaminant source types should be considered collectively for groundwater protection purposes. This would require expanding the existing boundaries of waste management areas for many of the tank farms to include waste transfer lines, distribution boxes, and disposal structures along with the SSTs.

3.1.4 Liquid Waste Disposal Facilities

The Hanford Site has more than 330 liquid-waste disposal facilities. Radioactive liquid waste was discharged to the lower vadose zone through reverse wells, French drains, cribs, and tile fields.

Some liquid effluent contained constituents known to migrate readily through the soil and would quickly add contaminants to the groundwater. Soil retention calculations were performed before the material was discharged to determine how much liquid waste could be discharged before breakthrough to groundwater occurred. During the 1950's over 140 million L (37 million gal) of radioactive waste was discharged to at least 28 "specific retention" cribs. Recent monitoring has shown that movement within the vadose zone beneath these cribs is continuing. An example is the specific retention cribs in the 200-BP-1 Operable Unit (216-B-43 through 216-B-49) located in the north-central area of the 200 East Area. Borehole geophysical measurements in well 299-E33-5 demonstrated that the radioactive contaminants from liquids that were discharged nearly 40 years ago continue to move through the vadose zone (Fassett 1995).

Operating practices changed when long-lived radioactive contaminants previously considered to be immobile were found in the groundwater. During the 1960's the total amount of radioactive contaminants discharged to the subsurface was drastically reduced in an effort to mitigate continued groundwater contamination.

Even though disposal of untreated waste water to the ground has been terminated, movement of certain contaminants can still occur in the soil column beneath past-practice waste sites. Vadose zone monitoring and characterization is one approach to evaluating possible leaks and or remobilization of contaminants caused by enhanced natural infiltration or other sources of surface water over or near disposal sites. The vadose zone monitoring methods in use at the Hanford Site for this purpose are described in the following sections.

3.2 VADOSE ZONE PROGRAM

The objectives of vadose zone monitoring and characterization are to identify, quantify, and document radionuclide movement in the soil column.

For this purpose, gamma-emitting radionuclides and moisture content are measured continuously with depth using in situ borehole geophysical detectors or sensors. Changes are documented by comparing baseline or initial survey results with subsequent surveys.

Two organizations performed borehole logging surveys at the Hanford Site in 1995. Rust Geotech conducted SST vadose zone characterization and WHC-Geophysics conducted vadose zone monitoring at liquid waste disposal sites and provided geophysical services for other Hanford Site contractors.

Sections 3.2.1 through 3.2.3 describe the instrumentation used in the vadose zone monitoring program, discuss the significance of subsurface radionuclide distribution patterns seen at selected sites that received intermediate- and high-level liquid waste, and summarize work conducted in 1995 at both tank farms (Rust Geotech) and past-practice disposal sites (WHC-Geophysics).

3.2.1 Borehole Geophysical Instrumentation

Borehole geophysical logging is conducted using truck-mounted equipment for in situ measurement of subsurface radioactive contaminants and formation moisture content. In preparation for the environmental mission at the Hanford Site and to correct deficiencies of earlier logging equipment (GAO 1992), the borehole geophysical measuring equipment was significantly upgraded. The new logging system operated by WHC is called the Radionuclide Logging System (RLS) and has demonstrated significant improvements in efficiency, precision, and accuracy.

3.2.1.1 Components and Calibration. The RLS logging equipment is calibrated in borehole calibration models constructed for long-term stability and to represent subsurface conditions (PNL 1995, Stromswold 1994a). The geophysical detection systems were calibrated in these models and corrections were established for differences between the calibration models and Hanford Site borehole construction conditions (Randall et al. 1994, Price et al. 1996). The subsurface geophysical surveys are acquired in accordance to defined standards (WHC-CM-7-7). The data reduction method was reviewed (Stromswold 1994b) and is performed following the vadose zone monitoring plan (Price 1995).

The truck-mounted borehole logging equipment consists of the following:

- Sonde (detection probe) for down-hole in situ measurements
- Cable and cable spool for suspending the sonde in the borehole and transmitting the detector responses to the truck-mounted electronics
- Cable depth position encoder for positioning the sonde and recording its depth in the borehole
- Precision electronics for tabulating the detector response signals and correcting for instrument processing dead time

- Data-acquisition control computer for controlling the cable winch, positioning the detector, activating the counting system electronics, and recording the measurements on digital media.

3.2.1.2 Advantages of the Radionuclide Logging System. The Radionuclide Logging Systems (RLS) are fundamental to understanding subsurface radionuclide identification and distribution. Measurements obtained at the Hanford Site using RLS equipment have resolved longstanding uncertainties in the occurrence and depth distribution of gamma-emitting radionuclides as illustrated by the following examples.

Radioactive vapor emissions from the subsurface have long been observed at the Hanford Site from venting boreholes. Surface contamination on equipment extracted from boreholes occasionally shows elevated radioactivity, but the radioactive wipes generally decay to non-detectable levels in a few hours. Fields of high gamma radiation have been observed around charcoal canisters used to remove carbon tetrachloride vapor from soil-gas extraction wells. The RLS system showed that most of the soil-gas-related radioactivity noted above could be attributed to the progeny (or decay products) of the noble gas, ^{222}Rn (3.8-day half life), which emanates from the natural uranium decay series in the soil.

Field screening of borehole drill cuttings using hand-held radiation detection instruments have long been used to report subsurface intervals of radioactive contamination. During one of the RLS's initial logging surveys, large intervals of radioactive contamination were identified. The hand-held field screening instruments had not detected the radioactive contaminants in the drill cuttings. Initially, contaminants were thought to be concentrated on the casing as the hole was being advanced. However, when the RLS surveyed the drummed drill cuttings in the field and found the same contaminants, the deficiency in the detection threshold of hand-held field screening instrumentation was recognized.

Borehole logging surveys using earlier equipment did not distinguish short-lived mobile radionuclides from longer lived components. This often obscured the status of the longer lived, less mobile radionuclides such as ^{137}Cs . RLS monitoring surveys indicate that most of the ^{137}Cs has remained fixed in place. However, in some cases, continued movement over time has been identified 35 years after waste disposal operations were terminated (Fassett 1995).

3.2.2 Soil Column Radionuclide Distribution Patterns

Several depth distribution patterns are presented in the following discussion. The examples demonstrate the following:

- Radionuclide movement beneath some disposal sites continues long after termination of input
- The lateral extent of movement can be much greater than the physical dimensions of the disposal structure.

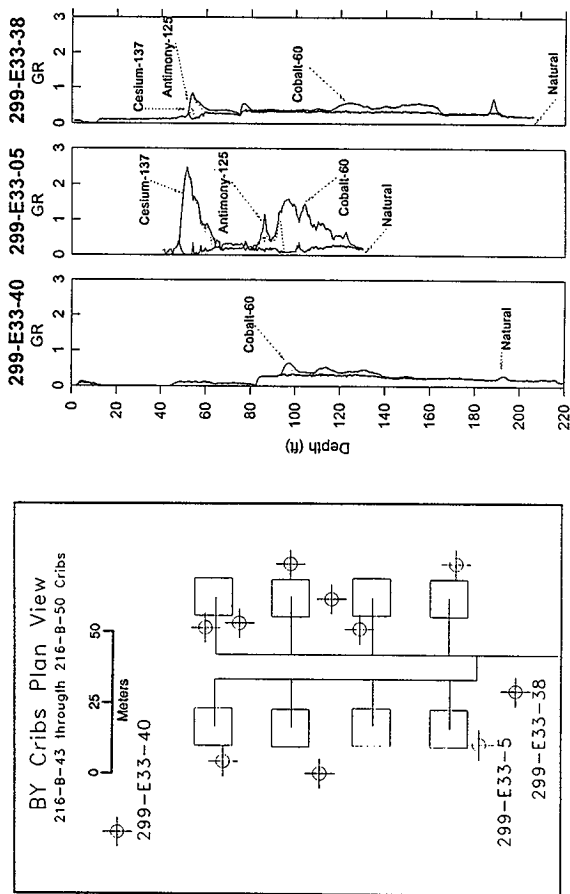
3.2.2.1 200 East Area Contaminant Spreading Horizons. In the 200-BP-1 Operable Unit, which is located in the north-central 200 East Area, at least seven cribs (216-B-43 through 216-B-49) received measurable quantities of potentially mobile radioactive waste from November 1954 through December 1955. The lower vadose zone sediments contain no widespread low-permeability zones similar to the caliche layer in the 200 West Area. Computer model simulations predicted a plume profile where the contaminants move essentially vertically through the soil to the groundwater. The calculations indicated that more than 90 percent of the discharged waste would be retained in the vadose zone above the water table.

Groundwater monitoring wells 299-E33-38 and 299-E33-40 were constructed outside the projected area of subsurface contamination. RLS spectral gamma-ray logs of both wells indicated radioactive contaminants to a depth of 58 m (190 ft) in well 299-E33-38. Examination of the drill cuttings identified a 0.3-m (1-ft)-thick fine-grained sand layer from well 299-E33-38 at about 34 m (110 ft) below the surface. The sediments above and below were sand with slightly higher gravel contents. Apparently the liquids discharged to the subsurface encountered the sand layer and spread (wicked) laterally for several meters. A plan view of the 200-BP-1 Operable Unit cribs, monitoring borehole locations, and RLS surveys of three wells are shown in Figure 3-1. The depth profile survey of well 299-E33-5 shows the interval where horizontal movement was identified at a depth of about 34 m (110 ft). Information currently available for the 200-BP-1 Operable Units is not sufficient to completely explain the character of subsurface contaminants and their migration pathways. However, it can be concluded that the contaminants discharged to the 200-BP-1 Operable Unit cribs are not localized below the crib perimeter fence and horizontal movement does appear to occur (Fassett 1995).

The RLS equipment was used to study subsurface radioactive contaminants in the 241-C Tank Farm (200 East Area). A study of the 241-C-103 tank (Kos et al. 1995) identified two sources of radioactive contamination. The largest concentration occurred from the high levels of ^{137}Cs surface contamination in a liquid mixture that saturated the soils above the tank, ran over the dome, down the sides, and to the footing. The contamination then migrated into the sediments around the tank. In addition, the old construction horizons at the tank bases and near the cascade line levels served as spreading horizons for the liquids migrating over the tank. Examination of the RLS logs (with the boreholes ordered by distance from the side of the tank) revealed that the source of the contaminants encountered below the tank's base actually originated from the surface spill. Figure 3-2 shows the borehole locations relative to tank 241-C-103 and the RLS survey results. After the report was published, an unusual occurrence report (UOR) was located that documented a leak of 25,000 Ci of ^{137}Cs at the surface of the 241-C Tank Farm in 1972 (Maxfield 1983).

Another radionuclide occurred at greater depths. For example, many boreholes that penetrated to a depth of 24 m (80 ft) intersected an interval of ^{60}Co contamination. Examination of the drilling records identified a fine-grained lens in the sediment. Review of tank farms moisture surveys confirmed that the high moisture content had been present for several years in the fine-grained layer; this could be traced through nearly the entire 241-C Tank Farm. Examination of the depths at which the ^{60}Co contamination and high-moisture layer were found shows that the beds dip toward the 241-C-103 Tank and the

Figure 3-1. RLS Survey of Wells 299-E33-5, 299-E33-38, and 299-E33-40.



contamination encountered in these boreholes may likely have originated from other sources. Other logging surveys in the tank farms showed an occurrence in dry wells 241-C-108 and 241-C-109 at the depth of 20 m (60 ft) that began increasing 2 years before the increased activity was seen in borehole 30-03-09 in the fine-grained moisture layer. The conclusion was that a fine-grained sediment layer is present under much of the 241-C Tank Farm. The sediment layer has retarded downward liquid migrations from tank leaks or transfer line malfunctions but spread the radioactive liquid across a large area, apparently by capillary action.

3.2.2.2 High Mobility of ^{137}Cs -Contaminated Liquid Discharges. A condition under which ^{137}Cs can be more mobile than expected is suggested by radionuclide depth profiles beneath the 216-T-19 Crib (200 West). This crib received steam condensate, second-cycle supernatant, and cell drainage waste from September 1951 to July 1980. Monitoring borehole 299-W15-4 was drilled January 1956, and was 20 m (65 ft) from the release point. A gamma log survey by the RLS shows the main contaminant plume at 12 m (40 ft) with a maximum concentration of 33,000 pCi/g. The RLS survey identified additional ^{137}Cs contamination at 47 m (150 ft) at concentrations as high as 8 pCi/g with no indications of contamination being smeared to lower depths by the drilling activity. The plot of the RLS survey and stratigraphy from drill cutting are shown in Figure 3-3. Note that the contamination at 47 m (150 ft) correlates with a texture change from gravel (that caved during drilling) to gravelly sand. The conclusion is that the migrating liquids from the crib discharges encountered the gravelly sand strata and spread horizontally at least 20 m (60 ft) before continuing their vertical travel to groundwater. The 200 West Area is known to have several stratigraphic interfaces that promote horizontal spreading and retardation of liquids migrating through the subsurface.

3.2.2.3 Directional Contaminant Spreading. Stratigraphic horizons can promote preferential spreading. This concept is understood by geologists, but generally is not included in demonstrations or incorporated into most studies or models because of localized conditions. A good example of the preferential spreading of radionuclides discharged to the vadose zone is the 216-T-6 Crib. The crib was in service from 1946 through 1951, receiving 45 million L (16 million gal) of low-salt, neutral to basic cell drainage. Records indicate that the crib contains 110 Ci of ^{137}Cs (decayed through January 1990) and other radioisotopes. Fifteen monitoring boreholes were drilled adjacent to the crib area between May 1947 and August 1951. Figures 3-4 and 3-5 show a plan view and cross section, respectively, of the crib structure, borehole locations, and maximum extent of contaminant concentrations that range from 10 to 1,000 pCi/g. The irregular shape of the the contaminant plume and the extent of lateral spreading suggest the following:

- The distribution of contaminants discharged to the vadose zone is influenced by hydrogeologic conditions.
- The influence of geologic conditions and surface water must be considered when planning remediation activities.

3.2.2.4 Active Zone of Contaminant Movement in the SX Tank Farm. A zone of subsurface radioactive contaminant movement was identified during baseline surveys in the 241-SX Tank Farm (refer to Section 3.2.3). Review of the gross-gamma dry-well surveillance logging runs, recorded before use of the

Figure 3-2. Borehole Locations and Survey Results
Around Tank 241-C-103.

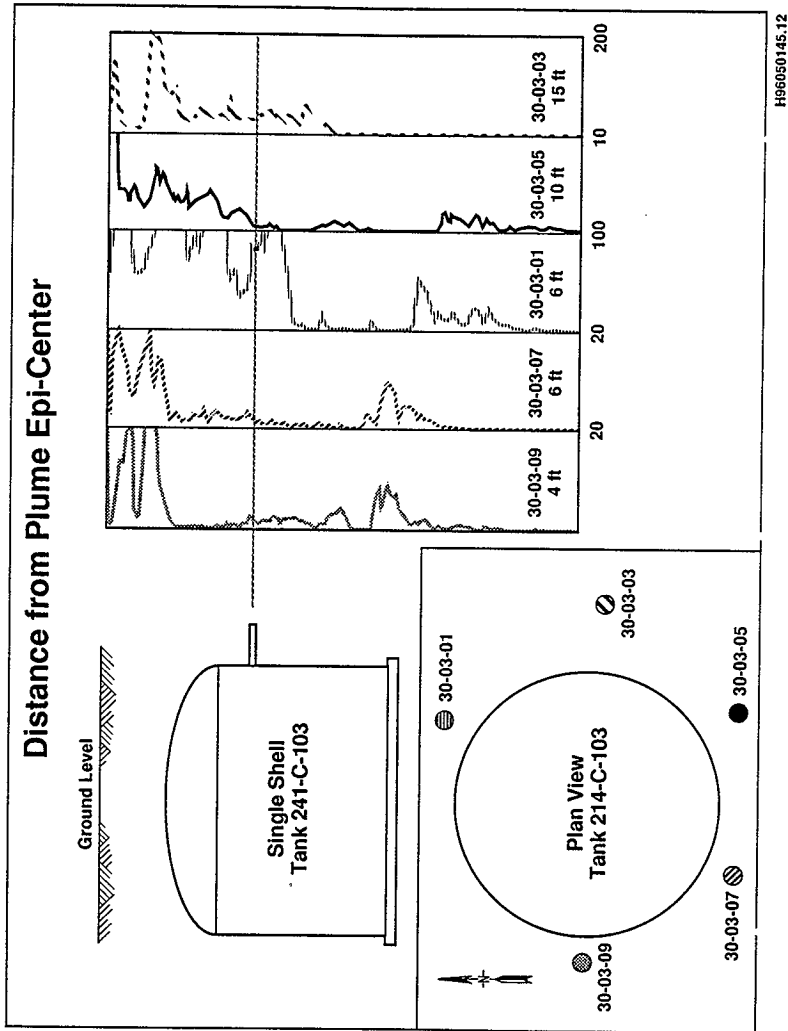


Figure 3-3. Stratigraphy and RLS Survey Plot for the 216-T-19 Crib (Well 2-W15-4).

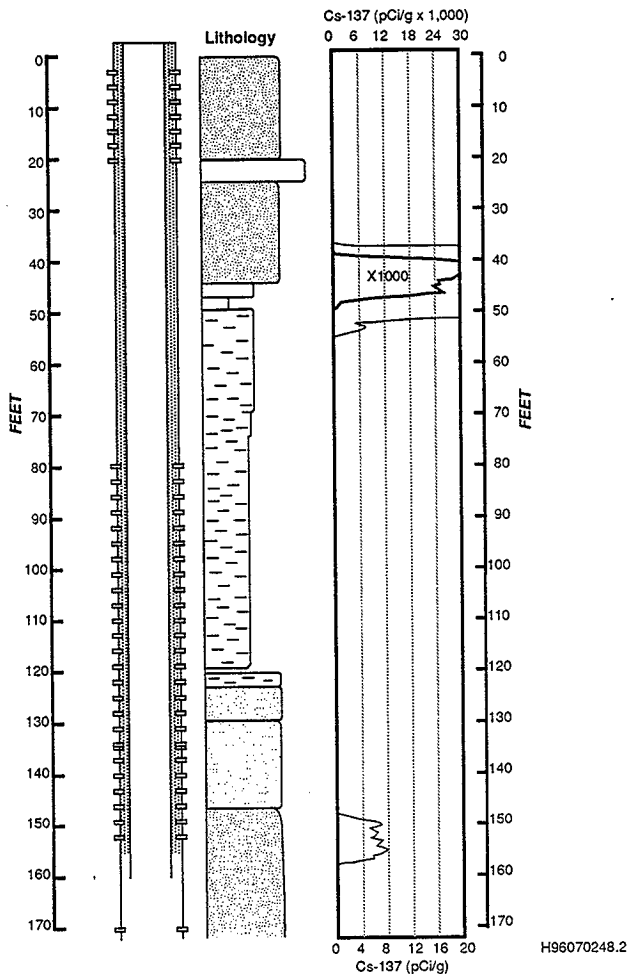


Figure 3-4. Plan of 216-T-6 Crib.

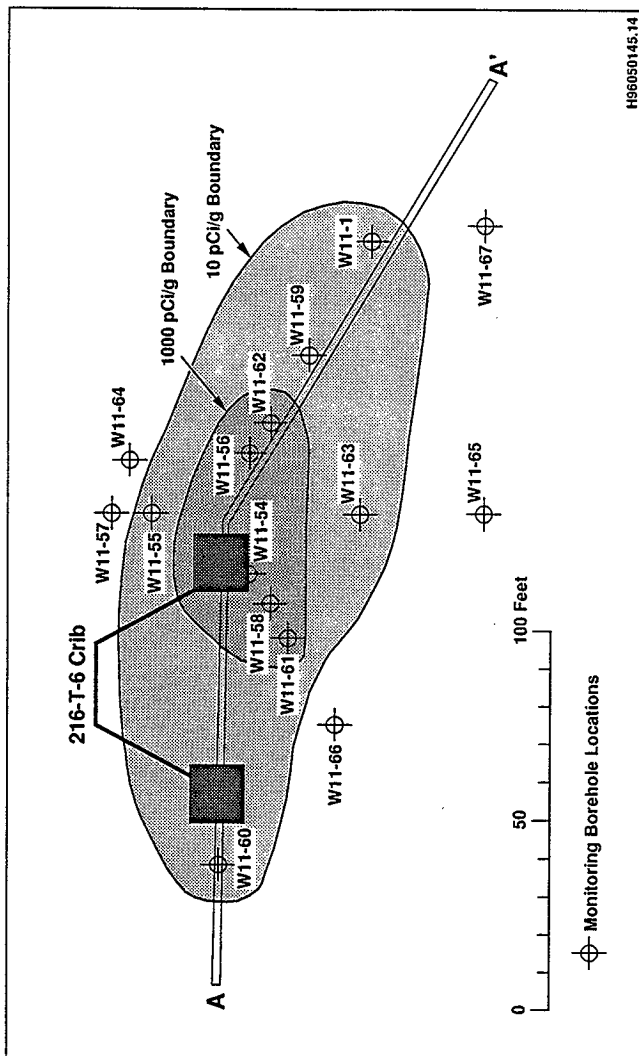
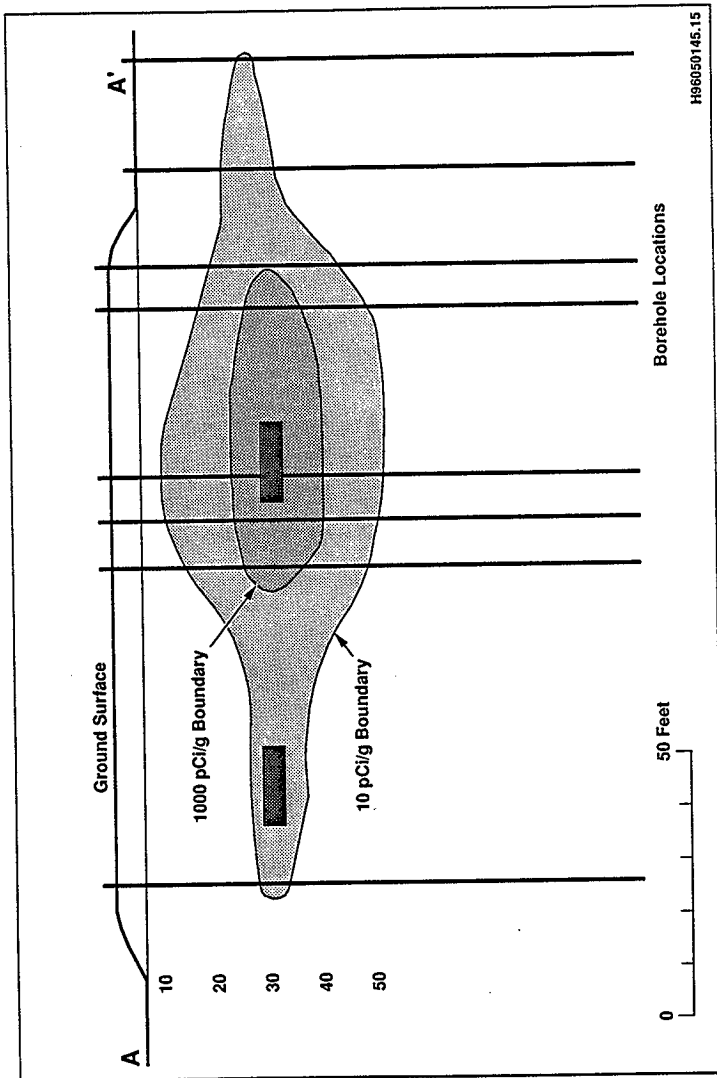


Figure 3-5. Cross Section of 216-T-6 Crib.



RLS, revealed an interval at 22 m (73.5 ft) in borehole 41-09-09 in which gamma activity has been increasing for at least 3 years. The contaminant concentration has increased by 450 percent since May 1986. The spectral gamma-ray survey of the borehole identified the radioisotope as ^{137}Cs , which normally is considered immobile. The 241-SX-109 tank was identified as a leaker in 1965 and all pumpable liquids were removed. The increasing radiation levels in borehole 41-09-09 suggest there is an actively migrating contaminant plume. An investigation of the 241-SX Tank Farm vadose zone to explain the source and migration pathway of the radioactive contaminants is under way.

3.2.2.5 Horizontal Movement in the 100 Areas. The distribution characteristics of the gamma-emitting radionuclides commonly encountered in the 100 Areas (e.g., ^{137}Cs , ^{152}Eu , and ^{60}Co) indicate that these radioisotopes are commingled over the full-depth interval through which they are encountered.

The direction of movement differs from that in the 200 Areas, where the radionuclide distribution profiles show marked differences in the lengths of vertical migration paths (see Figure 3-1).

The common radionuclide distribution in the 100 Areas, shown in Figure 3-6, does not show vertical separation of the gamma-emitting radionuclides. The absence of distinct radionuclide separation suggests that the migration path through the soils was horizontal toward the river and less vertical toward the groundwater. The coarse sands and gravels of the unconsolidated Hanford formation in the 100 Areas have a very low affinity for radionuclides. Mobile and moderately mobile radionuclides are not separated to the extent that occurs in fine-grained sediments. This implies that during operations when liquids were being discharged to the soil column, the volume of liquid discharge caused localized mounding of the water table and promoted the horizontal spreading. The conclusion is that radioactive contaminant distribution in the 100 Areas at relatively shallow depths, (less than 7 m [20 ft]), is likely to cover large areas.

3.2.2.6 Clastic Dikes as Vertical Pathways. Clastic dikes, which have been shown to transport liquid radioactive contaminants for significant distances both vertically and laterally, are present in the 200 Areas (Fecht and Price 1976). The dikes are polygonal vertical dikes composed of sands, silts, and clays that cut across up to tens of feet in the Hanford formation. The clastic dikes are generally composed of relatively uniformly sized unconsolidated sediments with high permeability that have been known to transport relatively small quantities of liquids great distances. Clastic dikes have been identified at multiple horizons in the Hanford Site subsurface. The size of the polygon patterns varies, but some are roughly the size of an underground storage tank, about 20 m (60 ft). Several well-site geologists have identified clastic dikes by studying core cuttings collected during drilling (Singleton and Lindsey 1994). These studies have shown that migrating liquids do not necessarily readily cross the interface from the host rock sediments into the clastic dike sediments when the outer boundaries of the dike sediments contain very fine-grained (clay-size) particles. However, not all clastic dikes are lined with clay-size particles, and once the liquids enter the dike, as can occur at bedding plane interfaces where they naturally terminate or at old construction surfaces, the liquid movement is similar to

that in a pipe. Clastic dikes should be considered as possible conduits for liquid waste migration.

3.2.3 Summary of Vadose Zone Logging Activity for 1995

Logging activities in tank farms and at past practice disposal sites are summarized separately as follows.

3.2.3.1 Tank Farm Characterization. The DOE Richland Operations Office (RL) tasked the DOE Grand Junction Projects Office (GJPO) with characterizing the radioactive contamination in the vadose zone at the SST farms. This involved establishing a baseline of the gamma-emitting radionuclide concentrations with spectral gamma-ray borehole geophysical logging measurements. Rust Geotech Inc., the contractor for GJPO, is performing this work in coordination with Hanford Site contractors and subcontractors, using tools developed by WHC at the Hanford Site.

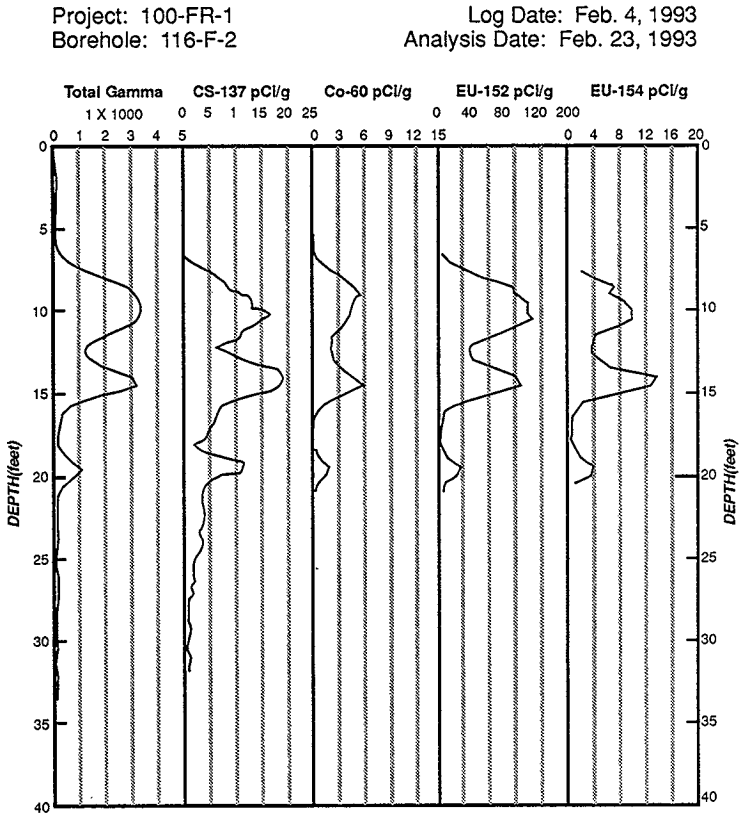
The spectral gamma-ray borehole logging measurements determine radionuclide concentrations in the sediment by logging preexisting, cased boreholes surrounding the SSTs. Technical details of this characterization and baseline development are described in *The Spectral Gamma-Ray Borehole Geophysical Logging Characterization and Baseline Monitoring Plan for the Hanford Single-Shell Tanks* (Rust 1995a).

All boreholes surrounding a tank are logged with spectral gamma-ray logging systems (SGLS) to produce profiles or logs of the radionuclide concentration. The logs are correlated with tank farm gross gamma-ray log data and historical information about each tank, and a Tank Summary Data Report (TSDR) is prepared. The TSDR documents the results of the logging in relation to tank leak history. After TSDRs are prepared for all of the tanks in a farm, a comprehensive Tank Farm Report is prepared. The Tank Farm Report provides a more complete assessment and correlation of all vadose zone contamination data to identify sources and to determine the nature and extent of the contamination.

The two SGLS used in 1995 were calibrated following Rust (1995b). The base calibration was performed using the DOE calibration models in Grand Junction, Colorado and is reported in *Calibration of Two Spectral Gamma-Ray Logging Systems for Baseline Characterization Measurements in Hanford Tank Farms* (Rust 1995b). The field calibrations are published biannually, most recently in Rust (1996a).

Data are recorded by the SGLS in accordance with procedures outlined in the *High Resolution Passive Spectral Gamma-Ray Logging Procedures* (Rust 1995c) and managed as outlined in the *Records Management Plan* (Rust 1995d). Documentation providing details on other aspects of the project are provided in the *Project Management Plan* (Rust 1995e), the *Quality Assurance Project Plan* (Rust 1996b), the *Health and Safety Plan* (Rust 1995f), and the *Training Integration Plan* (Rust 1994).

Figure 3-6. Common Radionuclide Distribution in the 100 Areas.



H96070248.3

SX Tank Farm. Logging of 95 vadose zone monitoring boreholes (Figure 3-7) in the SX Tank Farm with an SGLS was completed in August 1995 and TSDRs were completed in January 1996. The draft of a comprehensive SX Farm Report was prepared in early 1996. The final report will be published in 1996.

The boreholes in the SX Tank Farm are from 23 m to 38 m (75 to 125 ft) deep, which is well above groundwater levels. The groundwater is about 64 m (210 ft) below the SX Tank Farm.

^{137}Cs was found to be the most abundant and highest concentration of gamma-emitting contamination in the vadose zone sediment. Other radionuclides detected include ^{60}Co , ^{152}Eu , and ^{154}Eu . However, they were only detected at or very near the ground surface, except for one borehole where ^{60}Co was detected below the tank base.

A geostatistical model of the ^{137}Cs contamination was developed based on the observed contaminant distribution. Solid surface visualizations were created from the model to show three-dimensional representations of the contaminant from different angles.

Visualizations were prepared showing the contaminant distribution around each tank, usually from more than one angle. The visualizations show the sources of the contamination and, in almost all cases, confirm the current integrity designations for the tanks. The visualizations were used to help identify the sources and to show the extent of the contamination. The three-dimensional visualizations were prepared in color; black and white copies do not allow distinction between isoconcentration intervals. Therefore, the depth profile plots of the contamination identified in boreholes surrounding tanks SX-108, SX-109, and SX-112 are provided in Figures 3-8 through 3-10. See the SX Tank Farm Report (GJ-HAN-DOE/ID/12584-268) for the visualization/modeling results. The report is currently in final stages of review for publication in September 1996.

The deepest zone of contamination, and the zone of greatest concern in the SX Tank Farm, is the plume identified at a depth of 38 m (125 ft) around borehole 41-12-02 (Figure 3-7). This borehole is adjacent to Tank SX-112 (see Figure 3-10) which is designated as a leaker. High levels (>1000 pCi/g in "off-scale" shaded zones where detector saturation occurred) of contamination have reached the maximum extent of the boreholes, and the proximity of the plume to groundwater cannot be established. The contamination is assumed to actually be distributed within the sediments. However, all of the monitoring boreholes were drilled using cable-tool drilling methods and they may leave a gap behind the casing wall that could provide a pathway for vertical movement of contamination. Therefore, some contamination could have moved down the outside of the borehole casings.

In the case of the deep, extensive plume in the SX Tank Farm, the zones of high ^{137}Cs concentration in borehole 41-12-02 correlate with zones of contamination in surrounding boreholes. This could suggest that the major portion of the plume is somewhat continuous at depth in the horizontal dimension. Also, the contamination found deep in boreholes 41-09-04 and 41-12-02 was present in the formation when the boreholes were deepened in the mid-1970's, as indicated by sediment samples and gross gamma-ray logs.

Figure 3-7. Plan View of the SX Tank Farm Showing Locations of Boreholes and Laterals.

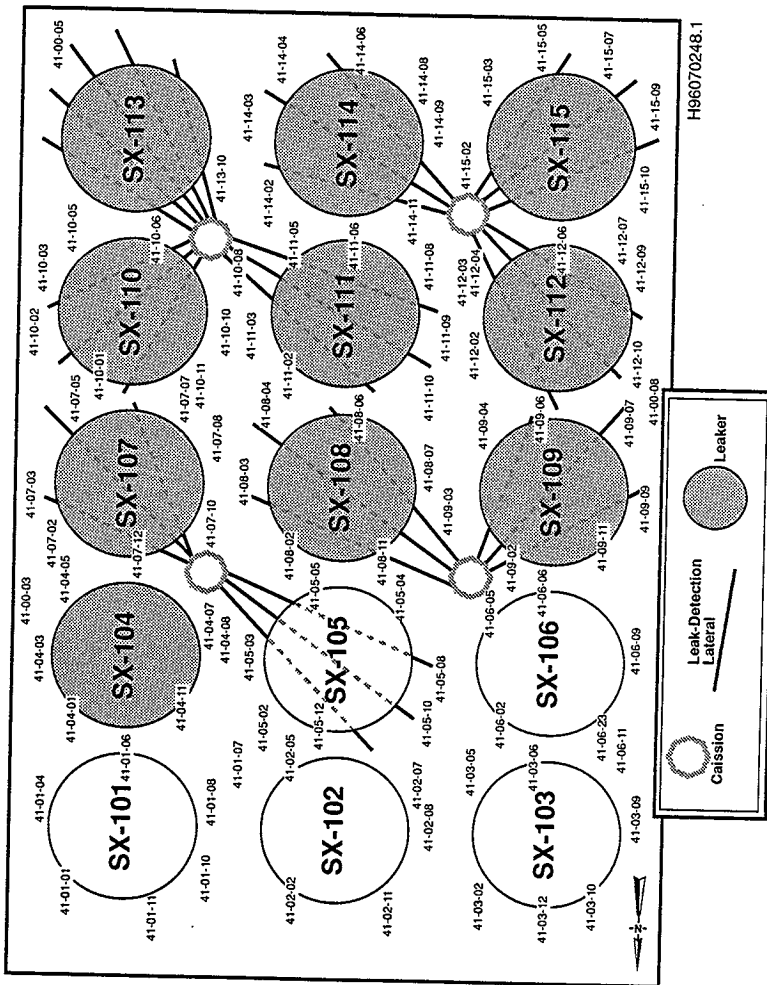
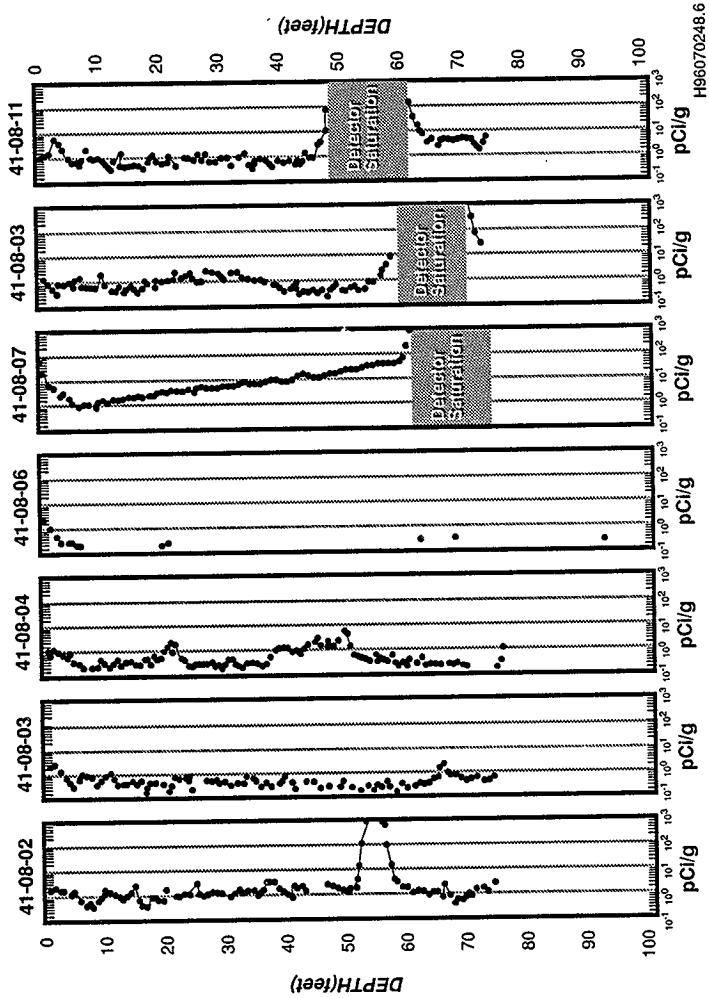


Figure 3-8. ^{137}Cs Contamination in Boreholes Around Tank SX-108.



H96070248.6

Figure 3-9. ^{137}Cs Contamination in Boreholes Around Tank SX-109.

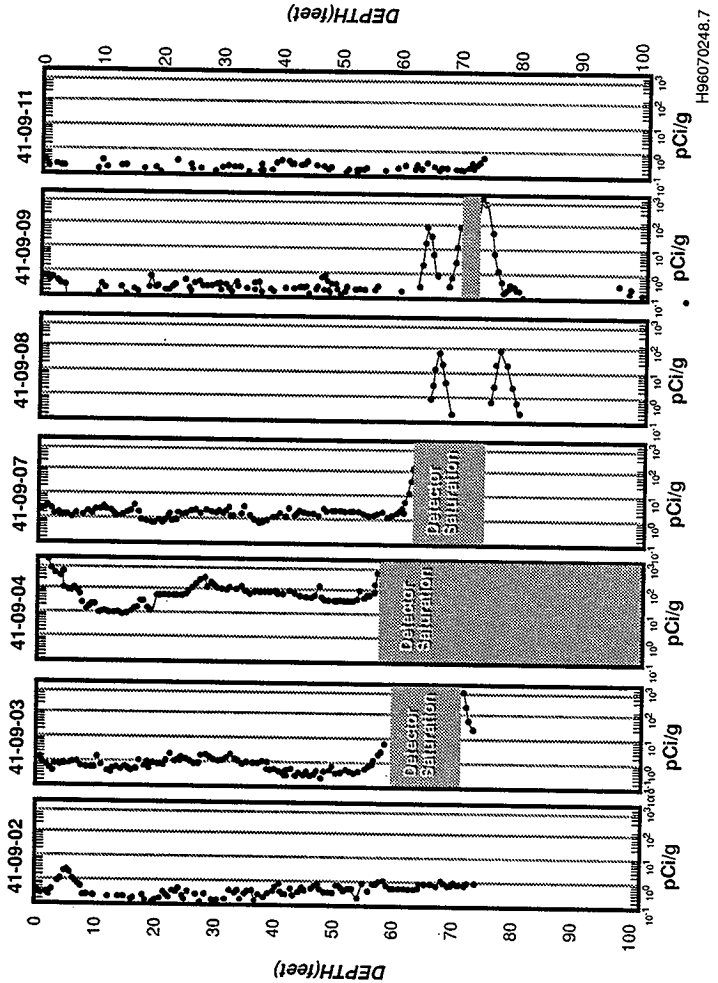
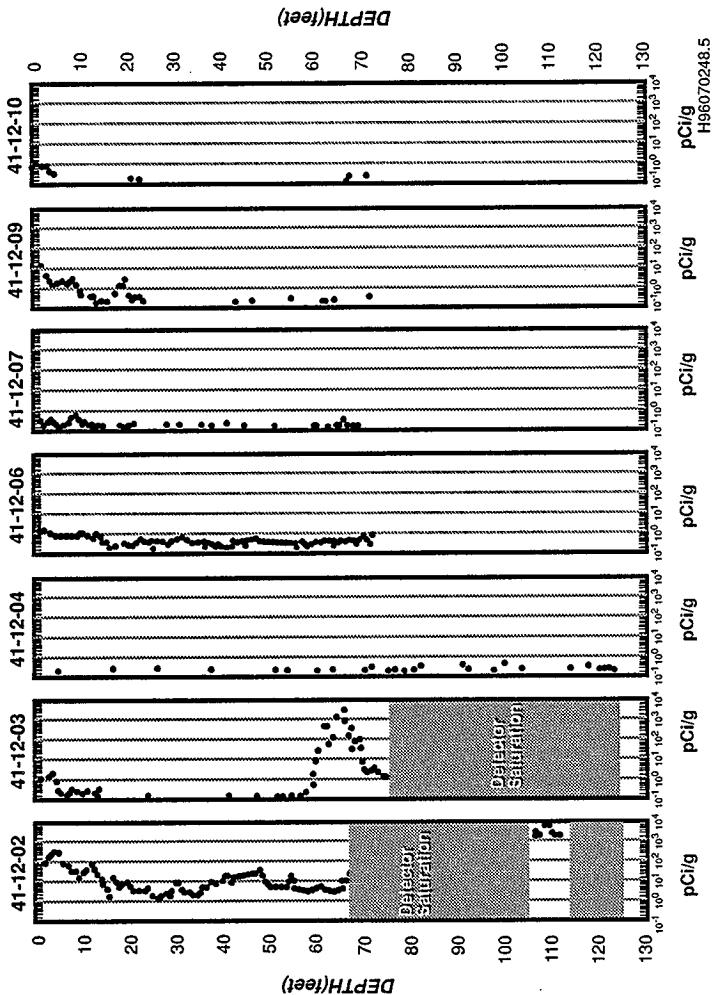


Figure 3-10. ^{137}Cs Contamination in Boreholes Around Tank SX-112.



Finally, gross gamma logs show no evidence of any changes in the activity profiles of the boreholes suggesting that no vertical movement of contamination since the boreholes were drilled.

The possibility that contamination was carried downward during drilling still remains although there is more evidence that the contamination is in the formation. Based on existing data, the most conservative interpretation is that the contamination is within the formation, and it migrated through the formation to reach its current depth. As discussed in Section 3.4, this will be adopted as one of the preferred conceptual models for the SX Tank Farm. Other major contaminant plumes in the SX Tank Farm can be attributed to known leaks from specific tanks or to surface contamination.

It was also determined from the SX Tank Farm vadose zone characterization work, that Tank SX-109 appears to continue to leak a small amount of liquid. A review of the gross gamma log data from borehole 41-09-09 (see Figure 3-7 for the location) shows an increasing trend in the activity profile from 1986 to 1989 as shown in Figure 3-11. This was the only region where gross gamma activity increased in a consistent manner with time, suggesting a continuing tank leak or movement of contaminants from a past leak.

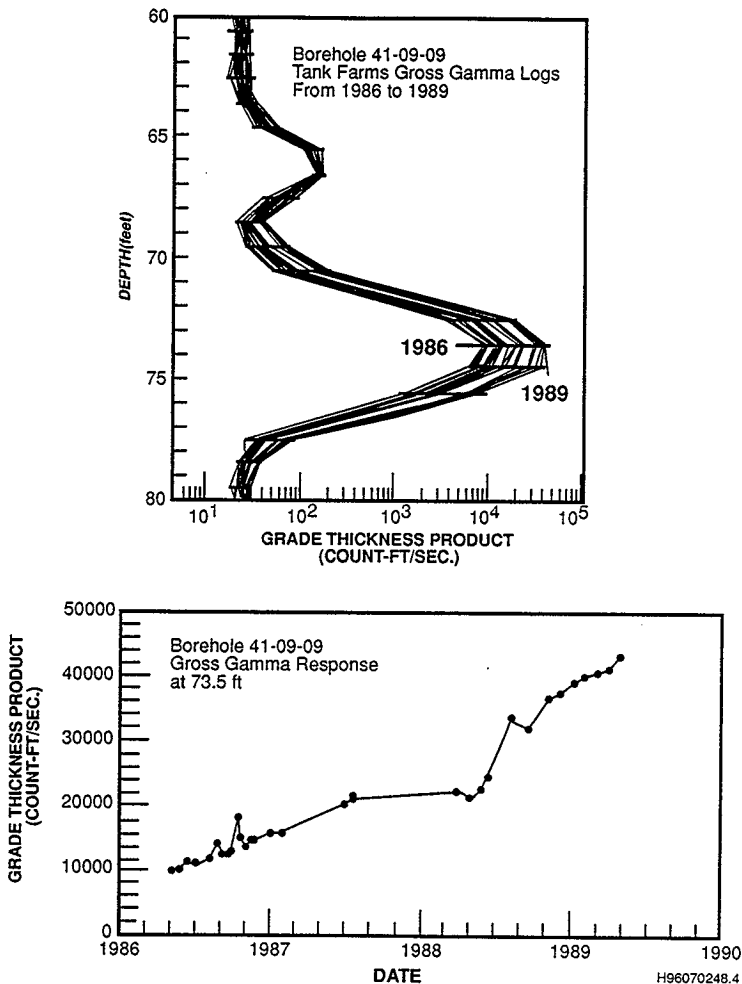
The impacts of SX Tank Farms operations on the groundwater were not conclusively defined by the vadose zone characterization work. However, from groundwater monitoring data (see Section 3.4), it was established that the groundwater beneath the SX Tank Farm is contaminated with ^{99}Tc , probably from the SX Tank Farm. This is discussed in detail in Section 3.4. Because the vadose zone boreholes do not extend deep into the lower vadose zone, the source of the groundwater contamination cannot be determined from an assessment of the vadose zone contamination. However, based on the depth of ^{137}Cs , a relatively low-mobility radionuclide, the vadose zone characterization results strongly suggest that the SX Tank Farm is a source of the mobile ^{99}Tc found in the groundwater.

The vadose characterization project is the first attempt at a comprehensive characterization of subsurface soils at the SX Tank Farm. Additional work has been recommended to assess the SX Tank Farm monitoring data in an attempt to quantify the tank leak volumes, test conceptual models, and develop better historical information on all the tanks.

Recommendations also were presented in the SX Tank Farm report to provide more vadose zone characterization data, including measurements of the in situ moisture content and formation bulk density. It has been suggested that future characterization should include determinations of concentrations of higher risk radionuclides that do not emit gamma rays, such as plutonium. Also, a program to periodically monitor the vadose zone boreholes could be implemented to track the contamination as it moves through the sediment and to help identify or verify the occurrence of leaks from tanks.

T Tank Farm. Most of the boreholes surrounding the 12 tanks in the T Tank Farm were drilled in the mid-1970's and completed with single 15-cm (6-in.)-diameter carbon steel casing. In the early 1980's, the boreholes were modified by perforating the existing 15-cm (6-in.) casing, inserting a 10-cm (4-in.) casing and pumping grout in the annulus between the two casings. Therefore, the configuration of the T Tank Farm boreholes consists of two

Figure 3-11. Gross Gamma Log History Summary for Borehole 41-09-09.



casings with about 2.5 cm (1 in.) of grout between the casings and an unknown thickness of grout between the outer perforated casing and the formation.

The configuration of these boreholes made quantifying radionuclide concentrations difficult because of the attenuation effects of the double casing and unknown grout thickness. Therefore, logging in the T Tank Farm was conducted only to establish a baseline against which future logging results could be compared in an effort to detect and quantify changes. This logging was performed around only two tanks that were considered potential leakers and that still have a significant amount of free liquid in them (T-107 and T-110).

The boreholes around tanks T-107 and T-110 also were logged because the ground surface in the farm is radiologically clean and access is unrestricted. This was advantageous for the first tests of the new SGLS logging systems and served as a "shakedown" operation for the new logging procedures.

Spectral gamma log data for tank T-107 indicated the presence of ^{137}Cs and ^{60}Co contamination at low concentrations just below the base of the tank. Elevated activities were identified by the tank farm gross gamma-ray logging system shortly after the boreholes were drilled. This contamination is most likely leakage from the tank. The data acquired in the boreholes surrounding tank T-110 did not reflect subsurface contamination that could be attributed to leakage from tank T-110.

3.2.3.2 Past-Practice Disposal Sites. During 1995, approximately 75 boreholes were logged by the WHC Geophysics Group around the inactive liquid waste disposal facilities on the Hanford Site for identifying and tracking radioactive plumes. The logging surveys of the boreholes identified gamma-emitting radionuclides and quantified the concentration as a function of depth. These survey data are the baseline for any further monitoring that is deemed prudent to protect the groundwater from additional contamination from these facilities.

Formation moisture measurements were acquired in approximately 30 boreholes in 1995 using a neutron moisture probe modified for the borehole conditions at the Hanford Site. Because moisture is the driving force for any contaminant movement, this probe (logging sonde) will continue to be used extensively to profile the moisture regime in the vadose zone to better define lateral and vertical distribution characteristics. The probe has been calibrated in the moisture calibration models constructed by PNNL under a Cooperative Research and Development Agreement (CRADA). Corrections for the borehole environment have been determined and are applied to the detector responses (Price et al. 1996).

While vadose logging is used primarily to define the plumes around liquid waste disposal facilities and map the moisture regime, it has been expanded to include surveying the wells that are being decommissioned to ensure that they contain no radiologic contaminants, to help develop the moisture regime statewide, and to collect additional data to fill in the geologic database for a more accurate determination of moisture and contaminant pathways. Approximately 35 borehole logs were acquired for wells being decommissioned.

These tools are also used for geologic logging to help determine the lithology a borehole penetrates by analyzing the natural radionuclides (potassium, uranium, and thorium) and to simply detect gamma-emitting radioactive contaminants. Depth distribution plots for the natural radionuclides are constructed for each borehole logged with the high-resolution High-Purity Germanium (HPGe) logging sensor. In addition, the staff and equipment have supported the ERC in characterizing subsurface radiological conditions at the sites of their new boreholes and cone penetrometer emplacements for delineating waste sites. Approximately 40 borehole logs were acquired in support of the ERC.

The RLS equipment was used to gather more than 180 separate borehole logging surveys during 1995. The data were analyzed, plotted, and filed in the geophysical logging files for ready reference. Table 3-1 lists the boreholes logged. Results for some of the boreholes listed in Table 3-1 are shown in Figures 3-1 through 3-5.

3.3 GROUNDWATER MONITORING

Groundwater monitoring at WHC-managed facilities is conducted at both *Resource Conservation and Recovery Act of 1976* (RCRA) and non-RCRA operational facilities. The primary purposes of groundwater monitoring in WHC-operated areas are to comply with interim- and final-status state and federal RCRA requirements, to assess the potential impact of facilities on groundwater quality and movement, and to provide an early warning of unusual occurrences and trends (WHC-CM-7-4, WHC-CM-7-5). The RCRA facilities include both liquid- and solid-waste TSD facilities. Those facilities with the potential to contaminate the uppermost aquifer require groundwater monitoring as prescribed in Title 40 *Code of Federal Regulation* (CFR) Parts 264 and 265 and *Washington Administrative Code* (WAC) 173-303-400 (interim status) and WAC 173-303-645 (final status). The non-RCRA facilities are controlled under DOE orders and by *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1996) milestones. The latter consist primarily of soil column disposal facilities for chemical and radioactive liquid waste that was associated with nuclear material processing, refining, and waste treatment activities. All discharges of untreated waste water were terminated in June 1995. In addition, an agreement was reached in December 1991 to include all miscellaneous waste streams and/or any new waste stream discharged to the ground under the Washington State waste discharge permit program (WAC 173-216). Some of the -216 permit sites also require groundwater monitoring.

The sitewide groundwater surveillance program, administered by PNNL, addresses "far-field" and offsite groundwater contaminant migration, while the RCRA and Operational Environmental Monitoring programs address more facility- and site-specific contamination. In addition, the ERC conducts site-specific groundwater monitoring to support groundwater remediation projects. Integration across programs and the Hanford Site is facilitated through the *Hanford Site Environmental Monitoring Plan*, *United States Department of Energy, Richland Operations Office*, DOE/RL-91-50 (DOE-RL 1994), and the *Hanford Site Groundwater Protection Management Plan* (DOE-RL 1995).

Table 3-1. 1995 Borehole Logging Inventory. (6 sheets)

Name	Site	Probe	Log Date
0299-E17-003	A-27 Crib	HPGe	06/27/95
0299-E24-059	A-10 Crib	HPGe	07/10/95
0299-E24-060	A-10 Crib	HPGe	07/12/95
0299-E24-078	A-38 Crib	MOIST	05/30/95
0299-E24-079	A-38 Crib	MOIST	05/30/95
0299-E24-084	A-38 Crib	HPGe	03/17/95
0299-E24-092	A-38 Crib	HPGe	02/24/95
0299-E24-100	A-38 Crib	HPGe	03/17/95
0299-E24-160	A-10 Crib	HPGe	06/12/95
0299-E25-004	A-8 Crib	HPGe	10/31/95
0299-E25-005	A-8 Crib	HPGe	11/28/95
0299-E25-005	A-8 Crib	MOIST	12/04/95
0299-E25-007	A-8 Crib	HPGe	11/08/95
0299-E25-007	A-8 Crib	MOIST	11/29/95
0299-E26-051	A-24 Crib	HPGe	09/26/95
0299-E26-052	A-24 Crib	HPGe	09/27/95
0299-E26-053	A-24 Crib	HPGe	10/11/95
0299-E26-056	A-24 Crib	HPGe	09/26/95
0299-E26-057	A-24 Crib	HPGe	11/01/95
0299-E26-060	A-24 Crib	HPGe	09/27/95
0299-E26-064	A-24 Crib	HPGe	10/27/95
0299-E26-071	A-24 Crib	HPGe	10/12/95
0299-E26-074	A-24 Crib	HPGe	10/11/95
0299-E26-076	A-24 Crib	HPGe	10/04/95
0299-E27-001	C-9 Crib	MOIST	05/18/95
0299-E32-002	E-10 Burial	HPGe	06/30/95
0299-E32-002	E-10 Burial	NA(I)	06/30/95
0299-E33-005	B43-50 Crib	MOIST	05/03/95
0299-E33-020	B-11 Crib	HPGe	05/25/95
0299-E33-020	B-11 Crib	MOIST	05/24/95
0299-E33-020	B-11 Crib	NA(I)	05/25/95
0299-E33-038	B43-50 Crib	HPGe	07/05/95

Table 3-1. 1995 Borehole Logging Inventory. (6 sheets)

Name	Site	Probe	Log Date
0299-E33-038	B43-50 Crib	MOIST	07/07/95
0299-E33-038	B43-50 Crib	NA(I)	07/05/95
0299-W11-001	T-6 Crib	HPGe	05/03/95
0299-W11-007	T-3 Crib	HPGe	10/25/95
0299-W11-007	T-3 Crib	MOIST	11/09/95
0299-W11-018	T-35 Crib	HPGe	10/23/95
0299-W11-052	T-224 Bldg	HPGe	05/16/95
0299-W11-054	T-6 Crib	HPGe	05/17/95
0299-W11-055	T-6 Crib	HPGe	05/13/95
0299-W11-057	T-6 Crib	HPGe	05/11/95
0299-W11-058	T-6 Crib	HPGe	04/18/95
0299-W11-058	T-6 Crib	MOIST	05/22/95
0299-W11-059	T-6 Crib	HPGe	04/17/95
0299-W11-060	T-6 Crib	HPGe	03/27/95
0299-W11-060	T-6 Crib	MOIST	05/23/95
0299-W11-061	T-6 Crib	HPGe	03/23/95
0299-W11-061	T-6 Crib	MOIST	05/22/95
0299-W11-062	T-6 Crib	NA(I)	10/18/95
0299-W11-063	T-6 Crib	HPGe	03/27/95
0299-W11-064	T-6 Crib	HPGe	04/18/95
0299-W11-065	T-6 Crib	HPGe	04/19/95
0299-W11-067	T-6 Crib	HPGe	04/18/95
0299-W11-067	T-6 Crib	NA(I)	10/18/95
0299-W11-070	T-26 Crib	HPGe	06/28/95
0299-W14-004	T-28 Crib	HPGe	05/23/95
0299-W15-004	T-19 Crib	HPGe	11/15/95
0299-W15-007	Z-7 Crib	HPGe	04/13/95
0299-W15-007	Z-7 Crib	MOIST	04/21/95
0299-W15-007	Z-7 Crib	MOIST	04/25/95
0299-W15-009	Z-9 Crib	HPGe	04/11/95
0299-W15-062	Z-5 Crib	HPGe	04/05/95
0299-W15-062	Z-5 Crib	MOIST	06/07/95

Table 3-1. 1995 Borehole Logging Inventory. (6 sheets)

Name	Site	Probe	Log Date
0299-W15-063	Z-5 Crib	HPGe	04/04/95
0299-W15-063	Z-5 Crib	MOIST	03/30/95
0299-W15-064	Z-5 Crib	HPGe	04/07/95
0299-W15-076	Z-7 Crib	HPGe	04/06/95
0299-W15-076	Z-7 Crib	MOIST	06/08/95
0299-W15-077	Z-7 Crib	HPGe	04/10/95
0299-W15-077	Z-7 Crib	MOIST	06/08/95
0299-W15-078	Z-7 Crib	HPGe	04/10/95
0299-W15-078	Z-7 Crib	MOIST	06/06/95
0299-W15-198	Z-8	HPGe	04/12/95
0299-W15-213	Z-8	HPGe	04/12/95
0299-W15-214	Z-8	HPGe	04/12/95
0299-W18-250	U-14 Ditch	MOIST	06/12/95
0299-W22-023	U-12 Crib	HPGe	08/08/95
0299-W22-028	U-12 : S-9	HPGe	09/06/95
0299-W23-004	S-21 Crib	HPGe	06/28/95
0299-W23-004	S-21 Crib	MOIST	06/27/95
0299-W23-004	S-21 Crib	NA(I)	06/28/95
0699-059-058	600 Area VZM	HPGe	07/10/95
0699-059-058	600 Area VZM	MOIST	07/10/95
0699-059-058	600 Area VZM	NA(I)	07/10/95
0699-060-057	600 Area VZM	HPGe	07/11/95
0699-060-057	600 Area VZM	MOIST	07/11/95
0699-060-057	600 Area VZM	NA(I)	07/11/95
0199-F02-001	Decon	MOIST	12/06/95
0199-F02-001	Decon	NA(I)	12/06/95
0199-F02-002	Decon	MOIST	12/14/95
0199-F02-002	Decon	NA(I)	12/12/95
0199-K-025	Decon	MOIST	05/02/95
0199-K-025	Decon	NA(I)	05/07/95
0699-040-012A	Decon	NA(I)	03/20/95
0699-049-012A	Decon	MOIST	04/27/95

Table 3-1. 1995 Borehole Logging Inventory. (6 sheets)

Name	Site	Probe	Log Date
0699-049-012A	Decon	NA(I)	04/27/95
0699-049-012B	Decon	MOIST	04/26/95
0699-049-012B	Decon	NA(I)	04/26/95
0699-052-018A	Decon	NA(I)	03/09/95
0699-052-018C	Decon	NA(I)	03/17/95
0699-054-018E	Decon	NA(I)	02/08/95
0699-056-026B	Decon	NA(I)	03/09/95
0699-057-025B	Decon	NA(I)	02/01/95
0699-059-101	Decon	NA(I)	01/11/95
0699-062-043B	Decon	NA(I)	01/26/95
0699-065-059B	Decon	NA(I)	01/30/95
0699-065-059C	Decon	NA(I)	01/26/95
0699-080-062	Decon	NA(I)	05/01/95
0699-097-051B	Decon	NA(I)	05/02/95
116-B4-01	116-B-4	CPT	08/08/95
116-B4-02	116-B-4	CPT	08/08/95
116-B4-03	116-B-4	CPT	08/08/95
116-B4-04	116-B-4	CPT	08/08/95
116-B4-05	116-B-4	CPT	08/08/95
116-B4-06	116-B-4	CPT	08/09/95
116-B4-07	116-B-4	CPT	08/09/95
116-B4-08	116-B-4	CPT	08/09/95
116-B4-09	116-B-4	CPT	08/09/95
116-B4-10	116-B-4	CPT	08/09/95
116-C1-01	116-C-1	CPT	08/11/95
116-C1-02	116-C-1	CPT	08/11/95
116-C1-03	116-C-1	CPT	08/11/95
116-C1-04	116-C-1	CPT	08/11/95
116-C1-05	116-C-1	CPT	08/14/95
116-C1-06	116-C-1	CPT	08/14/95
116-C1-07	116-C-1	CPT	08/14/95
116-C1-08	116-C-1	CPT	08/14/95

Table 3-1. 1995 Borehole Logging Inventory. (6 sheets)

Name	Site	Probe	Log Date
116-C1-09	116-C-1	CPT	08/14/95
116-C1-10	116-C-1	CPT	08/14/95
116-C1-11	116-C-1	CPT	08/15/95
116-C1-12	116-C-1	CPT	08/15/95
116-C1-13	116-C-1	CPT	08/15/95
116-C1-14	116-C-1	CPT	08/15/95
116-C1-15	116-C-1	CPT	08/15/95
116-C1-16	116-C-1	CPT	08/16/95
116-C1-17	116-C-1	CPT	08/16/95
116-C1-18	116-C-1	CPT	08/16/95
116-C1-19	116-C-1	CPT	08/16/95
116-C1-20	116-C-1	CPT	08/17/95
116-C1-21	116-C-1	CPT	08/17/95
116-C1-22	116-C-1	CPT	08/17/95
116-C1-23	116-C-1	CPT	08/17/95
116-C1-24	116-C-1	CPT	08/23/95
116-C1-25	116-C-1	CPT	08/23/95
116-C5-01	116-B-11	CPT	12/12/95
116-C5-02	116-B-11	CPT	12/12/95
116-C5-03	116-B-11	CPT	12/12/95
116-C5-04	116-B-11	CPT	12/12/95
116-C5-05	116-B-11	CPT	12/13/95
116-C5-06	116-B-11	CPT	12/13/95
116-C5-07	116-B-11	CPT	12/13/95
116-C5-08	116-B-11	CPT	12/15/95
116-C5-09	116-B-11	CPT	12/15/95
116-C5-10	116-B-11	CPT	12/15/95
116-C5-11	116-B-11	CPT	12/15/95
116-C5-12	116-B-11	CPT	12/20/95
0199-N-014	N Springs	HPGe	04/19/95
0199-N-035	N Springs	HPGe	06/21/95
0199-N-035	N Springs	MOIST	06/21/95

Table 3-1. 1995 Borehole Logging Inventory. (6 sheets)

Name	Site	Probe	Log Date
0199-N-103A	N Springs	HPGe	03/07/95
0199-N-104A	N Springs	HPGe	03/20/95
0199-N-105A	N Springs	HPGe	04/19/95
0199-N-106A	N Springs	HPGe	08/29/95
0199-N-045	1301-N	HPGe	07/14/95
0199-N-045	1301-N	MOIST	07/18/95
0199-N-067	1301-N	HPGe	07/20/95
0199-N-067	1301-N	MOIST	07/20/95
B2470	1301-N	NA(I)	07/20/95
B2536	1301-N	HPGe	12/21/95
B2536	1301-N	MOIST	12/21/95
B2537	1301-N	HPGe	12/04/95
B2539	1325-N	HPGe	12/20/95
0299-W15-031	200-ZP-2	HPGe	05/17/95
0299-W15-031	200-ZP-2	MOIST	05/17/95
0299-W15-031	200-ZP-2	NA(I)	05/17/95
0299-W15-031A	200-ZP-2	MOIST	08/17/95
ERT-1	ERT	MOIST	03/28/95
ERT-1	ERT	MOIST	07/18/95
ERT-1	ERT	NA(I)	07/18/95
ERT-2	ERT	MOIST	07/21/95
ERT-4	ERT	MOIST	03/28/95

3.3.1 RCRA Groundwater Monitoring Projects

During 1995, more than 300 wells were sampled quarterly or semiannually for about 900 sampling events. The formal sampling results are supplemented with data collected for other programs to assess the impact of adjacent contaminant plumes. The status of Hanford Site RCRA monitoring projects during 1995 is shown in Table 3-2 and the locations of the various monitored facilities are shown in Figure 3-12.

The RCRA projects meet the federal requirements for "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," 40 CFR 265, Subpart F, and "Criteria for Classification of Solid Waste Disposal Facilities and Practices," 40 CFR 257, for nonhazardous waste.

Results of the RCRA groundwater monitoring projects are reported to Ecology quarterly and annually in accordance with WAC 173-303 and -304. The annual reports discuss results by geographical area and include an overview of the Hanford Site hydrogeology. The quarterly and annual reports should be consulted for details about specific RCRA project results (Appendix L lists the RCRA reports).

3.3.2 Non-RCRA Groundwater Monitoring

The impacts of non-RCRA facilities on groundwater quality are assessed in accordance with Tri-Party Agreement Milestone M-17-13 and DOE Orders 5400.1 (DOE 1988a) and 5820.2A (DOE 1988b). Locations of major waste water disposal sites, including those designated as RCRA facilities, are shown in Figure 3-13. Table 3-3 lists the waste streams discharged to each disposal facility and its status in 1995. Miscellaneous waste streams and disposal sites requiring -216 Discharge Permits are listed in Table 3-4.

Table 3-2. Status of Hanford Site RCRA Interim-Status Groundwater Monitoring Projects as of September 30, 1995. (3 sheets)

Project (date initiated)	Program status		Regulatory requirements
	Indicator parameter evaluation	GW quality assessment (date initiated)	
100 D Ponds (4/92)	X ^b		40 CFR 265.93(b) WAC 173-303-400
183-H Basin (6/85)		X ^c (9/95)	40 CFR 264.99 WAC 173-303-645
1301-N LWDF (12/87)	X		40 CFR 265.93(b) WAC 173-303-400
1324-N/NA Pond (12/87)		X (5/89) Spe cond, TOX	40 CFR 265.93(d) WAC 173-303-400
1325-N LWDF (12/87)	X		40 CFR 265.93(b) WAC 173-303-400
216-B-3 Pond (11/88)		X (5/90) TOX	40 CFR 265.93(d) WAC 173-303-400
216-A-29 Ditch (11/88)		X (6/90) Spe cond	40 CFR 265.93(d) WAC 173-303-400
216-A-36B Crib (5/88)	X		40 CFR 265.93(b) WAC 173-303-400
216-A-10 Crib (11/88)	X		40 CFR 265.93(b) WAC 173-303-400
216-B-63 Trench (8/91)	X		40 CFR 265.93(b) WAC 173-303-400
216-S-10 Pond (8/91)	X		40 CFR 265.93(b) WAC 173-303-400

Table 3-2. Status of Hanford Site RCRA Interim-Status Groundwater Monitoring Projects as of September 30, 1995. (3 sheets)

Project (date initiated)	Program status		Regulatory requirements
	Indicator parameter evaluation	GW quality assessment (date initiated)	
216-U-12 Crib (9/91)		X (1/93) Spe cond	40 CFR 265.93(d) WAC 173-303-400
LRF (7/91)	X		40 CFR 265.93(b) WAC 173-303-400
2101-M Pond (8/88)	X		40 CFR 265.93(b) WAC 173-303-400
LLBG			
WMA 1 (9/88)	X		40 CFR 265.93(b) WAC 173-303-400
WMA 2 (9/88)	X		40 CFR 265.93(b) WAC 173-303-400
WMA 3 (10/88)	X		40 CFR 265.92(c) WAC 173-303-400
WMA 4 (10/88)	X		40 CFR 265.93(b) WAC 173-303-400
WMA 5 (3/92)	X		40 CFR 265.93(b) WAC 173-303-400
SST			
WMA-A-AX (2/90)	X		40 CFR 265.93(b) WAC 173-303-400
WMA-B-BX-BY (2/90)	X		40 CFR 265.93(b) WAC 173-303-400
WMA-C (2/90)	X		40 CFR 265.93(b) WAC 173-303-400
WMA-S-SX (10/91)	X		40 CFR 265.93(b) WAC 173-303-400
WMA-T (2/90)		X (7/93) Spec cond	40 CFR 265.93(d) WAC 173-303-400
WMA-TX-TY (9-10/91)		X (7/93) Spec cond	40 CFR 265.93(d) WAC 173-303-400
WMA-U (10/91)	X		40 CFR 265.93(d) WAC 173-303-400

Table 3-2. Status of Hanford Site RCRA Interim-Status Groundwater Monitoring Projects as of September 30, 1995. (3 sheets)

Project (date initiated)	Program status		Regulatory requirements
	Indicator parameter evaluation	GW quality assessment (date initiated)	
300 Area Process Trenches (6/85)		X (6/85)	<i>Consent Agreement and Compliance Order^a</i>
NRDWL (10/86)	X		40 CFR 265.93(b) WAC 173-303-400

Note: An X and a date in the third column indicate the following:

The date that the assessment was initiated

The indicator parameter that triggered assessment monitoring.

^aEcology and EPA, 1986, *Consent Agreement and Compliance Order*, Ecology No. DE 86-133, Washington State Department of Ecology and U.S. Environmental Protection Agency, Olympia, Washington.

^bBackground specific conductance is being reestablished.

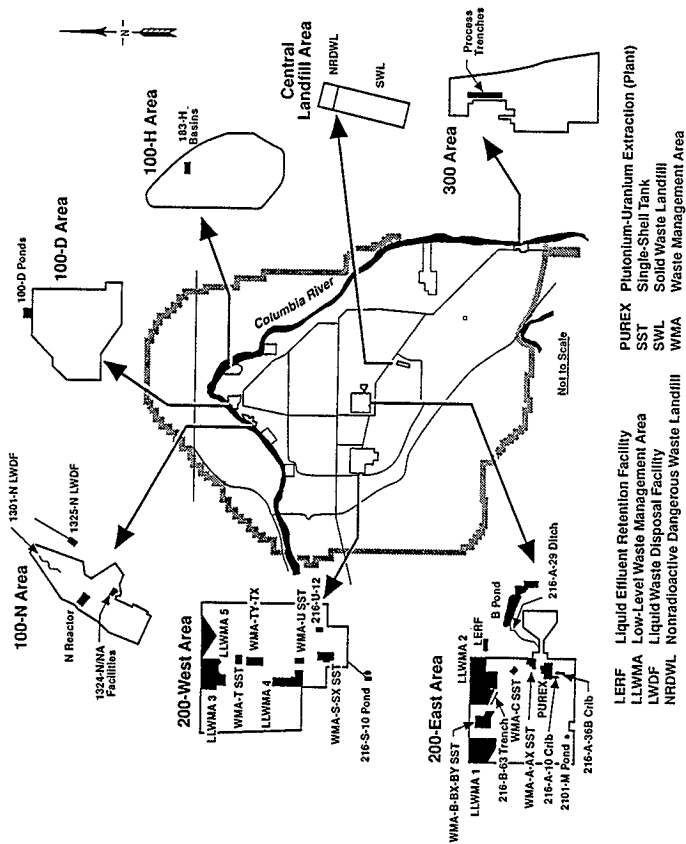
^cFinal Status compliance program implemented September 1995.

CFR *Code of Federal Regulations*
 GW groundwater
 LERF Liquid Effluent Retention Facility
 LLBG low-level burial grounds
 LWDF Liquid Waste Disposal Facility
 NRDWL Nonradioactive Dangerous Waste Landfill
 Spe cond specific conductance
 SST single-shell tanks
 TOX total organic halogen
 WAC *Washington Administrative Code*
 WMA waste management area

The primary emphasis for groundwater monitoring at non-RCRA sites was on liquid-waste disposal facilities. These sites have generally involved several wells that are located immediately adjacent to the disposal facility and were intended to detect the breakthrough of contaminants from the soil column directly beneath the disposal structure.

The network currently includes approximately 50 wells associated with active or recently active liquid waste disposal facilities. The monitoring wells and locations are listed in the *Hanford Site Environmental Monitoring Plan* (DOE-RL 1994). Samples are collected quarterly at active discharge sites and semiannually or annually at all other sites. Results are entered into the publically accessible Hanford Environmental Information System (HEIS) database along with the RCRA groundwater monitoring results. About 100 additional wells have been sampled annually to supplement available data for defining near-field plume distribution patterns. The latter sampling will decline significantly as *Comprehensive Environmental Response, Compensation, and*

Figure 3-12. Location of RCRA Groundwater Monitoring Projects.



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Figure 3-13. Major Past and Present Liquid Waste Disposal Sites.

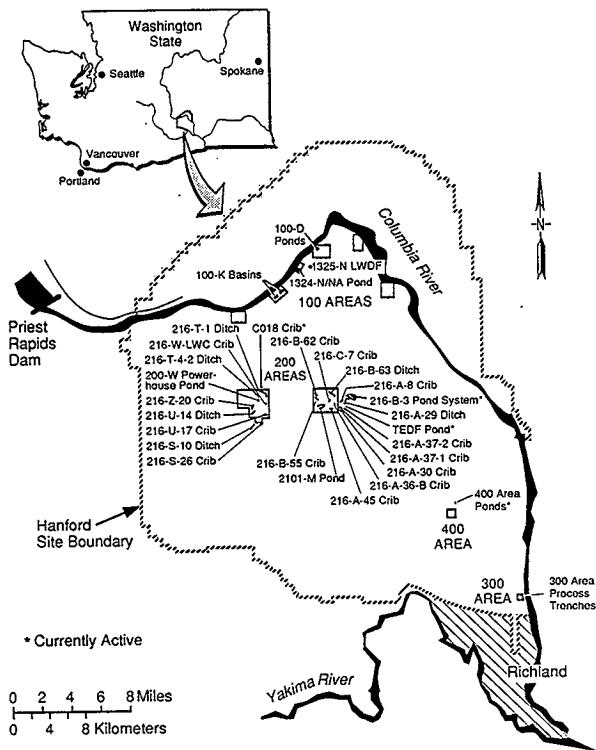


Table 3-3. Liquid Effluent Streams and Receiving Site Status,
December 1995. (2 sheets)

Receiving Site		Associated Effluent Stream	Receiving Site Status
100 D Ponds	R	183D filter backwash waste water	Inactive
1324N/NA Pond	R	163N Demineralization Plant waste water	Inactive
1325N LWDF Crib	R	N Reactor effluent	Inactive
216-A-8 Crib		241A and AZ Tank Farm steam condensate	Inactive
216-A-29 Ditch	R	PUREX Plant chemical sewer	Inactive
216-A-30 Crib		PUREX Plant steam condensate	Inactive
216-A-36B Crib	R	PUREX Plant ammonia scrubber condensate	Inactive
216-A-37-1 Crib		242-A Evaporator process condensate	Inactive
216-A-37-2 Crib		PUREX Plant steam condensate	Inactive
216-A-45 Crib		PUREX Plant process condensate	Inactive
216-B-3C Pond/TEDF		Combined wastewater (treated PFP effluent, 200 Areas cooling water, evaporator condensate and water softener regenerant from 284 West Power Plant)	Active
216-B-55 Crib		B Plant steam condensate	Inactive
216-B-62 Crib		B Plant process condensate	Inactive
216-B-63 Trench	R	B Plant chemical sewer	Inactive
216-C-7 Crib		209-E Laboratory reflector water	Inactive
216-S-10 Facility	R	S Plant waste water	Inactive
216-S-26 Crib		222-S Laboratory waste water	Inactive
216-T-1 Ditch		T Plant laboratory waste water	Inactive
216-T-4-2 Ditch		T Plant waste water	Inactive
216-U-14 Ditch		UO ₃ /U Plant waste water	Inactive
216-U-14 Ditch		242-A Evaporator steam condensate	Inactive
216-U-17 Crib		UO ₃ Plant process condensate	Inactive
216-W-LC Crib		2724-W Laundry waste water	Inactive
216-Z-20 Crib		Plutonium Finishing Plant waste water	Inactive
200 W Powerhouse Pond		284-W Power Plant waste water	Inactive
200 E Powerhouse Ditch		284-E Power Plant waste water	Active
2101-M Pond	R	2101-M Laboratory waste water	Inactive

Table 3-3. Liquid Effluent Streams and Receiving Site Status,
December 1995. (2 sheets)

Receiving Site		Associated Effluent Stream	Receiving Site Status
300 Area Process Trenches	R	300 Area process waste water	Inactive
400 Area Ponds		400 Area secondary cooling water	Active

PUREX Plutonium-Uranium Extraction (Plant)
R Resource Conservation and Recovery Act of 1976 site
TEDF Treated Effluent Disposal Facility
LWDF Liquid Waste Disposal Facility

Table 3-4. Liquid Effluent Receiving Sites Requiring a Groundwater Impact Assessment or a WAC 173-216 SWD Permit. (2 sheets)

Tri-Party Agreement Milestone M-17-06E (only groundwater impact assessment was required; discharges terminated in 1995)	
300 Area Process Trenches, Project L-045H	
Interim Compliance Waste Streams: Tri-Party Agreement Milestone M-17-13A (only groundwater impact assessments were required and discharges terminated in 1995)	
216-U-14 Ditch	1325-N LWDF
216-W-LC Crib	216-Z-20 Crib
216-U-17 Crib	216-S-26 Crib
216-T-1 Ditch	216-T-4-2 Ditch
284 West Powerhouse Pond	2101-M Pond
Other Phase II Waste Streams: Tri-Party Agreement Milestone M-17-13-A and WAC 173-216 State Waste Discharge Permit	
400 Area Ponds	
216-B-3 Pond System/Treated Effluent Disposal Facility (TEDF)	
Miscellaneous Waste Streams: WAC 173-216 State Waste Discharge Permit	
216-C-9 Pond	400 Area septic system
200 West Powerhouse ash pit	200 East Powerhouse ash pit
300 Area Powerhouse ash pit	300 Area sanitary sewer
100 N sewage lagoon	300 Area Backwash Pond
216-Z-21 Seepage Basin	200 East chemical drain field
(207-Z Retention Basin)	Unidentified waste streams-to be determined.
183-N Backwash Discharge Pond	

Table 3-4. Liquid Effluent Receiving Sites Requiring a Groundwater Impact Assessment or a WAC 173-216 SWD Permit. (2 sheets)

WAC 173-216 State Waste Discharge Permit Sites (began receiving treated effluent in 1995)

Project C-018H ("Tritium" Crib in 200 West Area)

Project W-049H Treated Effluent Disposal Site, 200 East Area

Liability Act of 1980 (CERCLA) groundwater pump-and-treat sampling expands and groundwater monitoring activities are consolidated. The consolidation is planned to occur during FY 1997.

Monitoring wells are sampled for site-specific chemical and radiological constituents, as well as general indicator parameters. Water table elevations in selected wells are used to determine the direction of groundwater movement in the vicinity of waste disposal and storage sites. Most of the monitoring wells are located immediately adjacent to the monitored facility, but others are located further away to aid in defining plume boundaries. Where possible, data from upgradient or local-area background wells are used for comparison with downgradient wells to assess the impact from a specific facility. The direction of groundwater movement is determined from water table elevation maps that are based on area-wide and facility-specific water-level measurements.

As noted, all data were entered into the HEIS database and were screened using a trending program that compares new analytical results with predicted values based on linear regression analysis of previous results. Trending reports were generated at least quarterly. Followup sampling and/or investigation of possible causes was conducted for confirmed upward trends in contaminant concentrations. Nearly all of the alerts flagged by the trending program during 1995 were for various contaminants in the 100 K Area (see Section 3.3.3.3).

3.3.3 Project Highlights

Major changes in groundwater contamination patterns and/or new occurrences associated with the RCRA/operational groundwater monitoring at WHC-operated facilities that have groundwater protection implications are summarized in Sections 3.3.3.1 through 3.3.3.8.

3.3.3.1 Single-Shell Tank Farms. The most significant groundwater protection issue associated with the SST Farms is the unknown nature, extent, and origin of contaminants associated with above-background occurrences of specific conductance. As indicated in Table 3-2, the T and the TX-TY Waste Management Areas (WMAs) were placed into assessment monitoring status because downgradient specific conductance was greater than the background or upgradient wells. Downgradient specific conductance values at other SST WMAs were not sufficiently high to exceed the upgradient critical means. However, the trends suggest that similar conditions might exist at the S-SX, B-BX-BY and A-AX waste management areas. At the S-SX WMA, elevated downgradient specific conductance at the southernmost end of the SX Tank Farm is also

associated with a set of co-contaminants that are consistent with the mobile fraction of SST waste (see Section 3.4). The dynamic or transient nature of the elevated co-contaminants at the S-SX WMA suggests the role of operational factors (e.g., utility line leakage over soil contamination sites, enhanced natural infiltration caused by the cover type over tank farms, etc.). This possibility, as well as other explanations, will be evaluated as additional tank farms are placed into assessment monitoring status and as a result of an enhanced tank farm vadose zone characterization study initiated in 1995. The additional source term characterization will permit better correlation between soil-column and groundwater contamination in the vicinity of the tank farms as indicated in Section 3.1 and discussed further in Section 3.4.

TWRS-Related EIS Issues. If the apparent mobility of tank farm related contaminants in the vadose zone is caused by operational factors that can be controlled (e.g., repair of leaking water lines and control of surface water), in-tank stabilization of SST waste may be one option for certain tanks. However, if the apparent mobility is caused by natural processes that cannot be corrected or controlled, removal and processing of all SST waste would be indicated. Thus, determining the cause of contaminants in groundwater beneath several of the SST TSD sites is of primary significance to one of the major Hanford Site mission objectives.

3.3.3.2 200 Area Waste Discharge Permit Disposal Sites. Operation of the C-018H and W-049H (Figure 3-13) disposal sites listed in Table 3-4 began during 1995. These disposal sites are part of the waste management system designed to implement the agreement to cease discharge of untreated waste water to the ground. As WAC 173-216 Waste Discharge Permit disposal facilities, both sites require effluent and groundwater monitoring. Groundwater monitoring at these facilities had not detected any changes in groundwater quality caused by operation by the end of CY 1995. Tritium in groundwater at the C-018H site in the 200 West Area is expected to reach relatively high concentrations as the treated, but tritium-containing, waste water reaches groundwater and arrives in the downgradient monitoring wells.

Discharge of the combined waste streams to the TEDF (W-049H) in the 200 East Area is not expected to have a major impact on groundwater quality. In this case, the most significant contaminant appears to be chloride and periodic releases of corrosion products (primarily iron and manganese [Chou and Johnson 1996]). Occasional spikes of chloride on the order of 100 ppm occur, but the overall average during the first 6 months of operation in 1995 was only 4.9 ppm (discharge-weighted average). The average specific conductance for 1995 was nearly identical to average Columbia River water (~140 $\mu\text{mhos/cm}$). The primary impact on groundwater will be to reduce the ambient specific conductance downgradient of the disposal site. This effect has been previously noted in relation to the B-Pond system in past groundwater monitoring reports (Johnson 1993, Johnson et al. 1995b). The new TEDF will continue to influence specific conductance in the vicinity of downgradient RCRA sites. The primary effect will be to decrease the specific conductance caused by mixing the low-specific-conductance waste water (140 $\mu\text{mho/cm}$) with the ambient groundwater (average Hanford Site natural background is 360 $\mu\text{mhos/cm}$).

3.3.3.3 Spent Nuclear Fuel Storage Basins. The distribution of groundwater contaminants in the vicinity of the 100 K Basins is illustrated in Figures 3-14 and 3-15. The radiological indicators, gross beta and tritium,

suggest that multiple sources of contaminants are still being transported through the vadose zone to groundwater more than 25 years after reactor operations ended. Individual contaminants and suspected sources are discussed in the following sections.

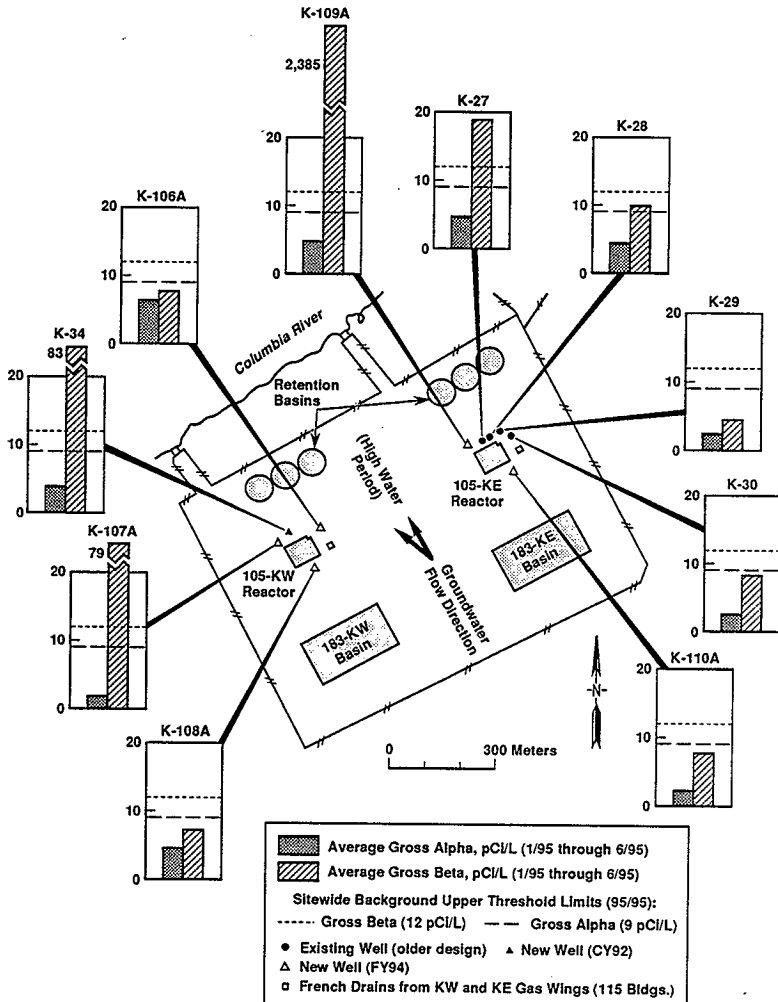
Tritium and ^{14}C . Multiple sources of tritium are suggested by Figure 3-16, which shows tritium in relation to suspected sources and expected flow direction of contaminant plumes from known source areas. Both tritium and ^{14}C are associated with the French drains that received condensate from the inert gas loop of KW and KE reactors. The continuing occurrence of tritium and ^{14}C in the two downgradient wells from these sources (wells K-106A and K-30, respectively) suggest that long-term drainage must be occurring. This process could be maintained or accelerated because of enhanced infiltration of surface water that has been observed to form shallow ponds over these sites during runoff events. The occurrence of road salt (chloride) in these and other wells suggests that a pathway exists for transport of near-surface contaminants to groundwater in this area (Johnson and Evelo 1995). The possible impact of surface water containing road salt from a parking lot in the 200 Area is discussed in Chapter 8.

The relative change in tritium concentration versus time for the two wells downgradient from the suspected French drain sources is shown in Figure 3-17. This figure also illustrates that basin water is not a contributor to the tritium levels observed in well K-106A because the maximum tritium in this well is 10 times the tritium content of KW Basin water (about 50,000 pCi/L). Also, significant concentrations of ^{14}C are found only in wells K-106A and K-30.

Leakage of KE Basin water is the assumed source of tritium in well K-27, which is located directly downgradient and near the center of the construction joint in the bottom of the basin, as illustrated in Figure 3-16. Figure 3-18 shows a pattern of continuing decline in tritium at well K-27 since early 1994. The linear semilog plot suggests an exponential decline consistent with termination of a source and drainage of the wetted soil zone. The linear regression of tritium concentration versus time for this well also suggests that the concentration should approach the drinking water standard of 20,000 pCi/L by the end of CY 1996.

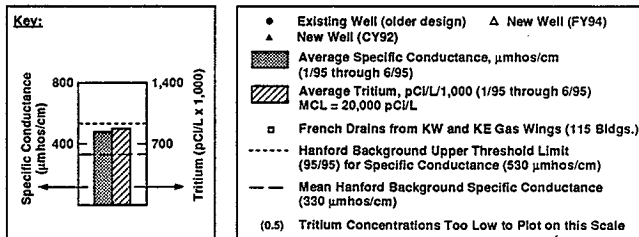
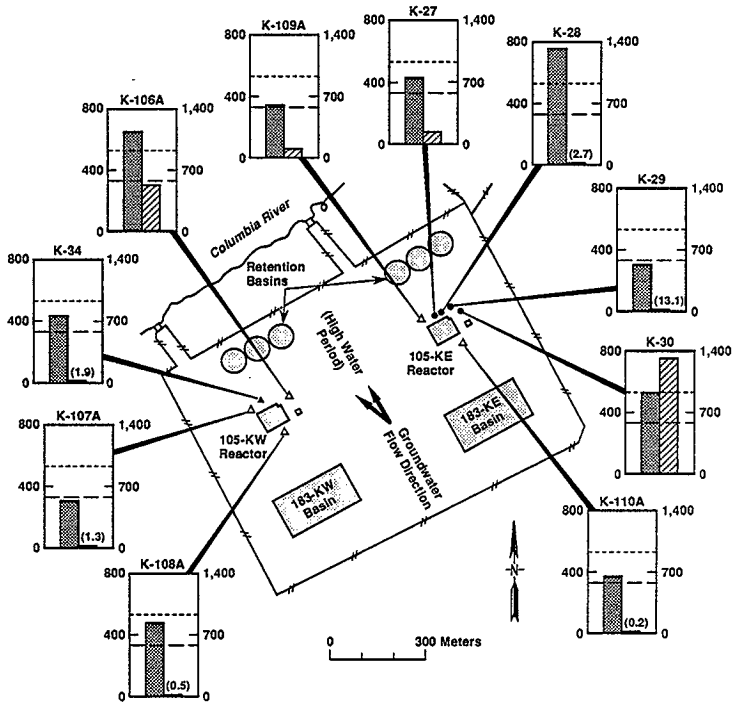
^{90}Sr . The most significant groundwater quality condition in the vicinity of the 100-K nuclear fuel storage basins was the increasing ^{90}Sr in well 1-K-109A near the northwest corner of the 105-KE reactor building. Concentrations increased to 2800 pCi/L (the corresponding gross beta was 5170 pCi/L) during 1995, compared to the DCG value of 1000 pCi/L and the drinking water standard of 8 pCi/L. The well is located adjacent to a past-practice disposal site that received storage basin overflow containing relatively high concentrations of long-lived fission products. Significant soil column contamination was identified when the monitoring well was drilled, as indicated by the gamma log (Figure 3-19). The occurrence of high gamma activity (^{137}Cs) shown in the borehole log at 11 m (35 ft) below grade is consistent with the depth of the drain tiles associated with the past-practice disposal site. A leaking utility line was located within about 4 m to 5 m (10 to 15 ft) of well K-109A. One possibility is that water from the utility line carried ^{90}Sr down the outside of the casing to groundwater. The gross beta, which is all attributable to ^{90}Sr in this well, increased to a maximum of 12,000 pCi/L in April 1996. Following repair of the leaking utility water

Figure 3-14. Areal Distribution of Gross Alpha and Gross Beta in Groundwater Near the 100-K Basins.



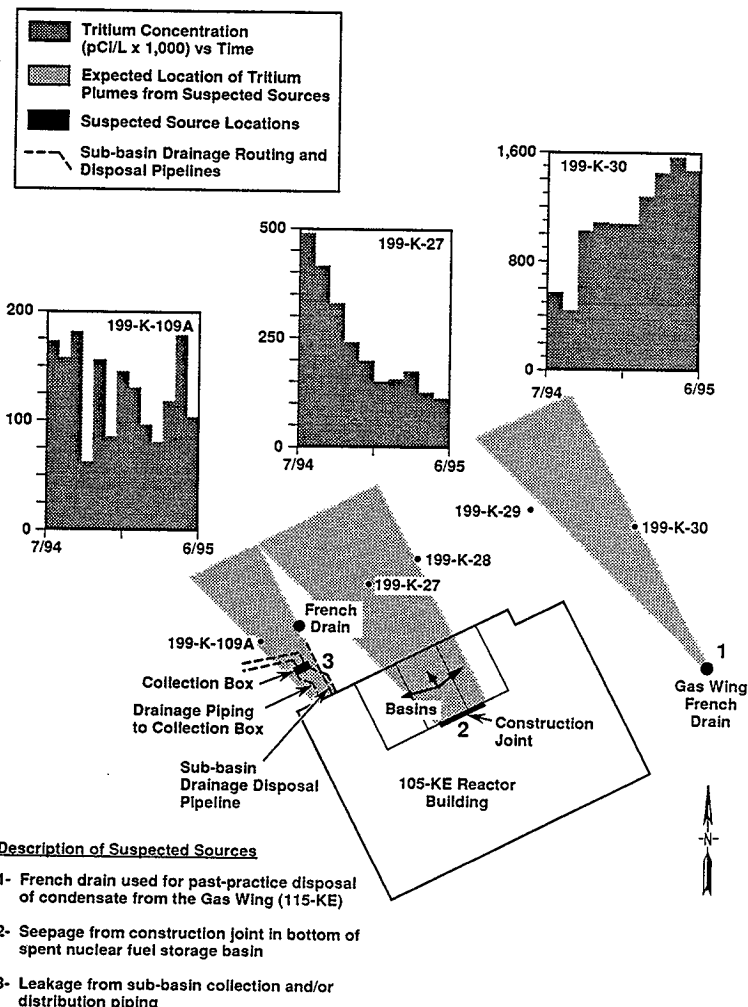
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Figure 3-15. Areal Distribution for Tritium and Specific Conductance in Groundwater Near the 100-K Basins.



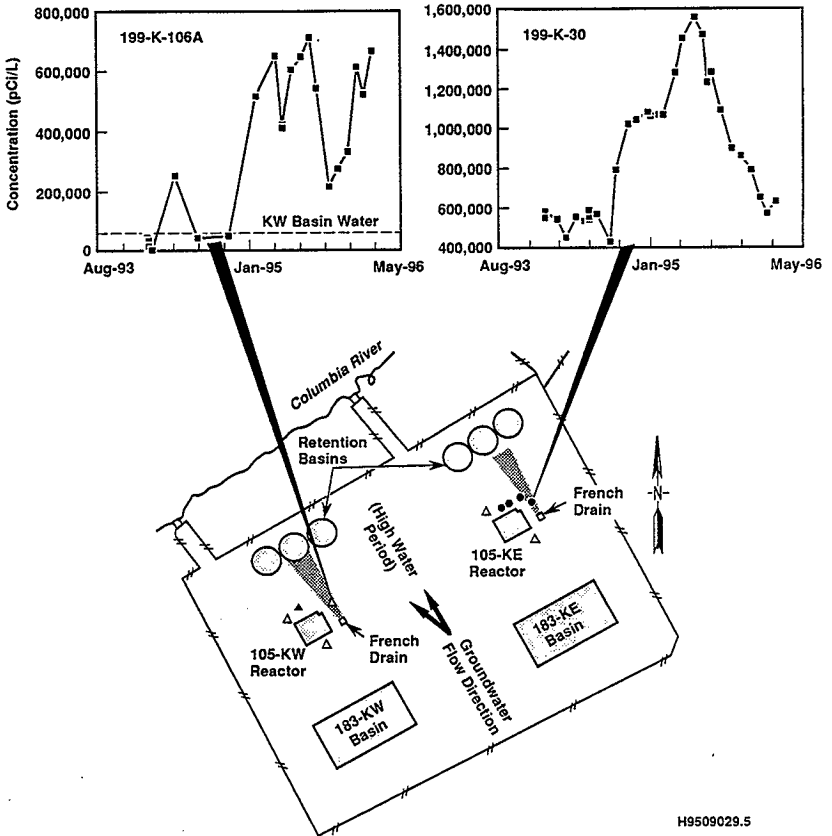
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Figure 3-16. Correlation of Tritium in Groundwater and Suspected Sources.



H9509029.2

Figure 3-17. Tritium Concentration vs. Time.



line, gross beta in well K-109A declined sharply to ~3000 pCi/L in June 1996). Whether the line leak caused the increasing trend observed during late 1995 and early 1996 is uncertain, but the decline after the repairs suggests that it did. The possible role of enhanced surface water infiltration and/or leakage of subsurface utility lines was identified and discussed in the 100-K monitoring plan and subsequent groundwater monitoring reports (Johnson et al. 1995a, Johnson and Chou 1995, Johnson and Evelo 1995). The observed ponding of surface water over other past-practice disposal sites and the occurrence of other utility line leaks (i.e., 100-KW) add to the concern that remobilization of soil column contaminants can occur, as indicated in the vadose monitoring discussion of soil column contamination (Sections 3.1 and 3.2.2).

The groundwater monitoring results for the 100-K basins suggest that significant improvement in groundwater quality is occurring because of changes in basin operations and other corrective measures. However, additional attention is needed to prevent enhanced infiltration of surface water over past-practice disposal sites and to eliminate leaking water lines that pass over or near past-practice disposal sites. Possible groundwater protection measures that have been suggested include the following (Johnson and Evelo 1995):

- Installation and repair of gutters on adjacent buildings
- Grading to eliminate depressions over waste sites and diversion of surface runoff away from the inert gas condensate French drains (tritium and ^{14}C sources)
- Location and elimination or repair of leaking utility lines near subsurface waste disposal sites.

3.3.3.4 216-A-37-1 Crib. The 216-A-37-1 Crib was previously omitted as a waste water disposal site requiring a RCRA-compliant monitoring network. The background and status of groundwater quality conditions for this crib are discussed in more detail here because it has not been included in the annual RCRA groundwater monitoring reports.

Background. The 216-A-37-1 Crib (see Figure 3-13 for location) began service in March 1977 and received process condensate from the 242-A Evaporator via the 207-A Retention Basin. The crib was originally designed to receive overflow waste from the 216-A-30 Crib, but was never used for this purpose. The waste disposed of to the 216-A-37-1 Crib was considered to be a low-salt, alkaline solution.

Four existing monitoring wells are located immediately adjacent to and along the length of the crib. Waste water entered the crib from the southeast (downslope) end of the crib where most of the infiltration probably occurred. The four wells have been cosampled for both RCRA and operational monitoring purposes.

The 216-37-1 Crib is one of several liquid effluent discharge sites excluded from the list of RCRA sites in the original (1989) iteration of the Tri-Party Agreement (Ecology et al. 1996). Under Tri-Party Agreement Milestones M-17-00A and M-17-000B, the excluded sites required groundwater impact assessment studies. However, listed waste types were identified in the effluent stream and discharges to the 216-A-37-1 Crib were terminated in

Figure 3-18. Semi-log Plot of Tritium Concentration vs Time for Well 199-K-27.

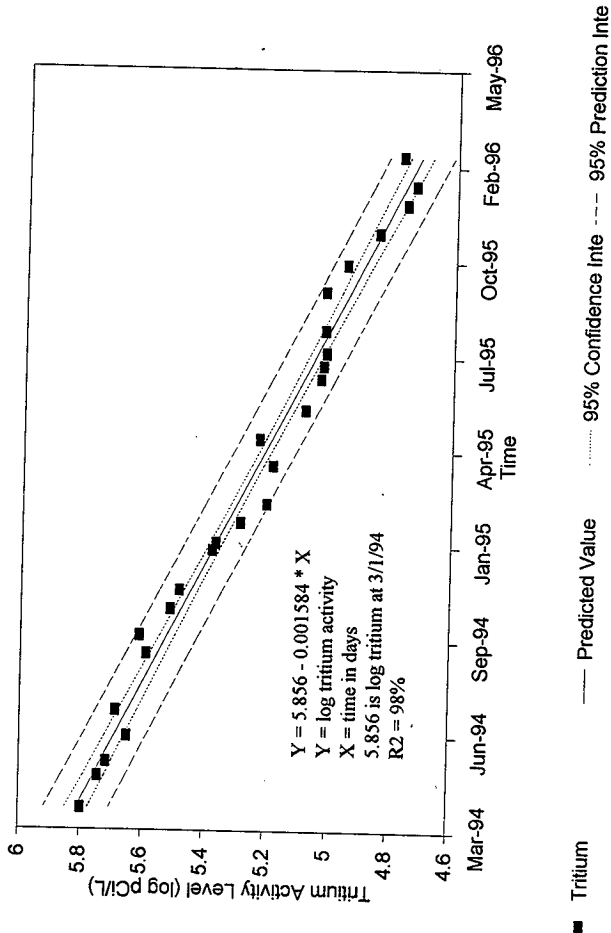
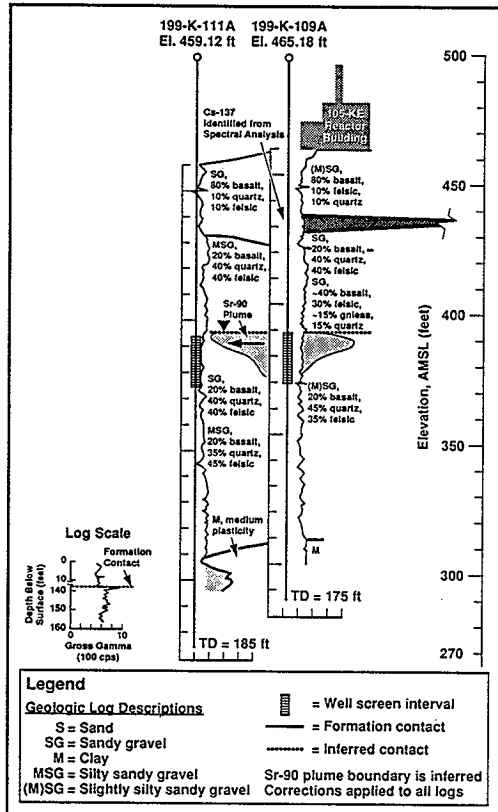


Figure 3-19. Correlation of Gross Gamma Log and Soil Column Contamination at Monitoring Well 199-K-109A.



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April 1989. A RCRA Part A Permit was then submitted for the site in February of 1990. Subsequent investigations indicated the potential presence of chlorinated hydrocarbon solvents from operations in B Plant and T Plant and a revised Part A (Rev. 1) was submitted in May 1993. Revision 2 of the Part A was submitted in June 1994 to transfer responsibility for the facility to the ERC. The facility is currently scheduled for closure under interim status with completion of a closure plan in 2003.

The 216-A-37-1 Crib was not included among the initial RCRA sites listed in the Tri-Party Agreement. However, it was subsequently monitored along with the other active non-RCRA effluent discharge sites under the Operational Environmental Monitoring Program (DOE-RL 1994) and as part of the 216-A-29 Ditch RCRA groundwater monitoring program. An internal audit by the ERC team in 1995 noted that the 216-A-37-1 Crib did not have a RCRA-compliant groundwater monitoring program as required by WAC 173-303-400. As a result, a monitoring plan was prepared and submitted to Ecology. Subsequent negotiations led to a revised plan that combines this crib with other past practice PUREX cribs (216-A-10, -A-45, and -36B) to form an aggregate unit with a single, wide-area monitoring network (Votava et al. 1996). This approach is consistent with the Hanford Site Groundwater Remediation Strategy and the Groundwater Protection Management Program Plan that recommended a shift to more regional monitoring networks rather than unit-specific monitoring now that liquid waste discharges to the ground are terminated.

The current status of groundwater quality and dynamics beneath the crib is summarized in the following sections.

Contaminants of Concern. Major contaminants of concern based on effluent measurements consisted of tritium, ammonium/nitrate, acetone, and hexone. Based on process knowledge, but not confirmed by effluent measurements, methylene chloride and trichloroethane are also suspected. Small quantities of fission products and transuranics were also discharged to the crib caused by carry over from the evaporator. To date, tritium and nitrate have been the only contaminants detected in groundwater beneath the site.

Soil Column Contaminant Status. Small quantities (<1 Ci total) of ^{90}Sr , ^{137}Cs , and less than 0.01 Ci of alpha-emitting radionuclides (isotopes of plutonium and uranium) are stored in the soil column. Previous estimates of depth of migration (WHC 1990) and groundwater monitoring results suggest the long-lived fission products and transuranics did not break through to groundwater and are probably retained in the upper 40 m of the soil column. No significant additional movement of these radionuclides should occur because discharge of waste water to the crib was eliminated in 1989 and the distribution box has been permanently sealed to prevent inadvertent entry of water to the crib. Only infiltration of natural precipitation on the unvegetated surface remains as a driving force.

Organics. The suspected occurrence of acetone, other ketones and alcohols were found in effluent but were not detected in groundwater. These constituents are not expected to be retained by the soil column. One possibility for their absence in groundwater is that biodegradation may have occurred rapidly enough in the soil column that they never reached groundwater. Other organics of interest, methylene chloride and trichloroethane (Votava et al. 1996), were suspected in the waste streams but

were not confirmed, nor were they detected in groundwater beneath the crib. Because of the volatile nature of these organic compounds, they may have been outgassed in the handling and transfer stages.

Nitrate/Ammonium Anomaly. The occurrence of relatively high levels of nitrate in groundwater beneath the crib (up to 250 ppm), but not in effluent (about 1 ppm) discharged to the crib, is attributed to the process of nitrification whereby ammonium (average of ~400 ppm in process condensate and a maximum of 0.3 ppm in groundwater beneath the crib) is converted to nitrate by microbial action. The nitrate declined slowly in groundwater in nearly the same pattern as tritium. Thus, the same transport process is apparently responsible for the slow decline of both nitrate and tritium. Regardless of the actual process involved, the concentration of nitrate in groundwater at this crib is declining. While tritium is also declining, it is still 10 to 20 times higher than the drinking water standard (20,000 pCi/L) in well 299-E25-19 at the southeast end of the crib where the highest groundwater concentrations occur. At the current observed rate of decline ($T_{1/2} = \sim 1.5$ yr) (see Figure 3-20), concentrations should decrease to below the current drinking water standard of 20,000 pCi/L within about 5 years. Even so, that such high concentrations (e.g., over 300,000 pCi/L in well 2-E25-19 near the close of 1995) in groundwater still occur beneath a crib that was taken out of service in 1989 is surprising.

Conceptual model. A schematic illustration or conceptual model of the processes and information about the nitrate/ammonium anomaly is provided in Figure 3-21. As suggested in the schematic, the long-term drainage of tritium and nitrate from the crib may be a result of enhanced infiltration of natural precipitation caused by loss of vegetation on the backfill over the crib. Some waste disposal sites are routinely treated with herbicides to prevent the growth of grasses and shrubs. Consequently, the absence of vegetative evapotranspiration allows most of the natural precipitation to drain through the soil column. In addition, a plastic covering at the top of the crib may create much higher infiltration rates along the sides and accelerate downward transport of residual nitrate and tritium through the underlying soil column. Restoration of surface vegetation could be a relatively inexpensive interim stabilization method to reduce continuing groundwater contamination at those waste sites that are subject to enhanced vadose zone transport. The importance of the evapotranspiration process to long-term waste management at the Hanford Site, especially in the 200 Areas, has been identified by several investigators (Routson and Johnson 1990, Gee et al. 1992). While preventing growth of vegetative cover with herbicides may eliminate plant uptake of contaminants, it destroys an important waste stabilizing feature of the desert-like environment. Effective waste site management methods are needed to achieve both surface contamination control and enhanced evapotranspiration over subsurface waste disposal and leak sites.

3.3.3.5 400 Area Process Ponds. The 400 Area Process Ponds, located north of the 400 Area fence, are unlined infiltration ponds (Figure 3-22) that receive waste water from the 400 Area facilities. The waste stream consists primarily of cooling water and intermittent small contributors (e.g., sinks and drains). The facility is designated as a discharge permit site for which the permit is pending. One permit condition is to add an additional downgradient monitoring well to the monitoring network.

Figure 3-20. Semilog Plot of Tritium Concentration vs Time at the 216-A-37-1 (Crib (Well 299-E25-19)).

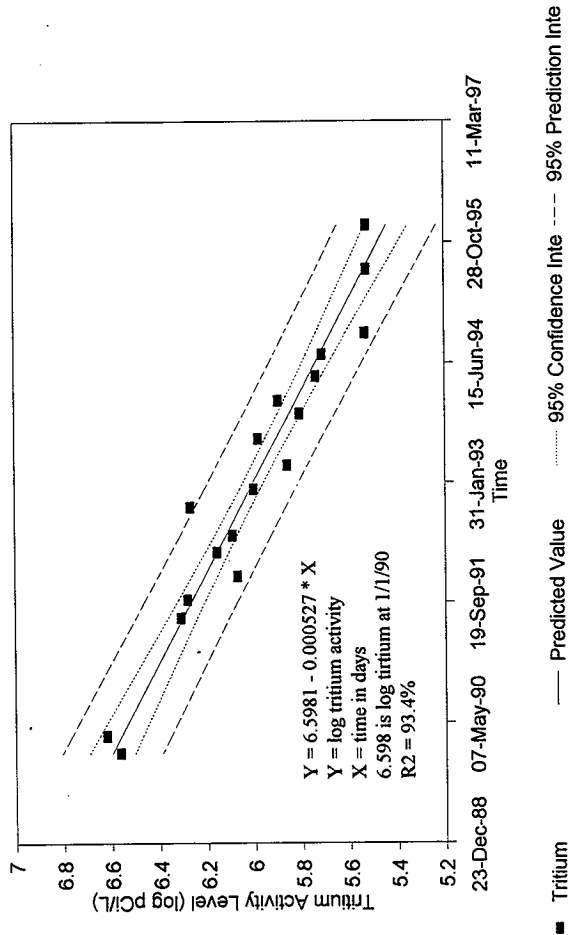
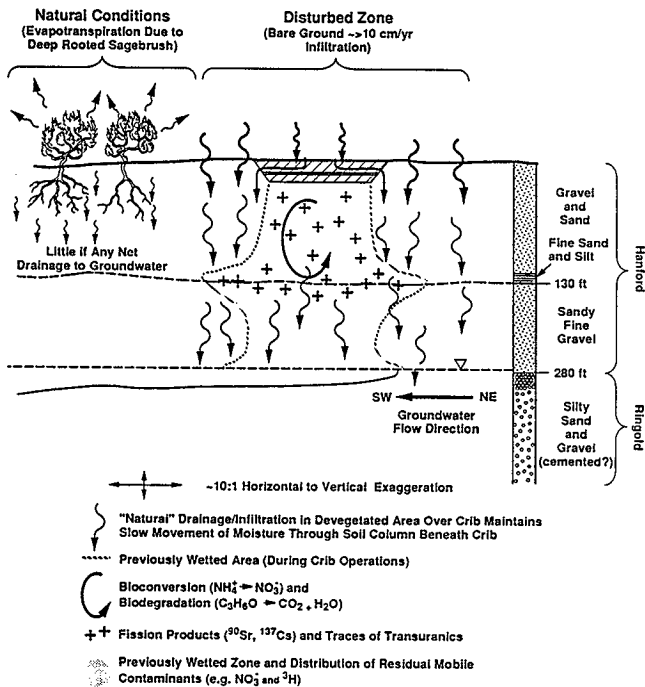


Figure 3-21. Conceptual Model of Moisture and Contaminant Movement Beneath the 216-A-37-1 Crib.



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Nitrate is the only significant contaminant in the single downgradient well that is attributable to 400 Area operations. Elevated nitrate concentrations of up to 95 ppm (drinking water standard is 45 ppm) have been attributed to the sanitary sewage lagoon (Tyler 1992) located to the immediate west and upgradient of the process ponds (Figure 3-22). Nitrate is also present in the upgradient groundwater (to 30 ppm) caused by the contaminant plume from the 200 East Area. A recently constructed treatment system for the sanitary sewage should eliminate this miscellaneous source of groundwater contamination.

3.3.3.6 216-U-14 Ditch. Discharges of waste water and cooling water to the U-14 Ditch, located in the south-central portion of the 200 West Area, were terminated in mid-1995. The last major input of waste water occurred during the final cleanout campaign of U Plant in 1994. During this period, which lasted for approximately 6 weeks, input rates to the ditch reached up to 2650 L/min (700 gal/min). Previous characterization of the ditch (Singleton and Lindsey 1994) determined that some ^{90}Sr and ^{137}Cs existed in the soil column beneath the ditch, but that it was unlikely to reach groundwater.

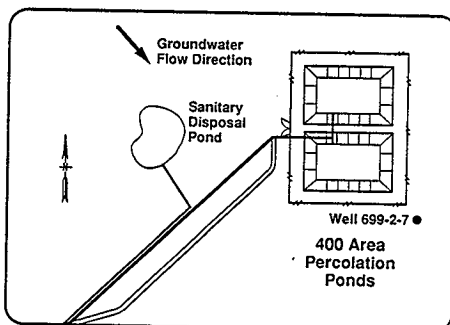
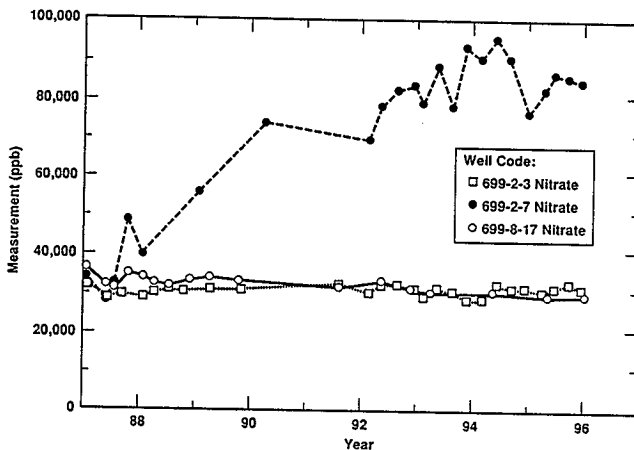
The highest downgradient concentrations of uranium, the primary constituent of interest, occur in wells 2-W19-27 and 2-W19-21. A general declining trend in uranium concentration beginning in 1992 appears to be continuing (Figure 3-23). Concentrations are currently below the chemical uranium drinking water standard of 20 ppb.

Water in the perched water monitoring wells (see Figure 3-23) has drained away following termination of input to the ditch. The most significant decline in water occurred after the final cleanout campaign at U Plant. Anomalous occurrences of arsenic and ^{90}Sr were detected in water from these wells, suggesting that downward movement was occurring, at least during the time when a source of water was present. With drainage of the perched water, movement of these constituents should stabilize. No significant long-term effects of this disposal facility are likely in view of the low soil column inventory of contaminants beneath the ditch.

Impact on Adjacent Facilities. During the groundwater impact assessment drilling that was conducted in 1993-94 for this facility, perched water was found at shallower depths than expected (Singleton and Lindsey 1994). The significance of this finding is that lateral movement of water in this area can occur at depths that are near the depths that could allow contact between adjacent water sources and SST leakage or leaks from transfer lines and diversion boxes that have occurred in the past. The U-14 Ditch terminates just north of the SY-S-SX Tank Farms. Whether water from this crib migrated along the shallow perching units all the way into the tank farm area is unknown. However, there are indications of transient occurrences of tank-related constituents, such as ^{99}Tc , in groundwater beneath the S Tank Farm that began shortly after the U-14 Ditch was dammed in 1985 as part of the U Pond closure (Caggiano et al. 1996).

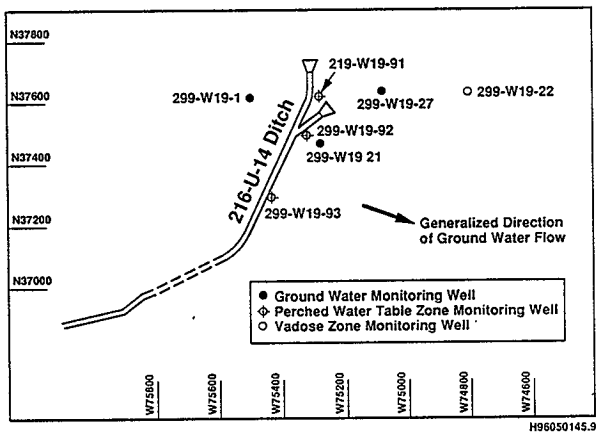
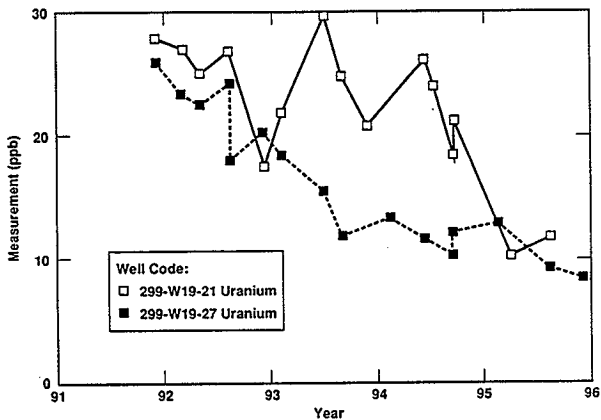
The lessons learned from this and other wastewater disposal sites are that more attention needs to be given to miscellaneous sources (or potential sources) of water near disposal sites with significant soil column inventories of waste. Discharges several hundred feet away can migrate laterally along the shallow perching layers, as discovered in the U-14 Ditch assessment and at

Figure 3-22. Nitrate Concentration vs. Time at the 400 Area Percolation Ponds.



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Figure 3-23. Uranium Concentrations vs Time Near the 216-U-14 Ditch.



the C Tank Farm (see Section 3.2.2). As previously indicated, more diligence is needed in accounting for and controlling unplanned artificial recharge near major subsurface soil contamination sites.

3.3.3.7 100-N Area Springs and Groundwater. Composite grab samples from the series of shallow wells along the stream bank at 100-N continue to exhibit maximum ^{90}Sr concentrations of several thousand pCi/L. Remedial investigation of the residual ^{90}Sr in the aquifer downgradient from the 1325-N and 1301-N Cribs, the past-practice sources of ^{90}Sr at N Springs, is currently under way. Two pumping wells and six new groundwater monitoring wells were installed by the ERC for this purpose. Groundwater monitoring is conducted by the ERC in the area to assess the effectiveness of the containment.

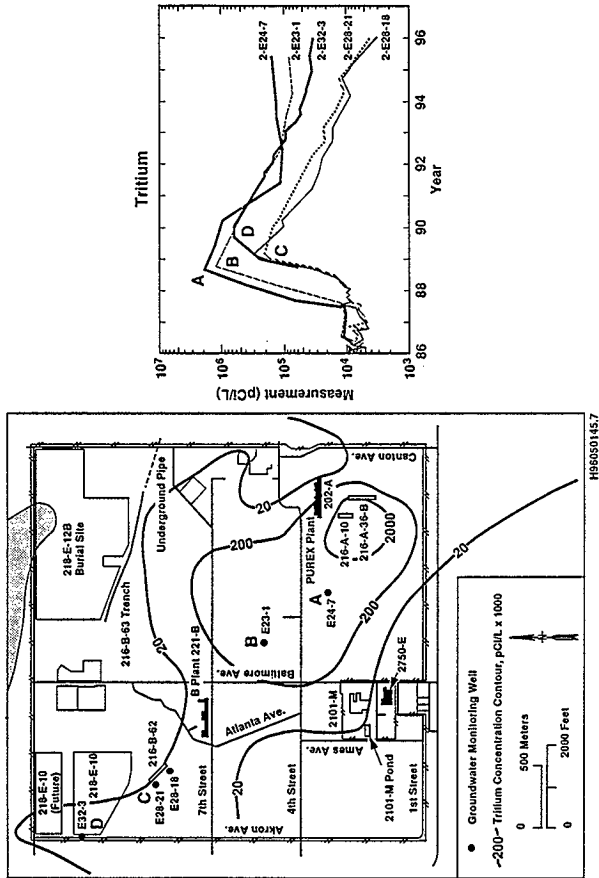
Currently the only groundwater wells located in the 100-N Area that are monitored through the OEMP are wells N-47 and N-48. Samples are collected monthly and are analyzed for gamma-emitting radionuclides. Trend analyses provide indications of the integrity of the underground piping associated with the 107-N facility. Wells N-47 and N-48 are located adjacent to the 107-N Fuel Storage Basin Recirculation Facility. Radionuclide concentrations detected in the groundwater samples are consistent with values reported in previous years.

3.3.3.8 Contaminant Plumes in the 200 Areas. Shifts in contaminant plumes continued in the 200 Areas in response to declining or terminated discharges to soil column disposal facilities. The discharges of relatively clean cooling water to the -3C lobe of B Pond and the new Treated Effluent Disposal Facility (TEDF) pond continue to cause the spread of groundwater radially outward from the ponds (Johnson et al. 1995b). The movement of relatively uncontaminated cooling water is gradually displacing contaminated groundwater in the vicinity of previous disposal sites. Evidence for this movement is illustrated in Figure 3-24 showing areal distribution of tritium concentration and tritium versus time in selected wells. This plot implies that tritiated groundwater has formerly migrated to the northwest across the 200 East Area. However, more recently, as water table declines continue because of reduced discharges and shifting of major discharge sites to the east (TEDF), a reversal in the northwesterly flow may be occurring. This is suggested by the "flattening" in tritium concentration-time plots for well 2-E24-7 located near the south-central portion of the 200 East Area. As groundwater that previously traveled northwest reverses and moves back toward the southeast, the monitoring wells should intercept the higher concentrations that passed by in previous years.

The significance of this effect is that upgradient and downgradient monitoring wells may be reversed at many RCRA and non-RCRA sites, making possible leaks difficult to detect and possibly invalidating many unit-specific RCRA monitoring networks.

Maps of contaminant plumes covering the 200 Areas, as well as the rest of the Hanford Site, are prepared and maintained by the ERC as part of the Hanford Geographic Information System (HGIS). Plume maps are also available in the Hanford Site Groundwater Monitoring and the Hanford Site Environmental Monitoring annual reports. These sources should be consulted for the official groundwater plume maps for the Hanford Site and subareas.

Figure 3-24. Tritium vs Time in Selected Locations in the 200 East Area.



In addition to plume maps, site-specific reports resulting from vadose zone characterization and groundwater monitoring and assessment activities at operating contractor facilities are listed in Appendix L. These reports should be consulted for more details about the waste sites addressed in this section or for additional information about the respective monitoring programs.

3.4 CORRELATION OF VADOSE ZONE AND GROUNDWATER DATA

The vadose zone spectral gamma logging results for the SST farms previously discussed (Section 3.2.3.1), as well as reevaluation of existing S-SX Tank Farm data during 1995, suggested that tank farm related contaminants could migrate to greater depths than previously thought. The presence of indicators of tank waste in groundwater (e.g., ^{99}Tc) beneath the S-SX Tank Farm also suggested that transport through the vadose zone to groundwater could occur. An occurrence report suggesting this possibility was issued in late 1995 for the S-SX Waste Management Area (WMA). This section summarizes initial efforts to correlate vadose zone monitoring and characterization data, SST source chemical characteristics, and groundwater monitoring data. Although the following discussion is focused primarily on the SX Tank Farm, similar conditions could exist for all of the SSTs and related waste handling systems as well as for past-practice liquid waste disposal sites.

3.4.1 Vadose Zone Gamma Log Data

As discussed in Section 3.2.3.1, initial spectral gamma logging was conducted in the southern section of the SX Tank Farm where the largest recorded volume of tank-related leaks in the S-SX WMA are known to have occurred. Spectral gamma logs indicated that ^{137}Cs , the most readily detectable SST waste constituent, was present in several boreholes along the southwest side of the SX Tank Farm. ^{137}Cs was also detected at the 38-m (125-ft) depth of several vadose zone monitoring wells in this area.

The initial spectral gamma log results prompted reevaluation of existing gross gamma log and groundwater data. The historical gross gamma log data revealed that, in addition to the presence of gamma-emitting radionuclides at greater depths than expected, at least one vadose well showed a regular pattern of increasing gamma-ray intensity over time (Section 3.2.3.1). This pattern suggested that some type of continuing movement of tank waste in the soil or vadose zone was occurring at this location. Because ^{137}Cs is expected to migrate more slowly than the more mobile waste constituents (e.g., NO_3^- and TcO_4^-), the preliminary vadose zone results suggested the mobile tank waste constituents could be at much greater depths. In addition, the occurrence of an anomalous pattern of technetium/uranium ratios in groundwater monitoring wells, both within and adjacent to the tank farm, suggested that a source could exist from somewhere within the S-SX WMA (Figure 3-25). The ratio of these two constituents, both of which are equally mobile in natural water, should be approximately uniform, regardless of their absolute concentrations, if they are both from the same source. In addition, because fractionations occurred in different waste streams, the magnitude of the ratio should reflect different sources. As indicated in Figure 3-25, a narrow zone of anomalously high technetium/uranium ratios occurs immediately beneath the S-SX Tank Farm. The groundwater from adjacent monitoring wells and waste water discharged to

cribs surrounding the S-SX Tank Farm have relatively low ratios (average ratios for each adjacent crib are shown in open boxes next to each location as shown in Figure 3-25). The technetium/uranium ratio in water wash fractions of sludge samples from the S-104 Tank were very high (>300), suggesting that an SST source should have a relatively high technetium/uranium ratio. The highest ratio in groundwater was 200 and occurred in well 2-W23-1 near the S-104 Tank. The wells with the high technetium/uranium ratios are also the wells with the highest technetium concentrations (up to 8,000 pCi/L).

Spatial Correlation Between Groundwater and Vadose Zone Anomalies. The spectral gamma logging results for the SX Tank Farm (see Section 3.2.3.1) indicated that near-surface contamination approximated the area that includes the 10 tanks with known or suspected leaks in the SX Tank Farm. The highest near-surface soil contamination appeared to be located between the center and the southwest corner of the SX Tank Farm. The latter location includes the tanks with the largest known leak volumes (SX-112 and SX-115) (see Section 3.2.3.1 for details). The highest subsurface contamination appeared to be near the west central area of the SX Tank Farm (i.e., between tanks SX-108 and SX-109).

The identified soil contamination zones only partially overlap the anomalous technetium/uranium ratios in groundwater. However, no groundwater monitoring wells are present along the west side of the SX Tank Farm. In addition, gamma logging results are not yet interpreted for the S Tank Farm. Distribution lines enter the S-SX Farm from the east side. Therefore, leakage from transfer lines and/or distribution boxes would be more likely to influence groundwater beneath the east side of the S-SX WMA. More information is needed to evaluate source-receptor relationships between soil and groundwater contamination in the S-SX WMA.

Nevertheless, based on available knowledge and expected behavior of mobile constituents, the following conceptual model of hypothetical pathways and transport processes is proposed.

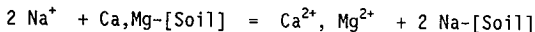
3.4.2 Conceptual Model

A conceptual model of waste migration through the vadose zone to groundwater is typically prepared as an investigative aid or as an integral part of the Data Quality Objectives (DQO) process. The proposed pathways depicted in graphical form are hypotheses that can hopefully be tested. Emphasis on preparing a conceptual model of subsurface contaminant transport beneath the S-SX Tank Farm is on preferential pathways to groundwater and possible sources of water to serve as a driving force for transporting contaminants from SST leak sites by either accelerated movement through the vadose zone or by rapid movement via preferential pathways. The following discussion and graphics are based on available data. On-going RCRA groundwater investigations and TWRS vadose zone characterization efforts will acquire new data and related information with which to confirm or reject proposed or hypothetical pathways.

Pathways and Driving Force. Hypothetical sources and migration pathways beneath the S-SX WMA are illustrated in Figure 3-26a and 3-26b. Pathways that could bypass the normal movement of moisture or liquid through the soil column are indicated in Figure 3-26a. Such paths are referred to as preferential

pathways and could involve both natural features such as clastic dikes and more direct paths along unsealed monitoring wells. (Five such wells are located inside the S-SX fence line, two of which are immediately adjacent to SSTs). As discussed in Section 3.2.2.6, Clastic dikes are common in the 200 West Area and consist of silt and sand infillings with clay boundaries of variable width that pass vertically through the horizontal sedimentary layers. These features have been shown to be capable of transmitting liquids more rapidly than the adjacent sediments or soil column through which they pass.

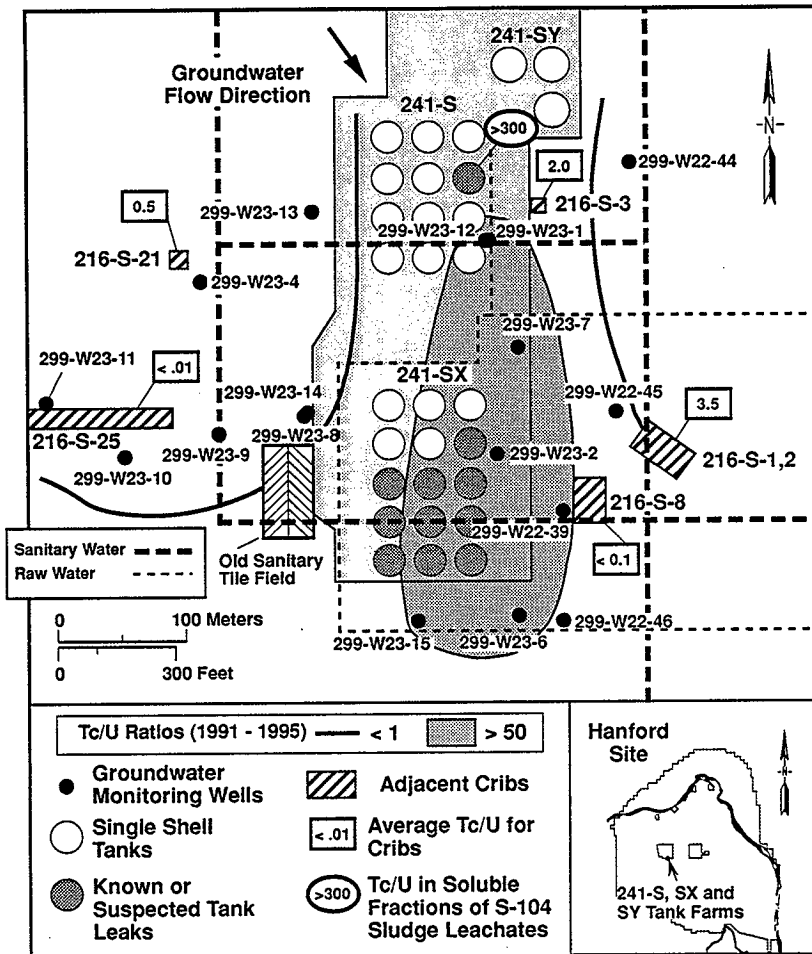
Direct infiltration of natural precipitation can also serve as a driving force (indicated by downward vertical arrows above ground surface in Figure 3-26). Calculations of natural infiltration rate, which is enhanced by the coarse gravel cover over the tank farms, suggest that an average rate of 10 cm/year or more is possible. This could be greatly enhanced by the runoff from the tank tops and migration of water downward along the tank walls. This process could significantly magnify the infiltration rate in the immediate vicinity of tank leaks. The effective infiltration rate from this process could be several times greater than a uniform areal infiltration rate of 10 cm/yr. Surface water runoff moving over or through the tank leak sites could then be carried into the older unsealed vadose monitoring wells or the adjacent groundwater monitoring wells and thereby provide a more rapid transport to groundwater. If the mobilized tank waste followed a more direct path to groundwater, most of the fractionation caused by different migration rates would occur in the saturated zone, as indicated in Figure 3-26a. A more diffuse pathway through the entire soil column without a preferential pathway would involve fractionation with depth or distance as suggested in Figure 3-26b. The latter case would present more opportunity for ion-exchange reactions to occur between waste constituents in the migrating fluid and the soil. Major cationic waste components, such as sodium, could be exchanged for the naturally occurring cations present in the soil column, depicted as follows:



Given enough time (path length) for the exchange process, the replacement could be nearly complete by the time a hypothetical waste/moisture front mixture reaches groundwater. If so, even though sodium is a major chemical constituent in tank waste, little if any may be present in the waste mixture that reaches groundwater. In addition, contaminants that migrate to groundwater under unsaturated flow conditions are more likely to be present at the very top of the aquifer. Contaminants that are transported under saturated conditions, are more likely to be distributed over a greater depth in the aquifer because of the hydrostatic pressure difference or "head" created by the column of water (pore fluid in the soil column or water filling the open casing of a monitoring well). The two possible cases are illustrated in Figure 3-26a and 3-26b as either a mobile contaminant plume with a greater depth distribution (a) or a shallow mobile contaminant plume (b).

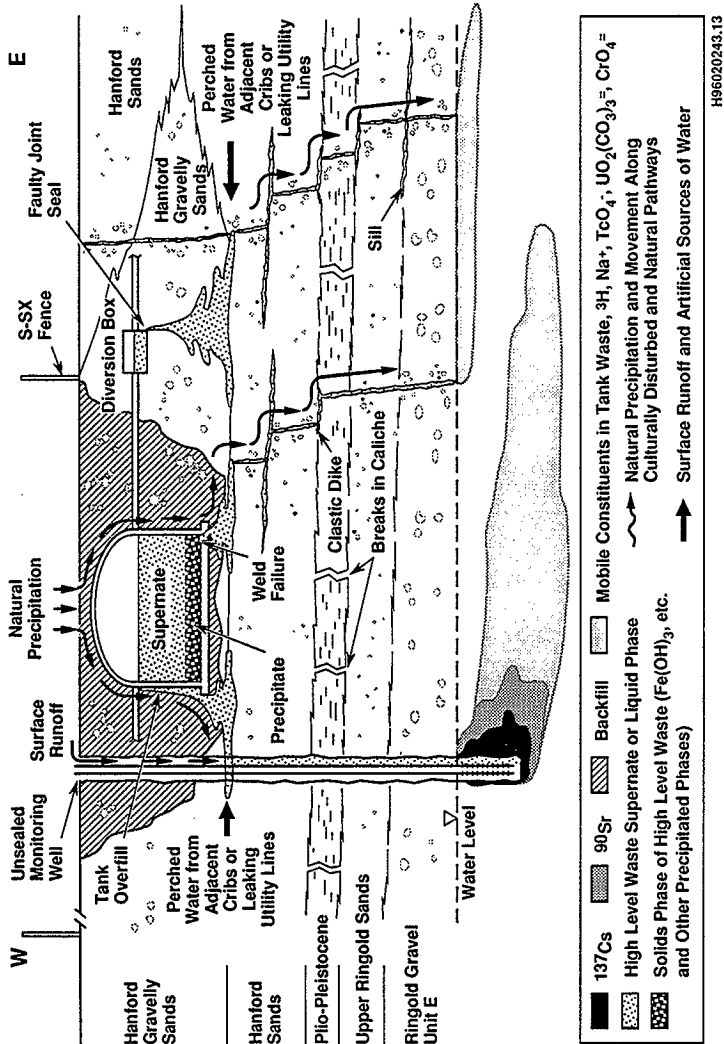
Tank Waste Chemical Considerations. The first cycle, aqueous waste stream generated from the REDOX process was a multimolar sodium nitrate/nitric acid mixture containing sodium dichromate and permanganate to control the oxidation state of plutonium. After extraction of the uranium and plutonium, the concentrated nitric acid process stream was neutralized with sodium hydroxide and routed to the S-SX Tank Farm as "R" waste (Figure 3-27). The waste was

Figure 3-25. Technetium/Uranium Ratio in Groundwater Near the S-SX Waste Management Area.



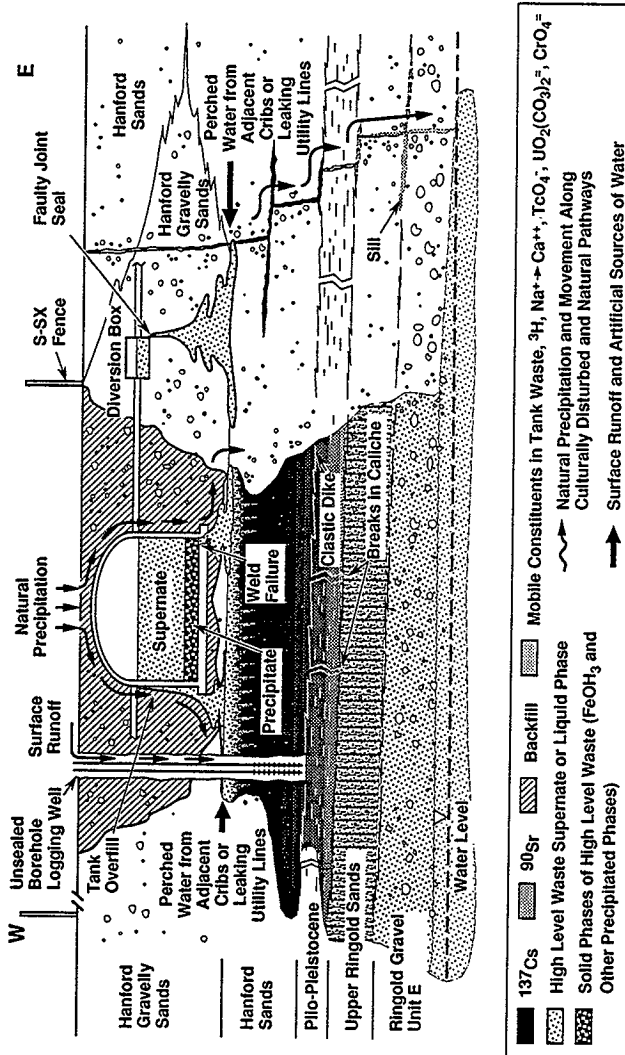
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 H96070262.2

Figure 3-26a. Hypothetical Preferential Pathways to Groundwater in the S-SX Waste Management Area.



H96020243.13

Figure 3-26b. Hypothetical Movement of Contaminants Through the Soil Column Beneath the S-SX Waste Management Area.



H96020243.13a

highly radioactive and generated enough heat to self-boil. The vapor, containing most of the tritium generated in the process, was condensed and routed to the adjacent S Cribs (S-3, S-4 and S-21). In addition to the in-tank phase separation caused by boiling, the high pH resulted in formation of precipitates of metal hydroxides including uranium. In addition, transfers within the tank farm and transfers from other tank farms included phosphate, which very likely contributed to formation of insoluble uranium phosphates.

Because the chemistry of tank contents varies, predicting the chemical form of waste constituents is difficult. A reasonable alternative is to use the relative composition of the easily solubilized fraction of tank sludge samples ("wash" fractions) as an indicator of the mobile constituents and relative amounts. Both earlier tank sampling efforts and more recent tank characterization studies included tanks in the S and SX Tank Farms. The water wash fraction of the sludge samples recovered from these tanks consists of water-soluble constituents that include sodium (Na^+), nitrate (NO_3^-) chromate (CrO_4^{2-}), sulfate (SO_4^{2-}), aluminate (AlO_2^-), ^{99}Tc (TcO_4^-), traces of uranium [$\text{UO}_2(\text{CO}_3)_2$] and plutonium, large amounts of ^{137}Cs (Cs^+), and ^{90}Sr (Sr^{2+}) at concentrations of about 1/10 to 1/100th of the ^{137}Cs concentration (most of the ^{90}Sr was associated with the solid phase). These soluble constituents are assumed to have been available to migrate through the soil column from a tank leak. The vertical distribution in the soil column would depend on the affinity of the constituents for the soil matrix through which the aqueous waste migrated. For example, as indicated in Figure 3-26b, ^{137}Cs would be expected to travel more slowly than ^{90}Sr , which should migrate more slowly than the highly mobile constituents.

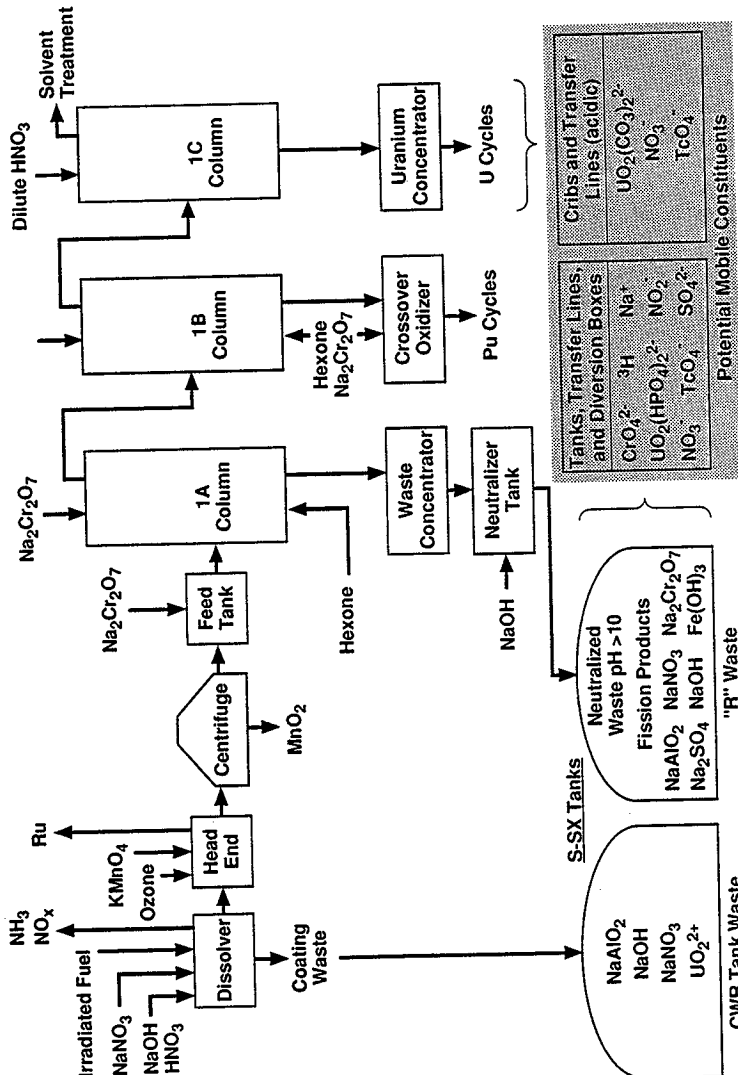
The high pH and high temperature of the tank waste, make dissolution of silica (in the portion of the soil column that initially contained the leak volume) likely to have occurred. Such reactions can result in a gelatinous precipitate that could have impeded moisture migration through the original contaminated soil volume. This type of waste-form soil-matrix effect is indicated in Figures 3-26a and 3-26b as the initial soil volume occupied by the leak (shaded waste area immediately beneath and adjacent to the tank). The permeability of such a mass is unknown, but should be less than the unaltered sedimentary material. Some fraction of the mobile constituents associated with the original leak volume, however, should be available for transport with any water or moisture movement through or adjacent to the mass.

The timing of the leaks may also be important because leaks that occurred early in the life of a tank would be less subject to additional chemical changes from tank transfers. In this regard, the SX-109 through SX-115 were of similar design and all are thought to have failed or leaked soon after they were placed into service.

3.4.3 Occurrence of Mobile Constituents in Groundwater

If the conceptual model (Section 3.4.2) of waste migration through the soil column to groundwater is correct, the hypothesized mobile tank waste constituents should be present in groundwater beneath the tanks, or downgradient from the tank farm. Based on the water wash fraction of sludge samples from the S-SX Tank Farm, the most abundant mobile components expected to appear in groundwater include sodium (or ion-exchange products, such as calcium and magnesium), nitrate, ^{99}Tc , tritium, and chromate. Figure 3-28

Figure 3-27. REDOX Chemical Separations Process and Main Waste Constituents Generated.

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shows the recent concentration history of these constituents in the nearest downgradient RCRA monitoring well located near suspected tank leak sources in the SX Tank Farm. As suggested by Figure 3-28, the expected major mobile constituents are present. However, some deviation from this pattern is evident, especially for tritium. In the case of sodium, the ion-exchange reaction noted above could account for the absence of excess sodium. The apparent covariance of calcium and magnesium with the other co-contaminants supports this explanation.

Net Calcium and Magnesium. Because groundwater contains naturally occurring calcium and magnesium, the increase in concentration of these divalent cations is somewhat obscured. In addition, to make a direct comparison with the major anionic components (nitrate), the units must be in milliequivalents per liter (meq/L) because calcium and magnesium are divalent and nitrate is monovalent. If these are the major ionic constituents, equal amounts (meq/L basis) of cations and anions should be present. That is, to satisfy the electroneutrality requirement, equal amounts (meq/L) of positive (cation) and negative (anion) charge must be present. Figure 3-28b compares the excess or net concentration (downgradient minus upgradient) of calcium plus magnesium versus nitrate. The shape of the excess cation plot and the nitrate plot are nearly identical. They, in turn, are very similar to the plots for the other mobile contaminants expected in tank waste. This correspondence adds credence to the sodium exchange hypothesis and explains the absence of excess sodium in those samples that apparently have mobile tank waste constituents.

Further support for the sodium-exchange hypothesis is provided by the T-106 soil data (Freeman-Pollard et al. 1994). The soil column chemical analysis results for a borehole drilled near the T-106 Tank leak in the T Tank Farm shows that sodium is separated from nitrate, as would be expected for a liquid containing high sodium salt migrating through a soil column rich in divalent cations (calcium and magnesium on soil particle ion-exchange sites).

Enhanced ^{90}Sr Mobility. If the divalent calcium ion is mobilized as a result of the sodium exchange mechanism, ^{90}Sr , which is chemically similar to calcium, could also be mobilized and migrate to a greater extent than expected under low salt conditions. Serne and Legore (1996) demonstrated that the sorption of ^{90}Sr by Hanford Site sediments was greatly reduced with increasing calcium concentrations. If the mobility of calcium and strontium are identical, ^{90}Sr should be detectable in groundwater at those locations where anomalous or excess calcium occur. However, strontium may be selectively incorporated into calcic mineral phases, which may offset this effect to some extent. Nevertheless, the hypothetical possibility of enhanced transport of ^{90}Sr caused by the sodium-exchange mechanism may require additional evaluation.

Tritium. Tritium should be present in any tank leak and should be covariant with the other mobile constituents. However, this constituent seems to deviate from this expectation. The plot shown in Figure 3-28c suggests that tritium in downgradient well 2-W23-15 could have peaked earlier than the other mobile constituents. This would require tritium, as the tritiated water molecule, to migrate more rapidly than the other constituents. Because tritium can move through the vadose zone as a vapor phase, as well as by liquid phase movement, perhaps the net movement is greater as a result of both processes. If so, this could explain what otherwise appears to be a

discrepancy in the expected covariance of mobile contaminants from SST or related waste sources.

3.4.4 Utility Line Leaks

Corrosion of older iron pipes used for sanitary water and raw water distribution occurs industry wide. The proximity of such lines to SST tank farms and the periodic water-line repairs provide at least circumstantial evidence that potential water-line leaks could have occurred near past tank leak locations. Such sources would provide a driving force for movement of waste to groundwater. For example, a sink hole caused by a leaking sanitary water line developed in the south-central area of the S Tank Farm (see Figure 3-25 for locations). The water line causing the sink hole was taken out of service in 1994. The leak rate and duration are unknown. However, until surface indications such as a sink hole appear, such leaks could go undetected for years.

This situation, combined with recently (1994-1995) discovered water-line leaks overlying past waste sites in the 100-K Area, which apparently resulted in transport of ^{90}Sr to groundwater, suggests utility line leaks could be common at the Hanford Site. The consequences of a water-line leak can be significant if it occurs in the vicinity of past-practice waste sites, spills, or tank waste leak sites.

Older, carbon steel utility lines can leak as a result of either chemical corrosion or electrolysis and/or by freezing. The latter typically occurs at fire plugs during a cold winter. In addition, recent experience with iron releases to the TEFB adds credence to the idea that the older cast iron water distribution lines at the Hanford Site undergo significant corrosion. For example, during 1995 and spring 1996, elevated iron concentrations (up to 3 ppm) occurred periodically in grab samples of effluent discharged to the TEFB. This was in part attributed to corrosion of sanitary water lines that had been "flushed" after a period of non-use. Tens of kilometers of water distribution lines cross the Hanford Site and many are near or pass over waste sites. Considering the age of most of these lines, leaks are likely to occur.

3.5 SAMPLING AND MONITORING WELL CONSIDERATIONS

3.5.1 Groundwater Sampling

Recurrent problems associated with the collection of groundwater samples for the ROM program include high turbidities, air bubbles in the water, and logistics in handling and disposing of purgewater (water removed from the well bore before sample collection). The air bubble problem was the subject of a Tiger Team finding and a value engineering exercise that addressed all these problems with only partial success.

High turbidities are attributed to disturbance of fine sediment in many of the wells caused by surging that occurs when the pump is first activated. This problem seems to be growing worse as the water level drops in response to reduced waste water discharges in the 200 Areas. As the water level drops,

the pump intakes are lowered to near the bottom of the well where fine sediment is more easily resuspended.

The presence of air bubbles in the sample stream is a chronic problem associated with the Hydrostar pumps. The concern is that air bubbles could cause erroneous volatile organic carbon (VOC) and dissolved oxygen results because of so called "air stripping". Several attempts to solve this problem over the last several years have been only partially successful. Much of the problem is attributed to improperly tightened or defective fittings in the stainless steel pump tubing and discharge assembly at the well head. In some cases, "weep" holes were intentionally cut in the pump tubing to allow water in the tubing to drain out to prevent freezing during subzero weather conditions. When weep holes are cut in the tubing above the water level in the well, air can be drawn into the sample stream. The number of wells that have weep holes of this type is unknown. (A work-off procedure for wells with air bubble problems involves checking the tubing string for joint tightness and eliminating weep holes above the water level).

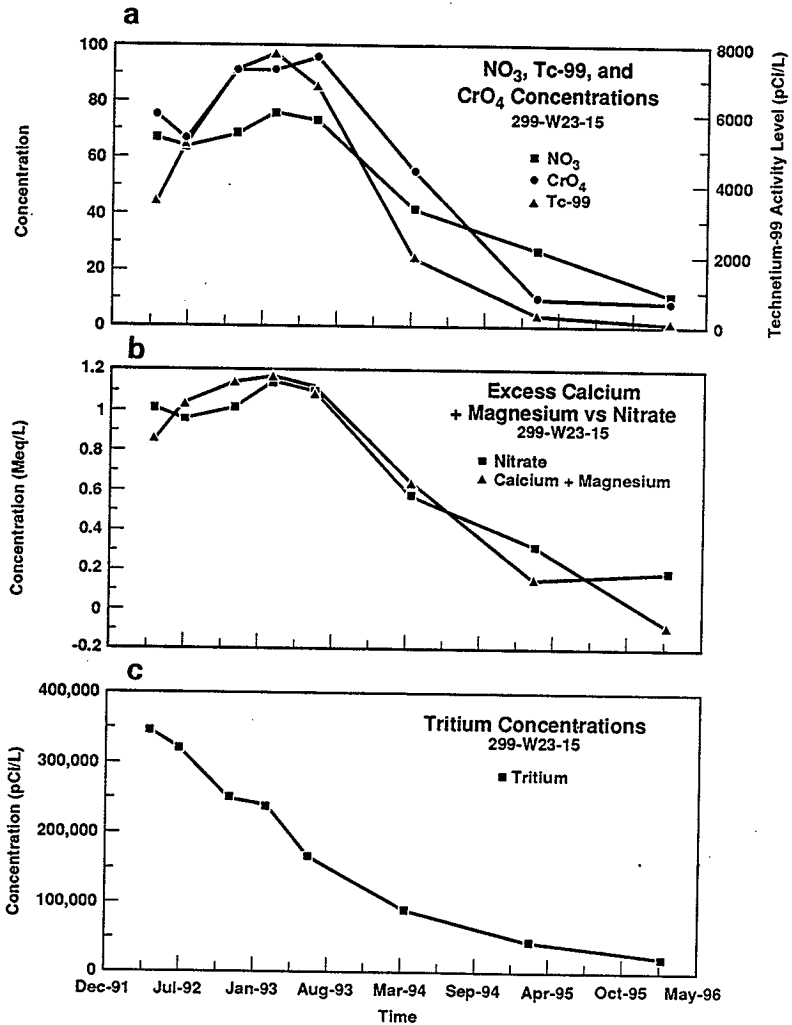
Purgewater is a logistics problem that both reduces the number of well trips that can be made per day and adds to sampling costs because of reduced efficiency and purgewater disposal charges. Conflicts over purgewater truck availability and scheduling transfer of the tank contents to the treatment facility have also accounted for increased costs.

Possible Solution Tested. A new sampling device was tested during the year that shows promise for reducing costs and solving these problems. The sampler is a discrete-depth, passive grab sampling device that collects both VOC samples and additional water for other constituents of interest. Because it is a passive sampler (i.e., no purge water is removed from the well) there is little chance of disturbing the well and causing turbidity. No air bubbles and purgewater disposal occur, eliminating the associated handling and logistics.

Initial testing of the device was conducted near PFP (well 2-W15-16 and 2-W15-30) during the year and a test plan was prepared for additional intercomparison sampling. The initial test compared standard sampling protocol using a Hydrostar pump to both low-volume purging and samples obtained with the KABIS^a (Model-1) discrete depth sampler. Air bubble problems were encountered with the Hydrostar that resulted in erratic and elevated dissolved oxygen results. However, carbon tetrachloride concentrations (3000 to 4000 ppb), as well as inorganic constituents, were comparable among all three sampling regimes. Thus, the excessive air bubbles did not significantly affect the VOC results. The discrete depth sampler was also used to define the variation in concentration with depth in the screened interval of the well. Concentrations of all analytes measured were nearly constant over the 12-m (40-ft) screened depth interval in well 2-W15-30 and over the 4.6-m (15-ft) screened interval in well 2-W15-16. The significance of the uniform carbon tetrachloride concentrations with depth is that it demonstrates that a vapor phase transport pathway cannot account for the carbon tetrachloride in the groundwater near PFP. If carbon tetrachloride vapor from PFP cribs settles over the aquifer and is absorbed by groundwater, the concentrations should decline exponentially with depth in the monitoring

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Figure 3-28. Mobile Co-contaminant Concentrations vs Time in Groundwater Downgradient from the SX Tank Farm.



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well. The observations at wells 2-W15-16 and 2-W15-30 support an alternative explanation involving a dense non-aqueous phase (DNAPL) of carbon tetrachloride. In this scenario, the DNAPL is distributed with depth in the aquifer and continues to slowly dissolve for 10's to 100's of years. Such sources are essentially impossible to remediate and will probably overshadow all other groundwater contaminants in the 200 West Area far into the future.

Limitations. Conditions under which the discrete depth sampling device may not be appropriate are in wells with very low hydraulic conductivity or old wells without screens and where large sample volumes are required. The maximum volume available at the present time is 2 L (plus triplicate 40-ml VOC bottles) but a prototype 6-L version has been designed.

Application. It is estimated that approximately two-thirds of the RCRA/Operational groundwater monitoring wells combined could be sampled for most purposes with the new groundwater sampling device. Use of the discrete depth device would eliminate pump maintenance, as well as purgewater handling and disposal costs. A cooperative effort to evaluate the sampler was organized by WHC-Geosciences and included the major Hanford Site contractors. Results of this effort are expected to provide the baseline data for establishing new sampling protocols for specific applications at the Hanford Site. Use of this device to obtain depth distribution data in Hanford Site monitoring wells will also provide valuable information that is not currently available.

3.5.2 Old Monitoring Wells

More than 200 older monitoring wells exist across the Hanford Site that could provide preferential pathways for contaminant transport to deeper portions of the unconfined and upper confined aquifers. Thus, the unsealed older wells constitute an unresolved groundwater protection issue.

During the year, older candidate wells with completion depths greater than 15 m (50 ft) below the water table were identified and a location map was prepared. A large number of the wells are in the 200 Areas near contaminant plumes or near subsurface TSD sites. The candidate wells identified were all constructed without seals between the casing and the borehole in which the casing was placed. Some perforated casings extend from the top of the unconfined aquifer into the uppermost basalt confined aquifer. Under these conditions, water can potentially flow from the unconfined aquifer into the deeper confined aquifers. The most critical well of this type is located near the center of the carbon tetrachloride plume in the 200 West Area (well 2-W15-5). This well extends to 180 m (600 ft) below ground surface and contains perforations at the top and at various depths down to the completion depth. The well is filled with coarse sand and the hydraulic head is greater in the unconfined aquifer than in the upper confined aquifer at its completion depth. The hydraulic head difference allows groundwater from the contaminated unconfined aquifer to theoretically move through the sand-packed interior of the well casing and into the deeper aquifer. A plan was prepared to correct this problem during the year and a proof-of-principal test was conducted on a well in an uncontaminated area. The procedure involves forcing grout under pressure through casing perforations and into the adjacent formation. Work was initiated on 2-W15-5 but progress has been hindered by both jurisdictional issues and equipment availability problems. Several other wells of a similar

design are located in the 200 West Area. A plan to systematically address all of the unsealed monitoring wells is being prepared. The plan will allow for prioritization (most critical first) and either decommissioning or remediation for future use as monitoring wells. Adequate funding to implement the plan once it is completed has not been identified. Consequently, this is an open groundwater protection issue that must be addressed by the new operating contractor for the Hanford Site.

3.6 SUMMARY AND CONCLUSIONS

Review of surveillance monitoring results from the gross gamma logging equipment and the initial monitoring surveys from the new RLS logging equipment indicate that a significant amount of the radioactive contaminants in the vadose zone are probably stable and remain immobile. However, because of its higher precision, results from the RLS logging efforts suggest that some movement is still occurring, even at locations where discharges have been discontinued for 40 years. The total number of subsurface locations where radioactive contaminant movement is occurring has not been identified. The vadose zone beneath liquid waste disposal facilities cannot be properly monitored either because no boreholes are present or those that exist are improperly positioned for adequate monitoring. Analogous units could be identified that have adequate borehole coverage to map subsurface contaminant distribution.

Termination of the disposal of untreated waste water to the ground in 1995 eliminated most of the active sources of groundwater contamination. Drainage of residual contaminants from the soil column beneath disposal sites will add some additional contaminants to groundwater. Such inputs should steadily decline, provided that surface or near-surface water in the vicinity of waste disposal sites is eliminated. The need for controlling surface runoff near subsurface contamination as a potentially significant groundwater protection measure was demonstrated at the 100-K Basins. Ponding of water in depressions over or near several waste sites in both the 100 and 200 Areas has been observed during the winter months. Thus, while most of the liquid waste discharges have been eliminated, groundwater contamination can still occur as a result of random events caused by surface water runoff and enhanced infiltration over past-practice disposal sites.

As shifts in groundwater flow direction occur with changing discharge conditions, area- rather than unit-specific monitoring networks are more appropriate. This approach, however, is based on the assumption that no new contaminant input to groundwater will occur. If contaminant input or drainage to groundwater occurs, it could remain undetected for years in an aggregate area monitoring network. Implementing this aspect of the Groundwater Remediation Strategy requires the following:

- The practice of vegetation control on some waste sites must be reconsidered and a different approach devised to achieve both surface contamination control and reduction in subsurface moisture movement
- Any leaking utility lines that pass close to subsurface waste sites must be located and repaired, especially in the tank farms.

- Preferential pathways caused by old wells located in zones of contamination must be eliminated.

Vadose zone monitoring and characterization efforts at both cribs and tank farm sites suggest lateral movement of waste constituents occurs to a greater extent than expected at many waste sites. Sink holes caused by leaking subsurface utility lines at the U and S-SX WMAs and standing water over other tank farms that have occurred in the past provide at least circumstantial evidence that controllable sources of surface or near-surface water may be a possible driving force. The continuing presence of mobile SST-related constituents in groundwater at the SX and T-TX-TY Tank Farms and possibly others (B-BX-BY and A-AX) suggests that some type of transport process exists for contaminant movement through the vadose zone to groundwater.

A major driving force and source of groundwater contamination has been eliminated by terminating untreated wastewater discharges to the ground. However, diligence in reducing surface water infiltration and miscellaneous sources of water and eliminating preferential pathways is still needed. This should be a long-term groundwater protection goal that supplements the landmark improvements in waste water treatment and management at the Hanford Site completed during 1995.

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4.0 SOIL AND VEGETATION MONITORING

4.1 INTRODUCTION

The radionuclide content of soil and vegetation was measured to evaluate long-term trends in environmental accumulation of radioactivity in the 100, 200, and 300/400 Areas. Soil and vegetation samples were collected on or near facilities that store, handle, or dispose of radioactive waste. Eighty soil samples (12 in the 100-N Area, 53 in the 200 Areas, and 15 in the 300/400 Areas) and 86 vegetation samples (20 in the 100-N Area, 50 in the 200 Areas, and 16 in the 300/400 Areas) were collected from locations shown in Appendix E, Figures E-1 through E-12. Collection of soil and vegetation samples near the retired 100 Areas was discontinued in 1993. Trend analysis of the data collected since 1980 indicated that migration of the contaminants was not occurring and therefore routine annual sample collection and analysis was no longer necessary. The analytical results of the data obtained from samples collected are presented in Tables E-1 and E-6 (Appendix E).

Each soil sample represents a composite of 5 plugs of soil 2.5 cm (1 in.) deep and 10 cm (4 in.) in diameter collected from each site. Each vegetation sample consists of new-growth leaf cuttings taken from the available species of interest at each sample location. Often, the vegetation sample collected is a composite of several like members of the sampling site community to avoid decimation of any individual plant through over-harvesting.

Early in the summer of each year, soil and vegetation samples are collected and submitted for radioanalyses. The analyses include those for radionuclides expected to be found in the areas sampled (i.e., gamma-emitting radionuclides, strontium isotopes, uranium isotopes, and/or plutonium isotopes). The results are then compared to levels found at the distant communities of Yakima and Sunnyside. These levels are derived from data reported from the distant communities by the PNNL surveillance program to determine the difference between contributions from site operations and contributions from natural causes and worldwide fallout. Soil and vegetation samples were not collected from the distant communities by PNNL during 1995. For more detail see Section 4.6, "Soil and Vegetation," *Hanford Site Environmental Report, Calendar Year 1995* (Dirkes and Hanf 1996). The results also are compared to soil concentration limits (Appendix J) developed by WHC for use at the Hanford Site.

Radioactive soil concentration limits for WHC were established to ensure that effective dose equivalents (EDE) to the public do not exceed the established limits for any reasonable scenario (such as direct exposure, inadvertent ingestion, inhalation, and ingestion of food crops, including animal products). Conservatism inherent in pathway programming ensures that the required degrees of protection are in place. The concentration limits specified apply to the Hanford Site with respect to onsite disposal operations, stabilization and cleanup, decontamination and decommissioning operations.

Special investigative soil and biota (plant and animal) samples are collected for site-specific monitoring, or whenever radiological contamination is known or suspected to have occurred. These special samples are discussed in Section 8.0.

4.2 SOIL SAMPLING

4.2.1 100-N Area

Surface soil samples collected near the 1301-N LWDF contain radionuclides that were typically present in the effluent stream discharge. Generally, the samples collected near this facility exhibit relatively higher radionuclide concentrations than those collected at the seven other soil sampling locations at 100-N. Average radionuclide concentrations detected in the surface soil samples near the 1301-N LWDF from 1980 through 1995 are presented in Table 4-1. Average radionuclide concentrations detected in the surface soil samples collected in the 100-N Area from 1980 through 1995 are presented in Table 4-2. The 1995 maximum average, the 1994 distant community average and the accessible soil concentration limits are compared in Table 4-3. Radionuclide concentrations are summarized in Appendix E, Table E-1.

4.2.1.1 ^{60}Co . The highest ^{60}Co result in 1995 was found at Site Y603 located near the 1301-N LWDF. The ^{60}Co concentration was $5.6 \text{ E}+00 \pm 10\% \text{ pCi/g}$. The distant community average for ^{60}Co pCi/g was not reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{60}Co in soils in the 100-N Area was $9.4 \text{ E}-01 \pm 105\% \text{ pCi/g}$.

4.2.1.2 ^{137}Cs . The highest ^{137}Cs result was found at Site Y603, located near the 1301-N LWDF. The ^{137}Cs concentration was $1.5 \text{ E}+00 \pm 11\% \text{ pCi/g}$, or 3 times the distant community measured concentration of $4.6 \text{ E}-01 \pm 7\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{137}Cs in soils in the 100-N Area was $5.1 \text{ E}-01 \pm 48\% \text{ pCi/g}$.

4.2.1.3 ^{90}Sr . The highest ^{90}Sr result was found at Site Y603, located near the 1301-N LWDF. The ^{90}Sr concentration was $4.8 \text{ E}-01 \pm 17\% \text{ pCi/g}$, or 5 times the distant community measured concentration of $9.4 \text{ E}-02 \pm 11\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{90}Sr in soil in the 100-N Area was $1.3 \text{ E}-01 \pm 53\% \text{ pCi/g}$.

4.2.1.4 $^{239, 240}\text{Pu}$. The highest $^{239, 240}\text{Pu}$ result was found at Site Y606, located near the 1301N LWDF. The $^{239, 240}\text{Pu}$ concentration was $5.6 \text{ E}-02 \pm 23\% \text{ pCi/g}$, or 5 times the distant community measured concentration of $1.1 \text{ E}-02 \pm 9\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of $^{239, 240}\text{Pu}$ in soil in the 100-N Area was $1.4 \text{ E}-02 \pm 67\% \text{ pCi/g}$.

Table 4-1. Average Radionuclide Concentrations Detected in Soil Samples Near the 1301-N Liquid Waste Disposal Facility from 1980 through 1995 (pCi/g).

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁸ Pu	^{239,240} Pu
1980	1.3 E+01	3.5 E-01	4.1 E+00	NR	2.5 E-02
1981	4.0 E+00	7.0 E-01	6.1 E+00	NR	4.4 E-02
1982	6.3 E+00	2.7 E-01	2.7 E+00	NR	1.8 E-02
1983	5.4 E+00	1.3 E+00	3.8 E+00	NR	4.3 E-02
1984	2.8 E+00	2.1 E-01	1.1 E+00	NR	1.7 E-02
1985	1.3 E+01	6.5 E-01	3.9 E+00	NR	3.2 E-02
1986	4.5 E+00	2.2 E-01	2.5 E+00	NR	1.7 E-02
1987	5.1 E+00	3.4 E-01	1.6 E+00	5.4 E-03	2.2 E-02
1988	7.8 E+00	3.5 E-01	2.0 E+00	2.3 E-03	1.7 E-02
1989	2.3 E+00	1.5 E-01	5.0 E-01	6.4 E-03	4.0 E-02
1990	4.7 E+00	3.2 E-01	1.7 E+00	4.6 E-03	3.5 E-02
1991	1.3 E+01	2.7 E-01	1.3 E+00	7.7 E-03	5.3 E-02
1992	6.7 E+00	2.2 E-01	1.1 E+00	3.5 E-03	2.3 E-02
1993	1.0 E+00	8.7 E-01	6.2 E+00	1.3 E-02	6.9 E-02
1994	3.7 E+00	3.3 E-01	1.5 E+00	9.3 E-03	2.8 E-02
1995	2.1 E+00	1.5 E-01	7.7 E-01	2.0 E-03	1.0 E-02

NR = Not Reported

Table 4-2. Average Radionuclide Concentrations Detected in 100 N Area Surface Soil Samples from 1980 through 1995 (pCi/g).

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁸ Pu	^{239,240} Pu
1980	8.5 E-01	1.8 E-01	5.0 E-01	NR	1.8 E-02
1981	1.3 E+00	2.1 E-01	1.0 E+00	NR	1.1 E-02
1982	1.6 E+00	9.9 E-02	3.4 E-01	NR	5.0 E-03
1983	2.7 E+00	2.9 E-01	4.4 E-01	NR	8.5 E-03
1984	8.8 E-01	2.8 E-01	6.2 E-01	NR	1.4 E-02
1985	1.2 E+00	1.3 E-01	5.2 E-01	NR	1.3 E-02
1986	4.1 E-01	8.3 E-02	5.0 E-01	NR	8.2 E-03
1987	4.1 E-01	1.1 E-01	3.9 E-01	1.1 E-03	6.7 E-03
1988	3.4 E-01	1.6 E-01	3.9 E-01	4.5 E-04	9.5 E-03
1989	1.4 E-01	2.1 E-01	1.3 E-01	1.1 E-03	1.3 E-02
1990	3.0 E-01	1.2 E-01	4.4 E-01	6.7 E-04	1.0 E-02
1991	4.3 E-01	1.1 E-01	4.5 E-01	6.2 E-04	7.8 E-03
1992	8.6 E-02	9.5 E-02	3.6 E-01	5.1 E-04	7.6 E-03
1993	3.0 E-02	1.2 E-01	1.6 E-01	1.8 E-04	3.4 E-03
1994	1.6 E+00	1.9 E-01	8.1 E-01	4.2 E-03	1.6 E-02
1995	9.4 E-01	1.3 E-01	5.1 E-01	1.9 E-03	1.4 E-02

NR = Not Reported

4.2.1.5 Uranium. The highest value for total uranium was found at Site Y609 located near the northwest end of the 1301-N LWDF. The uranium concentrations were $1.3 \text{ E-01} \pm 14\% \text{ pCi/g}$ for ²³⁴U, $8.6 \text{ E-03} \pm 35\% \text{ pCi/g}$ for ²³⁵U, and $1.5 \text{ E-01} \pm 13\% \text{ pCi/g}$ for ²³⁸U or 2.9 E-01 pCi/g uranium total. The total uranium concentration was 3 times less than the distant community concentration of $9.0 \text{ E-01} \pm 133\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration for total uranium in soil in the 100-N Area was $6.4 \text{ E-02} \pm 23\% \text{ pCi/g}$.

4.2.1.6 Comparison. The maximum, average, and distant community radionuclide concentrations, and the accessible soil concentration limits are compared for the 100 Areas in Table 4-3.

4.2.2 200 Areas

Soil samples from 53 of 110 sample locations were collected in 1995. Radionuclide concentrations are summarized in Appendix E, Table E-2. The following sections discuss the highest analytical result for specific radionuclides and compare them to the offsite average as measured by PNNL. Maximum, average, and distant community radionuclide concentrations and accessible soil concentration limits are compared in Table 4-4.

Table 4-3. 100-N Area Soils (pCi/g).

	⁶⁰ Co	¹³⁷ Cs	⁹⁰ Sr	^{239, 240} Pu	²³⁵ U	²³⁸ U
Maximum ± Counting Error(%)	Site Y003	Site Y003	Site Y003	Site Y006	Site Y009	Site Y009
	5.4 E+00 ± 10%	1.5 E+00 ± 11%	4.8 E-01 ± 17%	5.6 E-02 ± 23%	1.3 E-01 ± 14%	8.6 E-03 ± 35%
Average ± 2SEM(%)	9.4 E-01 ± 105%	5.1 E-01 ± 48%	1.3 E-01 ± 53%	1.4 E-02 ± 67%	9.1 E-02 ± 12%	3.9 E-03 ± 28%
PNL Distant Community Average ± 2SEM (%)*	NR	4.6 E-01 ± 7%	9.0 E-02 ± 11%	1.0 E-02 ± 9%	NR	1.7 E-01 ± 92%
Accessible soil concentration limits	7.1 E+00	3.0 E+01	2.8 E+03	1.9 E+02	6.3 E+02	1.7 E+02
						3.7 E+02

2SEM = 2 standard error of the mean.

NR = Not reported.

*Drinks and Hanf 1996

Table 4-4. 200 Area Soils (pCi/g).

	⁶⁰ Co	¹³⁷ Cs	⁹⁰ Sr	^{239, 240} Pu	²³⁵ U	²³⁸ U
Maximum ± Counting Error(%)	Site D021	Site D017	Site D059	Site D103	Site D045	Site D045
	4.5 E-02 ± 49%	2.6 E+01 ± 10%	3.5 E+00 ± 19%	5.3 E-01 ± 11%	4.7 E-01 ± 12%	4.4 E-01 ± 12%
Average ± 2SEM(%)	3.6 E-03 ± 102%	2.7 E+00 ± 39%	4.9 E-01 ± 37%	7.1 E-02 ± 43%	1.2 E-01 ± 14%	4.7 E-03 ± 16%
PNL Distant Community Average ± 2SEM (%)*	NR	4.6 E-01 ± 7%	9.0 E-02 ± 11%	1.0 E-02 ± 9%	NR	1.7 E-01 ± 92%
Accessible soil concentration limits	7.1 E+00	3.0 E+01	2.8 E+03	1.9 E+02	6.3 E+02	1.7 E+02
						3.7 E+02

2SEM = 2 standard error of the mean.

NR = Not reported.

*Drinks and Hanf 1996

4.2.2.1 ^{60}Co . The highest ^{60}Co result was found at Site D021, located northeast of the 216-T-33 Crib. The ^{60}Co concentration was $4.5 \text{ E-02} \pm 49\% \text{ pCi/g}$. The distant community average for ^{60}Co pCi/g was not reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{60}Co in soils in the 200 Areas was $3.6 \text{ E-03} \pm 102\% \text{ pCi/g}$.

4.2.2.2 ^{137}Cs . The highest ^{137}Cs result was found at Site D017, located north of the 241-T Tank Farms. The ^{137}Cs concentration was $2.6 \text{ E+01} \pm 10\% \text{ pCi/g}$, or 56 times the distant community measured concentration of $4.6 \text{ E-01} \pm 7\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{137}Cs in soils in the 200 Areas was $2.7 \text{ E+00} \pm 39\% \text{ pCi/g}$.

4.2.2.3 ^{90}Sr . The highest ^{90}Sr result was found at Site D059, located near 216-B-63 Ditch. The ^{90}Sr concentration was $3.5 \text{ E+00} \pm 19\% \text{ pCi/g}$, or 39 times the distant community measured concentration of $9.0 \text{ E-02} \pm 11\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{90}Sr in soil in the 200 Areas was $4.9 \text{ E-01} \pm 37\% \text{ pCi/g}$.

4.2.2.4 $^{239,240}\text{Pu}$. The highest $^{239,240}\text{Pu}$ result was found at Site D103, located near the 216-S-10 Ditch. The $^{239,240}\text{Pu}$ concentration was $5.3 \text{ E-01} \pm 11\% \text{ pCi/g}$, or 53 times the distant community measured concentration of $1.0 \text{ E-02} \pm 9\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of $^{239,240}\text{Pu}$ in soil in the 200 Areas was $7.1 \text{ E-02} \pm 43\% \text{ pCi/g}$.

4.2.2.5 Uranium. The highest total uranium was found at Site D045, located east of the 216-U-1 and -2 Crips. The uranium concentrations were $4.7 \text{ E-01} \pm 12\% \text{ pCi/g}$ for ^{238}U , $2.1 \text{ E-02} \pm 25\% \text{ pCi/g}$ for ^{235}U , and $4.4 \text{ E-01} \pm 12\% \text{ pCi/g}$ for ^{238}U or $9.1 \text{ E-01} \text{ pCi/g}$ uranium total. The total uranium concentration was the same as the distant community concentration of $9.0 \text{ E-01} \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). ^{234}U was not reported by PNNL. The average concentration for total uranium in soil in the 200 Areas was $2.4 \text{ E-01} \text{ pCi/g}$.

4.2.2.6 Comparison. The maximum, average, and distant community radionuclide concentrations and the accessible soil concentration limits are compared for the 200 Areas in Table 4-4.

4.2.3 300/400 Areas

This was the fifth year of sampling from locations established to monitor the near-field in the 300/400 Areas. Soil samples from 15 sample locations were collected in 1995; 14 from the 300 Area, and 1 from the 400 Area. Radionuclide concentrations are listed in Appendix E, Table E-3. Maximum, average, distant community, and accessible soil concentration limits are compared in Table 4-5.

4.2.3.1 ^{60}Co . The highest ^{60}Co result that was above the overall counting error was found at Site D121, located northeast of the 316-1 Process Pond. The ^{60}Co concentration was $1.5 \text{ E-02} \pm 83\% \text{ pCi/g}$. The distant community concentration of ^{60}Co was not reported in the *Hanford Site Environmental*

Table 4-5. 300/400 Areas Soils (pCi/g).

	⁶⁰ Co	¹³⁷ Cs	⁹⁰ Sr	²³⁸ U, ²⁴⁰ Pu	²³⁴ U	²³⁵ U	²³⁸ U
Maximum ± Counting Error(%)	Site D121	Site D125	Site D127	Site D119	Site D119	Site D119	Site D119
	1.5 E-02 ± 83%	7.2 E-01 ± 11%	1.4 E-01 ± 21%	1.7 E-01 ± 21%	1.6 E+01 ± 22%	7.6 E-01 ± 24%	1.7 E+01 ± 23%
Average ± 2SEM(%)	1.9 E-03 ± 217%	2.4 E-01 ± 46%	4.9 E-02 ± 40%	2.6 E-02 ± 95%	2.1 E+00 ± 95%	1.2 E-01 ± 86%	2.1 E+00 ± 102%
PNHL Distant Community average ± 2SEM(%)*	NR	4.6 E-01 ± 7%	9.0 E-02 ± 11%	1.0 E-02 ± 9%	NR	1.7 E-01 ± 92%	8.1 E-01 ± 140%
Accessible soil concentration limits	7.1	30	2,800	190	630	170	370

2SEM = 2 standard error of the mean. NR = Not reported. *Dikes and Hanf 1996

Report for Calendar Year 1994 (Dirkes and Hanf 1995). The average concentration of ^{60}Co in soil in the 300/400 Areas was $1.9 \text{ E-03} \pm 217\% \text{ pCi/g}$.

4.2.3.2 ^{137}Cs . The highest ^{137}Cs result was found at Site D125, located southwest the 618-3 Burial Ground. The ^{137}Cs concentration was $7.2 \text{ E-01} \pm 11\% \text{ pCi/g}$, and was not different from the distant community measured concentration of $4.6 \text{ E-01} \pm 7\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{137}Cs in soil in the 300/400 Areas was $2.4 \text{ E-01} \pm 46\% \text{ pCi/g}$.

4.2.3.3 ^{90}Sr . The highest ^{90}Sr result was found at Site D127, located south of the 618-7 Burial Ground. The ^{90}Sr concentration was $1.4 \text{ E-01} \pm 21\% \text{ pCi/g}$, and was not different from the distant community measured concentration of $9.0 \text{ E-02} \pm 11\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{90}Sr in soil in the 300/400 Areas was $4.9 \text{ E-02} \pm 40\% \text{ pCi/g}$.

4.2.3.4 $^{239}, ^{240}\text{Pu}$. The highest $^{239}, ^{240}\text{Pu}$ result was found at Site D119, located northeast of the 316-2 Process Pond. The $^{239}, ^{240}\text{Pu}$ concentration was $1.7 \text{ E-01} \pm 21\% \text{ pCi/g}$, or 17 times the distant community measured concentration of $1.0 \text{ E-02} \pm 9\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of $^{239}, ^{240}\text{Pu}$ in soil in the 300/400 Areas was $2.6 \text{ E-02} \pm 95\% \text{ pCi/g}$.

4.2.3.5 Uranium. The highest uranium result was found at Site D119, located northeast of the 316-2 Process Pond. The uranium concentrations were $1.6 \text{ E+01} \pm 22\% \text{ pCi/g}$ for ^{234}U , $7.6 \text{ E-01} \pm 24\% \text{ pCi/g}$ for ^{235}U , and $1.7 \text{ E+01} \pm 23\% \text{ pCi/g}$ for ^{238}U or $3.4 \text{ E+01} \text{ pCi/g}$ uranium total. The total uranium concentration was 37 times the distant community concentration of $9.0 \text{ E-01} \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). ^{234}U was not reported by PNNL. The average concentration of total uranium in soil in the 300/400 Areas was $4.3 \text{ E+00} \text{ pCi/g}$.

4.2.3.6 Comparison. The maximum, average, and distant community radionuclide concentrations and the accessible soil concentration limits are compared for the 300/400 Areas in Table 4-5.

4.3 VEGETATION SAMPLING

4.3.1 100 Areas

Vegetation samples collected near the 1301-N and 1325-N LWDFs contain radionuclides that were typically present in the effluent stream discharge. The levels of contaminant concentrations near the 1301-N facility were at or near historic levels, considerably lower than those seen in 1994. Average radionuclide concentrations detected in the vegetation samples near the 1301-N LWDF from 1980 through 1995 are presented in Table 4-6. Average radionuclide concentrations detected in the vegetation samples collected in the 100-N Area from 1980 through 1995 are presented in Table 4-7. Radionuclide concentrations are listed in Appendix E, Table E-4.

Table 4-6. Average Radionuclide Concentrations Detected in Vegetation Samples Near the 1301-N Liquid Waste Disposal Facility from 1980 to 1995 (pCi/g).

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁸ Pu	^{239,240} Pu
1980	4.0 E+00	NR	1.1 E+00	NR	NR
1981	1.2 E+01	1.8 E+00	1.8 E+00	NR	7.1 E-03
1982	1.6 E+00	1.2 E-01	2.6 E-01	NR	2.6 E-03
1983	1.9 E+00	6.0 E-01	3.9 E-01	NR	3.2 E-03
1984	1.0 E+00	1.2 E-01	8.3 E-02	NR	8.5 E-04
1985	1.7 E+00	1.9 E+00	1.0 E-01	NR	1.5 E-03
1986	3.5 E+00	7.3 E-02	6.5 E-01	NR	2.6 E-03
1987	2.8 E+00	6.3 E-02	2.0 E-01	1.2 E-03	5.6 E-03
1988	2.0 E+00	1.2 E-01	1.3 E-01	4.3 E-04	1.7 E-03
1989	1.3 E+00	3.8 E-02	1.5 E-01	2.8 E-04	2.0 E-03
1990	1.3 E+00	3.1 E-02	1.2 E-01	2.7 E-04	1.1 E-03
1991	6.3 E-01	1.5 E-02	6.0 E-01	8.1 E-05	1.2 E-03
1992	2.0 E-01	6.5 E-03	2.0 E-01	-2.8 E-05	1.6 E-04
1993	2.2 E-01	5.7 E-02	2.1 E-01	-7.8 E-04	4.1 E-04
1994	2.5 E+01	4.8 E+00	1.8 E+00	3.3 E-02	2.0 E-01
1995	5.4 E-02	6.4 E-02	1.2 E-01	1.3 E-03	8.6 E-03

NR = Not reported.

Negative value indicates results at or below background levels of radioactivity.

Table 4-7. Average Radionuclide Concentrations Detected in 100-N Vegetation Samples from 1980 to 1995 (pCi/g).

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁸ Pu	^{239,240} Pu
1980	1.0 E+00	NR	2.8 E-01	NR	NR
1981	2.5 E+01	5.8 E-01	7.1 E-01	NR	2.1 E-02
1982	1.5 E+00	2.0 E-01	1.3 E-01	NR	7.8 E-03
1983	1.0 E+00	2.9 E-01	9.0 E-02	NR	8.6 E-03
1984	4.6 E-01	8.1 E-02	9.0 E-02	NR	1.3 E-03
1985	1.4 E+00	5.1 E-02	1.6 E-01	NR	8.7 E-04
1986	9.5 E-01	2.2 E-01	7.9 E-01	NR	1.1 E-03
1987	7.0 E-01	2.6 E-01	9.4 E-02	1.3 E-04	5.7 E-04
1988	8.0 E-01	2.5 E-01	1.6 E-01	1.7 E-04	6.6 E-04
1989	3.2 E-01	6.8 E-02	1.5 E-01	1.1 E-04	8.7 E-04
1990	1.1 E-01	9.3 E-03	3.6 E-02	-9.6 E-05	1.7 E-04
1991	1.3 E-01	9.4 E-03	3.4 E-03	1.6 E-04	2.5 E-03
1992	5.6 E-02	5.6 E-02	7.8 E-02	-5.2 E-06	1.3 E-04
1993	1.0 E-01	3.6 E-02	6.5 E-02	-5.2 E-05	3.3 E-04
1994	6.5 E+00	2.5 E+01	5.8 E-01	8.6 E-03	5.3 E-02
1995	3.0 E-02	5.4 E+00	8.1 E-02	6.8 E-04	3.3 E-03

NR = Not reported.

Negative value indicates results at or below background levels of radioactivity.

Vegetation samples collected along the 100-N Area shoreline (N Springs) contain radionuclides that were not completely retained in the soil columns beneath the 1301-N/1325-N LWDFs. Biotransport via root uptake of ⁶⁰Co, ⁹⁰Sr, and ¹³⁷Cs was evident in the reed canary grass samples collected from this region. Most notable were the average levels of ⁹⁰Sr, which exhibited concentrations up to three orders of magnitude higher than the offsite average. Average radionuclide concentrations detected in the vegetation samples collected along the N Springs from 1980 through 1995 are presented in Table 4-8.

Table 4-8. Radionuclide Concentrations Detected in N Springs Vegetation Samples from 1980 to 1995 (pCi/g).

Year	⁶⁰ Co	⁹⁰ Sr	¹³⁷ Cs	²³⁸ Pu	^{239,240} Pu
1980	5.6 E+00	NR	4.4 E-01	NR	NR
1981	3.3 E+00	2.0 E+02	NR	NR	3.7 E-03
1982	2.8 E+00	4.8 E+02	NR	NR	8.3 E-03
1983	3.0 E+00	3.3 E+02	4.0 E-02	NR	8.0 E-03
1984	NS	NS	NS	NS	NS
1985	1.2 E+00	4.2 E+02	1.7 E-01	NR	4.4 E-04
1986	1.1 E+00	2.2 E+02	2.1 E-01	NR	4.2 E-04
1987	9.0 E-01	2.9 E+02	1.1 E-01	-1.3 E-04	7.6 E-04
1988	1.4 E+00	1.2 E+02	2.0 E-01	8.5 E-05	2.0 E-04
1989	4.3 E-01	8.0 E+01	1.5 E-01	1.1 E-03	4.5 E-04
1990	NS	NS	NS	NS	NS
1991	1.5 E-01	3.1 E+01	1.6 E-01	1.2 E-04	2.9 E-03
1992	4.2 E-02	7.8 E+01	3.0 E-01	1.5 E-04	2.9 E-04
1993	4.5 E-01	2.6 E+02	2.0 E-01	2.3 E-03	-8.5 E-04
1994	1.4 E-01	6.0 E+01	1.5 E-01	3.6 E-04	2.0 E-03
1995	1.4 E-02	1.3 E+01	9.4 E-02	5.9 E-04	2.8 E-03

NR = Not reported.

NS = No sample results.

Negative value indicates results at or below background levels of radioactivity.

4.3.1.1 ⁶⁰Co. The highest ⁶⁰Co result was found at Site Y711, located near the 1325-N LWDF. The ⁶⁰Co concentration was 2.4 E-01 ± 79% pCi/g. The distant community average for ⁶⁰Co was not reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ⁶⁰Co in vegetation in the 100-N Area was 3.0 E-02 ± 170% pCi/g.

4.3.1.2 ¹³⁷Cs. The highest ¹³⁷Cs result was found at Site Y704, located near the 1301-N LWDF. The ¹³⁷Cs concentration was 3.3 E-01 ± 57% pCi/g. The distant community average concentration for ¹³⁷Cs was not reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ¹³⁷Cs in vegetation in the 100-N Area was 8.1 E-02 ± 54% pCi/g.

4.3.1.3 ⁹⁰Sr. The highest ⁹⁰Sr result was found at Site Y721, located along the N Springs shoreline area. The ⁹⁰Sr concentration was 3.6 E+01 ± 19% pCi/g, or 2,250 times the distant community measured concentration of 1.6 E-02 ± 19% pCi/g reported in the *Hanford Site Environmental Report for*

Calendar Year 1994 (Dirkes and Hanf 1995). The average concentration of ^{90}Sr in vegetation in the 100-N Area was $5.4 \text{ E}+00 \pm 89\% \text{ pCi/g}$.

4.3.1.4 $^{239, 240}\text{Pu}$. The highest $^{239, 240}\text{Pu}$ result was found at Site Y703, located near the 1301-N LWDF. The $^{239, 240}\text{Pu}$ concentration was $1.2 \text{ E}-02 \pm 18\% \text{ pCi/g}$, or 66 times greater than the distant community measured concentration of $1.8 \text{ E}-04 \pm 72\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of $^{239, 240}\text{Pu}$ in vegetation in the 100-N Area was $3.3 \text{ E}-03 \pm 48\% \text{ pCi/g}$.

4.3.1.5 Uranium. The highest total uranium was found at Site Y724, located along the N Springs shoreline area. The uranium concentrations were $4.7 \text{ E}-02 \pm 18\% \text{ pCi/g}$ for ^{238}U , $2.5 \text{ E}-03 \pm 72\% \text{ pCi/g}$ for ^{235}U , and $3.3 \text{ E}-02 \pm 20\% \text{ pCi/g}$ for ^{238}U or $8.3 \text{ E}-02 \text{ pCi/g}$ uranium total. The concentration of ^{238}U was 9 times the distant community concentration of $9.0 \text{ E}-03 \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The concentration of ^{235}U was not reported by PNNL. The average concentration for total uranium in vegetation in the 100-N Area was $6.8 \text{ E}-03 \pm 44\% \text{ pCi/g}$.

4.3.1.6 Comparisons. The maximum, average, and distant community radionuclide concentration and accessible soil concentration limits are compared in Table 4-9.

4.3.2 200/600 Areas

In 1995, 50 vegetation samples were collected. Radionuclide concentrations for all sites sampled are listed in Table E-5 (Appendix E). The following sections provide more detailed discussions of the highest results for specific radionuclides.

4.3.2.1 ^{60}Co . The highest ^{60}Co result above the counting error was found at Site V087, located north of the 216-B-3 Pond. The ^{60}Co concentration was $1.6 \text{ E}-01 \pm 74\% \text{ pCi/g}$. The distant community concentration of ^{60}Co was not reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{60}Co in vegetation in the 200 Areas was $1.4 \text{ E}-02 \pm 150\% \text{ pCi/g}$.

4.3.2.2 ^{137}Cs . The highest ^{137}Cs result was found at Site V025, located near the headend of the 216-T-1 Ditch. The ^{137}Cs concentration was $3.3 \text{ E}+00 \pm 58\% \text{ pCi/g}$. The distant community measured concentration of ^{137}Cs was not reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{137}Cs in vegetation in the 200 Areas was $1.6 \text{ E}-01 \pm 85\% \text{ pCi/g}$.

4.3.2.3 ^{90}Sr . The highest ^{90}Sr result was found at Site V063, located east of the 218-C-9 Trench. The ^{90}Sr concentration was $1.4 \text{ E}+01 \pm 18\% \text{ pCi/g}$, or 875 times the distant community measured concentration of $1.6 \text{ E}-02 \pm 19\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{90}Sr in vegetation in the 200 Areas was $1.4 \text{ E}-02 \pm 151\% \text{ pCi/g}$.

4.3.2.4 $^{239, 240}\text{Pu}$. The highest $^{239, 240}\text{Pu}$ result was found at Site V033, located east of the 241-U Tank Farm. The $^{239, 240}\text{Pu}$ concentration was $5.9 \text{ E-02} \pm 15\% \text{ pCi/g}$, or 327 times the distant community measured concentration of $1.8 \text{ E-04} \pm 72\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of $^{239, 240}\text{Pu}$ in vegetation in the 200 Areas was $4.9 \text{ E-03} \pm 61\% \text{ pCi/g}$.

4.3.2.5 Uranium. The highest total uranium result was found at Site V007, located north of the 216-Z-12 Crib. The uranium concentrations were $8.5 \text{ E-02} \pm 18\% \text{ pCi/g}$ for ^{234}U , $5.9 \text{ E-03} \pm 56\% \text{ pCi/g}$ for ^{235}U , and $9.2 \text{ E-02} \pm 18\% \text{ pCi/g}$ for ^{238}U or 1.8 E-01 pCi/g total uranium. The total isotopic uranium concentration was 20 times the distant community measured concentration of 9.0 E-03 pCi/g reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The concentration of ^{235}U was not reported. The average concentration of total uranium in vegetation in the 200 Areas was 1.1 E-02 pCi/g .

4.3.2.6 Comparisons. The maximum, average, and distant community radionuclide concentrations and accessible soil concentration limits are compared for 200 Areas vegetation in Table 4-10.

4.3.3 300/400 Areas

This was the fifth year of sampling from locations established to more directly monitor facilities and active/inactive waste sites. In 1995, 16 vegetation samples were collected from 14 locations in the 300 Area and one in the 400 Area. Radionuclide concentrations for all sites sampled are listed in Appendix E, Table E-6. The following sections provide more detailed discussions of the highest results for specific radionuclides.

4.3.3.1 ^{60}Co . The highest ^{60}Co result was found at Site V129, located northwest of the 618-13 Burial Ground. The ^{60}Co concentration was $1.7 \text{ E-01} \pm 56\% \text{ pCi/g}$. The distant community measured concentration for ^{60}Co was not reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{60}Co in vegetation in the 300/400 Areas was $4.0 \text{ E-02} \pm 84\% \text{ pCi/g}$.

4.3.3.2 ^{137}Cs . The highest ^{137}Cs result, $3.3 \text{ E+00} \pm 58\%$, was found at Site V130, located near the 400 Area Process Pond. The ^{137}Cs concentration was not reported for the distant community in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{137}Cs in vegetation in the 300/400 Areas was $-6.6 \text{ E-04} \pm 5,000\% \text{ pCi/g}$.

4.3.3.3 ^{90}Sr . The highest ^{90}Sr result was found at Site V122, located south of the 316-1 Process Pond. The ^{90}Sr concentration was $2.0 \text{ E-01} \pm 27\% \text{ pCi/g}$, or 12 times the distant community measured concentration of $1.6 \text{ E-02} \pm 19\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of ^{90}Sr in vegetation in the 300/400 Areas was $5.1 \text{ E-02} \pm 48\% \text{ pCi/g}$.

Table 4-9. Radionuclide Concentrations in 100-N Area Vegetation (pCi/g).

	^{60}Co	^{137}Cs	^{90}Sr	$^{239}, ^{240}\text{Pu}$	^{234}U	^{235}U	^{238}U
Maximum ± Counting Error (%)	Site 711	Site 704	Site 721	Site 703	Site 724	Site 724	Site 723
	2.4 E-01 ± 7%	3.3 E-01 ± 57%	3.6 E+01 ± 19%	1.2 E-02 ± 18%	4.7 E-02 ± 18%	2.5 E-03 ± 72%	3.5 E-02 ± 20%
Average ± 2SEM (%)	3.0 E-02 ± 170%	8.1 E-02 ± 54%	5.4 E+00 ± 89%	3.3 E-03 ± 48%	1.1 E-02 ± 60%	2.5 E-04 ± 154%	9.2 E-03 ± 52%
PNHL Distant Community Average ± 2SEM (%)*	NR	NR	1.6 E-02 ± 19%	1.8 E-04 ± 72%	3.9 E-03 ± 99%	NR	5.1 E-03 ± 60%
Accessible soil concentration limits	7.1 E+00	3.0 E+01	2.8 E+03	1.9 E+02	6.3 E+02	1.7 E+02	3.7 E+02

2SEM = 2 standard error of the mean. NR = Not reported. *Dirkes and Hanf 1996

Table 4-10. 200 Areas Vegetation (pCi/g).

	^{60}Co	^{137}Cs	^{90}Sr	$^{239}, ^{240}\text{Pu}$	^{234}U	^{235}U	^{238}U
Maximum ± Counting Error (%)	Site V087	Site V025	Site V063	Site V033	Site V077	Site V007	Site V007
	1.6 E-01 ± 74%	3.3 E+00 ± 58%	1.4 E+01 ± 18%	5.9 E-02 ± 15%	1.4 E-01 ± 80%	5.9 E-03 ± 56%	9.2 E-02 ± 18%
Average ± 2SEM (%)	1.4 E-02 ± 150%	1.6 E-01 ± 85%	1.4 E-02 ± 151%	4.9 E-03 ± 61%	1.1 E-02 ± 57%	6.7 E-05 ± 917%	7.9 E-03 ± 56%
PNHL Distant Community Average ± 2SEM (%)*	NR	NR	1.6 E-02 ± 19%	1.8 E-04 ± 72%	3.9 E-03 ± 99%	NR	5.1 E-03 ± 60%
Accessible soil concentration limits	7.1 E+00	3.0 E+01	2.8 E+03	1.9 E+02	6.3 E+02	1.7 E+02	3.7 E+02

2SEM = 2 standard error of the mean. NR = Not reported. *Dirkes and Hanf 1996

4.3.3.4 $^{239}, ^{240}\text{Pu}$. The highest $^{239}, ^{240}\text{Pu}$ result was found at Site V122, located near the south corner of the 316-3 Process Pond. The $^{239}, ^{240}\text{Pu}$ concentration was $1.4 \text{ E-}03 \pm 62\% \text{ pCi/g}$, or 8 times the distant community measured concentration of $1.8 \text{ E-}04 \pm 72\% \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The average concentration of $^{239}, ^{240}\text{Pu}$ in vegetation in the 300/400 Areas was $3.5 \text{ E-}04 \pm 54\% \text{ pCi/g}$.

4.3.3.5 Uranium. The highest uranium result was found at Site V119, located near the northeast corner of the 316-2 Process Pond. The uranium concentrations were $2.8 \text{ E-}01 \pm 12\% \text{ pCi/g}$ of ^{238}U , $4.8 \text{ E-}01 \pm 21\% \text{ pCi/g}$ of ^{235}U , and $2.7 \text{ E-}01 \pm 13\% \text{ pCi/g}$ of ^{238}U or $1.0 \text{ E+}00 \text{ pCi/g}$ total isotopic uranium. The total isotopic uranium concentration was 111 times the distant community measured concentration of $9.0 \text{ E-}03 \text{ pCi/g}$ reported in the *Hanford Site Environmental Report for Calendar Year 1994* (Dirkes and Hanf 1995). The concentration of ^{235}U was not reported. The average concentration of total uranium in vegetation in the 300/400 Areas was $1.1 \text{ E-}01 \text{ pCi/g}$.

4.3.3.6 Comparisons. The maximum, average, and distant community radionuclide concentration and the accessible soil standards are compared for 300/400 Areas vegetation in Table 4-11.

4.4 CONCLUSIONS

The impact of past and current operations on the near-field environment, although above the concentrations in distant communities reported by PNNL, were below the accessible soil concentration limits (Appendix J, Table J-4). Trending of the average concentrations, contained in the summary (Figures S-2 and S-3), indicate the decrease in concentrations of certain radionuclides.

As the data show, the concentrations have a large degree of variance. In general, the samples collected on, or directly adjacent to, the waste disposal facilities had higher concentrations of radionuclides than those further away. The data also show, as expected, that certain radionuclides had higher concentrations within different operating areas. Generally speaking, the predominant radionuclides are: activation and fission products in the 100 Areas, fission products and plutonium in the 200 Areas, and uranium in the 300 Areas. Facility monitoring sites are selected to maximize detection of radionuclides in the near-facility environment and the results do not necessarily represent the entire operating area.

Table 4-11. 300/400 Areas Vegetation (pCi/g).

	⁶⁰ Co	¹³⁷ Cs	⁹⁰ Sr	²³⁹ , ²⁴⁰ Pu	²³⁴ U	²³⁵ U	²³⁸ U
Maximum ± Counting Error(%)	Site V129 1.7 E-01 ± 56%	Site V130 1.4 E-01 ± 69%	Site V122 2.0 E-01 ± 27%	Site V122 1.4 E-03 ± 52%	Site V122 2.8 E-01 ± 12%	Site V119 4.9 E-01 ± 21%	Site V119 2.7 E-01 ± 13%
Average ± 2SEM(%)	4.0 E-02 ± 84%	-6.6 E-4 ± 5000%	5.1 E-02 ± 48%	3.5 E-04 ± 54%	5.5 E-02 ± 74%	2.1 E-03 ± 77%	5.5 E-02 ± 74%
PNL distant community measured Average ± 2SEM(%)*	NR	NR	1.5 E-02 ± 19%	1.8 E-04 ± 72%	3.9 E-03 ± 99%	NR	5.1 E-03 ± 60%
Accessible soil concentration limits	7.1 E+00	3.0 E+01	2.8 E+03	1.9 E+02	6.3 E+02	1.7 E+02	3.7 E+02

2SEM = 2 standard error of the mean.

NR = Not reported.

*Dikes and Hamf 1986

5.0 EXTERNAL RADIATION MONITORING

5.1 INTRODUCTION

A network of thermoluminescent dosimeters (TLDs) was positioned in and around the 100, 200, and 300/400 Areas to monitor dose rates from external radiation sources (primarily gamma rays). The TLD measurements were taken to determine dose rates in the operations area environment. From these data, the contribution of Hanford Site activities to the dose rates in these areas can be discerned. Figures showing these sites and the TLD results can be found in Appendix F.

The environmental TLDs measure dose rates from all types of external radiation sources. These include cosmic radiation, naturally occurring radioactivity in air and soil, and fallout from nuclear weapons testing, as well as any contribution from Hanford Site activities. These outside radiation sources cause an expected ± 20 -percent deviation in TLD analyses. The results are reported in units of millirems per year (mrem/yr).

The new Harshaw TLD system was implemented at the Hanford Site in 1995. The system uses the Harshaw 8807 dosimeter and the Harshaw 8800 TLD reader. The new system may have attributed to the decrease of up to 65% in TLD analyses results. Pacific Northwest National Laboratories reported this system to be more efficient than the old Hanford system. Table 5-1 displays the results of an environmental colocation study performed by PNNL before the Harshaw system was issued (Endres 1995). The TLD reader has a better signal-to-noise ratio. The new TLD packaging, which uses an "O ring" seal, better protects the TLDs from light, heat, moisture, and dirt. The TLDs were placed 1 m (3 ft) above ground at each location. The TLDs were placed near active and inactive surface-water disposal sites, and near facilities (tank farms, active cribs, and the facility fence line). Changing conditions in the vicinity of the TLD sample locations, such as remediation activities, removal, or storage of radioactive material, and tank farm operations may also cause fluctuations in TLD analyses over time. The TLDs were exchanged and analyzed each calendar quarter. The PNL Radiation Calibration Laboratory has calibrated the response of the chips; results were reported in terms of external dose (mrem).

5.2 RESULTS

5.2.1 100 Area

5.2.1.1 100-N. The 1995 TLD results indicate that the DOE exposure guidelines for nonradiation area workers (100 mrem/yr) were not exceeded in any nonradiologically controlled area except near the N Springs shoreline. Reasons for this elevated radiation level are discussed later in this section. The overall trend is that dose rates at most locations continue to decrease.

Direct radiation levels were predictably higher near facilities that had contained or received liquid effluents from N Reactor or where mixed (radiological and hazardous) waste was stored. These facilities included the

Table 5-1. Results of Environmental TLD Colocation Study Performed by PNNL.

Colocation Study Monthly Results						
Location	Month	mR/day (8807)	2SD/day (8807)	mR/day (old system)	2SD/day (old system)	% Difference
267	July	0.49	0.068	0.53	0.128	-7.55
	August	0.53	0.032	0.63	0.149	-15.87
	September	0.53	0.039	0.59	0.110	-10.17
	October	0.53	0.000	0.65	0.264	-18.46
	November	0.50	0.028	0.51	0.077	-1.96
	December	0.50	0.040	0.62	0.279	-19.35
271	July	0.38	0.068	0.41	0.092	-7.32
	August	0.41	0.056	0.51	0.151	-19.61
	September	0.40	0.039	0.44	0.181	-9.09
	October	0.38	0.000	0.48	0.242	-20.83
	November	0.34	0.028	0.37	0.062	-8.11
	December	0.35	0.000	0.49	0.266	-28.57
272	July	0.36	0.034	0.38	0.047	-5.26
	August	0.38	0.032	0.49	0.136	-22.45
	September	0.38	0.000	0.39	0.077	-2.56
	October	0.38	0.000	0.54	0.177	-29.63
	November	0.34	0.048	0.38	0.047	-10.53
	December	0.35	0.000	0.50	0.263	-30.00
Colocation Study Quarterly Results						
Location	Month	mR/day (8807)	2SD/day (8807)	mR/day (old system)	2SD/day (old system)	% difference
200	September	0.22	0.020	0.27	0.043	-18.52
	December	0.20	0.014	0.28	0.076	-28.57
476	September	0.20	0.012	0.26	0.031	-23.00
	December	0.21	0.000	0.30	0.080	-30.00
562	September	0.32	0.012	0.37	0.079	-13.51
	December	0.34	0.013	0.34	0.049	0.00
603	September	0.23	0.050	0.32	0.088	-28.13
	December	0.22	0.012	0.25	0.117	-12.00
480	September	0.22	0.000	0.34	0.102	-35.29
	December	0.24	0.012	0.29	0.072	-17.24
166	September	0.24	0.000	0.35	0.082	-31.43
	December	0.26	0.012	0.27	0.044	-3.70

1301-N LWDF, the 1325-N LWDF, the 1304-N Emergency Dump Tank, and 116-N-8 (the 163-N Mixed Waste and Hazardous Waste Container Storage Pad).

Dose rates measured near the 1301-N LWDF in 1995 showed an annual average decrease of approximately 18 percent from 1994 levels. This decline represents a continuing trend of decreased dose rates at this facility, primarily caused by the decay of ^{60}Co (5.3-year half life).

The average environmental dose rates measured near the 1325-N LWDF in 1995 were approximately 22 percent lower than those measured in 1994. All four TLD sites at this facility showed decreases in 1995. This decline represents a trend of decreased dose rates at this facility, similar to that of the 1301-N LWDF, primarily caused by the decay of ^{60}Co .

Dose rates were measured at the N Springs shoreline to determine potential external radiation doses to the public as well as to a Hanford Site worker. Because of the "skyshine" effect from the 1301-N LWDF, dose rates at the N Springs were elevated above 100 mrem/year, the DOE annual external dose limit to members of the public. However, neither a member of the public nor a Hanford worker would conceivably spend an entire year at the N Springs; therefore, the values shown in Figure 5-1 are for comparison only. N Springs dose reduction measures are currently being studied.

Two projects performed by the ERC had a noticeable impact on radiation dose rates in the 100-N Area in 1995. Irradiated fuel spacers were removed from the 1303-N Spacer Silo between August 8 and August 31, 1995. Dose rates measured at TLD locations 6, 7, 16, 28, and 29, near the 105-N Reactor building were significantly elevated during this period. The maximum exposure rate recorded was 0.55 mrem/hour at location 28. Fourth quarter results for these locations showed an overall decrease in dose rate compared to those measured before the project.

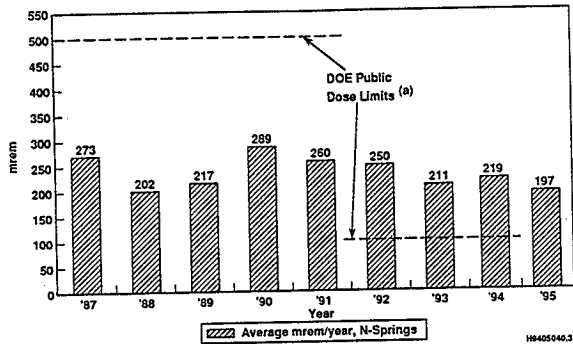
Also, during August and September, removal of the source term that was previously present in the 1304-N EDT occurred. Dose rates measured at Sites 7 and 29 in 1995 were approximately 22 percent lower than 1994. The overall effect of these two clean-up projects around the 105-N was to lower dose rates to a level below those measured before the project began.

Measurements obtained from TLD Site 18 showed a marked increase during the fourth quarter of 1995. This TLD site is near the 1310-N Radioactive Waste Storage Pad, which received the material that was removed from the 1304-N Emergency Dump Tank. The overall effect was an annual average increase of approximately 15 percent over the dose rate measured in 1994.

The TLD measurements from the 100-N Area for 1987 through 1995 are summarized in Figure 5-2; they are compared for 1994 and 1995 in Table 5-2.

5.2.1.2 100-K Area. This is the third year of external radiation monitoring at the 100-K Area. Dose rates observed were generally at typical Hanford Site background levels with a few exceptions. Sites K-9 and K-10 are adjacent to a radioactive rail car storage area and radioactive waste storage area, respectively. Site K-8 is also near the rail cars, though farther away. All three sites continue to show elevated readings, as expected. It is also of interest to note that sites K-3 and K-4 show slightly elevated readings in the

Figure 5-1. Annual Average Dose Rate at N Springs.



(a) DOE Limits were reduced from 500 mrem/yr to 100 mrem/yr in 1992. The lower value was selected in recognition of the International Commission of Radiation Protection (ICRP) recommendation to limit the long term average effective dose equivalent to 100 mrem (1mSv) per year or less. (DOE 5400.5)

Figure 5-2. Comparison of TLD Results at 100-N Area.

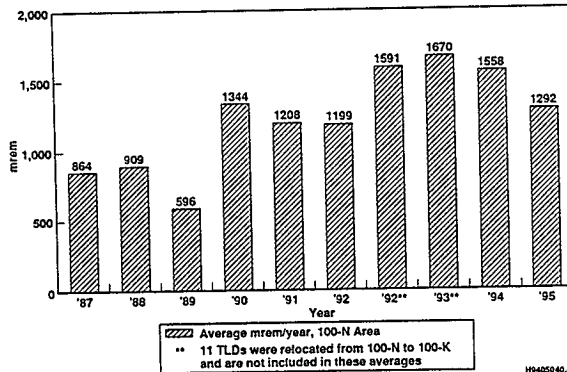


Table 5-2. 100 Areas Thermoluminescent Dosimeter Exposure Results
(mrem/yr).

100 N Area Site I.D.	1994 average	1995 average	95 vs 94 % Change
1	1121	924	-18%
2	1076	921	-14%
3	469	414	-12%
4	1902	1565	-18%
5	677	594	-12%
6	285	298	5%
7	1025	756	-26%
8	109	101	-8%
10	101	92	-9%
12	125	94	-25%
13	179	156	-13%
14	458	371	-19%
15	855	710	-17%
16	294	577	97%
17	503	196	-61%
18	453	520	15%
22	599	475	-21%
26	255	228	-11%
28	264	1380	423%
29	1635	1357	-17%
30	6943	5756	-17%
31	480	426	-11%
32	346	76	-78%
33	325	228	-30%
34	13055	9926	-24%
35	13122	10100	-23%
36	410	353	-14%
37	415	361	-13%
38	191	151	-21%
41	369	341	-8%
average	1.6 E+03	1.3 E+03	-17%

1301-N Site I.D.	95 vs 94 % Change
1	-18%
2	-14%
3	-12%
4	-18%
5	-12%
6	5%
15	-17%
18	15%
22	-21%
32	-78%
33	-30%
average	-18%

1325-N Site I.D.	95 vs 94 % Change
30	-17
34	-24
35	-23
36	-14
average	-19

fourth quarter only. These are attributed to the staging of rail cars and rail-car shipments of fuel from PUREX into 105-K West during this time.

For trending purposes, results were compared to the 1993 through 1994 averages at each site, as shown in Table 5-2. The largest increases were at sites K-3 and K-4 as explained in the previous paragraph. The largest decrease is at site K-10 and can be related to changes to the waste storage configuration near this TLD at 105-K East.

5.2.2 200 Areas

The 1995 TLD results for the 200 Areas indicated that the DOE exposure guidelines for nonradiation area workers (100 mrem/year) were not exceeded in any nonradiologically controlled areas. Figure 5-3 compares the external radiation monitoring results for 1991 through 1995.

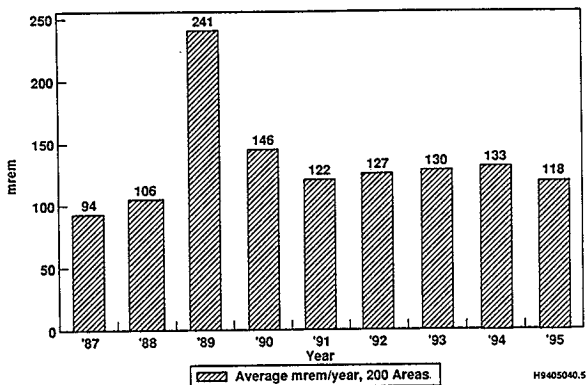
Three new TLD locations were established in 1995 to better evaluate the exposure in areas around the Central Waste Complex (CWC), the Solid Waste Operations Complex (SWOC), and the Waste Receiving and Packaging Complex (WRAP). Table 5-3 compares the results of the 60 TLD sites that remained the same for 1994 and 1995. Results indicated that operations in the 200 Areas did not contribute significantly to the external radiation dose rates of the general environment. The overall annual dose rate in the 200 Areas showed a 10 percent decrease from 1994 to 1995. Consequently, the exposure rate in the general 200 Areas environment was not significantly different from the exposure rate received off site from natural radiation sources. As expected, external radiation levels were elevated at certain sites, radiological control areas, and facilities, reflecting the proximity to radioactive waste management activities (e.g., Site 249 and 254 near the 241-C Tank Farm). TLDs are positioned to measure facilities of higher impact, as was the case in 1989, when the average annual dose rate increased from 106 to 241 mrem per year. TLDs were removed from the grid configuration, where many were located in remote areas, to a configuration closer to operations facilities (Figure 5-1).

5.2.3 300/300 TEDF/400 Areas

This was the fourth year of external radiation monitoring in the 300/400 Areas and the second year of external radiation monitoring at the 300 Treated Effluent Disposal Facility (TEDF). Figure 5-4 compares the external radiation monitoring results for 1991 through 1995. The 1995 TLD results for the 300/400 Areas indicate that the DOE exposure guidelines were not exceeded in any nonradiologically controlled area.

Comparing the results of external monitoring for 1995 and 1994 indicates that the 300/400 Areas did not contribute significantly to the external radiation dose rates of the general environment, as shown in Table 5-4. Consequently, the dose rate in the general 300/400 Areas environment was not significantly different from the dose rate received off site from natural radiation sources. The overall annual dose rate in the 300, 300 TEDF, 400 Areas showed a 20 percent decrease from 1994 to 1995. This significant decrease is attributable to the new Harshaw TLD system, rather than changes in

Figure 5-3. Comparison of TLD Results at the 200 Areas



Note: TLD results indicated on this chart are a result of all TLDs, including those that were relocated or added to the network.

Figure 5-4. Comparison of TLD Results at the 300/300 TEDF/400 Areas.

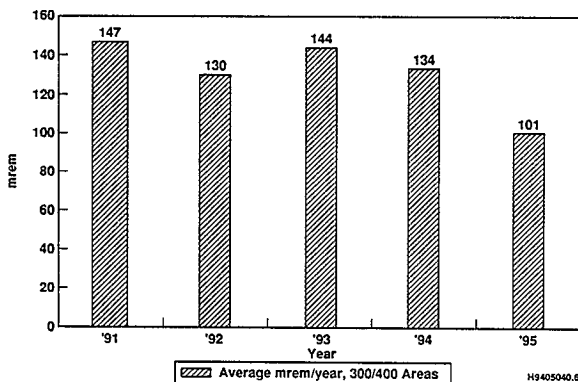


Table 5-3. 200 Area Thermoluminescent Dosimeter Comparisons
for 1994 and 1995 (mrem/yr). (3 sheets)

Site I.D.	1994 Average	1995 Average	95 vs 94 % Change
202	1.0 E+02	8.7 E+01	-13.9
203	1.0 E+02	9.0 E+01	-11.8
204	1.7 E+02	1.4 E+02	-16.5
205	9.6 E+01	8.2 E+01	-14.1
206	1.4 E+02	1.2 E+02	-13.2
207	1.2 E+02	9.5 E+01	-17.8
208	1.8 E+02	1.6 E+02	-11.0
209	9.8 E+01	8.3 E+01	-15.5
210	1.2 E+02	9.8 E+01	-17.8
211	9.8 E+01	8.7 E+01	-11.7
212	1.4 E+02	1.2 E+02	-14.5
213	2.1 E+02	2.0 E+02	-5.8
214	9.2 E+01	7.8 E+01	-14.9
215	1.1 E+02	9.0 E+01	-14.4
216	1.1 E+02	9.7 E+01	-13.0
217	9.2 E+01	8.3 E+01	-9.6
218	9.3 E+01	7.7 E+01	-17.6
219	1.0 E+02	9.2 E+01	-10.6
220	1.1 E+02	9.2 E+01	-14.2
221	1.1 E+02	8.7 E+01	-22.1
222	1.3 E+02	1.1 E+02	-14.5
223	1.6 E+02	1.4 E+02	-14.0
224	9.4 E+01	8.1 E+01	-13.1
226	8.0 E+01	8.3 E+01	4.0
227	9.5 E+01	8.0 E+01	-16.3
228	9.3 E+01	8.2 E+01	-11.1
229	1.0 E+02	9.2 E+01	-11.3
230	1.3 E+02	1.2 E+02	-6.6
231	1.1 E+02	9.0 E+01	-20.4
232	1.3 E+02	1.3 E+02	-0.3

Table 5-3. 200 Area Thermoluminescent Dosimeter Comparisons for 1994 and 1995 (mrem/yr). (3 sheets)

Site I.D.	1994 Average	1995 Average	95 vs 94 % Change
233	1.1 E+02	8.7 E+01	-22.6
234	1.2 E+02	1.2 E+02	0.7
235	1.1 E+02	6.1 E+01	-43.7
236	1.1 E+02	9.6 E+01	-10.3
237	9.8 E+01	7.7 E+01	-21.7
238	1.1 E+02	8.8 E+01	-20.8
239	1.1 E+02	8.7 E+01	-20.0
240	1.0 E+02	7.8 E+01	-24.2
241	1.1 E+02	9.6 E+01	-14.1
242	1.1 E+02	8.7 E+01	-22.8
243	1.0 E+02	8.0 E+01	-20.2
244	1.2 E+02	1.1 E+02	-3.3
245	1.0 E+02	8.2 E+01	-19.9
246	9.6 E+01	8.2 E+01	-14.5
247	1.0 E+02	8.2 E+01	-17.9
249	1.0 E+02	1.5 E+02	41.7
250	1.5 E+02	1.3 E+02	-12.1
251	1.5 E+02	1.8 E+02	18.3
252	1.3 E+02	1.4 E+02	2.0
253	1.0 E+02	1.0 E+02	1.7
254	1.8 E+02	2.8 E+02	53.2
255	1.4 E+02	1.2 E+02	-17.2
256	5.1 E+02	4.4 E+02	-13.7
258	7.7 E+02	7.0 E+02	-9.8
259	1.3 E+02	1.8 E+02	37.0
260	1.0 E+02	7.9 E+01	-23.2
261	1.1 E+02	1.0 E+02	-6.7
262	1.0 E+02	8.2 E+01	-18.1
263	8.3 E+01	7.6 E+01	-8.4
264	9.6 E+01	8.2 E+01	-14.5

Table 5-3. 200 Area Thermoluminescent Dosimeter Comparisons
for 1994 and 1995 (mrem/yr). (3 sheets)

Site I.D.	1994 Average	1995 Average	95 vs 94 % Change
All	1.3 E+02	1.2 E+02	-9.7

Note: Comparisons include the 60 TLD locations that remained unchanged between 1994 and 1995.

Table 5-4. 300/300 TEDF/400 Areas Thermoluminescent Dosimeter Comparisons for 1994 and 1995 (mrem/yr).

Site I.D. 300 Area	1994 Average	1995 Average	95 vs 94 % Change
1	9.1 E+01	8.0 E+01	-12.3
2	9.4 E+01	8.6 E+01	-8.5
3	1.0 E+02	8.5 E+01	-15.4
4	1.8 E+02	2.4 E+02	34.3
5	9.1 E+01	8.1 E+01	-10.9
6	1.1 E+02	9.6 E+01	-14.8
7	5.4 E+02	3.1 E+02	-42.1
8	1.4 E+02	1.3 E+02	-5.0
All	1.7 E+02	1.4 E+02	-9.3
Site I.D. TEDF (300 Area)	1994 Average	1995 Average	95 vs 94 % Change
301	1.0 E+02	8.1 E+01	-22.2
302	1.1 E+02	7.8 E+01	-30.5
303	1.2 E+02	8.2 E+01	-29.8
304	1.1 E+02	7.9 E+01	-31.0
305	1.1 E+02	8.4 E+01	-24.3
306	1.1 E+02	7.9 E+01	-29.6
All	1.1 E+02	8.1 E+01	-27.9
Site I.D. 400 Area	1994 Average	1995 Average	95 vs 94 % Change
1	9.2 E+01	7.9 E+01	-13.8
2	2.1 E+02	7.4 E+01	-64.1
3	1.2 E+02	8.1 E+01	-30.7
4	9.0 E+01	7.6 E+01	-15.9
5	9.2 E+01	7.5 E+01	-19.1
6	9.5 E+01	7.8 E+01	-17.9
7	1.0 E+02	7.7 E+01	-23.3
All	1.1 E+02	7.7 E+01	-26.4

decrease is attributable to the new Harshaw TLD system, rather than changes in the environment (e.g., rail car movements) in the vicinity of the TLD location.

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6.0 SURFACE WATER DISPOSAL UNITS AND SEEPAGES

6.1 INTRODUCTION

Water, vegetation, and sediment samples were collected from the active ponds and ditches and the N Springs in 1995. Springs, ponds, and ditches in the 100, 200, and 300/400 Areas receive or have received waste water from the chemical and waste processing plants, reactors, and other facilities. All water was sampled at the point of discharge to ensure compliance with internal contractor standards and applicable DOE standards. As an additional operational check, the WHC OEMP collects water samples from the ponds and ditches. Sampling locations are shown in Appendix G.

One-liter water samples were collected weekly from the active ponds and ditches. The pH was determined each week, then the samples were composited and analyzed monthly for gamma-emitting radionuclides, ^{238}Pu , ^{239}Pu , ^{240}Pu , ^{90}Sr , and uranium. Each site has replicate samples collected for 1 month (4 weeks) on a rotating basis. In addition, a 1-L sample was collected quarterly from each site for nitrate and ^3H analyses. Samples of aquatic vegetation were collected from ponds and ditches yearly to determine root uptake of radionuclides from potentially contaminated sediments. Along with vegetation samples, surface sediment samples were collected at ponds and ditches to measure the accumulation of radionuclides. Surface sediment samples consisted of a composite of five plugs, each 10 cm (4 in.) in diameter by 2.5 cm (1 in.) deep. The vegetation and sediments were analyzed for gamma-emitting radionuclides, ^{90}Sr , ^{239}Pu , ^{240}Pu , and uranium.

6.2 RESULTS

6.2.1 Water

6.2.1.1 100 Areas. Seepage wells and groundwater seepages along the 100-N Area shoreline (N Springs) were sampled to verify that the reported radionuclide releases to the Columbia River via the N Springs were credible. Release reporting uses conservatively based radionuclide concentrations, multiplied by the estimated groundwater flow into the river. After characterizing the radionuclide concentrations in the seeps along the shoreline at the 100-N Area, the results can be compared to the radionuclide concentrations measured in effluent monitoring well 199-N-46. Historically, the highest concentrations of radionuclides have been shown to be in the area of the effluent monitoring well, and these biased concentrations were applied to the entire N Springs discharge region, thereby providing conservatively high release values.

With the shutdown of N Reactor in January 1987 and the resultant decreased effluent flow to the 1325-N LWDF, concentrations of most of the radionuclides that were typically present in the N Springs discharge during reactor operation have significantly decreased. The single exception to this was the value reported for ^{90}Sr .

The shoreline seepage well samples were collected using a bailer, carefully lowered into each well water column to avoid sediment suspension.

A 4-L sample was collected. Tables 6-1 and 6-2 represent the historic concentrations for tritium and ^{90}Sr from samples collected from the N Springs shoreline wells, including effluent monitoring well 199-N-46. Since 1993, ^{90}Sr concentrations have not exceeded the DOE DCG values in the sample locations in the vicinity of the effluent monitoring well. Because of river fluctuations and groundwater discharge rates, some wells may not have been sampled; results from those wells are not shown in Tables 6-1 and 6-2.

Samples were collected on September 27, 1995 (for sample locations, see Figure G-1). Five sampling locations (Wells 1, 2, 4, 5, and 13) were dry at the time of sample collection. This is attributable to the cessation of discharges to the 1325-N LWDF in 1991, and the return of the natural groundwater migration pattern at the N Springs. The results obtained from the eight wells that were sampled indicated that the seepage wells with the highest concentrations of ^{90}Sr , the primary radionuclide of concern, were near the effluent monitoring well, indicating that this well continues to monitor N Springs discharge in the region that provides conservatively high readings.

6.2.1.2 200 Area. Water samples were collected from five sample locations from active ponds and ditches located in the 200 Areas. Aquatic vegetation and surface sediment samples were collected from four active ponds and ditches located in the 200 Areas. The number of sample locations was reduced to two during 1995 because three liquid waste disposal units were remediated. The 216-B-3C Pond and the 200 East Area Powerhouse Ditch are the two remaining water discharge locations in the 200 Areas. Ponds and ditches in the 200 Areas receive waste water from the waste processing plants and other facilities. All water is sampled at the point of discharge to ensure compliance with applicable DOE standards. As an additional check, the OEMP collects water samples at the ponds and ditches used to dispose of this waste water.

Radioanalytical results from water sampling of ponds and ditches are summarized in Appendix G.

6.2.1.3 300/400 Areas. No surface water was sampled in the 300 Area. The 400 Area FFTF Process Pond is sampled by PNNL and the results are reported in the Hanford Site Environmental Report (Dirkes and Hanf 1996). The data are shared with WHC after they have been validated by PNNL. Total beta concentrations in the Fast Flux Test Facility (FFTF) pond water were within the range observed in previous years. The concentrations of ^3H were comparable to those measured in the FFTF pond in the past. However, the tritium concentration in the July sample was 16,400 pCi/L, which is much higher than that observed previously. During this time, backup water supply well 499-50-7 was in use. Tritium levels in Well 49-50-7 are typically above 20,000 pCi/L. The use of backup water supply well 499-50-7 is most likely responsible for the high levels of tritium observed in the 400 Area FFTF Pond in July because the primary source of water to FFTF Pond is sanitary water. For a more detailed discussion, see Section 4.2, "Surface Water and Sediment Surveillance," *Hanford Site Environmental Report Calendar Year 1995* (Dirkes and Hanf 1996).

Table 6-1. N Springs Shoreline Tritium Concentrations, 1987 to 1995 (pCi/L). (2 sheets)

Year	Site 1	Site 2	Effluent Monitoring Well	Site 3	Site 4	Site 5	Site 6
1987	6.8 E+04	7.6 E+04	9.5 E+04	9.2 E+04	9.4 E+04	8.8 E+04	7.9 E+04
1988	5.7 E+03	2.8 E+04	7.5 E+04	6.9 E+04	7.4 E+04	NR	NR
1989	2.5 E+04	2.8 E+04	3.9 E+04	3.6 E+04	5.0 E+04	NR	6.8 E+04
1990	2.9 E+04	3.2 E+04	3.8 E+04	3.6 E+04	NR	NR	3.4 E+03
1991	2.2 E+02	8.4 E+01	3.7 E+04	2.6 E+03	3.4 E+04	NR	4.0 E+02
1992	7.2 E+02	NR	5.0 E+04	9.5 E-01	NR	NR	1.5 E+02
1993	2.8 E+02	1.3 E+02	2.7 E+04	1.4 E+02	5.6 E+02	1.0 E+02	1.8 E+02
1994	NR	NR	2.6 E+04	4.0 E+01	NR	NR	1.2 E+02
1995	NR	NR	5.2 E+03	<-1.2 E+01	NR	NR	<-4.4 E+01

Table 6-1. N Springs Shoreline Tritium Concentrations, 1987 to 1995 (pCi/L). (2 sheets)

Year	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13
1987	7.3 E+04	4.6 E+04	7.5 E+04	4.0 E+03	5.8 E+04	2.1 E+04	1.3 E+03
1988	1.1 E+04	3.0 E+04	1.0 E+04	NR	2.9 E+04	1.9 E+04	3.0 E+03
1989	NR	7.7 E+04	7.0 E+04	3.5 E+04	4.2 E+04	NR	NR
1990	NR	1.4 E+04	3.5 E+03	9.7 E+03	3.8 E+04	2.0 E+04	NR
1991	8.1 E+02	2.1 E+03	6.5 E+03	7.9 E+02	7.1 E+02	2.4 E+03	9.3 E+00
1992	NR	NR	3.0 E+02	4.3 E+02	6.5 E+02	1.7 E+02	NR
1993	NR	NR	NR	NR	NR	NR	NR
1994	8.5 E+01	1.3 E+02	8.4 E+01	4.0 E+02	4.5 E+02	2.9 E+02	NR
1995	< -2.1 E+00	< -2.3 E+01	< -3.1 E+01	< -1.2 E+01	3.2 E+02	5.0 E+02	NR

NR = Not Reported

< = Analytical results were less than the overall counting error

Negative value indicates results at or near background levels of radioactivity.

Table 6-2. N Springs Shoreline ⁹⁰Sr Concentrations, 1987 to 1995 (pCi/L). (2 sheets)

Year	Site 1	Site 2	Effluent Monitoring Well	Site 3	Site 4	Site 5	Site 6
1987	1.7 E+03	2.7 E+03	6.1 E+03	8.3 E+03	4.1 E+03	9.5 E+02	7.2 E+02
1988	8.7 E+02	3.0 E+03	7.9 E+03	9.1 E+03	3.5 E+03	NR	NR
1989	9.8 E+02	2.1 E+03	6.5 E+03	5.4 E+03	3.8 E+03	NR	8.9 E+02
1990	2.4 E+03	2.9 E+03	4.9 E+03	7.1 E+03	NR	NR	1.5 E+02
1991	1.6 E+01	2.4 E+01	6.9 E+03	1.4 E+03	3.2 E+03	NR	8.6 E+01
1992	NR	NR	6.3 E+03	1.5 E+02	NR	NR	9.6 E+00
1993	1.2 E+01	8.3 E+01	7.4 E+03	1.2 E+02	4.1 E+03	4.1 E+01	1.3 E+01
1994	NR	NR	6.6 E+03	1.2 E+02	NR	NR	6.4 E+00
1995	NR	NR	NR	3.0 E+02	NR	NR	7.0 E+00

Table 6-2. N Springs Shoreline ⁹⁰Sr Concentrations, 1987 to 1995 (pCi/L). (2 sheets)

Year	Site 1	Site 2	Effluent Monitoring Well	Site 3	Site 4	Site 5	Site 6
Year	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13
1987	1.3 E+01	4.2 E+01	2.4 E+02	5.7 E+01	6.6 E+02	5.8 E+01	5.0 E+01
1988	1.5 E+01	3.2 E+01	4.1 E+01	NR	3.4 E+02	4.0 E+01	5.8 E+01
1989	NR	7.8 E+01	2.9 E+02	1.6 E+02	9.5 E+02	NR	NR
1990	NR	9.0 E+01	4.4 E+01	3.1 E+01	5.8 E+02	5.4 E+01	NR
1991	1.4 E+01	2.8 E+01	1.0 E+02	1.5 E+01	4.0 E+02	8.9 E+00	8.1 E+00
1992	NR	NR	8.1 E+00	6.7 E+00	1.1 E+02	7.1 E+00	NR
1993	NR	NR	NR	NR	NR	NR	NR
1994	3.8 E+00	1.2 E+01	3.4 E+00	3.8 E+00	5.1 E+01	1.8 E+01	NR
1995	3.8 E+00	1.4 E+01	5.5 E+00	7.0 E+00	7.1 E+01	1.9 E+01	NR

NR = Not Reported

6.2.2 Nonradiological Parameters

6.2.2.1 100 Areas. No samples were analyzed for nonradioactive parameters in the 100 Areas during 1995.

6.2.2.2 200 Areas. Results of pH and nitrate determinations are summarized in Table G-2. The pH annual averages ranged from neutral to slightly basic. The highest annual average pH of 9.6 was found at the 200 East Area Powerhouse Ditch. The results for pH were well within the RCRA corrosivity designation limits of 2.0 to 12.5. The highest nitrate result of 3.7 mg/L was found in the only sample collected at the 200 West Area Powerhouse Pond before discharge to the pond was discontinued. All nitrate sample analyses were below the drinking water standard (40 CFR 141) for nitrates (45 mg/L).

6.2.2.3 300/400 Area. Currently, no surface water is sampled in the 300 Area. The 400 Area Process Pond is sampled by PNNL and the 1995 results are reported in the Hanford Site Environmental Report (Dirkes and Hanf 1996). The data are shared with WHC after they have been validated by PNNL.

6.2.3 Aquatic Vegetation

6.2.3.1 100 Areas. No aquatic vegetation samples were collected in the 100 Areas during 1995.

6.2.3.2 200 Areas. Aquatic vegetation samples are collected from ponds and ditches that have growing aquatic vegetation. Four vegetation samples were collected from four ponds and ditches in 1995. Each sample consisted of growing stems and leaves from the predominant plant species at each location. The vegetation was analyzed for gamma-emitting radionuclides, as well as ⁹⁰Sr, ²³⁹Pu, ²⁴⁰Pu, and uranium with the results reported in Table G-3.

6.2.3.3 300/400 Area. No aquatic vegetation was sampled in the 300 and 400 Areas.

6.2.4 Sediment (Surface Samples)

6.2.4.1 100 Areas. No samples were analyzed for radioactive parameters in the 100 Areas during 1995.

6.2.4.2 200 Areas. The results of pond and ditch sediment sampling are provided in Table G-4. The highest ¹³⁷Cs result was 6.6 pCi/g at the 216-B-3C Pond near the 200 East Area. The highest plutonium result was 2.0 pCi/g, also found at the 216-B-3C Pond. All ponds and ditches that received water effluents were within posted radiological control areas.

6.2.4.3 300/400 Areas. Currently, no surface water sediment is sampled in the 300 or 400 Area.

6.3 CONCLUSIONS

No significant changes in radioactivity were observed in surface water samples from ponds and ditches in 1995. All surface waters associated with separations-area operations were below the DOE DCG for all radionuclides. The analytical results of vegetation samples collected at the ponds and ditches revealed that, while some physiological uptake of radionuclides occurred, the amounts were relatively low. Sediment samples collected demonstrated elevated levels (above background) of mainly ^{137}Cs and plutonium.

The decrease in the number of seep sampling points at N Springs indicates the cessation of discharge of liquid effluents to the soil column via LWDFs 1301N and 1325N. Historical trending of these seep samples reveals an overall decrease in radionuclide concentrations in the seeps. However, as in past years, the seepage wells with the highest radionuclide concentrations were in the vicinity of the effluent monitoring well, indicating that this well continues to monitor N Springs discharges into the region of the highest concentrations.

7.0 RADIOLOGICAL SURVEYS

7.1 INTRODUCTION

Radiological surveys are conducted to determine changes in the radiological status of the 100, 200, and 300/400 Areas outdoor waste sites. These sites include surface-water disposal units, cribs, trenches, burial grounds, French drains, and reverse wells. The *Routine Environmental Monitoring Schedule, Calendar Year 1995*, WHC-SP-0098-6 (Schmidt et al. 1995), lists the waste sites and how frequently they are surveyed. Trends in radiation levels or radiological contamination may aid in assessing the adequacy of waste containment, indicating movement of radioactive material away from radiological control areas, or detecting releases that might otherwise go unrecognized. The *Quarterly Environmental Radiological Survey Summaries* (WHC-SP-0665-16 through -19, Markes and McKinney 1995a through 1995d) contains a summary of the radiological surveys that were performed. The radiological survey locations are shown in Figures H-1 through H-10 (Appendix H).

Activity in this report is shown in counts per minute (cpm) to accurately describe the contamination found in the field. The WHC Radiological Survey Reports and the ERC Radiological Survey Records (RSR) show the activity in desintegrations per minute (dpm). The radiological control technicians use the Hanford Site standard correction factor of 10 to convert the field instrument readings taken in cpm to the dpm reported on the RSR.

7.2 ROADS AND RAILROADS

7.2.1 Roads

Road surveys are performed using a vehicle equipped with sodium iodide detectors mounted on the undercarriage. The detector height is adjustable. The average survey height is 15 cm (6 in.) above the road or pavement.

The vehicle is driven at approximately 3 km/h (2 mi/h). When activity is detected, the vehicle is stopped, and a thorough survey is performed using a portable count rate meter equipped with a thin-window, pancake-type probe. The appropriate managers are notified if contamination is identified and corrective actions are then initiated.

Frequently traveled blacktop and improved roads and parking lots in and around the 200 Areas are surveyed bimonthly to detect the presence of radioactive material. Roads less frequently traveled or with low contamination potential are surveyed either quarterly or semiannually. Contamination was detected on the paved road east of the 241-U Tank Farm and on two dirt roads inside the BC controlled area in 1995.

7.2.2 Railroads

Radiological surveys of railroads are conducted with a vehicle equipped with "high railers" that allow the vehicle to travel on both roads and railroad tracks, and adjustable-height sodium iodide detectors. The average survey height is 15 cm (6 in.) The vehicle is driven at less than 8 km/hr (5 mi/hr). When activity is detected, the vehicle is stopped and portable hand-held survey instruments are used to thoroughly survey the area and identify the extent of the contamination. The appropriate managers are notified when contamination is identified. Corrective actions are then initiated.

The rail lines between the 300 Area and the 400 Area and inside the 200 West Area, including spurs and sidings, are surveyed semiannually. All other railroad tracks outside the facilities are surveyed annually, including spurs and sidings and up to Columbia Center. No contamination was encountered on the railroad tracks during 1995.

7.3 SURFACE-WATER DISPOSAL UNITS

Surface-water disposal units (pond and ditch banks) are routinely surveyed to identify potential contamination. The thin-window, pancake-type Geiger-Mueller probe is the principal instrument used in these surveys. Special survey plots are designated around the perimeters of these sites. They are marked with metal posts and numbered. The 216-B-3 Pond C Lobe and the 200 East Power House Ditch are the only two active surface-water disposal units remaining. The contamination levels remained at less than detectable values and no apparent changes were noted for 1995. The inactive 216-T-4 and 216-T-4-2 Ponds and the 216-T-1, 216-T-4-1, 216-T-4-2, and 216-U-14 (section between Cooper Ave. and 207-U Basin) Ditches were backfilled and stabilized and the recontaminated portions of the 216-U-10 and 216-U-11 Ponds and the 216-B-2-3 Ditch were backfilled and stabilized as corrective actions during 1995.

7.4 SOLID-WASTE DISPOSAL SITES

The retired solid-waste disposal sites are surveyed semiannually or annually to detect radiological changes, primarily via biological intrusion. Solid-waste disposal sites are located in the 100-B, -C, -D, -DR, -F, -K reactor areas; 200 East and 200 West; and the 600 Areas. (See Appendix H, Figures H-1 through H-10.)

Contaminated vegetation and specks were identified at the 118-D-3, 118-H-4, 118-H-5, 218-W-2A, 218-W-5, 218-W-4A, 218-W-11 218-E-2, 218-E-4, 218-E-8, 218-E-10, and 218-E-12B Burial Grounds in 1995 with a maximum contamination level higher than 100,000 cpm. The contamination was removed and/or backfilled shortly after it was identified. The 218-E-7 and 218-W-8 Burial Vaults were stabilized and small recontaminated areas of the 218-E-2, 218-E-10, 216-E-12B, and 218-W-4A Burial Grounds were restabilized during 1995.

7.5 200 AREAS LOW-LEVEL LIQUID-WASTE DISPOSAL SITES

Low-level liquid-waste disposal sites, other than open ponds and ditches, consist of cribs, French drains, reverse or injection wells, trenches, covered ponds and ditches, and unplanned release sites. As with solid-waste disposal sites, liquid-waste sites are surveyed at least annually, and as often as quarterly, to detect changes in surface radiological conditions. The most significant survey results in 1995 are listed in Paragraphs 7.5.1 through 7.5.8. Sites remediated or backfilled to meet radiological down-posting requirements are listed in Section 7.12.

The ERC and Tank Waste Remediation Systems develop individual annual schedules for remediation of identified contamination. Sites are cleaned or stabilized as soon as possible, but, because of previously scheduled remediation and prioritization of the sites, contamination may not always be stabilized in the same year it is found.

7.5.1 216-A Sites

A small recontaminated portion of the 216-A-24 Crib was backfilled and stabilized in 1995.

Contaminated vegetation and specks (e.g., single grains of soil, rust particles, feces, or pieces of vegetation) were found at the 216-A-30 Crib with a maximum reading of 2,000 cpm. The area was posted as soil contamination.

7.5.2 216-B Sites

Spotty contamination was noted at the 216-B-14 through -19 and 216-B-61 Cribs, and contaminated tumbleweed fragments were discovered at the 216-B-55 Crib. The maximum reading was 3,000 cpm at the 216-B-61 Crib. The contamination was picked up and placed in the low-level waste burial grounds.

7.5.3 216-C Sites

Contaminated tumbleweed fragments with a maximum reading of 10,000 cpm were found at the 216-C-4 Crib. The contamination was removed and placed in the low-level burial grounds.

7.5.4 216-S Sites

Speck contamination from insect intrusion reading up to 60,000 cpm was discovered at the 216-S-1 and -2 Cribs. The contamination was removed and placed in the low-level burial grounds. Contaminated tumbleweeds and mouse feces were found at the 216-S-4 and 21 Cribs with the mouse feces reading up to 30,000 cpm and the tumbleweeds reading up to 2,000 cpm. The area was posted and an investigation was initiated to determine the source of the contamination.

The 216-S-9 Crib was stabilized and the caved-in portion of the 216-S-20 Crib was backfilled in 1995.

7.5.5 216-T Sites

Speck contamination was found in the 216-T-4-1 and 216-T-4-2 Ditches and the 216-T-5 Crib Pond with readings up to 60,000 cpm. The contamination was removed and placed in the low-level burial grounds.

The 216-T-1, 216-T-4-1, 216-T-4-2 Ditches and the 216-T-4 and 216-T-4-2 Ponds were stabilized and down posted from SC to URM in 1995.

7.5.6 216-U Sites

Contaminated tumbleweeds and soil specks with readings of up to 25,000 cpm were found in the 216-U-1 and 216-U-2 Cribs and 216-U-10 Pond. The contamination was removed and placed in the low-level burial grounds.

The portion of 216-U-14 Ditch between Camden Avenue and the 207-U Basins was backfilled, stabilized, and down posted from SC to URM in 1995.

7.5.7 216-Z Sites

No activity took place at the 216-Z waste sites and no activity was found during the routine surveys.

7.5.8 Unplanned Release Sites

The most noteworthy contamination was found at the following unplanned release sites.

UN-216-E-41. The cross-site transfer line was stabilized and down posted to URM during the first quarter of 1995 except for the enclosed 241-EW-151 Vent Station and the 241-ER-151 Diversion Box.

Several contaminated areas were found along the underground radioactive materials area and sites up to 60,000 cpm were found in the 200 West Area portion of the cross-site transfer line. The contamination was removed and the area decontaminated at the time of the survey.

Spotty contamination was found over approximately 5.9 hectares (14.7 acres) located north and south of the 241-EW-151 vent station with contamination levels up to 25,000 cpm. The contamination was suspected to be caused by animal intrusion. The area was posted as a soil contamination area to indicate the status change.

UN-216-W-24 and UN-216-W-30. The unplanned release sites, UN-216-W-24 and UN-216-W-30, located to the east and north of the 241-S, 241-SX and 241-SY Tank Farm complex were stabilized and down posted to URM during 1995.

7.6 TANK FARM PERIMETERS

Tank farm perimeters and associated facilities are surveyed semiannually to detect any migration of contamination. Tank farms and related facilities are sources of environmental contamination migration. Recontamination along the same fence lines from year to year appears to be associated with the prevailing wind direction and the contamination located within the tank farms and associated with tank farm activities.

Areas adjacent to and south of the 241-C Farm and 271-CR Vault, including a portion of 7th Street, were found to be contaminated again in 1995 (up to 5,000 cpm). The contamination appeared to be from animal intrusion and wind-borne activity both inside and outside the tank farm. The area remained posted as a contamination area. The area north of the 241-C Tank Farm was stabilized and down posted from SC to URM in 1995.

Several other areas of speck and soil contamination were discovered in the 200 East (by the 241-AN, 241-AX, 241-AZ, 241-B, 241-BX/BY, and 241-C Tank Farms, and by the 244 lift station) and 200 West (by the 241-S/SX/SY, 241-T, -TX, -TY, and 241-U Tank Farms) Areas while performing the semiannual tank farm perimeter surveys. The specks consisted of tumbleweed fragments, soil, and rabbit and mice feces. The areas were decontaminated.

The 241-A, 241-AN, 241-T Tank Farms along with portions of the 241-AY, 241-AZ, 241-B, 241-BX/BY, 241-TY and 241-U Tank Farms were stabilized and down posted from SC to URM in 1995.

7.7 BC CRIBS AND CONTROLLED AREA

Speck contamination was found along the BC-controlled-area roads with readings up to 25,000 cpm. The specks were picked up at the time of survey, and disposed of in the low-level burial grounds.

The BC Cribs and trenches (Figure H-9) are a series of liquid-waste disposal sites that were active in the mid-1950's. In 1958, animal intrusion was determined to have caused radioactivity to be transported over an area estimated to exceed 1,000 ha (2,500 acres). In 1979, special survey plots were established throughout the controlled area to monitor for contaminant migration. Data accumulated during the 10-year period indicate that no significant additional migration of contamination away from the area has occurred. The cribs and trenches were surface stabilized in 1982.

This area, approximately 5.18 km square (2 mi square), is currently posted as a radiological controlled area (RCA) and bounds the south and east sides of an area leased to U.S. Ecology.

7.8 100 AREAS SITES

In October of 1990, contamination of the shoreline below 100-N Reactor was posted as a surface contamination area near the N Springs seeps. In 1991, the discovery of contaminated vegetation and mulberry trees resulted in the

zone being expanded. The contaminated trees were removed and a herbicide spray program was implemented in December 1991 and continued through 1995.

An area of speck contamination (e.g., a single grain of soil, rust particle, or piece of feces or vegetation) on the riverbank below the 107-KE and KW Retention Basins remains posted as a contamination area. The area is approximately 16.2 ha (40 acres) with contamination levels ranging from 200 to 20,000 cpm.

The 107-D, 107-DR, 107-KE, and 107-KW Retention Basins and the 116-H-2 Crib were stabilized and down posted from SC to URM.

7.9 100-N AREA RADIATION SURVEYS

Direct radiation levels are measured annually along the 100-N Area portion of the Columbia River shoreline. Annual environmental radiation surveys historically conducted at intersecting points of survey grids established around the 1301-N and 1325-N LWDFs to monitor radiation levels associated with the disposal facilities were discontinued in 1995. Data obtained from the TLD stations located around the perimeters of these facilities provide adequate radiation assessment because neither facility is active.

A hand-held micro-rem meter was used to survey points along the N Springs area. In previous years, the instrument used for this survey was a micro-R meter. This instrument, which measures exposure rates, was known to "over respond" to low-energy gamma radiation. The micro-rem meter more accurately measures the true dose rate.

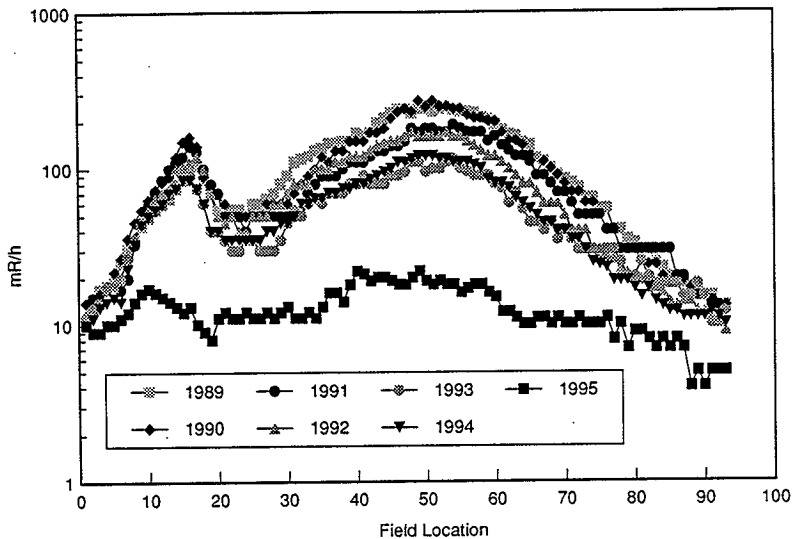
All readings were taken at a height of 1 m (3 ft) at 15-m (50-ft) intervals. The readings obtained for the survey reflect dose rates that are relative only to each other.

7.10 COLUMBIA RIVER SHORELINE SURVEY

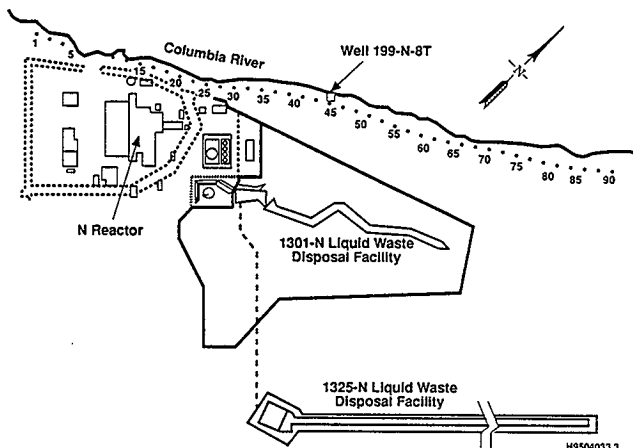
Relative dose rates were measured along the Columbia River shoreline starting near the N Area outfall (field location 5) and proceeding downstream past the N Springs. A graph of the shoreline survey data is presented in Figure 7-1. The locations of the 100-N Area facilities that potentially contribute to dose rates measured near the river shoreline are shown. At the time of the survey, N Reactor was shut down. The 1304-N Emergency Dump Tank was empty and there was no flow to the 1325-N LWDF. The 1310-N Radioactive Chemical Waste Storage Facility also was empty.

The overall shape of the curve shown on the graph (Figure 7-1) for 1995 indicates that the area along the N Springs shoreline with the highest exposure rate is, as in the past, along the area juxtapositional with the 1301-N LWDF. The radiation levels measured this year are not directly comparable to previous years, though the overall shape of the curve derived by graphing the results shows the region of highest exposure to again agree with historic survey results.

Figure 7-1. 100-N Shoreline Survey Results.



SG96050145.5



H9504033.3

Results of the shoreline survey are presented in Table H-1 (Appendix H).

7.11 Retired 100 Area Waste Disposal Facilities

Routine environmental surveillance was performed semiannually on the retired 100 Area waste disposal facilities in 1995. The contamination levels remained at less than detectable values except as listed in Table 7-1. Contamination has been noted in previous radiation surveys in most of these areas.

Table 7-1. Samples with Contamination above Detectable Levels.

Waste Site/Location	Activity (cpm)	Type
105-KE Women's Change Room	15,000	Mouse
East Side of 105-KE at Bunker	35,000	Speck
105-N	200	Snake
107-KE Basin	1,200	Speck
116-H-3	50,000	Speck
116-H-4	50,000	Speck
116-H-9	40,000	Speck
116-K-1	2,000	Speck
116-KW-1	70,000	Speck
118-D-3	30,000	Speck
118-H-4	50,000	Speck
118-H-5	50,000	Speck

7.12 STABILIZATION AND SITE REMEDIATION

In 1995, several contaminated sites were interim surface stabilized by scraping the contaminated top soil and consolidating the contamination into smaller areas. These smaller areas were covered with 15 cm (6 in.) of clean dirt. Other sites were backfilled with 15 cm to 0.6 m (6 in. to 2 ft) of clean dirt. Both methods resulted in surface contamination area postings being reduced to underground radioactive material areas or being released from radiological control. The sites remediated and/or radiologically reposted in 1995 are shown in Table 7-2.

Table 7-2. Sites Remediated or Radiologically Reposted in 1995
[approximate surface area in hectares (acres)].

Site Designation	Status change	Area in hectares (acres)
107-D and 107-DR Basins	SC to URM	2.7 (6.7)
107-KE and 107-KW Basins	SC to URM	8.1 (20.0)
116-H-2 Crib	SC to URM	0.04 (0.1)
216-S-9 Crib	SC to URM	0.28 (0.7)
216-S-20 Crib	SC to URM	0.03 (0.07)
216-T-1 Ditch	SC to URM	0.22 (0.53)
216-T-4 Pond	SC to URM	6.5 (16.0)
216-T-4-1 Ditch	SC to URM	0.065 (0.16)
216-T-4-2 Ditch	SC to URM	0.12 (0.32)
216-T-4-2 Pond	SC to URM	0.93 (2.29)
216-U-14	SC to URM	2.73 (6.7)
218-E-7 Burial Vault	SC to URM	0.008 (0.02)
218-W-8 Burial Vault	SC to URM	0.028 (0.07)
241-B-154 Diversion Box	SC to URM	0.45 (1.12)
241-ER-151 Diversion Box	SC to URM	0.34 (0.84)
241-EW-151 Vent Station area	URM to SC	5.9 (14.7)
UN-216-E-41	SC to URM	11.83 (29.24)
UN-216-W-24	SC to URM	2.6 (6.5)
UN-216-W-30	SC to URM	4.1 (7.75)
TC-4 rail spur	SC to URM	0.4 (0.9)
241-A Tank Farm perimeter	SC to URM	0.1 (0.25)
241-AN Tank Farm	SC to URM	1.26 (3.1)
241-A/AY/AZ/C/TY/U portions	SC to URM	1.96 (4.83)
241-B Tank Farm small area	SC to URM	0.075 (0.19)
241-BX/BY Tank Farm	SC to URM	1.7 (4.3)
241-C Tank Farm north side	SC to URM	0.003 (0.008)
241-T Tank Farm	SC to URM	2.56 (6.3)
241-TY Tank Farm	SC to URM	0.83 (2.04)
241-U Tank Farm perimeter	SC to URM	0.1 (0.25)

SC = contamination/soil contamination area.
URM = underground radioactive material.

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8.0 INVESTIGATIVE SAMPLING, MONITORING, AND SPECIAL CHARACTERIZATION PROJECTS

8.1 INTRODUCTION

Investigative samples were collected in and near facility and waste site environments (i.e., operations areas) at the Hanford Site during 1995 to confirm the absence or detect the presence of potential radioactive contaminants. Investigative sampling and monitoring were conducted to determine whether effluent controls and waste containment systems were adequate. Samples for investigative monitoring could be collected from the following types of areas:

- An expanded area of a routinely monitored site, when results from a radiological survey showed elevated contamination levels
- An area where scheduled activities (e.g., demolition or stabilization) at or near a contamination source made demonstrating the radiological condition of the area necessary
- A site where biotic intrusion (e.g., animal burrows or deep-rooted vegetation) created the potential for the spread of contaminants
- A site where the integrity of waste maintenance systems needed to be demonstrated
- A spill or release site to determine the concentrations of radioactive contamination.

Types of investigative samples in previous years have included air; water; snow; sediment; soil; vegetation such as grass, tumbleweed, sagebrush, trees, and fruit; and various wildlife and their products (e.g., nests and feces) such as spiders, ants, termites, fish, toads, snakes, birds, rabbits, mice, and carnivores (e.g., coyotes and bobcats).

The results of the Operational Environmental Monitoring Program (OEMP) have been combined in a single report only since 1991. Therefore, data comparisons and trend determinations must be made with care. For example, to identify a trend in Russian thistle (tumbleweed) contamination over the entire Hanford Site, it would be necessary to look at various contractors' annual environmental reports from the years before 1991 for each area (e.g., 100, 200, and 300 Areas), the *Westinghouse Hanford Company Operational Environmental Monitoring Annual Report* since 1991, and the *Hanford Site Environmental Report* produced by PNNL. Also, some incidents of radioactive contamination were discovered during operations (e.g., cleanup) and not reported directly to OEMP staff. Incidents of radioactively contaminated soil or biota found during radiological surveys of individual operations (e.g., 241-C Tank Farms) are reported through the RAD Control Radiation Problem Report (RPR). This section also includes a synopsis of the RPR data (Appendix I, Tables I-4, I-6, and I-8). Radioisotopic analyses were not done for these contaminated specimens, so only field-instrument readings were available.

8.2 1995 SAMPLE TYPES

Samples in 1995 included air, water, soil (including surface soil, ant mounds, and sediment), vegetation (tumbleweeds and cryptogams), a wasp's nest, gopher snakes, western rattlesnakes, domestic pigeons, a house finch, a bat, deer mice, a coyote jaw bone, and coyote feces.

8.3 COLLECTION AND ANALYSES METHODS

Methods for collecting or otherwise obtaining investigative samples, as well as instructions for field preparation of samples, are found in *Operational Environmental Monitoring*, WHC-CM-7-4. Investigative samples were sent to the WHC 222-S Analytical Laboratory in the 200 West Area because radioactive contamination levels were known or suspected to be above environmental levels.

8.3.1 Air

Investigative air samples were collected at selected surface contamination sites to evaluate several of the Hanford Site's major diffuse and fugitive emission sources and to evaluate the effectiveness of monitoring these sources individually, rather than collectively (Schmidt et al. 1996).

8.3.2 Surface Water

Investigative surface-water samples were collected from two of the tank farms in the 200 West Area in 1995. The samples of runoff water were collected following a heavy rainstorm that caused erosion and pooling in the 200 Areas.

8.3.3 Soil

Investigative soil samples were collected either from areas previously identified as being contaminated or from areas to be characterized. If contamination was known or suspected, surface samples were collected from the contaminated area rather than randomly from the area.

8.3.4 Vegetation

Investigative vegetation samples were collected either from plants previously identified as being contaminated or from areas to be characterized as part of preoperational monitoring. Contaminated vegetation was not randomly collected.

8.3.5 Wildlife

Procedures for safe handling of animal samples and development of appropriate barriers during the previous year to eliminate the concern for employee exposure to the hantavirus resulted in a moratorium on rodent

sampling being lifted. Exposure to all wildlife-borne diseases (e.g., hantavirus, plague, and rabies) was prevented by physical and administrative barriers that eliminated respiratory or skin contact with rodents.

Animals captured or carcasses found near facilities or waste disposal sites were collected by Site Support Services Radiological Control or by Animal Control Operations. Samples were collected under authority of the pest control license granted through the Washington State Department of Fish and Wildlife, and submitted to the 222-S Analytical Laboratory for analyses.

8.3.6 Laboratory Analyses of Biota

Physical and administrative barriers at the laboratory were found to be adequate to prevent transmission of wildlife-borne diseases to laboratory staff. When necessary, animal samples of selected larger specimens are divided into portions to separate skin, gastro-intestinal organs, muscle, and bone. Small animals are dissolved in acid before analysis because dissection would not yield a large enough sample.

Vegetation samples occasionally included the entire plant, including roots if required. However, in most situations terminal branches and leaves were collected. Deciduous material (e.g., litter, dead leaves) and cryptogams (i.e., mosses and lichens) were collected because of indications that they may act as a radiological reservoir or environmental "sink."

8.4 RESULTS

Field monitoring results are usually expressed as cpm, dpm, or millirads per hour. They were obtained using a Geiger-Mueller Counter or dose rate meter. Laboratory sample analyses are expressed in picocuries per gram for most solid samples (e.g., soil or animals), picocuries per liter for liquids, and picocuries per sample for extremely small samples. Analytical results of the more biologically important radionuclides are summarized in Table 8-1. Tables I-1 through I-9 in Appendix I contain the complete results.

8.4.1 Air

In 1995 special studies were completed to measure fugitive and diffuse air emissions at four sites in the 100 Areas during decontamination and decommissioning by the ERC. These included 10 air samplers at the 116-B-4 French Drain/Disposal Crib, the 116-C-1 Liquid Waste Disposal Trench, the 116-B-5 Crib, and the 183-H Solar Evaporation Basin. Analytical results for the 10 air samplers, although above background values, indicated that emissions were within the DOE DCG values (Tables 8-1 and I-1). The maximum concentrations were 1.4 E-04 pCi/m^3 of ^{60}Co at 116-B-5, 3.2 E-04 pCi/m^3 of ^{90}Sr at 183-H, 1.2 E-04 pCi/m^3 of ^{137}Cs at 116-B-4, and 1.1 E-04 pCi/m^3 at 183-H, 2.2 E-04 pCi/m^3 of total U at 116-B-5, and 1.5 E-05 pCi/m^3 of $^{239, 240}\text{Pu}$ at 116-C-1.

The results from this evaluation also may be used to demonstrate WHC's compliance with the applicable air emissions regulations and determine if additional studies and/or evaluations are necessary.

The total alpha, total beta, and isotopic analytical results indicated that the emissions from these selected diffuse sources were below, near, or slightly above the minimum detection limits of the analytical processes used. In most cases, the analytical results for samples collected downwind were not significantly different from those collected upwind, which would indicate that, for the meteorological conditions during sampling, emissions from these diffuse sources were not measurable.

8.4.2 Surface Water

Samples of runoff water were collected at the 200 East Area in 1995 to determine if radionuclide contaminants were present. Measurable radionuclides included ^{90}Sr (47 pCi/L), ^{137}Cs (<59 pCi/L), and $^{239, 240}\text{Pu}$ (<7.8 pCi/L), indicating that runoff water may be a source of radionuclide contamination outside the tank farms. Results of surface water sampling are listed in Table 8-1 and Appendix I, Table I-2.

8.4.3 Soil

Of the 11 investigative soil samples collected in 1995, 9 showed levels of radioactivity exceeding 10 pCi/g for at least 1 nuclear-process-origin radionuclide (see Table 8-1 and Appendix I, Table I-3). The highest ^{137}Cs concentrations (7,900 pCi/g) were found in ant mounds near the 241-C Tank Farm; the highest $^{239, 240}\text{Pu}$ concentrations (2,200 pCi/g) were also found near the 241-C Tank Farm; and the highest ^{90}Sr concentrations (1,900 pCi/g) were found near Unplanned Release Site UN-216-E-6 in 200 East Area. In addition, 62 incidents of contaminated soil or specks were found during cleanup operations and disposed of in low-level burial grounds (see Appendix I, Table I-4).

In 1995, the number of contamination incidents, the range of radiation dose levels, and radionuclide concentrations were generally within historical limits. Areas of special soil sampling that were outside radiological control areas and had radiation levels greater than WHC radiological control limits (HSRCM-1) were posted as surface contamination areas.

8.4.4 Biota

8.4.4.1 Vegetation. Three tumbleweeds were analyzed for radionuclides in 1995 (Tables 8-1 and I-5). Maximum radionuclide concentrations in the tumbleweeds included ^{137}Cs (14 pCi/g), $^{239, 240}\text{Pu}$ (20 pCi/g) and ^{90}Sr (390 pCi/g). Analytical results were below WHC radiological control limits. In addition, 36 instances of contaminated vegetation (mostly tumbleweeds) were recorded in the operational areas in 1995 (see Appendix I, Table I-6). This vegetation was discovered during remedial operations, surveyed with field instruments, and disposed of to low-level burial grounds. The field-instrument readings for these vegetation samples ranged from less than

1 mrad/h (100 cpm) to 50 mrad/h (>1,000,000 cpm), which were within the ranges reported for the past few years (Schmidt et al. 1995).

During 1995 the numbers of contaminated vegetation, the radioactivity levels, and the range of radionuclide concentrations were all within historical ranges. In the past, the largest number of contaminated vegetation samples (42) were submitted for analyses in 1978 (Johnson et al. 1994).

As part of the baseline investigation in the 200 Areas, 37 cryptogam samples were collected and analyzed for gamma-emitting radionuclides. Cryptogams were selected because of their ability to act as highly sensitive indicators of environmental quality (Landeem et al. 1994), particularly for radionuclide contamination. The highest value observed in the cryptogam samples was 29 pCi/g of ¹³⁷Cs.

8.4.4.2 Wildlife. In 1995 wildlife and wildlife-related samples (feces, nests, etc.) were collected either as part of the Integrated Pest Management program designed to limit the exposure and potential contamination of animals to radioactive material or as a result of finding a radiologically contaminated animal. Animals were collected directly from or near facilities to identify potential problems with preventive measures designed to inhibit animal intrusion. Surveys were performed after collection to determine whether an animal was radioactively contaminated. If a live animal was found free of contamination, it was taken to an area of suitable habitat and released. If an animal was contaminated, a decision based on the level of contamination, facility, and frequency of occurrence was made to either collect the animal as a sample or to dispose of the animal in a low-level burial ground.

Twenty-two of the 25 special animal samples (including nests and feces) analyzed in 1995 showed detectable levels of contamination. The number of incidents increased slightly in 1995 from 16 in 1994; but decreased from 32 incidents in 1993. The greatest number of contaminated animals (44, mostly pigeons) submitted for analysis occurred in 1982 (Johnson et al. 1994).

The maximum radionuclide concentrations were for ¹³⁷Cs (960,000 pCi/g) and ⁹⁰Sr (35,000 pCi/g) in a bull snake from the 200 West Area and ⁶⁰Co (2,500 pCi/g) in a wasp nest from the 100-N Area (Tables 8-1 and I-7). In addition, 14 cases of contaminated wildlife or related samples were discovered during cleanup operations; they were disposed of without being analyzed (Table I-8). The numbers of animals found to be contaminated with radioactivity, the radioactivity levels, and the range of radionuclide concentrations were within historical limits (Johnson et al. 1994).

As part of a baseline investigation in the 200 Areas, 39 fecal samples (37 coyote and 2 deer) were collected and analyzed for gamma-emitting radionuclides. The feces were selected as an indicator of transport pathways for radionuclide contamination from waste sites into the environment. The maximum radionuclide concentration, ¹³⁷Cs (1,330 pCi/g) in a coyote fecal sample, was higher than expected for a randomly selected sample.

8.4.5 Investigation of Dead Vegetation

In 1995, an area of dead vegetation (viz., primarily big sagebrush [*Artemisia tridentata*] and gray rabbitbrush [*Chrysothamnus nauseosus*]) was observed west of the 221-T Parking Lot. Visual inspection showed the area of the die-off to be a shallow depression running from the parking lot in a westerly direction approximately 50 meters (164.04 ft) and extending irregularly north and south approximately 20 meters (65.62 ft). Site Services Support Radiological Control conducted a radiological survey of the area and found only background radioactivity. Four soil and two vegetation samples were collected by Field Analytical Services from the affected area and analyzed for organics, pesticides, metallic salts, anions (viz., fluoride, chloride, nitrate, phosphate, and sulfate), conductivity, and pH. Results indicated that only nitrates, phosphates, and sulfates were elevated (Table 8-2, Appendix I-9). These anions are all constituents in fertilizer. Followup research discovered that fertilizer had been stockpiled on the 221-T Parking Lot for use as a deicer the previous winter. When the weather turned wet and warm, the runoff water, which was saturated with fertilizer, followed the natural land depression and flowed to the west.

Table 8-1. Investigative Samples Collected from the Operations Areas, 1995. (5 sheets)

Sample Type	Location	Radionuclides	Concentration
Air ^a	116-B-4 Crib, 100-BC Area	⁶⁰ Co ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	-8.5 E-06 1.2 E-04 -2.4 E-07 -6.5 E-04 5.3 E-05
	116-B-5 Crib, 100-BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	1.1 E-04 -2.0 E-03 2.3 E-06 3.6 E-06 1.8 E-04
	116-B-5 Crib, 100-BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	-1.1 E-04 -2.3 E-03 5.6 E-04 -1.6 E-05 1.8 E-04
	116-B-5 Crib, 100-BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	1.4 E-04 -2.1 E-03 2.9 E-04 1.4 E-05 2.2 E-04
	116-C-1 Trench/100 BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	5.2 E-05 -9.5 E-05 9.7 E-05 -9.7 E-06 6.1 E-05
	116-C-1 Trench/100 BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	1.1 E-04 -8.6 E-04 7.1 E-06 1.5 E-05 4.7 E-05
	116-C-1 Trench/100 BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	-6.2 E-05 -6.8 E-04 9.0 E-05 7.0 E-07 4.7 E-05
	183-H Burial Ground/100 H Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	4.5 E-05 -3.3 E-05 2.4 E-05 -5.4 E-06 1.4 E-04
	183-H/100 H Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	1.1 E-04 -2.7 E-04 8.0 E-05 7.4 E-06 9.5 E-05

Table 8-1. Investigative Samples Collected from the Operations Areas, 1995. (5 sheets)

Sample Type	Location	Radionuclides	Concentration
Air (cont)	183-H Burial Ground/100 H Area	^{60}Co	-9.9 E-05
		^{90}Sr	3.2 E-04
		^{137}Cs	1.1 E-04
		$^{239}, ^{240}\text{Pu}$	-1.2 E-06
		Total U	1.2 E-04
Water ^b	West of 241-AN and south of 17th St.	^{137}Cs	<5.9 E+01
		$^{239}, ^{240}\text{Pu}$	<5.9 E+00
	East of 241-BX and west of Baltimore	^{90}Sr	<8.3 E+00
		Total U	5.0 E-01
Soil ^c	199-K-109A, 100-K Area	^{137}Cs	<3.1 E-01
		$^{239}, ^{240}\text{Pu}$	<3.7 E-01
	TLD Location 65, 100-N	^{90}Sr	7.9 E-05
		Total U	9.7 E-07
	TLD Location 67, 100-N	^{137}Cs	2.1 E+01
		$^{239}, ^{240}\text{Pu}$	<2.9 E-01
	TLD Location 69, 100-N	^{212}Bi	1.2 E+00
		^{90}Sr	1.9 E+00
	UN-216-E-7, 200 East	Total U	5.8 E-07
	TLD Location 67, 100-N	^{137}Cs	1.5 E-01
		^{212}Pb	1.0 E+00
	TLD Location 69, 100-N	^{214}Pb	1.4 E+00
		^{228}Ac	1.1 E+00
	UN-216-E-7, 200 East	$^{239}, ^{240}\text{Pu}$	<2.8 E-01
		^{90}Sr	2.1 E+01
	241-SY Tank Farm, 200 West	Total U	5.4 E-07
	TLD Location 69, 100-N	^{212}Pb	7.3 E-01
		^{214}Pb	1.2 E+00
	UN-216-E-7, 200 East	^{224}Ra	2.4 E+00
		$^{239}, ^{240}\text{Pu}$	<3.0 E-01
	241-SY Tank Farm, 200 West	^{90}Sr	6.1 E-01
		Total U	4.2 E-07
	TLD Location 67, 100-N	^{137}Cs	3.8 E+01
		$^{239}, ^{240}\text{Pu}$	2.4 E+00
	UN-216-E-7, 200 East	^{90}Sr	1.8 E+01
		Total U	2.0 E-07
	241-SY Tank Farm, 200 West	^{137}Cs	2.9 E+02
		$^{239}, ^{240}\text{Pu}$	<2.0 E-01
		^{90}Sr	8.7 E-01
		Total U	1.4 E-08

Table 8-1. Investigative Samples Collected from the Operations Areas, 1995. (5 sheets)

Sample Type	Location	Radionuclides	Concentration
Soil (cont.)	UN-216-E-6, 200 East	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	<1.9 E+00 <1.1 E+01 1.9 E+03 1.3 E-07
	North side of 241-B, 200 East (green sediment)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	6.8 E+01 3.6 E-01 2.9 E+02 1.3 E-07
	Cross-Site transfer line east/west vent station	^{137}Cs ^{241}Bi ^{228}Ac $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	6.3 E+02 6.5 E-01 6.7 E-01 <2.1 E-01 1.9 E+01 4.6 E-07
	241-C Tank Farm, 200 East (ant mound)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	1.2 E+01 2.2 E+03 8.0 E+02 7.5 E-10
	0.3 mile east of vent station, 600 Area (ant mound)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	7.9 E+03 <4.2 E-01 8.2 E-04 5.1 E-07
Vegetation ^c	216-A-3, 200 East (tumbleweed)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	9.0 E-01 2.0 E+01 7.9 E+01 1.1 E-07
	Cross-Site transfer line, 600 Area (tumbleweed)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	2.6 E+00 <7.3 E-01 1.8 E+02 7.7 E-09
	UN-216-E-44, 200 East (tumbleweed)	^{137}Cs ^{214}Pb $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	1.4 E+01 4.5 E+00 <1.8 E-01 3.9 E+02 1.6 E-08
Insects ^c	1301-N, 100-N (wasp's nest)	^{137}Cs ^{60}Co	4.8 E+02 2.5 E+03
Reptiles ^c	200 West (snake)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{134}Cs ^{90}Sr	9.6 E+05 <2.8 E+00 1.4 E+02 7.5 E-10

Table 8-1. Investigative Samples Collected from the Operations Areas, 1995. (5 sheets)

Sample Type	Location	Radionuclides	Concentration
Reptiles (cont.)	105-N/100-N (rattlesnake)	^{137}Cs ^{60}Co $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	1.2 E+02 2.0 E+02 1.6 E+00 1.4 E+01 1.6 E-09
	Camden & 19th, ICF KH Complex, 200 West (bullsnake)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	2.0 E+00 2.6 E-01 3.1 E+02 2.4 E-08
	20 meters west of 241-AZ, 200 East (bull snake)	^{137}Cs ^{214}Bi $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	5.4 E+02 1.9 E+00 <1.1 E+00 9.9 E+01 1.6 E-08
Birds ^c	105-N, 100-N (pigeons)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	<3.2 E-02 <5.0 E-02 5.1 E-02 9.3 E-08
	221-U, 200 West (pigeons)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{234}Th ^{90}Sr Total U	<3.4 E-01 <1.4 E-01 9.4 E+00 <3.1 E-01 2.4 E-05
	200 Areas (pigeon)	^{60}Co ^{154}Eu $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	2.0 E+01 1.4 E+00 <1.5 E-01 1.3 E-01 5.4 E-04
	271-U, 200 West (house finch)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr	5.4 E+00 3.5 E+01 2.3 E+02
Mammals ^c	190-D, 100-D (bat)	^{137}Cs ^{60}Co $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	2.2 E+02 1.6 E+03 <7.6 E+00 1.1 E+04 6.8 E-06
	105-KE, 100-K (mouse)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	3.7 E+02 1.3 E+00 2.2 E+02 1.2 E-08
	272-U, 200 West (mouse)	^{137}Cs $^{239}, ^{240}\text{Pu}$ ^{90}Sr Total U	<4.5 E+00 6.5 E-01 1.0 E+01 2.6 E-08

Table 8-1. Investigative Samples Collected from the Operations Areas, 1995. (5 sheets)

Sample Type	Location	Radionuclides	Concentration
Mammals (cont.)	DACS Trailer, 200 West (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	1.2 E+03 5.5 E-01 1.6 E+03 8.3 E-09
	241-C laundry shack, 200 East (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	<1.5 E+01 1.5 E+00 9.0 E+00 4.2 E-08
	2713 WB, 200 West (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	1.2 E+00 2.4 E-01 5.8 E+01 7.7 E-08
	KEH trailer near 241-A, 200 East (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	2.2 E+00 1.5 E-01 3.1 E+02 9.7 E-09
	202-A PUREX, 200 East (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	<1.4 E+01 <2.8 E+00 <2.9 E+00 1.4 E-07
	2247-B, 200 East (deer mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	<4.2 E+00 <2.3 E+00 3.4 E+00 8.4 E-08
	241-AY, 200 East (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	<1.9 E+00 <2.2 E+00 9.3 E+02 4.0 E-09
	2707-SX Lunchroom, 200 West (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	2.7 E+02 <3.2 E+00 4.8 E+03 5.1 E-09
	200 Areas (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	8.3 E+02 7.5 E+00 1.4 E+03 1.0 E-02
	200 Areas (mouse)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	<3.4 E+00 <4.0 E+00 6.9 E+02 8.4 E-03
	East of B Plant, South of 207-B, 200 East (coyote feces)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	6.2 E+00 <2.1 E-01 3.3 E+02 2.6 E-07

Table 8-1. Investigative Samples Collected from the Operations Areas, 1995. (5 sheets)

Sample Type	Location	Radionuclides	Concentration
Mammals (cont.)	200 Areas (coyote feces)	¹³⁷ Cs ¹⁵⁴ Eu ¹⁵⁵ Eu ⁶⁰ Co ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	1.6 E+02 1.5 E+01 1.5 E+01 1.3 E+00 <5.7 E-01 5.0 E+02 8.9 E-02
	202-A, 200 East (coyote jaw)	¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	<1.2 E+01 <1.0 E+01 1.3 E+02 2.2 E-08

^aValues expressed in pCi/m³^bValues expressed in pCi/L^cValues expressed in pCi/g

< indicates uncertainty in analytical result because of low detectable concentrations

Table 8-2. Investigative Samples Collected at the Vegetation Die-Off West of 221-T Parking Lot. (2 Sheets)

Sample type	Sample Location	Chemical Constituent	Concentration
Soil (loose sandy soil with little organic matter)	West of 221-T Parking Lot	organics (%) pesticides (ppm) metallic salts (ppm) anions (ppm): fluoride chloride nitrate phosphate sulfate conductivity (ms/cm) pH (units)	< MQL < MQL < MQL < MQL < MQL < MQL 331.3 < MQL < MQL 0.168 7.3
	West of 221-T Parking Lot	organics (%) pesticides (ppm) metallic salts (ppm) anions (ppm): fluoride chloride nitrate phosphate sulfate conductivity (ms/cm) pH (units)	< MQL < MQL < MQL < MQL < MQL < MQL 288.5 < MQL < MQL 0.158 7.6

Table 8-2. Investigative Samples Collected at the Vegetation
Die-Off West of 221-T Parking Lot. (2 Sheets)

Sample type	Sample Location	Chemical Constituent	Concentration
Soil (loose sandy soil with little organic matter) (cont.)	West of 221-T Parking Lot	organics (%) pesticides (ppm) metallic salts (ppm) anions (ppm): fluoride chloride nitrate phosphate sulfate conductivity (ms/cm) pH (units)	< MQL < MQL < MQL < MQL < MQL 55.7 161.0 121.1 0.206 7.7
	West of 221-T Parking Lot	organics (%) pesticides (ppm) metallic salts (ppm) anions (ppm): fluoride chloride nitrate phosphate sulfate conductivity (ms/cm) pH (units)	< MQL < MQL < MQL < MQL < MQL 308.0 120.7 < MQL 0.151 8.0
Vegetation (rabbitbrush and sagebrush stems and leaves)	West of 221-T Parking Lot	organics (%) pesticides (ppm) metallic salts (ppm) anions (ppm): fluoride chloride nitrate phosphate sulfate conductivity (ms/cm) pH (units)	< MQL < MQL < MQL < MQL < MQL < MQL 292.1 < MQL 0.182 7.0
	West of 221-T Parking Lot	organics (%) pesticides (ppm) metallic salts (ppm) anions (ppm): fluoride chloride nitrate phosphate sulfate conductivity (ms/cm) pH (units)	< MQL < MQL < MQL < MQL < MQL < MQL 112.6 325.5 298.8 0.201 6.6

MQL = method quantitation limit

ppm = parts per million

ms/cm = millisiemens per centimeter

8.5 SPECIAL CHARACTERIZATION SAMPLING

Special characterization projects were conducted or completed in 1995 to verify the radiological and, in some cases, hazardous chemical status of several operations. These included the following:

- Conducted ambient air monitoring to determine the levels of diffuse and fugitive air emissions at 116-B-1, 116-B-4, 116-B-5, 116-C-1, 183-H Solar Evaporation Basin, all in the 100 Areas, and the area downwind of WHC operations in the 200 East Area. The diffuse effluent air sampling being conducted downwind of the 200 East Area operations is ongoing. Analytical data for the 100 Areas sites indicated that all radionuclides were well below the DOE DCG values. The analytical data for the samples collected downwind from the 200 East Area operations are being evaluated and the study is ongoing.
- Issued the *Preoperational Environmental Survey Report: 200 Areas Effluent Treatment Facility, State Approved Land Disposal Structure, and Liquid Effluent Retention Facility (C-018H)* (Johnson et al. 1995) completing the 2-year preoperational environmental monitoring survey for those projects. The analytical data did not identify any environmental concerns that would delay startup of those facilities.
- Submitted the *Preoperational Environmental Survey Report: 200 Areas Cross-Site Transfer Line Replacement (W-058)* (Johnson et al. 1996), completing the 2-year preoperational environmental monitoring survey for this project. The analytical data did not identify any environmental concerns that would delay startup of this system.
- Completed ambient air monitoring and issued a letter report for the Transuranic Waste Retrieval Pilot Project (Johnson 1996). The analytical data indicated elevated levels of ^{241}Pu at one location, however the concentrations were below the DOE DCG.
- Continued preoperational monitoring in support of Solid Waste Operations Complex projects (Waste Receiving and Packaging and the Central Waste Complex) in the 200 West Area. Preoperational monitoring in 1995 included collection of surface soil, vegetation, and small mammal samples. Sampling in 1996 will include vadose soil samples and verification sampling at selected sample locations. A final report of these activities is scheduled to be issued near the end of calendar year 1996.

The practical results of these data, in addition to those mentioned previously were to identify locations where pest control, waste containment, or biotic barriers needed to be improved or added, and to use vegetation and wildlife as indicators of radiological environmental quality. Benefits derived from this sampling included improved worker health and safety, reduced potential exposures, and reduced cleanup costs by early identification of loss of contaminant control.

8.6 SUSPECT WASTE SITE INVESTIGATIONS

The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1996), also known as the Tri-Party Agreement, identifies the Waste Information Data System (WIDS) as the official listing of Hanford waste management units. The ERC is contracted by DOE to administer the WIDS.

Before a waste management unit is entered into the WIDS, a suspect waste site investigation is conducted and the site is evaluated. Not all sites investigated will meet the criteria to be designated waste management units. Table 8-3 describes the suspect waste site investigations that were conducted by Near-Field Monitoring in 1995.

Table 8-3. Results of Suspect Waste Site Investigations, 1995.

Site identification	Location	Result	Waste management unit
200-W-10 Grout Wall Test Site	200 West and north of 201W	Preexisting depression/pit where experiments were conducted with grout (nondangerous/nonradioactive)	yes
200-W-11 S-Farm Foundation and Dump Site	200 West and south of 241SX	Preexisting dumping area suspected of being used as laydown yard, for vehicle maintenance, and for fabrication	yes
200-W-12 201-W Soil Mound and Plastic Pipe	200 West and north of 201W	Preexisting dumping area where is appears a scientific experiment was conducted	yes
200-W-13 2713-WB Green Hut Complex	200 West and west of the powerhouse	Preexisting building and surrounding grounds used for maintenance on vehicles contaminated with radioactive material and storage (mixed waste)	yes
200-W-14 200 West Heavy Equipment Staging Area	200 West and west of the powerhouse	Existing staging/parking area for heavy equipment which leaks/overflows petroleum products to soil (hazardous/dangerous)	yes
200-W-15 S-Plant Project W-087 Hexone Discovery	200 West near southwest corner of 202S	Preexisting unplanned release of hexone to soil was found during pipe trench excavation (hazardous/dangerous)	yes

Table 8-3. Results of Suspect Waste Site Investigations, 1995.

Site identification	Location	Result	Waste management unit
100-D-27 151-D substation UPR	100D	Non-PCB oil leak discovered and waste removed (nondangerous/nonradioactive)	no
600-65 607 Batch Plant Drum Site	600 Area and north of the 607 Batch Plant	Preexisting dumping area	yes
200-E-8 200 East Trench 94 Diesel Spill	200 East and within the 218-E-12B solid waste	Inadvertent spill of diesel to soil and waste removed	no

9.0 REFERENCES

- 40 CFR 61, Subpart H, "National Emissions Standards for Hazardous Air Pollutants," *Code of Federal Regulations*, as amended.
- 40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.
- 40 CFR 257, "Criteria for Classification of Solid Waste Disposal and Facilities and Practices," *Code of Federal Regulations*, as amended.
- 40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.
- 40 CFR 265, "Interim-Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.
- AEC, 1974, *Measurements of Radionuclides in the Environment, Sampling and Analysis of Plutonium in Soil*, Nuclear Regulatory Guide 4.5, U.S. Atomic Energy Commission, Washington, D.C.
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APPENDIX A
QUALITY ASSURANCE

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QUALITY ASSURANCE

Quality Assurance (QA) may be defined as the actions necessary to ensure the accuracy of a program. Westinghouse Hanford Company's (WHC) environmental surveillance QA program consists of procedures and guides to demonstrate that environmental monitoring techniques and analyses are performed within established limits of acceptance. This is documented in the Operational Environmental Monitoring Program (OEMP) QA Project Plan (Perkins 1994).

Written operating procedures are an integral part of the WHC OEMP QA program. Procedures for field operations are provided in an internal WHC manual. This appendix briefly describes the essential components of the WHC OEMP QA program.

DOCUMENTATION

Record keeping is a vital part of any environmental monitoring program. Maintenance of environmental data is important from a QA standpoint, from a regulatory standpoint, and for trend analyses and optimization of environmental monitoring procedures. For these reasons, each phase of the WHC OEMP is documented. This documentation includes sampling logs, annual reports, and occurrence reports.

SAMPLE REPLICATION

Replicate sampling and subsequent analysis are the primary means of assessing sample variability. Duplicate samples of air, water, soil, sediment, and vegetation are collected as part of the routine OEMP.

DATA ANALYSIS

Environmental data are reviewed to determine compliance with applicable Federal and company guides. The data are analyzed both graphically and by standard statistical tests to determine trends and impacts on the environment. Newly acquired data are compared with historical data and natural background levels. Routine environmental data are stored on both magnetic media (i.e., in a computer environment) and hard-copy printouts.

TRAINING

To ensure quality and consistency in sample collection and handling, all personnel performing such work received formal training. All WHC health physics technicians (HPT) are required to complete a certification program through the WHC Health Physics Department. In addition, those HPTs assigned to environmental programs receive special classroom orientation and on-the-job training by experienced personnel. Environmental Engineering Studies personnel, in addition to their formal training received while obtaining

professional degrees, received training in such courses as "Radiation in the Environment," taught through the Washington State University, courses taught at the Harvard School of Public Health, and various short courses.

SAMPLE FREQUENCY

The frequency of sample collection is as follows.

1. Ambient air sample filters are collected biweekly.
2. Water samples from active ponds and ditches are collected weekly.
3. Radiological surveys of roads are performed quarterly, bimonthly, or annually, as stated in Section 7.0.
4. The thermoluminescent dosimeters (TLD) at facilities, ponds, and ditches are exchanged quarterly.
5. Radiological surveys of waste sites are performed quarterly, semiannually, or annually depending on the operating status, condition, and history of the site.
6. The soil, vegetation, and fecal samples are collected annually. Mud and vegetation samples from active ponds and ditches also are collected annually.

ANALYTICAL PROCEDURES

Three laboratories provided analytical support to the WHC OEMP; these are the Quanterra Environmental Services and Waste Sampling and Characterization Facility, and the WHC 222-S Analytical Laboratory. The environmental samples are analyzed in accordance with prescribed procedures and quality control guides. The analytical procedures necessary to implement the environmental monitoring program are described briefly in the following paragraphs and are listed according to the respective laboratory.

Quanterra Environmental Services

Much of the OEMP involves measuring radionuclide concentrations at or near background levels. These environmental measurements require a very low detection limit and typically are performed at Quanterra Environmental Services. The analytical laboratory routinely analyzes soil, vegetation, animal feces, and air samples. Analyses are performed according to procedures and quality control guides described by the Environmental Measurements Laboratory (EML 1972), the U.S. Atomic Energy Commission (AEC 1974), and the National Council on Radiation Protection and Measurements (NCRPM 1976).

1. Air Samples

- a. Gamma Energy Analysis - Gamma-emitting radionuclides are measured by direct counting of the air sample filter with a germanium detector. The gamma spectra are analyzed using a Nuclear Data 7700 software system.
- b. Strontium - Airborne ^{89}Sr and ^{90}Sr are determined by leaching the composited air sample filters with nitric acid and initially precipitating them as a nitrate. The sample is purified by iron and barium scavenging. The final precipitate, strontium carbonate, then is counted for total beta (needed to set the ^{89}Sr value) with a low-background beta proportional counter. Both ^{89}Sr and ^{90}Sr are calculated from the resulting count data using a computer.
- c. Plutonium - The various plutonium isotopes are leached from the air sample filter with nitric acid and passed through an ion-exchange resin. Further decontamination from lead, bismuth, and other transuranics by washing with nitric and hydrochloric acids is done. The plutonium then is eluted from the resin and electrodeposited on a stainless-steel disk, where it is counted using a surface barrier alpha spectrometer, and data are collected on a Nuclear Data system.
- d. Uranium - The uranium is leached from the air sample filter and extracted as tetrapropyl ammonium uranyltrinitrate followed by back extraction into water. Following treatment with sodium and LiF, the aqueous sample is analyzed with a fluorometer to determine the mass of uranium.

2. Groundwater Samples

- a. Total Alpha and Beta Activity - The total activity caused by alpha- and beta-emitting radionuclides is measured by directly counting the dried residue with a gas-flow proportional counter.
- b. Strontium-90 - The strontium is removed from the water sample by precipitating it as a nitrate using nitric acid. The sample is purified by repeated scavenging with barium chromate and precipitating with barium carbonate. The strontium carbonate then is counted with a low-background gas-flow proportional counter.
- c. Gamma Energy Analysis - Gamma-emitting radionuclides are analyzed by directly counting the water sample with a germanium-lithium Ge(Li) detector equipped with a multichannel pulse-height analyzer.
- d. Tritium - Water samples are analyzed for tritium with a liquid scintillation spectrometer.
- e. Total Uranium - The water samples are analyzed for uranium first by treating them with sodium and lithium fluoride and then analyzing them with a fluorometer.

3. Soil Samples

- a. Gamma Energy Analysis - Gamma-emitting radionuclides in soil are measured using a Marinelli beaker and counting with a Ge(Li) detector equipped with a multichannel pulse-height analyzer.
- b. Strontium-90 - The ^{90}Sr is removed from the soil sample by leaching the dried sample with nitric acid. The strontium in solution is converted to an oxalate followed by precipitation as strontium carbonate. The carbonate is deposited on a planchet and counted in the same manner as the ^{90}Sr water samples.
- c. Technetium-99 - The ^{99}Tc is isolated from other elements using hydroxide carbonate coprecipitation, leaving it in solution as the pertechnetate ion (TcO_4^-). Further purification is achieved by an anion-exchange column path, followed by liquid scintillation spectrometry.

4. Vegetation Samples

- a. Gamma Energy Analysis - Gamma-emitting radionuclides in vegetation are measured by direct counting of the sample with a Ge(Li) detector equipped with a multichannel pulse height analyzer.
- b. Strontium-90 - The ^{90}Sr is removed from the vegetation sample by leaching the dried sample with nitric acid. The strontium in solution is converted to an oxalate followed by precipitation as strontium carbonate. The carbonate is deposited on a planchet and counted in the same manner as the ^{90}Sr water samples.
- c. Technetium-99 - The ^{99}Tc is isolated from other elements using hydroxide carbonate coprecipitation, leaving it in solution as the pertechnetate ion (TcO_4^-). Further purification is achieved by an anion-exchange column path, followed by liquid scintillation spectrometry.

Pacific Northwest National Laboratory Radiation Standards and Engineering

Thermoluminescent Dosimeters - External radiation levels are measured using TLDs. TLDs at each sampling location monitor facilities, water sampling sites, active tank farms and various cribs, and trenches. The Hanford Site uses the Harshaw 8807 dosimeter and the Harshaw 8800 reader.

The TLDs are calibrated, packaged, and read by the PNNL Radiation Calibration Laboratory, Radiation Standards and Engineering Department. All TLD work is performed in accordance with the procedures and specific guides from the American National Standards Institute (ANSI 1975) and PNNL.

Westinghouse Hanford 222-S and Waste Sampling and Characterization Facility (WSCF) Analytical Laboratories

The WHC 222-S and Waste Sampling and Characterization Facility (WSCF) laboratories also provides analytical support to the OEMP. The

222-S Laboratory is the one normally used for samples containing higher than normal environmental levels of radioactivity. Analytical procedures and quality control guides are described by the Environmental Measurements Laboratory (EML 1972), the American Society for Testing and Materials (ASTM 1976), the American Public Health Association (APHA 1980), and the U.S. Environmental Protection Agency (EPA 1979). A brief description of the routine analyses performed by the 222-S and WSCF Laboratories follows.

1. Pond and Ditch Water

- a. Total Alpha and Beta Activity - An aliquot of the pond or ditch water is added to a stainless-steel dish and evaporated to dryness. The total alpha and beta activities are measured by direct counting with a gas flow proportional counter.
- b. Gamma Energy Analysis - The liquid sample is sealed inside a geometrically approved container. The gamma-emitting radionuclides are measured by direct counting with a Ge(Li) detector equipped with a multichannel analyzer.
- c. Strontium-90 - The ^{90}Sr is removed from the aqueous sample by precipitating it out with barium carbonate. The strontium carbonate is purified by redissolving with nitric acid, precipitating as a nitrate, and precipitating again as a carbonate. The ^{90}Sr activity is determined by beta counting with a gas flow proportional counter.
- d. Plutonium - Actinides are removed from the aqueous sample by precipitation with iron. The precipitate is redissolved in hydrochloric acid and the plutonium is separated from the other actinides by ion exchange. The plutonium is electrodeposited on a planchet and counted using alpha spectrometry.

2. Pond and Ditch Mud and Sediment

- a. Gamma Energy Analysis - The gamma-emitting radionuclides are measured by direct counting of the dried sediment sample using a Ge(Li) detector equipped with a multichannel analyzer.
- b. Soil Leach - Strontium, plutonium, americium, and other elements are leached from the soil sample using a mixture of hydrochloric and nitric acids. The leachate is then analyzed for specific radionuclides as is done with the liquid samples.

3. Pond and Ditch Vegetation

- a. Gamma Energy Analysis - The liquid sample is sealed inside a geometrically approved container. The gamma-emitting radionuclides are measured by direct counting with a Ge(Li) detector equipped with a multichannel analyzer.
- b. Vegetation Leach - The vegetation samples are dry ashed in a furnace and then leached with a mixture of hydrochloric and nitric acids. The leachate is analyzed for specific radionuclides as is done with the liquid samples.

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APPENDIX B

GLOSSARY

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APPENDIX B

GLOSSARY

Definitions

Aboveground Tank - A tank situated so that its entire surface area is completely above the plane of the adjacent surrounding surface and the entire surface area of the tank (including the tank bottom) can be visually inspected (WAC 173-303-040).

Accessible Soils - Hanford soils that are not behind security fences must meet the Table 6.2 values found in the Westinghouse Hanford Company *Environmental Compliance Manual*, WHC-CM-7-5. The values reflect a 10-mrem/yr effective dose equivalent (EDE) limit from Hanford Site operations to the most exposed member of the public.

Administrative Control Value (ACV) - Operating contractor's internally imposed release limit for an airborne or liquid effluent. The ACV is usually expressed as a fraction or multiple of the derived concentration guide (DCG)-public but may also be expressed as a total release value (curies per year for Kr-85 and tritium). In applying the ACV, the "Unity Rule" applies; the sum of the fractions of the ACV in an effluent shall not exceed 1.

Airborne Radioactive Effluents - Radioactive particles, mists, vapors, fumes, and/or gases contained or entrained in airborne effluents.

Aquifer - A subsurface formation consisting of sufficient saturated permeable material to yield significant quantities of water.

Areal Contamination - Contamination generally confined to less than the first centimeter of soil. Numerically, the radioactivity content averaged over a suitable area.

As Low As Reasonably Achievable (ALARA) - The implementation of ALARA is described in WHC-CM-4-11, *ALARA Program Manual*. This concept applies to maintaining releases at or below prescribed regulatory limits.

Assure - To remove any doubt, to promise.

Audit - An announced examination of a facility or operation to determine compliance with the specific requirements.

Average Soil Contamination - Contamination generally dispersed through the soil. Numerically, the radioactivity content averaged over a suitable mass of soil.

Backfill Soil - The soil used as a plant growth medium between the depths of 30-120 cm as measured at the restabilization site.

Background Radiation - Refers to regional levels of radioactivity produced by sources other than those of specific interest (e.g., the nuclear activities at the Hanford Site).

Barrier or Engineered Barrier - At a disposal site, a manufactured addition designed to retard or preclude radionuclide or other contaminant transport and/or preserve the integrity of the disposal site.

Becquerel (Bq) - The standard international unit of radioactivity. One Bq is one disintegration per second or:

$$\text{Bq} = 2.7 \text{ E} - 11 \text{ Ci}$$

Biological Transport - Means of biological transport may include one or more of the following processes:

- Movement of subsurface radioactivity to the surface by physiological vegetative processes
- Dispersion of such vegetation by the wind
- Contaminated urine and feces deposited by animals that have gained access to and ingested radioactive materials
- Contaminated animals themselves that have ingested radioactive materials directly or ingested other contaminated animals or plants
- Physical displacement of radioactive materials by burrowing animals
- Nests built using contaminated materials.

Biota - The plant and animal life of a specific region.

Building - A structure created to shelter any form of human activity, such as a house, barn, church, hotel, or similar structure; it also may refer to a historically related complex, such as a courthouse and jail; or, on the Hanford Site, buildings to include: old reactor buildings, office buildings, e.g., 2750 Building, 222-S Laboratory Building, etc.

Burial Ground - A land area specifically designated to receive contaminated solid or solidified liquid waste packages and equipment. The contaminated articles are usually placed in trenches and covered with overburden.

Byproduct - A material that is not one of the primary products of a production process and is not solely or separately produced by the production process. Examples are process residues such as slags or distillation column bottoms. The term does not include a coproduct that is produced for the general public's use and is ordinarily used in the form in which it is produced by the process.

Calibration - Determining the deviation of an instrument from a standard traceable to the National Bureau of Standards (NIST) or other recognized agency and reporting the deviations and/or eliminating them by adjustment.

Central Landfill - The contractor-operated, U.S. Department of Energy (DOE)-owned disposal site used for disposal of trash and other nonhazardous nonradioactive wastes.

Chemical Processing - Chemical treatment of material to separate desired components selectively. At the Hanford Site, plutonium, uranium, and fission products were chemically separated from irradiated fuels.

Chemical Substance - Any organic or inorganic substance except the following:

1. Any mixture
2. Any pesticide when used as a pesticide
3. Any tobacco product
4. Any source material, special nuclear material, or byproduct material
5. Any firearms, shells, or cartridges
6. Any food, food additive, drug, cosmetic, or device, when used for its intended purpose.

Manufacture for Commercial Purpose - To import, produce, or manufacture with the purpose of obtaining commercial advantage for the manufacturer, including manufacturing any amount of a chemical substance or mixture for the following reasons:

1. Distribution in commerce
2. Use by the manufacturer, including use for product research and development, or as an intermediate. The definition of manufacturer includes extracting a chemical from another chemical substance or mixture of substances.

Chemical Trench - The central landfill trench that is used for the disposal of chemicals, hazardous wastes, and hazardous substances.

Committed Dose Equivalent - The predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert).

Committed Effective Dose Equivalent - The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighing factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

Composite Sample - A number of random samples initially collected from a waste and combined into a single sample; this sample is analyzed for the contaminants of concern.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) - Commonly known as "Superfund," CERCLA was enacted to respond to uncontrolled releases of hazardous substances to the environment, primarily at inactive sites that were not adequately addressed by the **Resource Conservation and Recovery Act of 1976 (RCRA)**. CERCLA also applies to actively managed facilities and any onshore or offshore facility.

Confined Aquifer - A subsurface water-bearing region having defined and relatively impermeable upper and lower boundaries.

Conserve - Use methods and procedures necessary to protect any endangered or threatened species. Such methods and procedures include, but are not limited to, activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation. In the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, methods and procedures may include regulated taking.

Controlled Area - An area where access is controlled to protect individuals from exposure to radiation and radioactive materials.

Construction - Addition, enlargement, modification, replacement, alteration, or restart (after a period of 5 years of nonoperation) of any process or stationary source that may increase emissions or ambient air concentrations of any contaminant for which federal or state ambient or emission standards have been established.

Contamination Limit - That concentration limit or activity limit for radioactive materials below which posting restrictions and environmental controls to protect personnel or the environment are not necessary.

Crib - An underground structure designed to receive liquid waste that percolates into the soil directly or percolates into the soil after having traveled through a connected tile field.

Decommissioning - Actions taken to reduce the potential health and safety impacts of DOE-controlled contaminated facilities. Actions could include stabilizing, reducing, or removing radioactivity or demolishing the contaminated facilities.

Decommissioning - The process of removing a facility or area from operation, often involving decontamination and/or disposal and incorporating appropriate controls and safeguards.

Decontamination - The removal of contamination from a surface or from within another material.

Decontamination - The removal of radioactive or hazardous contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical treating, mechanical cleaning, or other techniques.

Demolition Waste - Solid waste, made up largely of inert waste resulting from the demolition or razing of buildings, roads, and other manufactured structures. Demolition waste consists of, but is not limited to, concrete,

brick, bituminous concrete, wood and masonry, composition roofing and roofing paper, steel, and minor amounts of other metals such as copper.

Plaster (sheet rock or plaster board), asbestos, or any material other than wood that is likely to produce gases or a leachate during the decomposition process is not considered to be demolition waste.

Derived Concentration Guide for Occupational Exposure (DCG-Occupational) - Those concentrations in air or water that an occupationally exposed individual would have to inhale/ingest in a year to result in 5,000 mrem/50 year dose commitment.

Derived Concentration Guide for Public Exposure (DCG-Public) - The concentration of radioactive materials in air or water specified in Appendix A, "Derived Concentration Guides for Controlling Exposure to Members of the Public," of this manual. The DCG-Public are those concentrations of radionuclides in air or water that would result in a maximum effective committed dose equivalent of up to 100 mrem per year using ICRP-30 dose methodology under conditions of continuous exposure or use (i.e., continuously breathing or being in contact with contaminated air or exclusively drinking contaminated water).

Diffuse Source - A source or sources of radioactive or chemical contaminants released into the environment that do not have a defined point or origin of release (a nonpoint source). Such sources are also known as area sources.

Dispersible - Capable of being widely spread.

Disposal - Discharging, discarding, or abandoning dangerous waste, or the treatment, decontamination, or recycling of such waste once it has been discarded or abandoned. This includes the discharge of any dangerous waste into or on any land, air, or water (WAC 173-303-040). This definition also includes radioactive materials.

Disposal Facility - Any facility or part of a facility where hazardous and/or radioactive waste is intentionally placed or where any land or water waste will remain after closure.

District - A geographically definable area (urban or rural) with a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united either by past events or aesthetically by planned physical development. A district may also be individual elements that are separated geographically but linked by association or history.

Disturbance - Includes, but is not limited to, the following: leveling; firebreak, road, or utility line construction; excavation of pits, foundations and trenches; quarrying and borrowing of rock and soils; seismic testing; and stockpiling of earth.

Ditch - An open surface site for transport of liquid wastes to a pond or trench structure designed for percolation.

Ecology - The Washington State Department of Ecology.

Effective Dose Equivalent (EDE) - The summation of the products of the dose equivalent received by specified tissues of the body and a tissue-specific weighing factor. This sum is a risk-equivalent value and can be used to estimate the health-effects risk of the exposed individual. The tissue-specific weighing factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The EDE includes the committed EDE from internal deposition of radionuclides and the EDE caused by penetrating radiation from sources outside the body. EDE is expressed in units of rem (or sievert).

Effluent - An airborne or liquid discharge from a facility after all engineered waste treatment and effluent controls have been performed. The term includes onsite discharges to the atmosphere, lagoons, ponds, cribs, injection wells, French drains, or ditches. The term does not include solid waste stored or removed for disposal or waste that is contained in retention basins or tanks before treatment and/or disposal.

Emissions Unit - Regarding air pollutant emissions, any part of a stationary source that emits or would have the potential to emit any pollutant subject to regulation.

Ensure - To make certain, make sure, make safe.

Environmental Monitoring Plan (EMP) - A two-part document prepared for each site, facility, or process that uses, generates, releases, or manages significant pollutants or hazardous materials.

Environmental Sites Database (ESD) - A database of environmental Sites which is administered by the ERC.

Exhaust System - A stack, gaseous effluent system, building ventilation system, or any system that vents air or gaseous material to the atmosphere.

Expedited Response Action - An interim response action (IRA) or interim measure (IM) process. This includes any onsite response action (under CERCLA or RCRA authority) to mitigate site contamination conducted before initiation of remedial action or corrective action in accordance with final record of decision (ROD) or permit modifications.

Facility - A processing plant, tank farm, shop, laboratory, powerhouse, or laundry. Including all contiguous land and structures, other appurtenances, and improvements on land used for recycling, reusing, reclaiming, transferring, storing, treating of dangerous waste (including treatment, storage, and disposal sites as well as groundwater wells). (40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment Storage and Disposal Facilities," and WAC 173-303-040.)

Facility-Specific Environmental Monitoring - Routine environmental monitoring of all environmental media (air, biota, etc.) around facility parameters.

Field Blank - Aliquots of analyte-free water or solvents brought to the field in sealed containers and transported to the laboratory with the sample container. Field blanks include trip blanks and equipment blanks.

Field Duplicate - Field duplicates are collected at specified frequencies and are used to document precision. The field duplicate precision depends on the variance of waste composition, sampling techniques, and analytical technique.

Fish or Wildlife - Any member of the animal kingdom including (without limitation) any mammal, fish, bird, amphibian, reptile, mollusk, crustacean, arthropod, or other invertebrate--including any part, product, egg, offspring, or the dead body or parts of the offspring.

French Drain - A covered or rock-filled encasement with the bottom end open to allow liquids to seep into the ground.

Fugitive Emissions - Material that is generated incidental to an operation, process, or activity and that is released or dispersed into the open air. Fugitive emissions occur via pathways that do not allow routine measurement at the point of release.

Grab Sample - A single sample removed from a stream over a short time interval.

Groundwater - Water that exists below the water table, also referred to as the zone of saturation. However, the capillary fringe directly above can be completely saturated if the sediment is fine enough. To avoid this ambiguous term, the use of phreatic water, which is water that enters freely into wells under both confined and unconfined conditions is suggested. Phreatic water is a term originally applied only to water that occurs in the upper part of the zone of saturation under water table conditions (unconfined groundwater or well water), but has come to be applied to all water in the zone of saturation, thus making it an exact synonym of groundwater. Above the water table is the vadose zone, where water pressures are less than atmospheric pressure. This zone still contains water, but the water is held to the soil particles or other groundwater material by capillary force. Thus, while this water still can move within the vadose zone, it cannot move out of the zone into a well or other places that are exposed to atmospheric pressure. The dividing line between water in the vadose zone and phreatic water is the atmospheric pressure between the two, with the pressure of vadose water being below atmospheric pressure and that of phreatic water (i.e., groundwater) above atmospheric pressure.

High-Efficiency Particulate Air (HEPA) Filter - To qualify as a HEPA filter, a filter must achieve an efficiency of 99.97 percent under laboratory conditions and 99.95 percent after installation for the removal of airborne particulates greater than 3 E-05 cm (0.3 microns).

High-Level Nuclear Waste - Spent nuclear fuel or radioactive waste resulting directly from the dissolution and reprocessing of spent nuclear fuel. Secondary waste streams resulting from the dissolution and reprocessing of spent nuclear fuel are not considered high-level waste.

Immobile Radionuclides - All those radionuclides that are sorbed onto Hanford Site soils and usually would not migrate through the vadose zone or the groundwater below the future control zone.

Inaccessible Soils - Areas from which the general public is excluded (by fences, posting, patrols, or distance), but that are still subject to meteorological effects, are subject to a 10-mrem/yr operational EDE limit, as reflected in Table 6-1.

Inactive Crib - A crib that has been designated as permanently out of service.

Inactive Radioactive Waste Site - Any waste site that is no longer needed for current operational programs and that is not currently an active waste disposal site.

Inactive Waste Sites - Inactive waste sites include units such as burial grounds, unplanned release sites, cribs, ditches, ponds, trenches, and basins, abandoned storage areas, drains, single-shell tank piping, transfer pits, and jumper boxes.

Injection Well - A well used for mixing liquid waste with groundwater.

Inert Waste - Noncombustible, nondangerous solid waste that is likely to retain its physical and chemical structure under expected conditions of disposal, including resistance to biological attack and chemical attack from acidic rainwater.

Insure - To cover by insurance against loss.

Less Than Detectable - An analytical term for a concentration in a sample that is lower than the minimum detection capabilities of that analytical equipment or process.

Low-Level Waste - Any gaseous, liquid, or solid radioactive waste not classified as high-level waste, transuranic (TRU) waste, or spent nuclear fuel, as defined by DOE Order 5820.2. Also see Threshold Concentrations.

Maximum Contaminant Level (MCL) - The drinking water standards specified in 40 CFR 141, "National Primary Drinking Water Regulations." See Appendix C, "Maximum Contaminant Levels."

Minimum Detection Limit - See detection limit.

Mixed Waste - Dangerous waste that also contains enough radioactivity to be classified as radioactive waste.

Modification - Any physical or operational change to a stationary source that results in an increase in the rate of emission to the atmosphere of an air pollutant to which a standard applies.

Monitored Sample - A sample collected in a monitoring system and used to alert operations to nonroutine releases and to provide process control.

Monitoring System - Instrumentation that provides measurement of an airborne or liquid waste stream parameters. The system includes a detector and associated readout components. A continuous monitoring system measures the stream parameters on a near-real-time basis or as specified in applicable

EPA regulations, 40 CFR 52, "Approval and Promulgation of Implementation Plans," Appendix E; 40 CFR 51, "Requirements for Preparation, Adoption, and Submittal of Implementation Plans," Appendix P, or as defined in applicable ANSI Standards. A radiation monitoring system is a system in which radiation or radioactivity is the measured parameter. An integrating monitoring system totals the instantaneously measured parameter over some time period. A sampling system does not measure or read out an instantaneous stream parameter.

Naturally Occurring Radioactive Materials - Also see Threshold Concentrations.

Nonroutine Activities - Any actions on a large-scale (>5 acres), including stabilization, soil removal, fixative or sealant application, other surface treatments, or other activities that could affect future remediation activities in an inactive waste site.

Normally Contaminated Airborne or Liquid Effluent - An airborne or liquid effluent from a facility or area that contains dispersible or unsealed radioactive materials in quantities sufficient to cause releases of radioactive materials in excess of 10 percent of the administrative control limit (ACL) averaged over 1 year (i.e., the total activity present times an appropriate suspendable or immersible fraction divided by the total annual flow exceeds 10 percent of the ACL).

Operate - As used in this section with respect to the activities of WHC, the term "operate" (and other forms of the term) will refer to the performance by WHC of its day-to-day activities in connection with the tanks and tank systems. Such activities shall be subject to the overall management, control, and oversight by DOE.

Operational Environmental Monitoring - The collection and analysis of samples of air, water, soil, biota, and other media near nuclear facilities on DOE sites and their environs and the measurement of external radiation to demonstrate compliance with applicable standards and assess radiation exposures to employees and members of the public, and the near-field environment.

Operations - In this report this term loosely refers to WHC activities including chemical processing, waste management, and decommissioning.

Operations - The contractor organization responsible for operating plants and facilities.

Overall Error - In this report, this term means the overall analytical error supplied by the laboratory performing the analysis.

Percolation - Downward movement of water through the interstices of unsaturated rock or soil because of gravity or hydrostatic pressure.

Pesticide - In this manual, as defined in 40 CFR 162, the term pesticide covers all pest-control chemicals such as herbicides, rodenticides, and insecticides.

Plutonium Processing and Handling Facility - Any facility constructed primarily to process plutonium (including ^{238}Pu) and that handles in-process plutonium.

Plutonium Storage Facility - Any facility constructed to store strategic (category I) quantities of plutonium.

Point of Release - The point at which a material is released to the environment such as the top of a stack or the end of a pipe.

Point Source - A single defined point (origin) of an airborne release, such as a vent or stack.

Pond - A surface impoundment used to contain or percolate low-level liquid radioactive waste, mixed waste, or hazardous waste.

Potentially Contaminated Airborne or Liquid Effluent - An airborne or liquid effluent from a facility or area that contains radioactive materials in quantities sufficient to cause releases of radioactive materials in excess of 10 percent of the ACV averaged over 1 year (the total activity present times a reasonable suspendable or immisible fraction divided by the annual flow equals more than 10 percent of the ACV).

Potentially Corrosive Liquid Waste Stream - Any liquid waste stream that has been identified as having the potential, during upset conditions, to discharge liquid with a pH value of less than or equal to 2, or greater than or equal to 12.5.

Previously Disturbed Ground - Ground that has had its contours altered by leveling, filling, or excavation or that has been contaminated by radiation or dangerous chemicals to the extent that an individual cannot enter the area without wearing protective clothing. Disturbance is determined by observation, aerial photographs, and topographic maps.

Quality Assurance - A process designed to maintain the quality of the results of a program within established limits of acceptance.

Quality Assurance - All those planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service.

Radiation Survey - Evaluation of an area or object with portable instruments to identify radioactive materials and radiation fields present.

Radioactive Byproduct - Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or using special nuclear material (*Atomic Energy Act of 1954*, as amended). The nonradioactive hazardous component of the waste material will be subject to regulation under the RCRA.

Radioactive Liquid Effluent - A liquid effluent that has a reasonable potential for containing radioactive materials in quantities such that the annual average concentration is equal to or greater than the MCL. Also see Threshold Concentrations.

Radioactive Solid Waste - See Threshold Concentrations.

Radiological Control Area - An area where access is controlled to protect individuals from exposure to radiation and/or radioactive materials. Radiological control areas include, but are not limited to, areas posted as Radiation Area, Surface Contamination, and Underground Radioactive Materials, to describe the radiological condition of the area within.

Radiological Posting - Information in the form of signs and chains to inform people of conditions that warrant avoidance or special precautions for entry.

Release From Radiological Posting - Removal of signs and chains when access to an area no longer needs to be restricted for radiological protection purposes.

Representative Sample - The average stream parameter being measured occurs in the sample in the same average proportion that it occurs in the environmental discharge.

Retired Waste Site - A waste site that is isolated and no longer available to receive waste in any form.

Reverse Well - Same as injection well.

Routine Activities - Any actions on a small-scale (<5 acres), including radioactive hot-spot removal, vegetation removal, fencing, posting, herbicide spraying, stabilization, or immediate spill response) in an inactive waste site. In general, these routine actions shall not interfere with RCRA/CERCLA response or site investigations.

Routine Emissions - Air emissions of pollutants or releases from accidents are not considered routine. However, releases of air pollutants to the atmosphere that result from normal operations and releases that are not routine, but are more likely than not to occur, are included as routine emissions.

Sampling System - Instrumentation and equipment that remove a part of a liquid or airborne waste stream for subsequent quantitative determination of stream parameters. The system generally employs such devices as filters, other sample collection media, or effluent traps of some kind. A continuous sampling system removes a part of the stream continuously except during sample change, maintenance, repair, or other necessary outages. A grab sampling system removes an instantaneous part of the stream or removes a part of the stream over a time period.

Sealed - A container having a cover bonded with the container or a cover strong enough to prevent contact with and dispersion of the contents of the container under conditions of use and wear for which it was designed.

Sediment Column - The sediment beneath a crib. It can mean either all the sediment beneath the bottom of the crib extending to the water table or all sediment beneath a crib contaminated by radioactive materials.

Separation Areas - The fenced 200 Areas and those areas (such as B Pond and Gable Mountain Pond) that have received or continue to receive liquid waste discharged from previous or current chemical processing and waste management operations. The future control zone includes the separation area.

Separations Area - The primary area on the Hanford Site where chemical processing and most waste management activities are performed. It includes the 200 Areas and nearby 600 Area sites. WHC is landlord of the Separations Area.

Site - The location of a significant event, a prehistoric or historic occupation or activity, or a building or structure (whether standing, ruined, or vanished) where the location itself maintains historical or archeological value, regardless of the value of any existing structure.

Soil at depth - Soil below 36 in.

Solid Waste - Any discarded material that is not excluded by WAC 173-303-017(2) or that is not excluded by a variance granted under WAC 173-303-017(5). Materials are solid waste if they are: (1) abandoned by being disposed of, burned, or incinerated, or (2) accumulated, stored, or treated (but not recycled) before (or in lieu of) being abandoned by being disposed of, burned, or incinerated. In addition, a solid waste includes any material considered to be inherently waste-like.

Specific Contamination - Single grains of soil, rust particles, feces, or pieces of vegetation.

Speculative Accumulation - A material accumulated before being recycled. If the material is potentially recyclable and at least 75 percent is recycled during the calendar year (commencing on January 1), it is not a speculative accumulation.

Spent Materials - Used materials that are no longer usable without being regenerated, reclaimed, or reprocessed. Examples are spent solvents, spent activated carbon, spent catalysts, and spent acids. Does not include spent fuel from reactors.

Spot Contamination - A spot or quantity of contamination less than 1 cm³ in volume, or areal contamination less than 15 cm² in area.

Stabilization - The process of covering surface contaminated areas with clean backfill or topsoil.

Standard - A specified set of rules or conditions concerned with the classification of components; delineation of procedures; definition of terms; designation of materials, performance, design, or operations; or measurements of quality in describing materials, products, systems, services, or practices. A standard is more general than a procedure or specification and more specific than a criterion.

Standard Error of the Mean - A measure of the uncertainty in the estimated averages of data because of random variations.

Stationary Source - Any building, structure, facility, or installation that emits or may emit any air pollutant.

Structure - A work constructed by humans that consists of interdependent and interrelated parts in a definite pattern of organization. It is often a large-scale engineering project.

Suitable Surface Area - Area no more than 15 cm² over which spot contamination may be averaged in determining areal contamination.

Sump - Any stationary pit or reservoir, including those troughs/trenches connected to it, that serve to collect oil products, hazardous substances, low-level radioactive material, dangerous waste, mixed waste, high-level radioactive materials, or TRU materials.

Surface Contamination - A radiological control status that refers to radioactivity on the surface of the ground that exceeds the soil contamination standard.

Surface Soil - Soil from 0- to 2-in. deep.

Surface Stabilization - A remedial action program on waste disposal sites that includes the addition of at least 46 to 50 cm (18 to 20 in.) of clean soil followed by revegetation. It is designed to cover surface contamination and inhibit biological and wind transport.

Surplus Facilities - Surplus facilities include all facilities that have been accepted into a decommissioning program.

Survey - A method to detect the release, disposal, or presence of radioactive materials or hazardous substances under a specific set of conditions to determine actual or potential hazards. Such an evaluation may include, but is not limited to, tests, physical examinations, and measurements of radiation or concentrations of materials.

Suspect Waste Site - A site, believed to have been previously unknown or undocumented, that, because of characteristics present at the site or historical information about the site, is suspected of containing waste (i.e., non-dangerous, hazardous, dangerous, mixed, and radioactive).

Suspendable Fraction - The fraction of material that may become airborne.

Taking of Any Animal - To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any animal or attempt to engage in any such activity.

Tank - A stationary device designed to contain an accumulation of oil products, hazardous substances, low-level radioactive material, dangerous waste, mixed waste, high-level radioactive materials, or TRU materials, that is constructed primarily of nonearthen materials (e.g., wood, concrete, steel, plastic) that provide structural support.

Tank Farm - An area of large underground tanks designed to store up to 1 Mgal each of high-level liquid waste.

Technologically Enhanced Naturally Occurring Radioactivity - Refined or processed ores or other materials containing naturally occurring radioactive materials, such that radiation exposure or potential radiation exposure is increased.

Thermoluminescent Dosimeter - A chip or series of chips used for measuring external gamma radiation. It consists of a material capable of absorbing energy imparted by ionizing radiation, then emitting light as a result of thermal stimulation. A measure of that light is proportional to the radioactivity absorbed.

Threshold Concentrations - Those concentrations of radionuclides in various waste or substances that do not require the controls of radioactive waste disposal.

1. Air. No threshold value exists.
2. Liquid. Liquids containing radionuclides in a concentration of less than $0.04 \times \text{DCG}$ may be disposed of as nonradioactive liquid waste. This threshold level is equivalent to the EPA Drinking Water Standard (40 CFR 141).
3. Soil/Solid. Soils or other solids containing radionuclides below those listed in Table 6-1 (on hold) may be released for onsite disposal as nonradioactive waste. No offsite release criteria exist.

Threshold Limit Value (TLV) - Threshold limit value time-weighted average (TLV-TWA). The time-weight average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

Topsoil - The soil used as a plant growth medium at the surface to a depth of 30 cm as measured at the restabilization site. Topsoil is added soil to support the stabilization of a retired disposal facility with the objective of controlling erosion, establishing the growth of perennial grasses, and preventing the growth of deep-rooted vegetation.

Transuranic (TRU) Radionuclide - Any radionuclide having an atomic number greater than 92 (DOE Order 5820.2).

Transuranic Waste - Without regard to source or form, radioactive waste that at the end of institutional control periods is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g (3700 Bq/g). The Waste Isolation Pilot Plant, high-level waste, and spent nuclear fuel as defined by DOE Order 5820.2 are specifically excluded from this definition.

Trip Blank - A type of field blank used to accompany sample containers to and from the field and to detect contamination or cross-contamination that occurs during sample handling and transportation.

Unconfined Aquifer - An aquifer that has a water table or surface at atmospheric pressure.

Uncontaminated Soil - A soil or a land area that requires no controls or restrictions in any way for radiation protection purposes and/or meets the contamination limit specifications.

Underground Radioactive Material - A radiological posting status where subsurface radioactivity is present but where surface contamination does not exceed the soil standards.

Underground Storage Tank - Any one or any combination of tanks (including underground connection pipes) used to contain an accumulation of regulated substances. At least 10 percent of the volume of the tanks (including the volume of underground pipes) is beneath the surface of the ground (WAC 173-360-120). A tank situated in an underground area (such as a basement, cellar, etc.) is not considered to be underground if the tank is situated on or above the surface of the floor (WAC 173-360-110). Surface impoundments, pits, ponds, lagoons, storm water collection systems, or septic tanks are not considered to be underground storage tanks, and are not subject to the underground storage tank requirements (WAC 173-360-110).

Unity Rule - If more than one radionuclide is present, the sum of the fractions represented by each radionuclide concentration divided by its respective limiting concentration (ACV) shall not exceed unity. This rule could also apply to parameters other than radionuclide concentration.

Unplanned Radioactive Release Site - Any site thought to contain radioactive material that is released unintentionally (spills, windblown contamination, tumbleweeds, etc.).

Unplanned Release Site - An area that was contaminated by an unplanned release of radioactive contamination, making it a radiological control area.

Unrestricted Release - Values below which unrestricted release of soils will occur will be defined in an applicable record of decision.

Unsampled Liquid Disposal Site - A liquid waste disposal site that is currently receiving an effluent stream that does not require sampling.

U.S. Environmental Protection Agency (EPA) - The federal agency chartered with carrying out and monitoring the environmental regulations.

Vadose Zone - The zone of aeration in the earth's crust above the groundwater level.

Vadose Zone - The unsaturated region of soil or the zone of aeration between the ground surface and the water table.

Vector - A vertebrate or invertebrate that can transmit toxic, radioactive, or infectious material from a disposal or storage site to uncontrolled areas. Vectors include flies, birds, and mice.

Waste Information Data System (WIDS) - A database that identifies waste management units on the Hanford Site. It is a subset of the ESD.

Waste Management - The activity involved with storing, disposing of, shipping, handling, and monitoring all radioactive waste.

Waste Sites - Any facility used for the planned disposal of hazardous, radioactive, toxic, or nonradioactive/nontoxic waste.

Water Table - The upper boundary of an unconfined aquifer below which saturated groundwater occurs.

Table B-1. Radionuclide Nomenclature

Radionuclide	Symbol	Half-Life	Radionuclide	Symbol	Half-Life
tritium	³ H	12.3 yr	cesium-137	¹³⁷ Cs	30.3 yr
beryllium-7	⁷ Be	53.28 d	cerium-144	¹⁴⁴ Ce	284.6 d
carbon-14	¹⁴ C	5,715 yr	promethium-147	¹⁴⁷ Pm	13.4 m
sodium-22	²² Na	2.6 yr	europium-152	¹⁵² Eu	13.5 y
potassium-40	⁴⁰ K	1.26 x 10 ⁹ yr	europium-154	¹⁵⁴ Eu	8.6 y
argon-41	⁴¹ Ar	1.8 h	europium-155	¹⁵⁵ Eu	4.7 yr
chromium-51	⁵¹ Cr	27.7 d	thallium-208	²⁰⁸ Tl	3.1 min
manganese-54	⁵⁴ Mn	312 d	bismuth-212	²¹² Bi	60.6 min
cobalt-57	⁵⁷ Co	271.8 d	lead-212	²¹² Pb	10.6 h
cobalt-60	⁶⁰ Co	5.3 yr	polonium-212	²¹² Po	0.3 x 10 ⁻⁶ s
nickel-63	⁶³ Ni	100 yr	polonium-216	²¹⁶ Po	0.15 s
zinc-65	⁶⁵ Zn	243.8 d	radon-220	²²⁰ Rn	55.6 s
krypton-85	⁸⁵ Kr	10.7 yr	radium-226	²²⁶ Ra	1,600 yr
strontium-89	⁸⁹ Sr	50.5 d	radium-228	²²⁸ Ra	5.75 yr
strontium-90	⁹⁰ Sr	29.1 yr	thorium-232	²³² Th	1.4 x 10 ¹⁰ yr
niobium-95	⁹⁵ Nb	35.0 d	uranium total	U or uranium	--
zirconium-95	⁹⁵ Zr	64.0 d	uranium-234	²³⁴ U	2.4 x 10 ⁵ yr
molybdenum-99	⁹⁹ Mo	2.7 d	uranium-235	²³⁵ U	7 x 10 ⁸ yr
technetium-99	⁹⁹ Tc	2.12 x 10 ⁵ yr	uranium-236	²³⁶ U	2.3 x 10 ⁷ yr
ruthenium-103	¹⁰³ Ru	39.4 d	uranium-238	²³⁸ U	4.5 x 10 ⁹ yr
ruthenium-106	¹⁰⁶ Ru	1.0 yr	plutonium-238	²³⁸ Pu	87.7 yr
tin-113	¹¹³ Sn	115 d	neptunium-239	²³⁹ Np	2.4 d
antimony-125	¹²⁵ Sb	2.7 yr	plutonium-239	²³⁹ Pu	2.4 x 10 ⁴ yr
iodine-129	¹²⁹ I	1.7 x 10 ⁷ yr	plutonium-240	²⁴⁰ Pu	6537 yr
iodine-131	¹³¹ I	8.0 d	plutonium-241	²⁴¹ Pu	14.4 yr
barium-133	¹³³ Ba	10.53 yr	americium-241	²⁴¹ Am	433 yr
cesium-134	¹³⁴ Cs	2.1 yr			

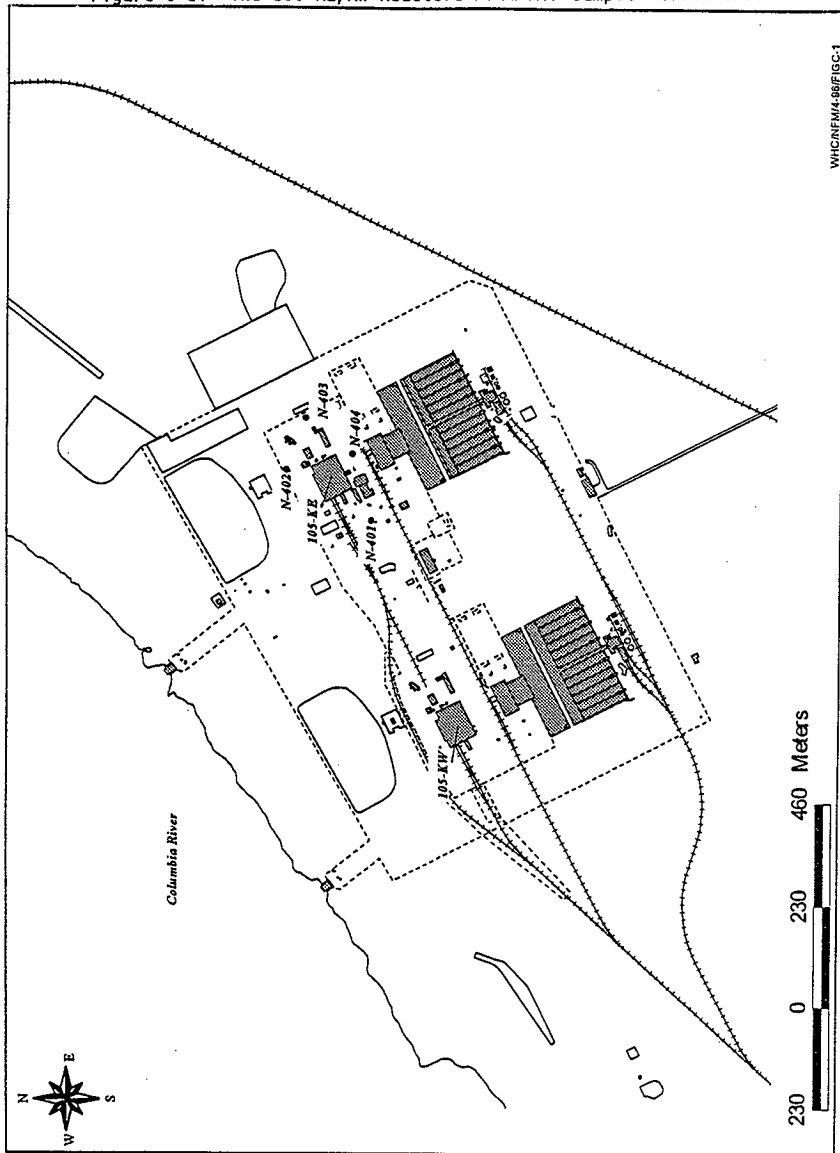
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APPENDIX C

**AMBIENT AIR MONITORING FIGURES
AND TABLES**

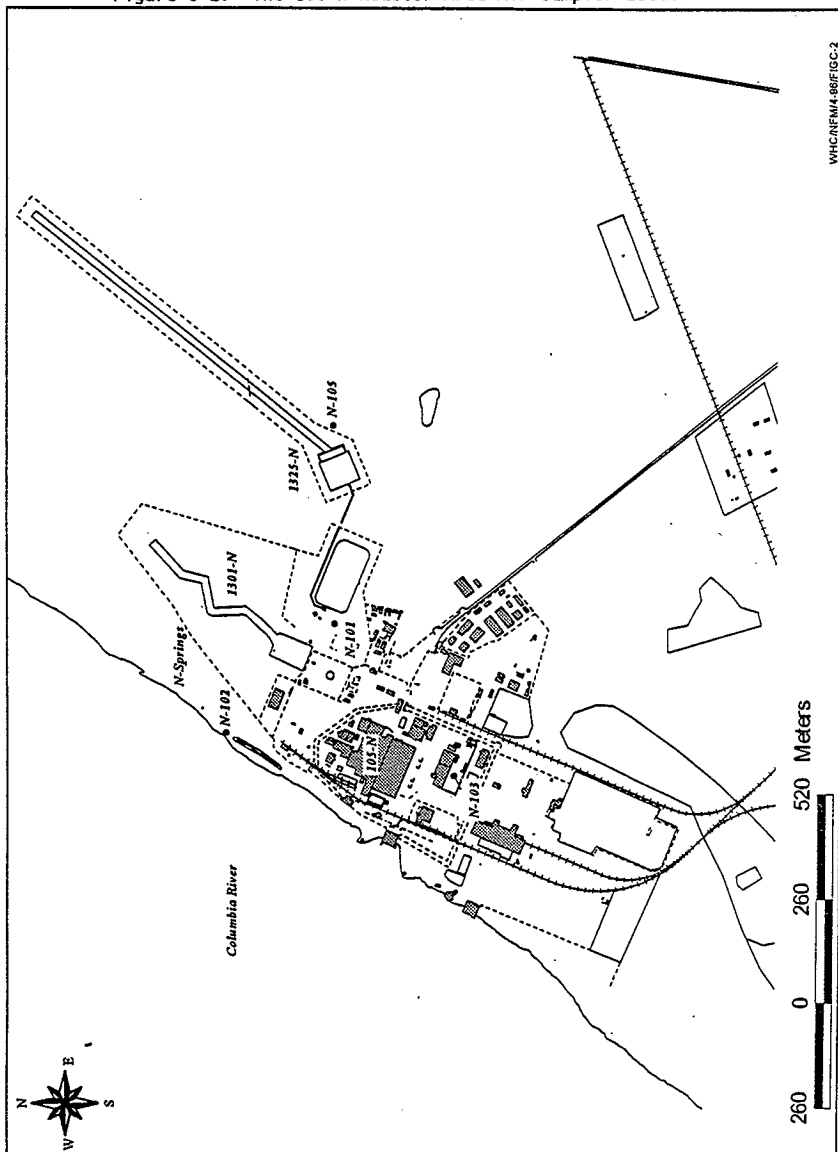
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Figure C-1. The 100 KE/KW Reactors Area Air Sampler Locations.



WHC/NFM/4-SB/FIG-C-1

Figure C-2. The 100 N Reactor Area Air Sampler Locations.



WHC/NEM/4-86/FIG C-2

C-3

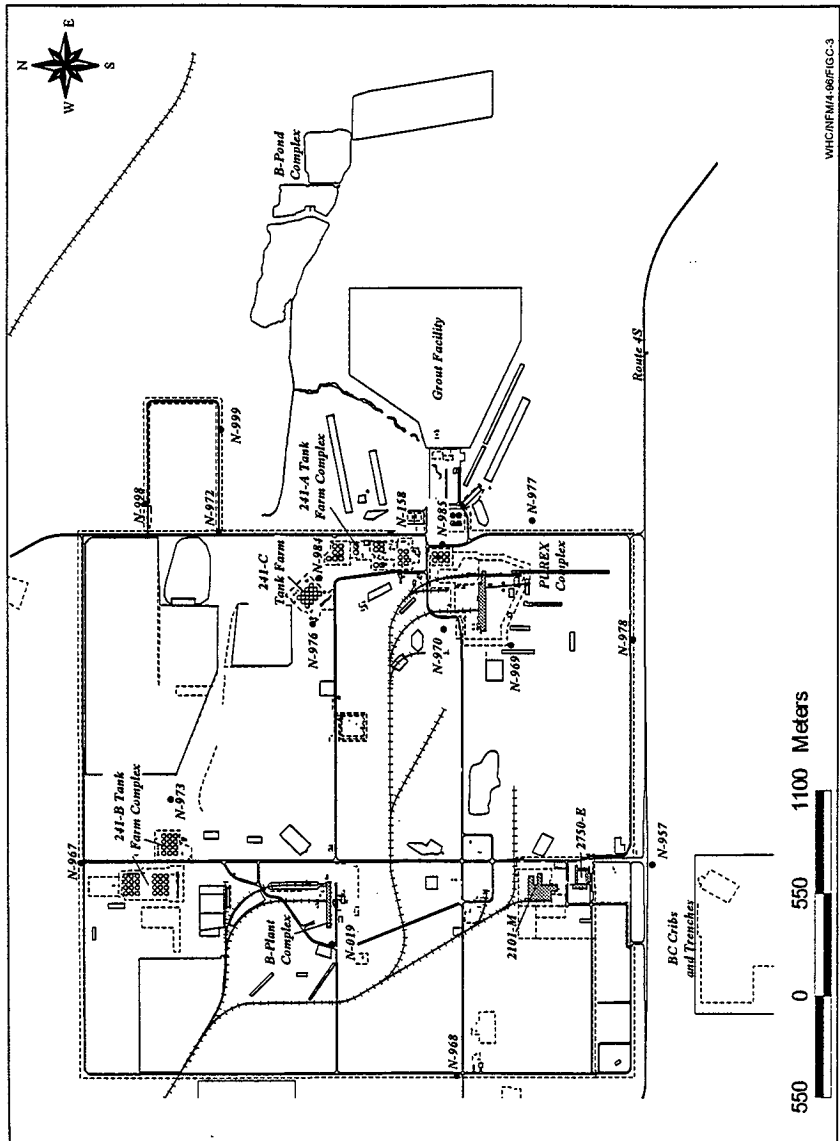
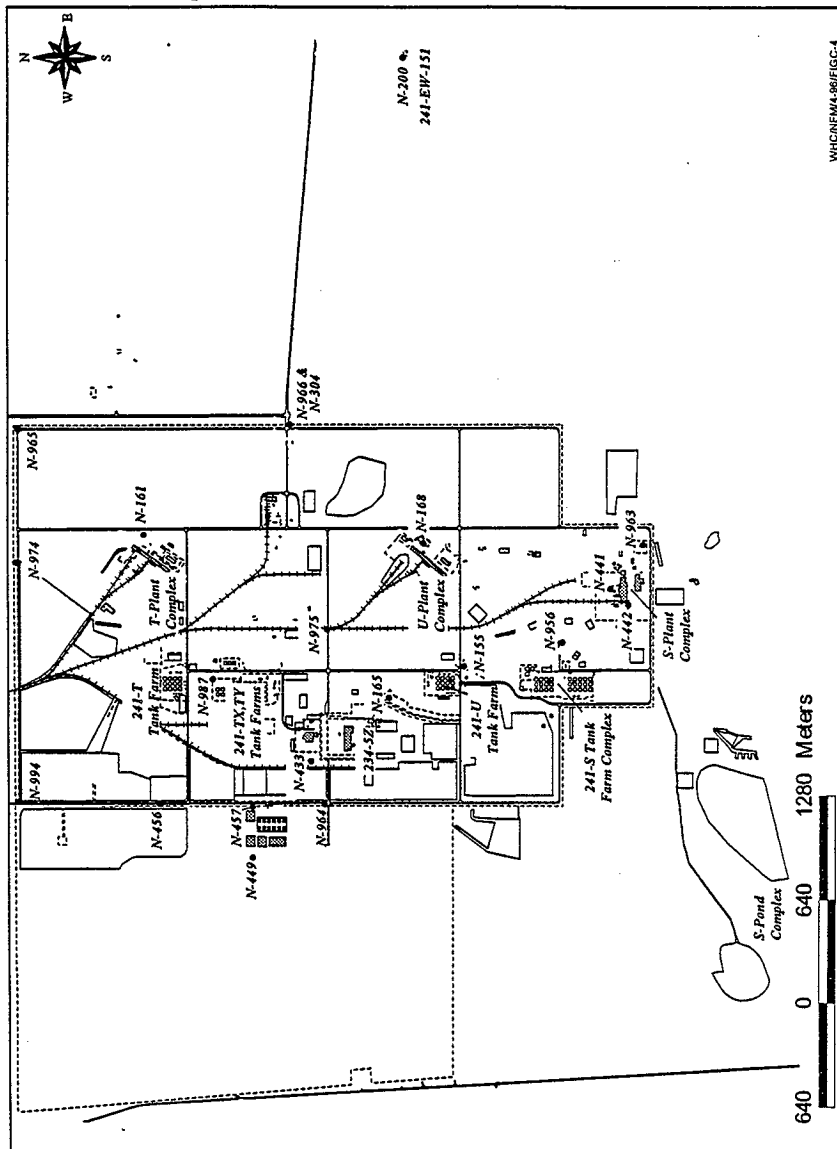


Figure C-4. 200 West Area Air Sampler Locations.



WHC/NEMA-90/IGC-4

Figure C-5. The 300 Area TEF Air Sampler Location.

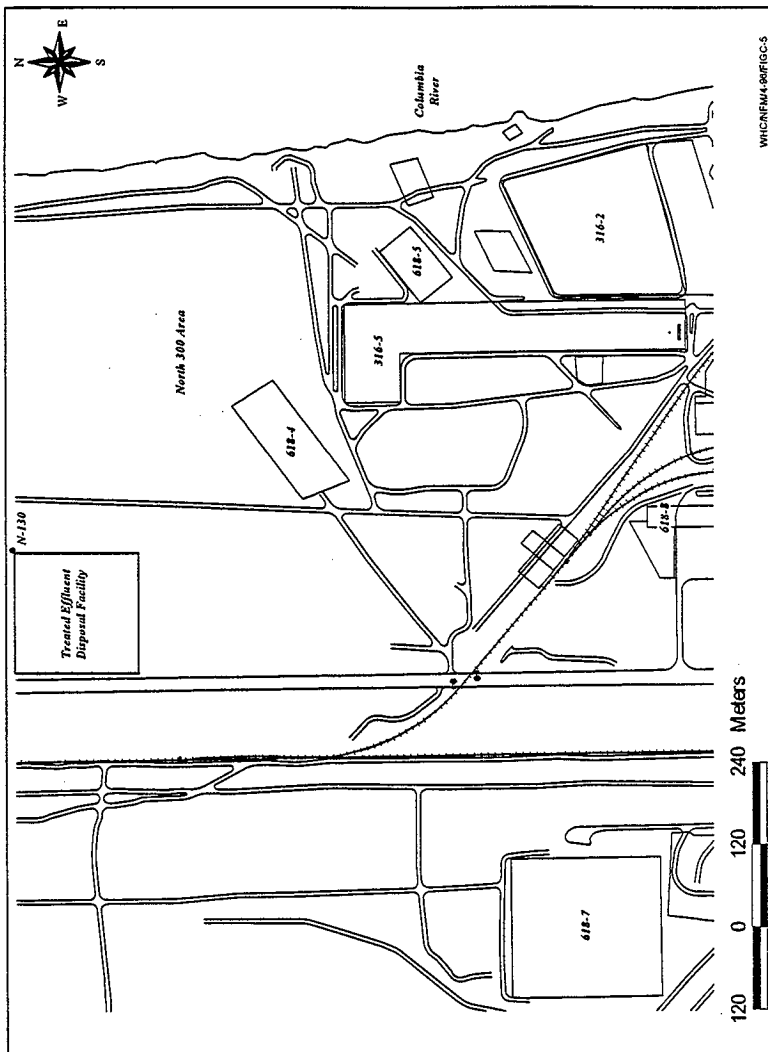


Figure C-6. The 600 Area Air Sampler Location.

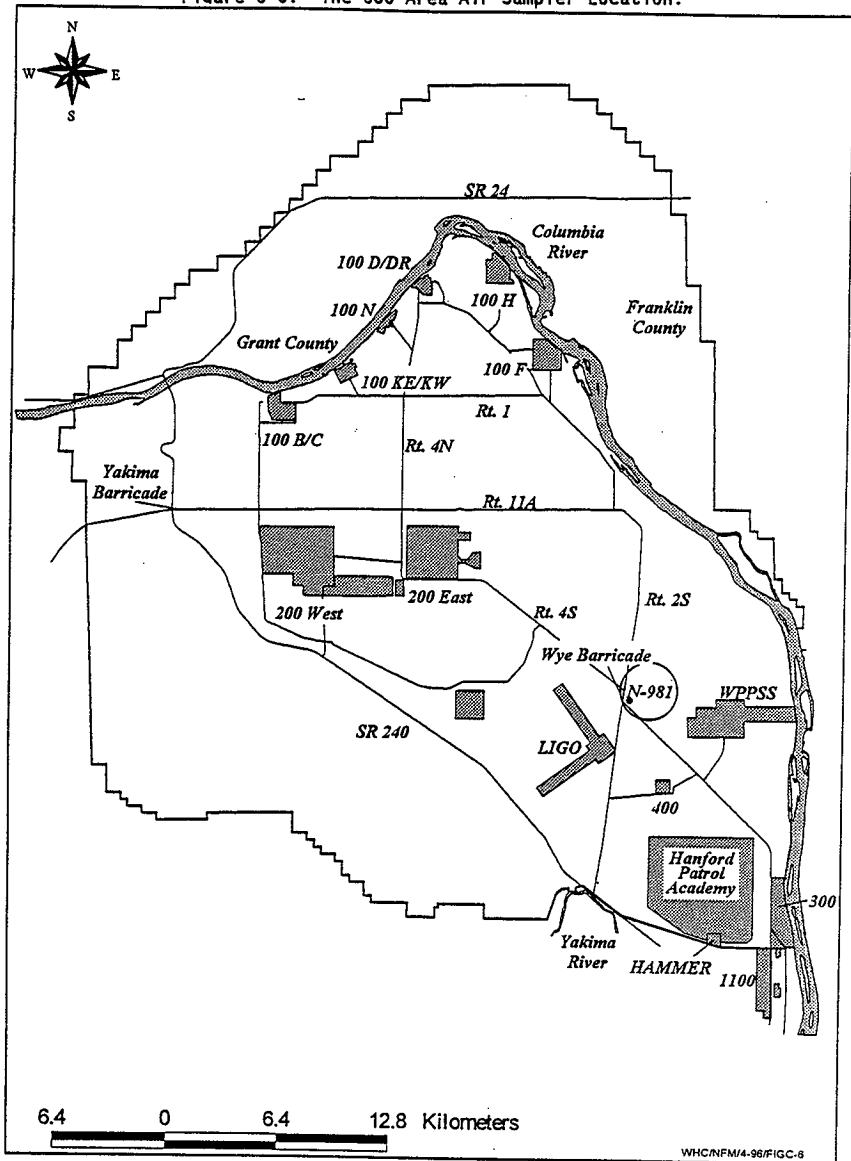


Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
100-N Area							
N101	⁴⁰ K	1.6 E-02	30.7	NR	NR	NA	NA
N101	⁶⁰ Co	-6.3 E-05	510.3	3.9 E-04	146	1.6 E-04	277.5
N101	⁹⁰ Sr	1.3 E-05	229.2	3.1 E-04	40	1.6 E-04	183.7
N101	¹³⁴ Cs	1.3 E-04	216.3	NR	NR	NA	NA
N101	¹³⁷ Cs	-3.6 E-05	859.2	-1.1 E-04	423	-7.1 E-05	99.6
N101	¹⁵⁴ Eu	2.5 E-04	274.9	1.1 E-03	98	6.9 E-04	126.8
N101	¹⁵⁵ Eu	-6.7 E-05	737.8	-1.8 E-04	401	-1.2 E-04	91.3
N101	²³⁴ U	4.0 E-07	690.8	8.8 E-06	140	4.6 E-06	182.5
N101	²³⁵ U	4.3 E-07	224.2	5.8 E-06	170	3.1 E-06	172.3
N101	²³⁸ U	1.9 E-06	145	2.0 E-05	90	1.1 E-05	164.8
N101	²³⁸ Pu	1.3 E-07	500.8	-1.5 E-07	202	-1.0 E-08	2,839
N101	^{239/40} Pu	1.4 E-06	81.2	9.3 E-06	92	5.3 E-06	148.1
N102	⁴⁰ K	1.4 E-02	32.8	NR	NR	NA	NA
N102	⁶⁰ Co	2.1 E-04	148.8	3.3 E-04	137	2.7 E-04	41.3
N102	⁹⁰ Sr	1.2 E-05	281.9	7.6 E-05	23	4.4 E-05	146.7
N102	¹³⁴ Cs	1.8 E-04	158.4	NR	NR	NA	NA
N102	¹³⁷ Cs	1.7 E-04	155.6	2.7 E-04	122	2.2 E-04	46
N102	¹⁵⁴ Eu	4.7 E-05	1,095	1.1 E-03	145	5.9 E-04	184
N102	¹⁵⁵ Eu	5.1 E-04	86.4	-6.3 E-04	1,287	-5.9 E-05	1,938
N102	²³⁴ U	-1.2 E-06	256.5	1.5 E-05	83	6.7 E-06	234.2
N102	²³⁵ U	-1.5 E-07	664.9	-6.3 E-07	143	-3.9 E-07	124
N102	²³⁸ U	1.3 E-07	2,111	5.6 E-06	299	2.9 E-06	190.6
N102	²³⁸ Pu	-7.2 E-07	73.1	-5.5 E-07	117	-6.3 E-07	26
N102	^{239/40} Pu	1.5 E-07	333.3	-4.5 E-07	143	-1.5 E-07	405.4
N103	⁴⁰ K	1.1 E-02	37.9	NR	NR	NA	NA
N103	⁶⁰ Co	-3.0 E-04	99.7	1.1 E-03	36	4.1 E-04	347.2
N103	⁹⁰ Sr	8.5 E-06	413.3	1.2 E-04	44	6.6 E-05	174.2
N103	¹³⁴ Cs	1.1 E-04	218.7	NR	NR	NA	NA

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N103	¹³⁷ Cs	-1.5 E-05	1,329	2.0 E-04	65	9.2 E-05	233.6
N103	¹⁵⁴ Eu	1.9 E-04	289.3	2.0 E-04	275	2.0 E-04	8.7
N103	¹⁵⁵ Eu	5.4 E-05	825	4.9 E-05	646	5.1 E-05	9.6
N103	²³⁴ U	7.7 E-07	399.5	7.1 E-06	117	3.9 E-06	160.8
N103	²³⁵ U	-3.9 E-07	240.6	-6.3 E-07	102	-5.1 E-07	47
N103	²³⁸ U	5.4 E-07	516.7	7.5 E-06	109	4.0 E-06	173.3
N103	²³⁸ Pu	-2.6 E-07	237.7	1.1 E-06	237	4.1 E-07	326.4
N103	^{239/40} Pu	1.1 E-06	98.1	-3.0 E-07	117	3.7 E-07	363
N105	⁴⁰ K	7.6 E-04	720.9	NR	NR	NA	NA
N105	⁶⁰ Co	-4.0 E-04	104.8	2.1 E-04	167	-9.7 E-05	626.9
N105	⁹⁰ Sr	-1.0 E-05	316.6	2.0 E-04	39	9.5 E-05	221.1
N105	¹³⁴ Cs	-1.5 E-04	173.3	NR	NR	NA	NA
N105	¹³⁷ Cs	4.2 E-05	574.1	1.1 E-04	175	7.7 E-05	90
N105	¹⁵⁴ Eu	7.4 E-04	91.1	6.0 E-04	108	6.7 E-04	21.3
N105	¹⁵⁵ Eu	-9.8 E-05	480	-3.0 E-04	145	-2.0 E-04	102.5
N105	²³⁴ U	1.3 E-06	259.5	5.9 E-06	127	3.6 E-06	130
N105	²³⁵ U	3.2 E-07	327.2	-3.4 E-07	141	-1.0 E-08	6,680
N105	²³⁸ U	1.4 E-06	193.7	3.6 E-06	169	2.5 E-06	86.5
N105	²³⁸ Pu	-3.0 E-07	105.9	-9.5 E-08	198	-2.0 E-07	105.1
N105	^{239/40} Pu	4.0 E-07	201.7	3.4 E-06	120	1.9 E-06	158.1
100-K Area							
N401	⁴⁰ K	4.7 E-03	103.8	5.5 E-03	114	5.1 E-03	16.1
N401	⁶⁰ Co	1.4 E-04	150.7	-1.7 E-05	1,896	6.1 E-05	256.2
N401	⁹⁰ Sr	6.8 E-05	58	2.4 E-04	30	1.5 E-04	111.3
N401	¹³⁴ Cs	-1.8 E-04	137.5	-9.4 E-05	267.9	-1.4 E-04	64.7
N401	¹³⁷ Cs	1.5 E-03	26.7	1.0 E-03	32.7	1.3 E-03	41.3
N401	¹⁵⁴ Eu	-2.8 E-04	320.6	6.3 E-04	108	1.7 E-04	524.1
N401	¹⁵⁵ Eu	2.8 E-04	116.3	-3.7 E-05	1,136	1.2 E-04	261.9
N401	²³⁴ U	9.5 E-07	307.9	5.6 E-06	59	3.3 E-06	142.2

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N401	²³⁵ U	-3.2 E-07	155	-3.5 E-07	326	-3.3 E-07	9
N401	²³⁸ U	2.6 E-07	930.8	6.6 E-06	51	3.4 E-06	184.8
N401	²³⁸ Pu	1.4 E-06	100	NR	NR	NA	NA
N401	^{239/40} Pu	8.4 E-06	34.8	NR	NR	NA	NA
N401	²⁴¹ Pu	2.0 E-04	0	NR	NR	NA	NA
N401	²⁴¹ Am	6.1 E-07	355	7.0 E-06	39	3.8 E-06	167.7
N402	⁴⁰ K	1.0 E-02	36.7	1.4 E-06	35.3	5.1 E-03	199.9
N402	⁶⁰ Co	-1.5 E-04	190.7	-8.8 E-05	221.6	-1.2 E-04	52.7
N402	⁹⁰ Sr	1.9 E-05	162.9	1.4 E-04	42	8.0 E-05	151.3
N402	¹³⁴ Cs	-1.1 E-04	275	7.5 E-05	239.1	-1.6 E-05	1109
N402	¹³⁷ Cs	2.7 E-04	88.3	7.5 E-05	318.5	1.7 E-04	114
N402	¹⁵⁴ Eu	1.2 E-04	611	-4.8 E-04	200.3	-1.8 E-04	330.4
N402	¹⁵⁵ Eu	-2.1 E-04	244.7	-1.6 E-04	245.6	-1.8 E-04	26.1
N402	²³⁴ U	3.3 E-06	111.9	1.3 E-05	36	8.1 E-06	119.6
N402	²³⁵ U	-1.1 E-07	821.9	9.1 E-07	181	4.0 E-07	257.3
N402	²³⁸ U	5.3 E-08	4771	3.9 E-06	72	2.0 E-06	194.7
N402	²³⁸ Pu	1.2 E-06	102.4	1.2 E-06	91	1.2 E-06	2.5
N402	^{239/40} Pu	1.1 E-05	30.2	5.3 E-06	41	8.0 E-06	67.5
N402	²⁴¹ Pu	2.5 E-04	82	2.1 E-04	123	2.3 E-04	17.4
N402	²⁴¹ Am	2.4 E-06	77.6	4.6 E-06	48	3.5 E-06	64
N403	⁴⁰ K	9.1 E-03	56.2	1.1 E-02	45.2	1.0 E-02	19
N403	⁶⁰ Co	1.1 E-04	185.8	1.1 E-05	2376	6.2 E-05	164.5
N403	⁹⁰ Sr	3.9 E-05	90.1	1.7 E-04	39	1.0 E-04	125
N403	¹³⁴ Cs	-1.7 E-04	194.5	-3.2 E-04	84.1	-2.4 E-04	63.9
N403	¹³⁷ Cs	2.4 E-04	94.1	-1.3 E-04	191.2	5.4 E-05	681.5
N403	¹⁵⁴ Eu	3.8 E-04	151	1.5 E-03	49.5	9.4 E-04	118.8
N403	¹⁵⁵ Eu	2.0 E-04	210	-1.8 E-05	2,555	9.1 E-05	239.3
N403	²³⁴ U	6.3 E-07	463.3	5.4 E-06	63	3.0 E-06	158.4
N403	²³⁵ U	7.7 E-08	1,462	-9.8 E-07	66	-4.5 E-07	233.9

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N403	²³⁸ U	9.5 E-07	284.7	4.9 E-06	63	2.9 E-06	135.3
N403	²³⁸ Pu	2.3 E-06	67.8	2.9 E-06	54	2.6 E-06	24.4
N403	^{239/40} Pu	1.7 E-05	25	1.2 E-05	26	1.5 E-05	36.7
N403	²⁴¹ Pu	2.8 E-04	81	3.4 E-04	72	3.1 E-04	19.4
N403	²⁴¹ Am	5.3 E-06	46	1.0 E-05	31	7.7 E-06	61.3
N404	⁴⁰ K	1.1 E-02	40.4	2.4 E-02	26.1	1.8 E-02	72.7
N404	⁶⁰ Co	-2.8 E-04	102.5	-2.1 E-04	185.7	-2.5 E-04	28.6
N404	⁹⁰ Sr	8.9 E-06	344.6	1.5 E-04	44	7.9 E-05	177.6
N404	¹³⁴ Cs	2.2 E-04	97.7	-3.0 E-05	1,070	9.6 E-05	262.5
N404	¹³⁷ Cs	-3.2 E-05	826.5	2.4 E-04	150.4	1.0 E-04	260.9
N404	¹⁵⁴ Eu	1.2 E-04	513	1.1 E-03	81.5	6.1 E-04	159.8
N404	¹⁵⁵ Eu	1.7 E-04	231.6	-9.0 E-05	630.1	4.1 E-05	644.4
N404	²³⁴ U	2.0 E-06	168	6.0 E-06	61	4.0 E-06	98.9
N404	²³⁵ U	-1.2 E-07	1,131	1.4 E-07	1,172	9.0 E-09	2,911
N404	²³⁸ U	-1.9 E-06	107.9	9.3 E-07	238	-4.9 E-07	579.6
N404	²³⁸ Pu	9.9 E-07	111.4	6.7 E-06	45	3.8 E-06	148.6
N404	^{239/40} Pu	7.7 E-06	39.7	7.7 E-06	42	7.7 E-06	0.5
N404	²⁴¹ Pu	1.3 E-04	0	1.9 E-04	158	1.6 E-04	37.5
N404	²⁴¹ Am	2.0 E-06	83.5	5.0 E-06	53	3.5 E-06	85.7
200 Areas							
N019	⁴⁰ K	6.2 E-03	96.8	6.9 E-03	40.5	6.5 E-03	10.4
N019	⁶⁰ Co	1.8 E-04	139.2	-6.9 E-05	362.4	5.4 E-05	456.1
N019	⁹⁰ Sr	1.1 E-05	517.9	8.4 E-05	47.7	4.8 E-05	153.1
N019	¹³⁴ Cs	2.0 E-04	122.1	9.5 E-06	1449	1.0 E-04	181.7
N019	¹³⁷ Cs	6.1 E-05	373	5.2 E-06	3,030	3.3 E-05	168.9
N019	¹⁵⁴ Eu	-1.3 E-04	620	3.8 E-04	139.1	1.2 E-04	424.1
N019	¹⁵⁵ Eu	5.0 E-04	86.2	2.9 E-06	9,999	2.5 E-04	197.7
N019	²³⁴ U	-3.8 E-06	131.6	3.1 E-06	84	-3.5 E-07	1,948
N019	²³⁵ U	1.7 E-06	153.2	3.0 E-07	431.4	1.0 E-06	140.5

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N019	²³⁸ U	-3.7 E-07	1,358	2.5 E-06	100	1.1 E-06	268.1
N019	²³⁸ Pu	-9.1 E-07	119.6	2.4 E-07	397.5	-3.4 E-07	340.7
N019	^{239/40} Pu	-6.2 E-07	264.4	3.4 E-06	57.6	1.4 E-06	290.9
N155	⁴⁰ K	1.5 E-02	32.6	6.9 E-03	45.6	1.1 E-02	73.3
N155	⁶⁰ Co	1.1 E-04	259.3	-6.9 E-05	362.4	2.0 E-05	899.2
N155	⁹⁰ Sr	4.0 E-05	86	2.9 E-04	27.4	1.7 E-04	151.7
N155	¹³⁴ Cs	1.0 E-04	211.7	6.0 E-05	318.8	8.1 E-05	53.4
N155	¹³⁷ Cs	6.6 E-04	34.8	5.4 E-05	444.9	3.6 E-04	169.7
N155	¹⁵⁴ Eu	2.0 E-04	360	1.2 E-05	3,371	1.1 E-04	177.2
N155	¹⁵⁵ Eu	-4.0 E-04	118.4	1.8 E-04	175.8	-1.1 E-04	526.6
N155	²³⁴ U	5.2 E-06	76.5	1.5 E-06	187	3.3 E-06	112.7
N155	²³⁵ U	9.7 E-07	143.7	-1.1 E-07	1,225	4.3 E-07	251.4
N155	²³⁸ U	4.4 E-06	77.1	4.6 E-06	74.6	4.5 E-06	3.3
N155	²³⁸ Pu	-3.0 E-07	106.1	5.4 E-08	1,046	-1.2 E-07	289.9
N155	^{239/40} Pu	6.6 E-06	38.3	3.7 E-06	57.1	5.2 E-06	57.2
N158	⁴⁰ K	2.8 E-03	192.6	1.5 E-02	35.5	8.8 E-03	135.6
N158	⁶⁰ Co	-2.3 E-05	1,146	-2.1 E-04	152.4	-1.1 E-04	160.6
N158	⁹⁰ Sr	3.8 E-05	93.5	3.8 E-04	28	2.1 E-04	163.3
N158	¹³⁴ Cs	-2.6 E-04	105.5	-8.5 E-05	303.5	-1.7 E-04	100.3
N158	¹³⁷ Cs	-1.6 E-04	180	5.5 E-04	48.2	2.0 E-04	364.1
N158	¹⁵⁴ Eu	-6.7 E-04	140.3	-5.6 E-04	110.3	-6.2 E-04	17.8
N158	¹⁵⁵ Eu	-1.4 E-04	435.8	6.3 E-04	72.4	2.5 E-04	311.2
N158	²³⁴ U	6.4 E-06	71.3	1.2 E-05	49.5	9.1 E-06	60.1
N158	²³⁵ U	-1.1 E-06	120.4	-1.0 E-06	157.4	-1.0 E-06	6.7
N158	²³⁸ U	4.3 E-06	92.3	1.2 E-05	50.2	8.0 E-06	93
N158	²³⁸ Pu	-3.4 E-07	182	-1.3 E-06	69.3	-8.0 E-07	115.9
N158	^{239/40} Pu	5.4 E-06	43.4	-1.9 E-07	534.8	2.6 E-06	214.2
N161	⁴⁰ K	3.4 E-03	124.1	2.1 E-02	30.6	1.2 E-02	145.2
N161	⁶⁰ Co	-2.2 E-04	132.9	-3.1 E-04	115.1	-2.7 E-04	33.7

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N161	⁹⁰ Sr	1.0 E-05	304	4.5 E-04	27.4	2.3 E-04	191.4
N161	¹³⁴ Cs	1.1 E-04	225.2	-1.0 E-04	335.9	4.0 E-06	5,349
N161	¹³⁷ Cs	9.6 E-05	194.2	1.3 E-04	229.5	1.1 E-04	31.8
N161	¹⁵⁴ Eu	3.7 E-05	2,097	1.4 E-04	688.1	9.0 E-05	118.1
N161	¹⁵⁵ Eu	-4.6 E-05	952.1	3.9 E-05	1,451	-3.2 E-06	2,624
N161	²³⁴ U	-3.3 E-07	887.9	9.0 E-06	61.9	4.3 E-06	215.3
N161	²³⁵ U	6.2 E-07	244.3	3.4 E-07	585.3	4.8 E-07	58
N161	²³⁸ U	3.2 E-07	790.1	6.7 E-06	76.1	3.5 E-06	181.5
N161	²³⁸ Pu	-4.0 E-07	117.2	-4.8 E-07	106.9	-4.4 E-07	16.9
N161	^{239/40} Pu	4.3 E-06	44.6	1.1 E-05	40.9	7.4 E-06	85.3
N165	⁴⁰ K	1.6 E-02	31.1	1.3 E-03	325.8	8.7 E-03	170.5
N165	⁶⁰ Co	-2.4 E-05	1,147	4.7 E-06	3,361	-9.9 E-06	294.7
N165	⁹⁰ Sr	2.0 E-05	178.9	2.2 E-04	30.5	1.2 E-04	167
N165	¹³⁴ Cs	-1.0 E-04	269.9	1.2 E-04	162.6	6.0 E-06	3,633
N165	¹³⁷ Cs	-2.8 E-04	92.1	2.1 E-04	75.7	-3.2 E-05	1,558
N165	¹⁵⁴ Eu	-6.4 E-05	1,148	-2.0 E-04	267.2	-1.3 E-04	101.7
N165	¹⁵⁵ Eu	-1.5 E-04	363.6	7.1 E-05	450.4	-4.0 E-05	551.2
N165	²³⁴ U	5.2 E-07	689.2	8.1 E-06	51.6	4.3 E-06	176
N165	²³⁵ U	7.2 E-08	1,740	3.5 E-07	517	2.1 E-07	132.2
N165	²³⁸ U	2.6 E-07	1,173	6.4 E-06	59.7	3.3 E-06	184.5
N165	²³⁸ Pu	9.3 E-07	117.1	7.1 E-08	1402	5.0 E-07	171.5
N165	^{239/40} Pu	1.1 E-04	13.8	2.5 E-05	23.9	6.7 E-05	126.1
N168	⁴⁰ K	2.3 E-02	26.9	1.3 E-02	34.4	1.8 E-02	52.3
N168	⁶⁰ Co	-2.7 E-04	134.5	2.3 E-04	121	-2.1 E-05	2,419
N168	⁹⁰ Sr	7.5 E-06	451.5	2.6 E-04	33	1.4 E-04	188.9
N168	¹³⁴ Cs	-7.9 E-05	334.6	2.0 E-05	1,248	-3.0 E-05	333.1
N168	¹³⁷ Cs	-1.0 E-04	251.9	2.7 E-04	90.3	8.1 E-05	455.2
N168	¹⁵⁴ Eu	-5.7 E-04	156	-7.5 E-04	105.5	-6.6 E-04	28.1
N168	¹⁵⁵ Eu	8.7 E-05	548.1	2.2 E-04	193.1	1.5 E-04	84.8

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N168	²³⁴ U	9.7 E-06	49.5	7.6 E-06	58.7	8.6 E-06	25.1
N168	²³⁵ U	7.6 E-07	197.1	-5.1 E-07	247.5	1.3 E-07	1,007
N168	²³⁸ U	6.7 E-06	60.9	6.8 E-06	64.4	6.7 E-06	1.5
N168	²³⁸ Pu	-2.1 E-07	365.5	-2.7 E-07	632.7	-2.4 E-07	28.7
N168	^{239/40} Pu	1.3 E-06	87.3	-9.8 E-08	1,746	6.2 E-07	231.5
N200	⁴⁰ K	1.3 E-02	35.9	8.5 E-04	462.8	6.9 E-03	175.5
N200	⁶⁰ Co	1.6 E-04	134	-1.3 E-05	1,898	7.5 E-05	234.3
N200	⁹⁰ Sr	2.5 E-05	132.3	7.9 E-05	51.6	5.2 E-05	103.4
N200	¹³⁴ Cs	2.1 E-04	115.5	2.4 E-05	599.2	1.1 E-04	158.7
N200	¹³⁷ Cs	2.5 E-04	83.5	-1.4 E-04	151.8	5.6 E-05	689.3
N200	¹⁵⁴ Eu	8.3 E-04	77.9	5.4 E-04	71.5	6.9 E-04	42
N200	¹⁵⁵ Eu	4.6 E-04	107.3	1.5 E-04	203.4	3.0 E-04	101.8
N200	²³⁴ U	3.5 E-06	97.5	1.1 E-05	42.4	7.3 E-06	103.3
N200	²³⁵ U	-1.7 E-07	647.4	6.9 E-07	272.9	2.6 E-07	334.1
N200	²³⁸ U	4.8 E-06	70.4	7.0 E-06	55.5	5.9 E-06	36.3
N200	²³⁸ Pu	-1.9 E-07	412.8	-4.8 E-07	163.5	-3.4 E-07	88.7
N200	^{239/40} Pu	1.4 E-06	75.7	6.5 E-07	153.6	1.0 E-06	73
N304	⁴⁰ K	3.0 E-03	174.1	9.9 E-04	574.6	2.0 E-03	100.4
N304	⁶⁰ Co	NA	NA	4.4 E-05	686.2	NA	NA
N304	⁹⁰ Sr	1.1 E-05	294.4	2.1 E-04	34.4	1.1 E-04	180.5
N304	¹³⁴ Cs	2.1 E-04	119.2	-7.7 E-06	3,159	1.0 E-04	215.3
N304	¹³⁷ Cs	9.2 E-05	180.7	1.2 E-04	200	1.0 E-04	23.5
N304	¹⁵⁴ Eu	7.7 E-05	1,076	-3.0 E-04	320.6	-1.1 E-04	337.7
N304	¹⁵⁵ Eu	3.3 E-04	125.8	NR	NR	NA	NA
N304	²³⁴ U	-2.4 E-07	1,216	7.2 E-06	66.7	3.5 E-06	213.9
N304	²³⁵ U	6.5 E-09	9,999	5.2 E-08	3,185	2.9 E-08	155.7
N304	²³⁸ U	1.8 E-06	169.9	6.2 E-06	71	4.0 E-06	111.2
N304	²³⁸ Pu	-6.0 E-07	167.5	2.6 E-07	521.1	-1.7 E-07	505.3
N304	^{239/40} Pu	1.3 E-06	91.7	5.9 E-06	55.6	3.6 E-06	127.3

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N433	⁴⁰ K	1.2 E-02	38.4	7.8 E-03	49.2	9.7 E-03	40.1
N433	⁶⁰ Co	1.8 E-04	81.9	-1.6 E-04	152.8	1.0 E-05	3,266
N433	⁹⁰ Sr	-4.2 E-06	712.6	1.9 E-04	32.3	9.4 E-05	209
N433	¹³⁴ Cs	-1.2 E-04	176	-6.3 E-05	365.7	-9.2 E-05	63.2
N433	¹³⁷ Cs	3.2 E-05	599.4	1.7 E-04	115.9	1.0 E-04	136.3
N433	¹⁵⁴ Eu	-4.0 E-04	192	3.2 E-04	165.4	-3.8 E-05	1,905
N433	¹⁵⁵ Eu	1.9 E-04	214.4	-3.9 E-05	1,161	7.8 E-05	300.3
N433	²³⁴ U	9.6 E-07	303.9	4.3 E-06	70.8	2.6 E-06	127.1
N433	²³⁵ U	-3.8 E-07	243.2	-5.6 E-07	183.6	-4.7 E-07	38.5
N433	²³⁸ U	-6.0 E-08	3,775	3.8 E-06	77.3	1.9 E-06	206.3
N433	²³⁸ Pu	7.0 E-09	6,960	1.4 E-08	6,394	1.0 E-08	64.2
N433	^{239/40} Pu	-7.2 E-08	1,430	1.7 E-06	104.7	8.1 E-07	217.8
N441	⁴⁰ K	NR	NR	5.3 E-03	67.6	NA	NA
N441	⁶⁰ Co	NR	NR	3.3 E-05	510.6	NA	NA
N441	⁹⁰ Sr	NR	NR	1.8 E-04	33.9	NA	NA
N441	¹³⁴ Cs	NR	NR	-1.7 E-04	128.7	NA	NA
N441	¹³⁷ Cs	NR	NR	-1.4 E-04	163.2	NA	NA
N441	¹⁵⁴ Eu	NR	NR	5.4 E-04	108	NA	NA
N441	¹⁵⁵ Eu	NR	NR	-8.4 E-05	408.1	NA	NA
N441	²³⁴ U	NR	NR	8.7 E-06	48.2	NA	NA
N441	²³⁵ U	NR	NR	5.8 E-07	253.9	NA	NA
N441	²³⁸ U	NR	NR	6.8 E-06	56.1	NA	NA
N441	²³⁸ Pu	NR	NR	4.6 E-07	225.6	NA	NA
N441	^{239/40} Pu	NR	NR	1.2 E-06	104.3	NA	NA
N442	⁴⁰ K	NR	NR	1.1 E-02	59.6	NA	NA
N442	⁶⁰ Co	NR	NR	1.3 E-04	208.5	NA	NA
N442	⁹⁰ Sr	NR	NR	1.3 E-04	53.8	NA	NA
N442	¹³⁴ Cs	NR	NR	2.8 E-04	88.7	NA	NA
N442	¹³⁷ Cs	NR	NR	5.8 E-04	49.2	NA	NA

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N442	¹⁵⁴ Eu	NR	NR	-3.1 E-04	155.7	NA	NA
N442	¹⁵⁵ Eu	NR	NR	-3.0 E-04	161.5	NA	NA
N442	²³⁴ U	NR	NR	2.2 E-05	40.8	NA	NA
N442	²³⁵ U	NR	NR	7.0 E-07	456.4	NA	NA
N442	²³⁸ U	NR	NR	9.4 E-06	66.4	NA	NA
N442	²³⁸ Pu	NR	NR	-2.4 E-07	428.6	NA	NA
N442	^{239/40} Pu	NR	NR	4.4 E-06	68.3	NA	NA
N449	⁴⁰ K	1.4 E-02	56.3	NR	NR	NA	NA
N449	⁶⁰ Co	-1.6 E-04	276.6	-6.9 E-06	1,000	-8.2 E-05	183.3
N449	⁹⁰ Sr	5.1 E-05	118.7	-6.5 E-04	100	-3.0 E-04	233.8
N449	¹³⁴ Cs	-4.2 E-04	107.2	-2.3 E-05	300	-2.2 E-04	179.4
N449	¹³⁷ Cs	2.1 E-04	155.6	5.5 E-05	120	1.3 E-04	118.1
N449	¹⁵⁴ Eu	1.6 E-03	56.3	3.6 E-05	600	7.9 E-04	190.8
N449	¹⁵⁵ Eu	5.4 E-04	113.8	-1.3 E-04	120	2.1 E-04	321.1
N449	²³⁴ U	-2.9 E-06	164.9	2.4 E-05	70	1.0 E-05	254.4
N449	²³⁵ U	1.5 E-06	179.5	1.5 E-05	90	8.2 E-06	164.5
N449	²³⁸ U	-1.7 E-06	235.6	1.2 E-05	90	5.3 E-06	265.3
N449	²³⁸ Pu	-7.9 E-07	118.7	4.9 E-06	140	2.1 E-06	276.7
N449	^{239/40} Pu	2.6 E-07	544.4	6.9 E-06	150	3.6 E-06	185.5
N456	⁶⁰ Co	NR	NR	1.4 E-05	430	NA	NA
N456	⁹⁰ Sr	NR	NR	-4.3 E-04	100	NA	NA
N456	¹³⁴ Cs	NR	NR	1.1 E-05	460	NA	NA
N456	¹³⁷ Cs	NR	NR	1.8 E-04	50	NA	NA
N456	¹⁵⁴ Eu	NR	NR	-7.2 E-05	220	NA	NA
N456	¹⁵⁵ Eu	NR	NR	9.4 E-05	120	NA	NA
N456	²³⁴ U	NR	NR	2.5 E-05	40	NA	NA
N456	²³⁵ U	NR	NR	3.8 E-06	140	NA	NA
N456	²³⁸ U	NR	NR	1.9 E-05	50	NA	NA
N456	²³⁸ Pu	NR	NR	-9.4 E-07	210	NA	NA

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N456	^{239/40} Pu	NR	NR	2.1 E-06	200	NA	NA
N457	⁶⁰ Co	NR	NR	-1.5 E-06	1,000	NA	NA
N457	⁹⁰ Sr	NR	NR	-3.0 E-04	100	NA	NA
N457	¹³⁴ Cs	NR	NR	1.1 E-05	370	NA	NA
N457	¹³⁷ Cs	NR	NR	1.9 E-05	210	NA	NA
N457	¹⁵⁴ Eu	NR	NR	-1.1 E-05	1,000	NA	NA
N457	¹⁵⁵ Eu	NR	NR	3.2 E-05	320	NA	NA
N457	²³⁴ U	NR	NR	1.0 E-05	70	NA	NA
N457	²³⁵ U	NR	NR	1.6 E-06	280	NA	NA
N457	²³⁸ U	NR	NR	1.2 E-05	70	NA	NA
N457	²³⁸ Pu	NR	NR	6.1 E-07	500	NA	NA
N457	^{239/40} Pu	NR	NR	1.8 E-05	50	NA	NA
N956	⁴⁰ K	2.8 E-03	186.3	3.9 E-03	159.4	3.3 E-03	34
N956	⁶⁰ Co	2.1 E-04	113.5	4.2 E-05	611.9	1.2 E-04	132.8
N956	⁹⁰ Sr	2.6 E-05	194	1.2 E-04	44.8	7.2 E-05	126.1
N956	¹³⁴ Cs	9.5 E-05	279.2	6.5 E-05	308.2	8.0 E-05	37.5
N956	¹³⁷ Cs	3.4 E-04	84.9	2.3 E-04	102.6	2.9 E-04	37.2
N956	¹⁵⁴ Eu	3.4 E-04	212.4	5.3 E-04	147.2	4.3 E-04	44
N956	¹⁵⁵ Eu	-2.1 E-04	234.1	1.2 E-04	396.6	-4.7 E-05	697.9
N956	²³⁴ U	1.2 E-06	637.9	9.1 E-06	50.8	5.1 E-06	154.6
N956	²³⁵ U	3.1 E-07	1,305	-1.4 E-07	1,091	8.6 E-08	530.2
N956	²³⁸ U	5.6 E-07	980.3	7.4 E-06	58.2	4.0 E-06	172
N956	²³⁸ Pu	7.9 E-09	9,999	-4.5 E-07	94	-2.2 E-07	207.2
N956	^{239/40} Pu	1.9 E-06	130.2	4.8 E-05	18.2	2.5 E-05	184.5
N957	⁴⁰ K	1.0 E-02	51	4.7 E-03	66.7	7.5 E-03	73.9
N957	⁶⁰ Co	1.6 E-04	174.7	-7.6 E-05	267.5	4.1 E-05	569.8
N957	⁹⁰ Sr	3.3 E-06	800.6	1.0 E-04	45.8	5.2 E-05	187.3
N957	¹³⁴ Cs	8.4 E-05	249.7	-6.9 E-05	328.5	7.5 E-06	2,042
N957	¹³⁷ Cs	5.2 E-05	395	2.5 E-04	76.4	1.5 E-04	131.2

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N957	¹⁵⁴ Eu	4.2 E-05	1,095	2.3 E-04	116.4	1.3 E-04	137.7
N957	¹⁵⁵ Eu	4.4 E-05	1,043	1.4 E-04	245.1	9.3 E-05	105.5
N957	²³⁴ U	-1.9 E-07	1,787	3.3 E-06	82.5	1.5 E-06	224.5
N957	²³⁵ U	8.7 E-07	209.2	-3.9 E-07	222.3	2.4 E-07	530
N957	²³⁸ U	2.9 E-06	135.2	3.7 E-06	78.2	3.3 E-06	24.5
N957	²³⁸ Pu	3.7 E-07	234.2	-3.0 E-07	106.4	3.5 E-08	1,933
N957	^{239/40} Pu	2.1 E-07	816.9	3.7 E-06	52.2	2.0 E-06	178.3
N963	⁴⁰ K	1.1 E-03	573.6	1.3 E-02	32.3	7.1 E-03	170.3
N963	⁶⁰ Co	1.8 E-04	163.7	8.4 E-06	2371	9.5 E-05	182.4
N963	⁹⁰ Sr	2.5 E-06	1,060	1.8 E-04	32.9	9.0 E-05	194.5
N963	¹³⁴ Cs	-6.5 E-05	406.8	-7.2 E-05	221.9	-6.8 E-05	10.5
N963	¹³⁷ Cs	-8.7 E-06	2,789	1.3 E-04	140.2	5.9 E-05	229.5
N963	¹⁵⁴ Eu	1.0 E-03	56.5	6.0 E-04	67.4	8.2 E-04	53.5
N963	¹⁵⁵ Eu	-1.8 E-04	277.3	-8.3 E-05	384.1	-1.3 E-04	74.5
N963	²³⁴ U	2.9 E-06	150.5	7.7 E-06	51.6	5.3 E-06	90.7
N963	²³⁵ U	2.8 E-07	692.6	3.3 E-07	532.3	3.0 E-07	13.8
N963	²³⁸ U	7.7 E-07	423.7	8.0 E-06	50.8	4.4 E-06	165
N963	²³⁸ Pu	3.4 E-06	54.8	9.9 E-06	33.6	6.7 E-06	97.5
N963	^{239/40} Pu	4.7 E-06	49.8	9.7 E-06	33.5	7.2 E-06	70.6
N964	⁴⁰ K	1.2 E-02	41.9	1.9 E-02	29.4	1.6 E-02	44
N964	⁶⁰ Co	3.3 E-04	64.2	3.6 E-04	91.9	3.5 E-04	6.1
N964	⁹⁰ Sr	2.2 E-05	134.7	1.2 E-04	46.9	7.2 E-05	139.8
N964	¹³⁴ Cs	2.0 E-04	122.3	7.9 E-05	274	1.4 E-04	85.3
N964	¹³⁷ Cs	1.3 E-04	148.8	2.0 E-04	135.9	1.6 E-04	43.7
N964	¹⁵⁴ Eu	3.1 E-04	185.5	1.3 E-04	514.8	2.2 E-04	78.7
N964	¹⁵⁵ Eu	4.2 E-04	105.4	-1.7 E-04	305.7	1.2 E-04	482.3
N964	²³⁴ U	1.5 E-06	303.3	1.0 E-05	47.3	5.8 E-06	148.7
N964	²³⁵ U	-2.1 E-07	927.9	3.6 E-07	455.8	7.7 E-08	740.3
N964	²³⁸ U	4.3 E-06	111.5	9.5 E-06	50.4	6.9 E-06	74.1

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N964	²³⁸ Pu	-1.8 E-09	9,999	-5.4 E-07	94.6	-2.7 E-07	198.6
N964	^{239/40} Pu	2.6 E-06	60.9	2.2 E-06	90.1	2.4 E-06	15
N965	⁴⁰ K	1.6 E-02	41	7.7 E-04	696.6	8.6 E-03	182.1
N965	⁶⁰ Co	4.0 E-05	1,115	1.6 E-05	1,937	2.8 E-05	86
N965	⁹⁰ Sr	5.5 E-05	77.5	9.1 E-05	52.5	7.3 E-05	49
N965	¹³⁴ Cs	1.9 E-04	164.8	-5.7 E-05	394.4	6.8 E-05	368.9
N965	¹³⁷ Cs	1.9 E-05	1,537	7.4 E-05	287.1	4.6 E-05	119.1
N965	¹⁵⁴ Eu	-6.5 E-04	159.8	6.0 E-04	107.9	-2.4 E-05	5,340
N965	¹⁵⁵ Eu	1.1 E-05	6,630	-1.2 E-04	334.4	-5.5 E-05	240
N965	²³⁴ U	-1.2 E-06	346.3	5.7 E-06	65.7	2.2 E-06	311.1
N965	²³⁵ U	4.3 E-07	639.3	1.0 E-06	201.9	7.3 E-07	83.6
N965	²³⁸ U	-4.8 E-07	922.8	4.4 E-06	79.2	2.0 E-06	249.1
N965	²³⁸ Pu	-5.4 E-07	94.2	5.5 E-08	1,186	-2.4 E-07	245.6
N965	^{239/40} Pu	1.1 E-06	126.2	1.1 E-05	35.2	6.0 E-06	164.2
N966	⁴⁰ K	6.9 E-03	125.8	5.6 E-03	61.8	6.2 E-03	19.6
N966	⁶⁰ Co	2.2 E-04	139.1	-4.6 E-05	617.6	8.7 E-05	304.3
N966	⁹⁰ Sr	9.6 E-06	286.2	4.2 E-05	87.2	2.6 E-05	125.9
N966	¹³⁴ Cs	3.3 E-04	78.1	1.9 E-04	109.4	2.6 E-04	54
N966	¹³⁷ Cs	9.0 E-05	402	NR	NR	NA	NA
N966	¹⁵⁴ Eu	-7.5 E-05	1,148	3.3 E-04	165.4	1.3 E-04	316.2
N966	¹⁵⁵ Eu	1.6 E-04	408.8	1.3 E-04	241.9	1.4 E-04	20.8
N966	²³⁴ U	8.1 E-07	557.6	9.4 E-06	48.9	5.1 E-06	168.3
N966	²³⁵ U	-4.7 E-07	150.9	2.2 E-06	107.3	8.6 E-07	308.7
N966	²³⁸ U	3.6 E-06	123.5	4.9 E-06	73.2	4.2 E-06	31
N966	²³⁸ Pu	-5.5 E-07	150.3	-3.2 E-07	284.2	-4.4 E-07	52.1
N966	^{239/40} Pu	2.7 E-06	66.7	2.9 E-06	65.2	2.8 E-06	7.1
N967	⁴⁰ K	1.1 E-02	35.2	1.2 E-02	35.3	1.1 E-02	9
N967	⁶⁰ Co	-1.1 E-04	252.3	1.3 E-04	138.8	1.2 E-05	2,130
N967	⁹⁰ Sr	-2.8 E-06	961	5.0 E-05	69.3	2.3 E-05	224

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N967	¹³⁴ Cs	3.9 E-05	591.8	6.5 E-06	2870	2.3 E-05	142.7
N967	¹³⁷ Cs	3.6 E-05	633.3	4.3 E-04	60.1	2.3 E-04	169
N967	¹⁵⁴ Eu	2.7 E-04	208.3	-6.4 E-04	99.5	-1.9 E-04	481.2
N967	¹⁵⁵ Eu	-2.6 E-05	1,613	-1.7 E-04	198.2	-9.6 E-05	145.4
N967	²³⁴ U	5.7 E-06	178	7.0 E-06	51.5	6.4 E-06	20.1
N967	²³⁵ U	-4.5 E-06	132.7	-3.1 E-07	403.8	-2.4 E-06	174
N967	²³⁸ U	9.2 E-07	942.3	4.3 E-06	69	2.6 E-06	130.2
N967	²³⁸ Pu	1.9 E-07	458.4	2.3 E-07	366.4	2.1 E-07	22.5
N967	^{239/40} Pu	1.9 E-06	70.6	3.7 E-06	57.8	2.8 E-06	64.5
N968	⁴⁰ K	2.6 E-02	26.6	1.2 E-02	39.4	1.9 E-02	75.3
N968	⁶⁰ Co	2.0 E-04	192.1	1.7 E-05	1251	1.1 E-04	169.6
N968	⁹⁰ Sr	7.0 E-06	573.9	8.2 E-05	52.1	4.5 E-05	168.4
N968	¹³⁴ Cs	-2.1 E-04	173.8	2.9 E-04	80.8	4.1 E-05	1,217
N968	¹³⁷ Cs	9.3 E-05	339.8	5.0 E-05	465.7	7.1 E-05	61.2
N968	¹⁵⁴ Eu	-1.2 E-03	125	-4.6 E-04	172.8	-8.5 E-04	92.5
N968	¹⁵⁵ Eu	4.0 E-04	166.5	1.3 E-04	315.2	2.6 E-04	105.3
N968	²³⁴ U	7.1 E-06	112.7	3.7 E-06	80.8	5.4 E-06	61.6
N968	²³⁵ U	2.4 E-07	1,450	-7.9 E-07	75.1	-2.8 E-07	374.2
N968	²³⁸ U	3.0 E-07	1,664	4.2 E-06	75	2.3 E-06	173
N968	²³⁸ Pu	2.3 E-07	455.8	-5.3 E-07	128.8	-1.5 E-07	493.5
N968	^{239/40} Pu	1.6 E-06	104.4	5.5 E-07	164.7	1.1 E-06	97.2
N969	⁴⁰ K	1.6 E-02	33.4	5.5 E-03	69	1.1 E-02	96.8
N969	⁶⁰ Co	2.1 E-04	82.2	6.3 E-05	290	1.4 E-04	108.6
N969	⁹⁰ Sr	2.7 E-06	1,224	5.4 E-05	75	2.8 E-05	180.7
N969	¹³⁴ Cs	1.9 E-05	1,185	-1.4 E-04	124.1	-6.3 E-05	260
N969	¹³⁷ Cs	-2.3 E-04	119.3	1.7 E-04	116	-3.2 E-05	1,256
N969	¹⁵⁴ Eu	6.1 E-04	113.6	9.3 E-04	58.6	7.7 E-04	41.4
N969	¹⁵⁵ Eu	6.1 E-05	708.9	8.9 E-05	424.1	7.5 E-05	37.5
N969	²³⁴ U	-5.7 E-07	697.6	4.4 E-06	75	1.9 E-06	260.4

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N969	²³⁵ U	-5.0 E-09	9,999	1.1 E-06	191.1	5.6 E-07	201.8
N969	²³⁸ U	1.7 E-06	243.8	3.5 E-06	88.3	2.6 E-06	69.5
N969	²³⁸ Pu	-1.3 E-08	4,045	-2.2 E-07	346.1	-1.2 E-07	176.9
N969	^{239/40} Pu	5.9 E-07	174.4	1.1 E-06	114.7	8.4 E-07	60.3
N970	⁴⁰ K	1.4 E-02	34.2	5.7 E-03	75.9	1.0 E-02	87.4
N970	⁶⁰ Co	1.6 E-04	164	-1.7 E-04	152.3	-5.0 E-06	6,759
N970	⁹⁰ Sr	2.2 E-05	140.3	2.2 E-04	33.6	1.2 E-04	163
N970	¹³⁴ Cs	4.4 E-05	569.5	-2.7 E-04	82.5	-1.2 E-04	276
N970	¹³⁷ Cs	2.9 E-04	79.7	-7.8 E-05	314.4	1.1 E-04	345.5
N970	¹⁵⁴ Eu	1.1 E-04	710.1	2.8 E-04	259.3	1.9 E-04	87.9
N970	¹⁵⁵ Eu	2.8 E-04	151.8	-2.4 E-04	145.5	2.0 E-05	2,620
N970	²³⁴ U	-1.2 E-06	247.1	8.6 E-06	48.7	3.7 E-06	265.7
N970	²³⁵ U	-2.8 E-07	435.7	3.3 E-07	448.8	2.6 E-08	2,353
N970	²³⁸ U	1.0 E-06	319.4	6.4 E-06	59.5	3.7 E-06	144.3
N970	²³⁸ Pu	9.4 E-07	113	1.2 E-07	824	5.3 E-07	153
N970	^{239/40} Pu	1.3 E-06	100.8	1.6 E-06	86.4	1.5 E-06	22.7
N972	⁴⁰ K	1.2 E-02	49.1	6.6 E-03	75.6	9.5 E-03	60.5
N972	⁶⁰ Co	-8.4 E-05	456.7	2.5 E-04	71.6	8.3 E-05	403.5
N972	⁹⁰ Sr	1.9 E-05	166.1	9.5 E-05	52.2	5.7 E-05	134.3
N972	¹³⁴ Cs	9.8 E-05	250.3	1.9 E-05	1091	5.8 E-05	136.4
N972	¹³⁷ Cs	3.5 E-05	868.2	-3.5 E-05	600	2.0 E-07	9,999
N972	¹⁵⁴ Eu	-3.4 E-04	252.7	-2.8 E-04	313.7	-3.1 E-04	19.2
N972	¹⁵⁵ Eu	-3.7 E-04	157.3	2.2 E-04	158.2	-7.2 E-05	829.4
N972	²³⁴ U	2.2 E-06	227.4	8.0 E-06	56.1	5.1 E-06	113.9
N972	²³⁵ U	-2.1 E-07	1,136	7.4 E-07	287.8	2.7 E-07	353.3
N972	²³⁸ U	3.7 E-06	129.3	4.0 E-06	89.8	3.9 E-06	7.5
N972	²³⁸ Pu	2.6 E-07	387.6	3.9 E-07	286.1	3.2 E-07	40.2
N972	^{239/40} Pu	1.4 E-06	113.3	4.0 E-06	55.8	2.7 E-06	98.3
N973	⁴⁰ K	2.1 E-04	2,816	1.3 E-02	30.5	6.8 E-03	193.7

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N973	⁶⁰ Co	1.8 E-04	200.6	-6.2 E-05	379.4	5.9 E-05	411.2
N973	⁹⁰ Sr	1.2 E-06	3,008	1.6 E-04	36.7	7.9 E-05	197
N973	¹³⁴ Cs	-2.7 E-04	113.9	4.5 E-05	354	-1.1 E-04	279.4
N973	¹³⁷ Cs	3.4 E-04	86	5.6 E-04	49.3	4.5 E-04	49.7
N973	¹⁵⁴ Eu	-7.9 E-04	123.5	4.4 E-05	1250	-3.8 E-04	223.4
N973	¹⁵⁵ Eu	-2.3 E-04	278.4	-3.4 E-04	122.8	-2.9 E-04	38.7
N973	²³⁴ U	2.0 E-06	256.4	2.8 E-06	105.8	2.4 E-06	34
N973	²³⁵ U	3.6 E-07	656.5	1.7 E-07	833.3	2.6 E-07	73
N973	²³⁸ U	2.3 E-06	197.8	1.9 E-06	140.1	2.1 E-06	19.8
N973	²³⁸ Pu	-2.5 E-07	334	1.7 E-07	449.1	-4.0 E-08	1,034
N973	^{239/40} Pu	6.8 E-07	134	1.0 E-06	107.8	8.6 E-07	40.7
N974	⁴⁰ K	2.5 E-03	241.7	1.3 E-02	29.7	7.9 E-03	135.5
N974	⁶⁰ Co	-9.2 E-05	267.7	1.7 E-04	121.1	3.7 E-05	696.1
N974	⁹⁰ Sr	1.5 E-05	387.7	1.5 E-04	39.3	8.3 E-05	164.9
N974	¹³⁴ Cs	-1.4 E-04	160.7	1.0 E-04	198	-1.9 E-05	1,273
N974	¹³⁷ Cs	-1.7 E-04	170.6	3.0 E-05	632.5	-7.0 E-05	286.4
N974	¹⁵⁴ Eu	5.6 E-04	121.2	9.5 E-05	612.8	3.3 E-04	142
N974	¹⁵⁵ Eu	-1.0 E-04	489.4	-3.2 E-04	122.9	-2.1 E-04	104
N974	²³⁴ U	2.3 E-06	318.3	5.3 E-06	54.5	3.8 E-06	77.1
N974	²³⁵ U	3.8 E-06	121.5	9.8 E-08	1,199	2.0 E-06	190
N974	²³⁸ U	1.1 E-06	566	5.5 E-06	54.2	3.3 E-06	135.4
N974	²³⁸ Pu	9.3 E-08	1,310	1.0 E-07	798	9.7 E-08	8.1
N974	^{239/40} Pu	-1.6 E-07	1,037	2.0 E-06	78.3	9.1 E-07	234.9
N975	⁴⁰ K	1.9 E-02	35.3	5.6 E-03	61.7	1.2 E-02	108.7
N975	⁶⁰ Co	-2.5 E-04	160.6	1.2 E-04	100.8	-6.7 E-05	563.9
N975	⁹⁰ Sr	1.1 E-05	373.7	1.2 E-04	46.4	6.6 E-05	165.6
N975	¹³⁴ Cs	5.9 E-04	62.7	1.3 E-04	169.8	3.6 E-04	129.9
N975	¹³⁷ Cs	-2.2 E-05	1,645	-4.6 E-05	357.5	-3.4 E-05	71
N975	¹⁵⁴ Eu	9.1 E-04	121.3	-1.3 E-04	442.5	3.9 E-04	268.6

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N975	¹⁵⁵ Eu	1.7 E-04	494.8	2.3 E-04	147.6	2.0 E-04	28.7
N975	²³⁴ U	2.0 E-06	257.9	6.4 E-06	62.3	4.2 E-06	107
N975	²³⁵ U	-1.1 E-01	93.9	7.9 E-07	265.9	-1.8 E-07	1,088
N975	²³⁸ U	4.2 E-06	119.6	5.7 E-06	67.1	5.0 E-06	29.2
N975	²³⁸ Pu	1.6 E-09	9,999	-2.2 E-07	504.5	-1.1 E-07	202.9
N975	^{239/40} Pu	5.3 E-06	50.7	9.9 E-07	162	3.2 E-06	137.2
N976	⁴⁰ K	1.5 E-02	37.2	1.2 E-02	44.7	1.4 E-02	23.7
N976	⁶⁰ Co	-1.2 E-04	221.5	1.0 E-05	2,366	-5.5 E-05	236.4
N976	⁹⁰ Sr	5.0 E-05	75.4	8.7 E-05	54.8	6.9 E-05	53.1
N976	¹³⁴ Cs	5.6 E-06	5,870	7.6 E-06	2,866	6.6 E-06	31.3
N976	¹³⁷ Cs	1.5 E-04	185.9	-1.1 E-04	219.4	2.0 E-05	1,153
N976	¹⁵⁴ Eu	4.5 E-04	178.7	8.0 E-04	64.1	6.2 E-04	56.8
N976	¹⁵⁵ Eu	-1.5 E-04	409.6	1.8 E-05	1,773	-6.4 E-05	256.6
N976	²³⁴ U	3.3 E-06	117.3	1.4 E-05	41.7	8.8 E-06	125.6
N976	²³⁵ U	8.7 E-07	244.2	2.3 E-07	646.3	5.5 E-07	116.5
N976	²³⁸ U	6.4 E-06	68.1	1.6 E-05	39.4	1.1 E-05	84.7
N976	²³⁸ Pu	7.9 E-09	9,999	2.0 E-07	1,799	1.0 E-07	184.7
N976	^{239/40} Pu	6.0 E-07	133.9	1.7 E-06	194.6	1.1 E-06	94
N977	⁴⁰ K	1.3 E-02	39.6	1.1 E-02	35.8	1.2 E-02	16.1
N977	⁶⁰ Co	1.2 E-04	100.8	-8.1 E-05	265.5	2.1 E-05	978.7
N977	⁹⁰ Sr	9.4 E-06	303.4	2.1 E-04	32.3	1.1 E-04	183
N977	¹³⁴ Cs	-2.7 E-05	793.4	-7.8 E-05	283.1	-5.2 E-05	96.6
N977	¹³⁷ Cs	4.7 E-05	377.1	9.1 E-05	169.2	6.9 E-05	63.4
N977	¹⁵⁴ Eu	4.0 E-04	174.9	6.6 E-04	81.4	5.3 E-04	48.8
N977	¹⁵⁵ Eu	-8.8 E-05	413.8	2.9 E-04	119.7	1.0 E-04	371.4
N977	²³⁴ U	5.4 E-07	564.6	3.3 E-06	80.1	1.9 E-06	143.7
N977	²³⁵ U	-1.9 E-07	656.1	-3.0 E-07	419.5	-2.4 E-07	44.8
N977	²³⁸ U	-1.2 E-06	178.6	5.1 E-06	62.3	2.0 E-06	320
N977	²³⁸ Pu	-1.6 E-07	366	-1.5 E-07	402.6	-1.6 E-07	4.5

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N977	^{239/40} Pu	7.4 E-07	126.6	9.0 E-07	109.9	8.2 E-07	18.6
N978	⁴⁰ K	3.4 E-03	179.2	1.4 E-02	31.3	8.9 E-03	124.1
N978	⁶⁰ Co	2.1 E-04	178.5	-7.6 E-05	267.8	6.5 E-05	434.7
N978	⁹⁰ Sr	-5.1 E-06	515.6	4.3 E-05	77	1.9 E-05	253.5
N978	¹³⁴ Cs	-1.3 E-04	218.5	1.1 E-04	144.6	-1.1 E-05	2,147
N978	¹³⁷ Cs	-3.8 E-04	84.3	1.2 E-04	118	-1.3 E-04	388.4
N978	¹⁵⁴ Eu	-1.3 E-03	70.5	5.3 E-04	76.3	-3.9 E-04	473.6
N978	¹⁵⁵ Eu	2.8 E-04	170.1	3.4 E-04	121.9	3.1 E-04	19.9
N978	²³⁴ U	-2.2 E-07	1,757	5.3 E-06	65.3	2.5 E-06	217.2
N978	²³⁵ U	-1.5 E-06	73	-6.3 E-07	80.9	-1.1 E-06	80
N978	²³⁸ U	6.1 E-07	579.8	3.4 E-06	89.1	2.0 E-06	139
N978	²³⁸ Pu	-1.3 E-07	715.1	-3.0 E-07	106	-2.1 E-07	82.2
N978	^{239/40} Pu	7.5 E-07	145.7	9.6 E-07	108.6	8.6 E-07	23.7
N984	⁴⁰ K	4.9 E-03	107.1	1.7 E-02	35.9	1.1 E-02	110.5
N984	⁶⁰ Co	1.1 E-04	260.2	1.1 E-04	208	1.1 E-04	0
N984	⁹⁰ Sr	1.8 E-04	34.2	6.9 E-04	23	4.4 E-04	115
N984	¹³⁴ Cs	1.6 E-04	138.1	-6.3 E-05	394.6	4.8 E-05	460.5
N984	¹³⁷ Cs	6.1 E-05	538.3	6.3 E-04	54.1	3.5 E-04	164.5
N984	¹⁵⁴ Eu	3.8 E-04	165.3	-6.3 E-05	1,148	1.6 E-04	280.9
N984	¹⁵⁵ Eu	-1.8 E-04	296.7	1.1 E-04	397.3	-3.6 E-05	811.1
N984	²³⁴ U	5.0 E-06	84.9	9.5 E-06	57.2	7.3 E-06	61.2
N984	²³⁵ U	1.1 E-06	161.9	8.3 E-08	2285	5.7 E-07	170.8
N984	²³⁸ U	4.9 E-06	79.9	1.0 E-05	55.2	7.6 E-06	72.3
N984	²³⁸ Pu	4.2 E-07	218.4	8.2 E-08	1,000	2.5 E-07	135.2
N984	^{239/40} Pu	2.9 E-06	60.4	6.3 E-07	234.9	1.8 E-06	128.2
N985	⁴⁰ K	1.3 E-02	38.3	1.4 E-02	30.1	1.4 E-02	6.5
N985	⁶⁰ Co	1.4 E-04	241.3	-2.3 E-04	102.6	-4.6 E-05	800
N985	⁹⁰ Sr	5.0 E-06	586	1.1 E-04	43.7	5.6 E-05	182.1
N985	¹³⁴ Cs	2.8 E-04	96.1	8.9 E-05	245.8	1.8 E-04	103.1

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N985	¹³⁷ Cs	1.1 E-04	283	2.2 E-04	79.2	1.7 E-04	65.5
N985	¹⁵⁴ Eu	-4.6 E-04	217	-6.1 E-04	102.5	-5.3 E-04	28.4
N985	¹⁵⁵ Eu	3.0 E-05	1,802	-2.0 E-05	1,775	5.2 E-06	961.2
N985	²³⁴ U	7.4 E-06	58.3	8.8 E-06	46.4	8.1 E-06	18.2
N985	²³⁵ U	8.5 E-07	169	1.3 E-06	153	1.1 E-06	43.8
N985	²³⁸ U	7.1 E-06	56.9	1.1 E-05	41.1	9.0 E-06	43.5
N985	²³⁸ Pu	-9.5 E-07	75.4	-3.4 E-07	192.1	-6.4 E-07	93.6
N985	^{239/40} Pu	2.1 E-06	85.4	1.0 E-06	106.9	1.6 E-06	70.1
N987	⁴⁰ K	1.2 E-02	47.6	1.1 E-02	37.7	1.1 E-02	9.6
N987	⁶⁰ Co	5.4 E-05	389.6	-1.4 E-04	201.4	-4.2 E-05	456.4
N987	⁹⁰ Sr	5.2 E-05	79.7	5.4 E-05	83.1	5.3 E-05	2.8
N987	¹³⁴ Cs	3.8 E-05	599	-3.9 E-05	592.4	-5.5 E-07	9,999
N987	¹³⁷ Cs	-1.5 E-04	206.7	6.0 E-05	444.3	-4.5 E-05	467.4
N987	¹⁵⁴ Eu	-3.8 E-04	245.3	-2.2 E-04	267.3	-3.0 E-04	54.6
N987	¹⁵⁵ Eu	-2.7 E-05	1,776	-3.7 E-05	1,316	-3.2 E-05	30.8
N987	²³⁴ U	2.8 E-06	141.7	5.2 E-06	76.9	4.0 E-06	59.9
N987	²³⁵ U	5.7 E-07	215.8	-6.0 E-07	198.3	-1.3 E-08	9,319
N987	²³⁸ U	2.5 E-06	139.7	9.4 E-06	50.6	6.0 E-06	115.6
N987	²³⁸ Pu	-2.9 E-07	233.4	-1.8 E-07	371.2	-2.3 E-07	48.4
N987	^{239/40} Pu	4.6 E-06	48.2	2.7 E-06	63.1	3.7 E-06	51.3
N994	⁴⁰ K	1.2 E-03	481.7	1.5 E-03	213.2	1.3 E-03	27.1
N994	⁶⁰ Co	3.5 E-04	80.2	-1.9 E-05	1,151	1.7 E-04	222.4
N994	⁹⁰ Sr	9.8 E-06	318	4.9 E-05	74.5	2.9 E-05	133.3
N994	¹³⁴ Cs	1.2 E-04	191	-2.9 E-05	565.5	4.6 E-05	324.7
N994	¹³⁷ Cs	2.2 E-04	127.3	-1.2 E-04	188.1	5.1 E-05	662.7
N994	¹⁵⁴ Eu	2.2 E-04	247.5	-3.7 E-05	1,897	9.1 E-05	281.1
N994	¹⁵⁵ Eu	5.6 E-05	839.6	-3.0 E-05	1,162	1.3 E-05	653.8
N994	²³⁴ U	-2.4 E-06	89	5.5 E-06	60.7	1.6 E-06	503.8
N994	²³⁵ U	2.0 E-07	553.3	-1.1 E-06	68.1	-4.4 E-07	290.3

Table C-1. 1995 Air Sample Results, All Areas (pCi/m³).

Sample I.D.	Isotope	1st Half	Overall Error (%)	2nd Half	Overall Error (%)	Average	Overall Error (%)
N994	²³⁸ U	2.1 E-06	143.3	3.1 E-06	87.4	2.6 E-06	38.5
N994	²³⁸ Pu	-6.9 E-08	834.1	1.7 E-07	430.6	5.1 E-08	471.3
N994	^{239/40} Pu	1.0 E-06	107.9	1.7 E-06	79.9	1.4 E-06	50.4
300 Area (TEDF)							
N130	⁴⁰ K	1.2 E-02	46.5	4.2 E-04	1,287	6.3 E-03	186.6
N130	⁶⁰ Co	-4.0 E-04	99.5	1.2 E-04	165.6	-1.4 E-04	375.5
N130	⁹⁰ Sr	4.6 E-06	731	2.7 E-04	29.3	1.4 E-04	193.2
N130	¹³⁴ Cs	1.9 E-04	169.8	-1.8 E-04	133	5.0 E-06	7,359
N130	¹³⁷ Cs	2.0 E-04	91.6	1.7 E-04	127.5	1.9 E-04	19.5
N130	¹⁵⁴ Eu	8.0 E-04	76.2	4.1 E-04	170.8	6.1 E-04	63.1
N130	¹⁵⁵ Eu	-5.1 E-04	113.4	5.8 E-05	806.5	-2.3 E-04	251.3
N130	²³⁴ U	6.1 E-06	85.8	5.4 E-06	67.8	5.8 E-06	11.8
N130	²³⁵ U	-5.1 E-08	3274	3.1 E-06	90	1.5 E-06	206.7
N130	²³⁸ U	1.6 E-06	260.3	6.5 E-06	59.8	4.0 E-06	122.3
N130	²³⁸ Pu	-4.7 E-07	93.8	-6.0 E-07	86.6	-5.3 E-07	24
N130	^{239/40} Pu	2.4 E-06	73.3	8.1 E-07	167.7	1.6 E-06	100.5
600 Area							
N981	⁴⁰ K	3.5 E-03	203.4	6.1 E-03	48.9	4.8 E-03	53
N981	⁶⁰ Co	1.9 E-04	170.4	-1.4 E-05	1,890	8.8 E-05	231.3
N981	⁹⁰ Sr	1.2 E-05	249.6	2.6 E-04	26.6	1.4 E-04	182.1
N981	¹³⁴ Cs	4.8 E-04	59.5	8.1 E-05	265.5	2.8 E-04	142.1
N981	¹³⁷ Cs	-1.2 E-04	188.6	-1.1 E-04	180.5	-1.2 E-04	8.5
N981	¹⁵⁴ Eu	-1.4 E-04	618.4	-4.8 E-05	1149	-9.5 E-05	97.9
N981	¹⁵⁵ Eu	-5.4 E-04	98.1	-3.8 E-05	835.5	-2.9 E-04	173.9
N981	²³⁴ U	3.9 E-06	103.4	3.0 E-06	92.1	3.4 E-06	24.4
N981	²³⁵ U	1.1 E-06	170.5	2.2 E-06	109	1.7 E-06	65.9
N981	²³⁸ U	2.7 E-06	123.1	2.9 E-06	95.3	2.8 E-06	9.6
N981	²³⁸ Pu	5.7 E-09	9999	-4.8 E-07	85.3	-2.4 E-07	204.8
N981	^{239/40} Pu	1.2 E-06	88.8	6.8 E-07	145.7	9.6 E-07	59.2

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APPENDIX D
GROUNDWATER MONITORING FIGURES

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Figure D-1. Location of Groundwater Wells at 100-K Area.

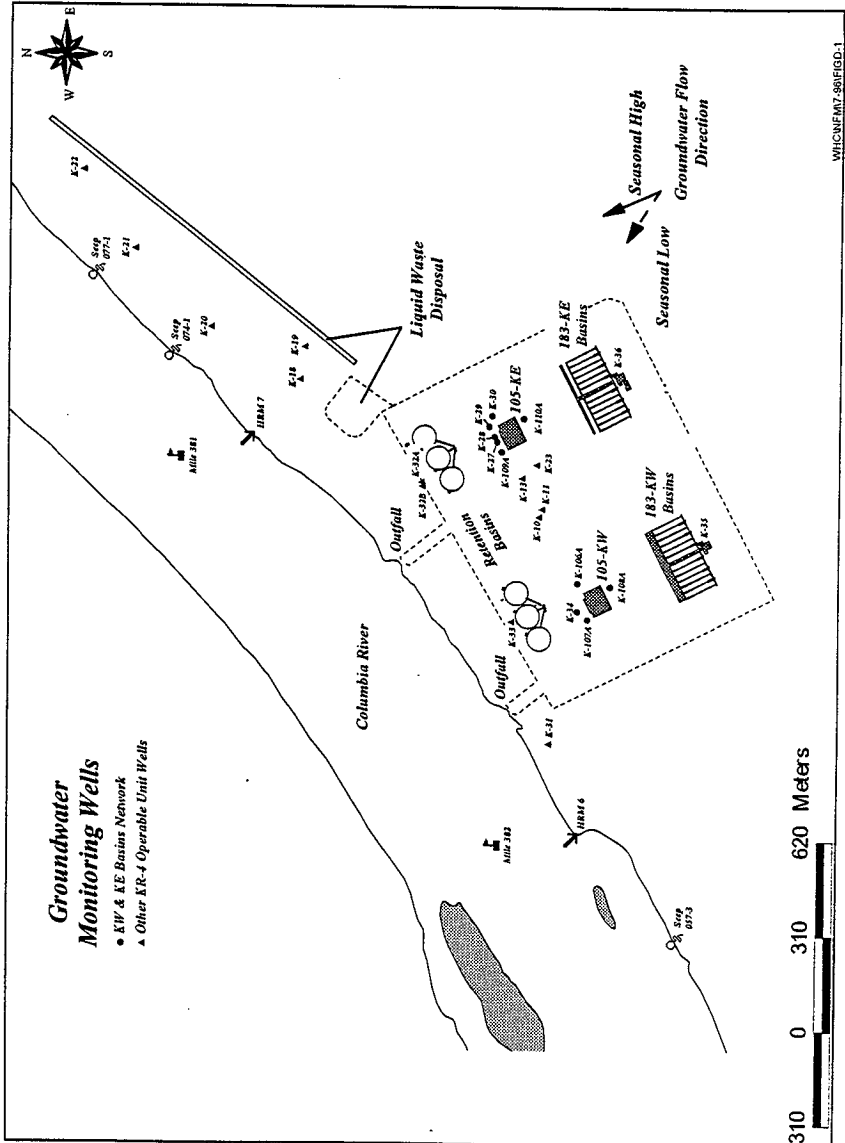
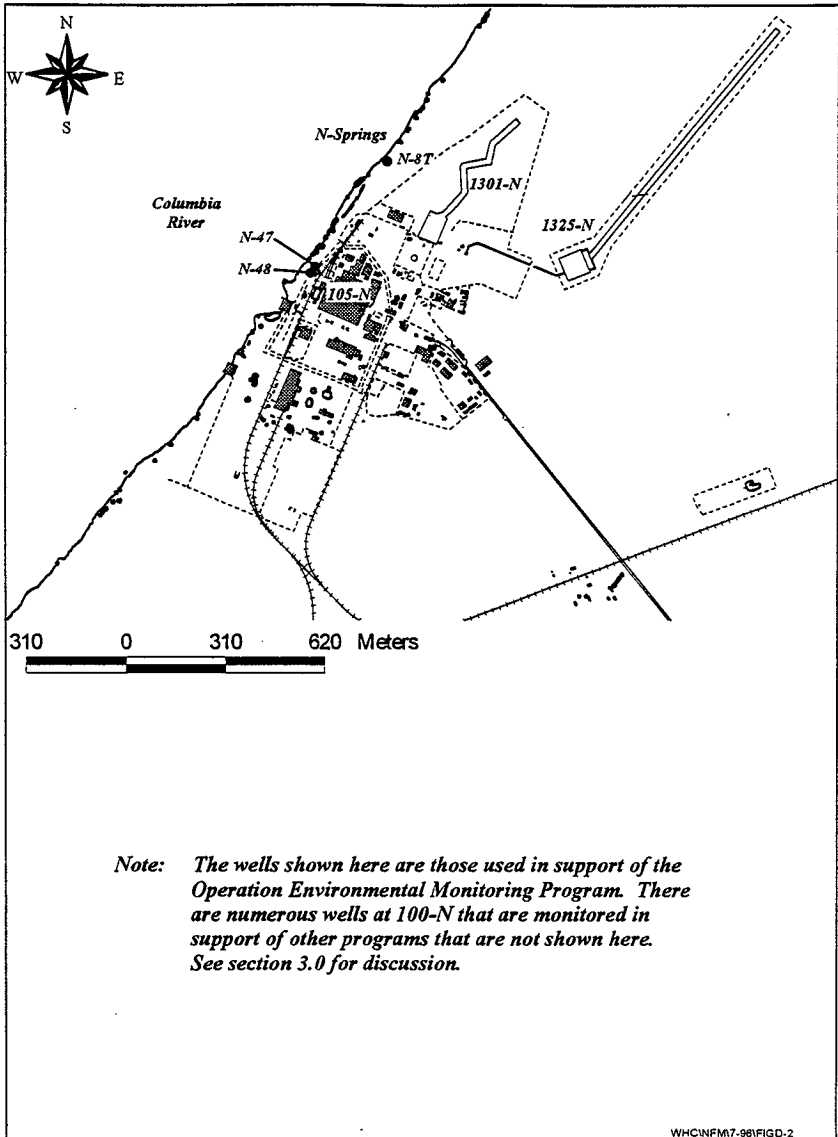


Figure D-2. Location of Groundwater Wells at 100-N Area.

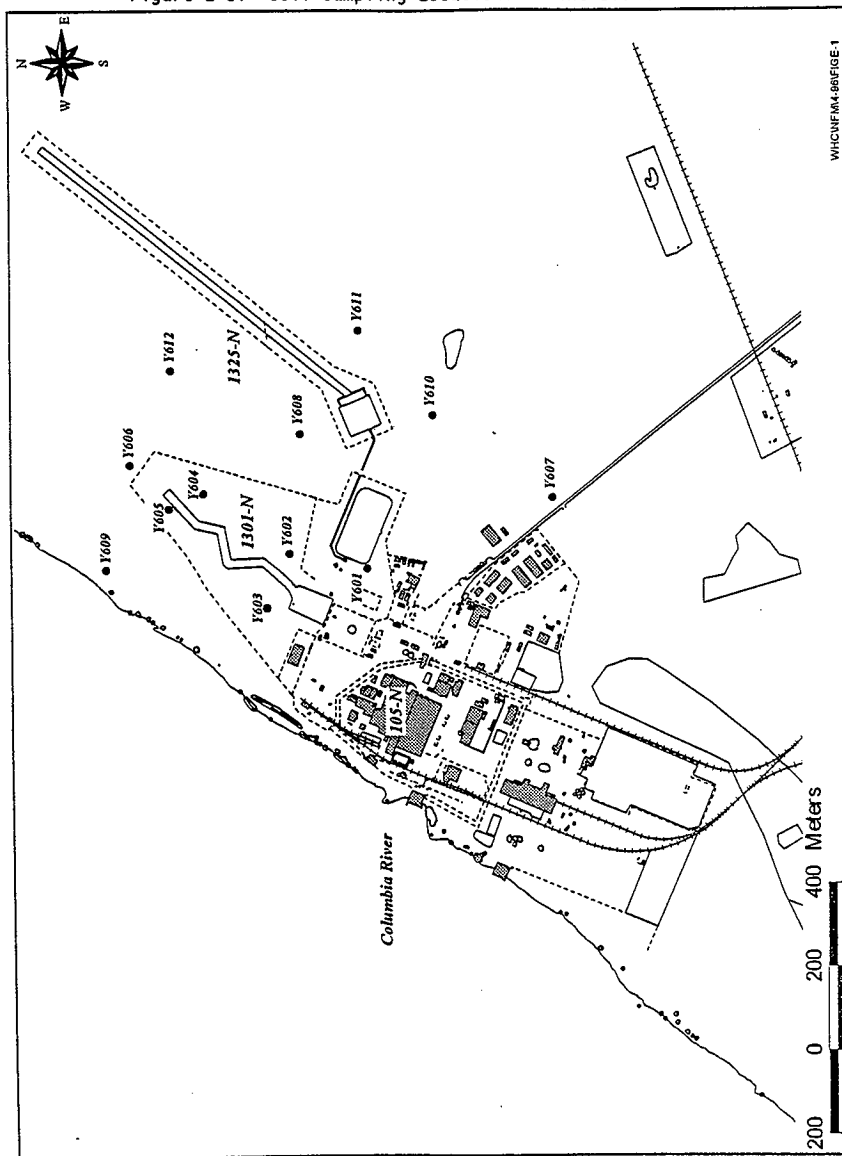


APPENDIX E

**SOIL AND VEGETATION MONITORING
FIGURES AND TABLES**

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Figure E-1. Soil Sampling Locations in the 100-N Area.



E-2

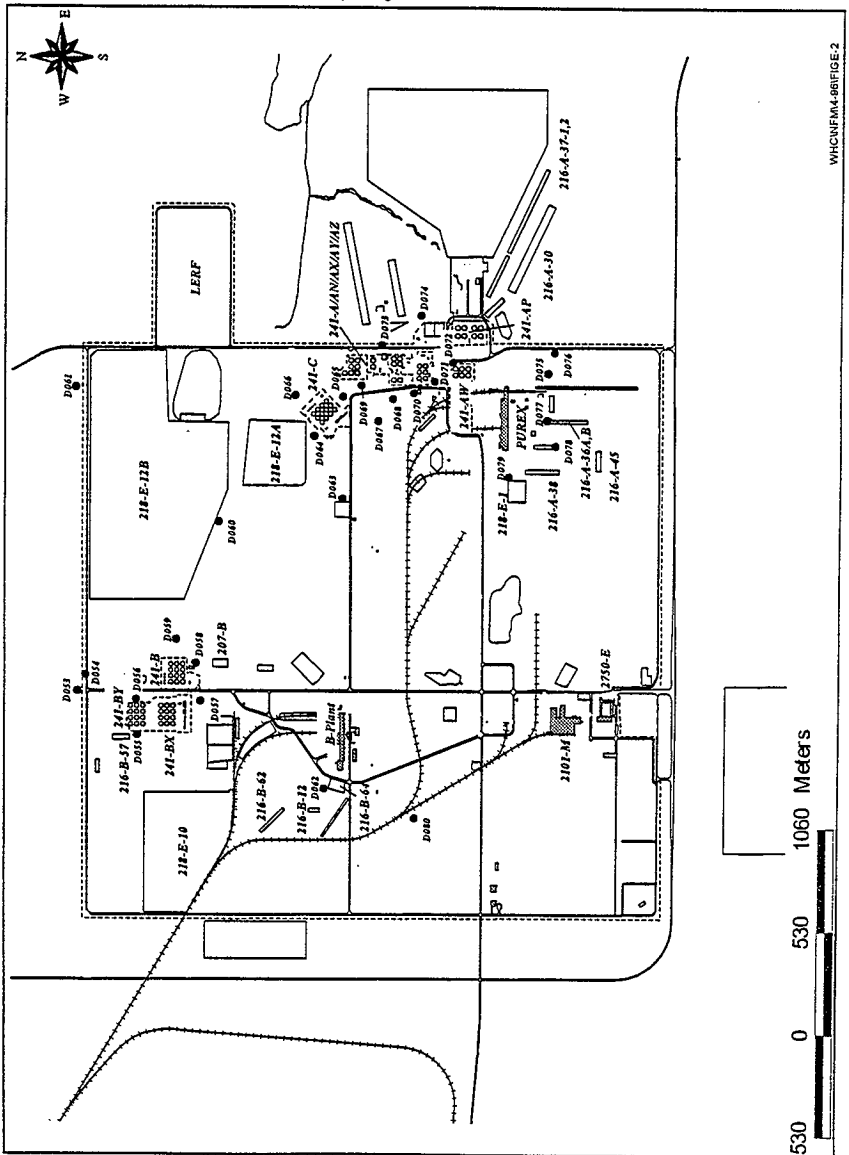
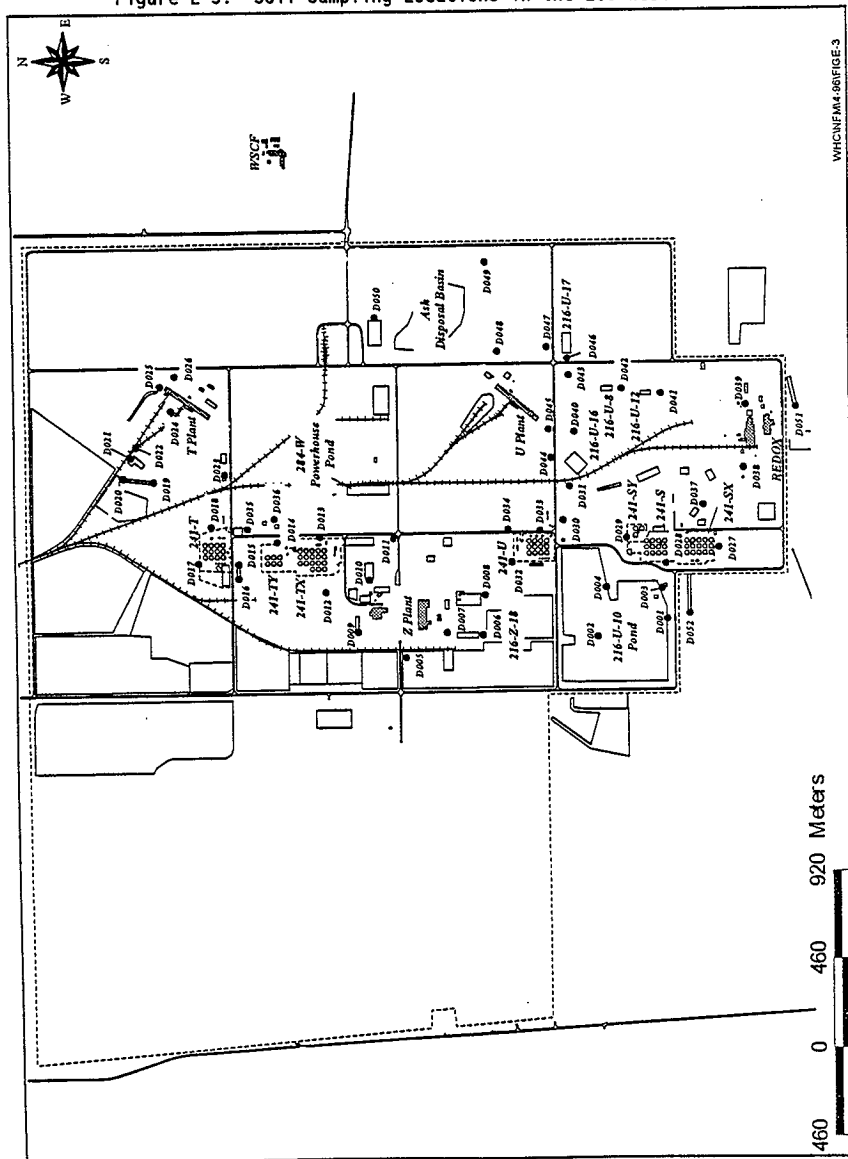
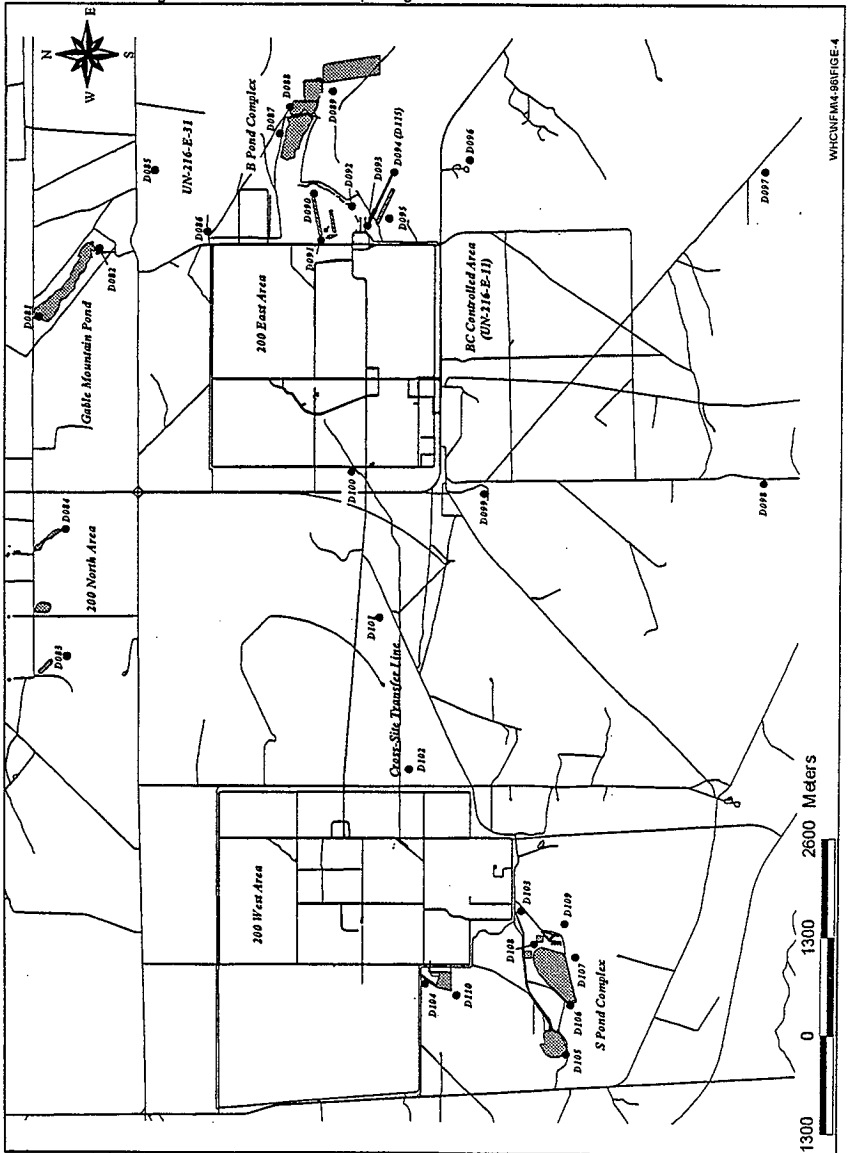


Figure E-3. Soil Sampling Locations in the 200 West Area.



WHC/NM4-96FIG-E-3

Figure E-4. Soil Sampling Locations in the 600 Area.



WHC/NM-98/FGE-4

Figure E-5. Soil Sampling Locations in the 300 Area.

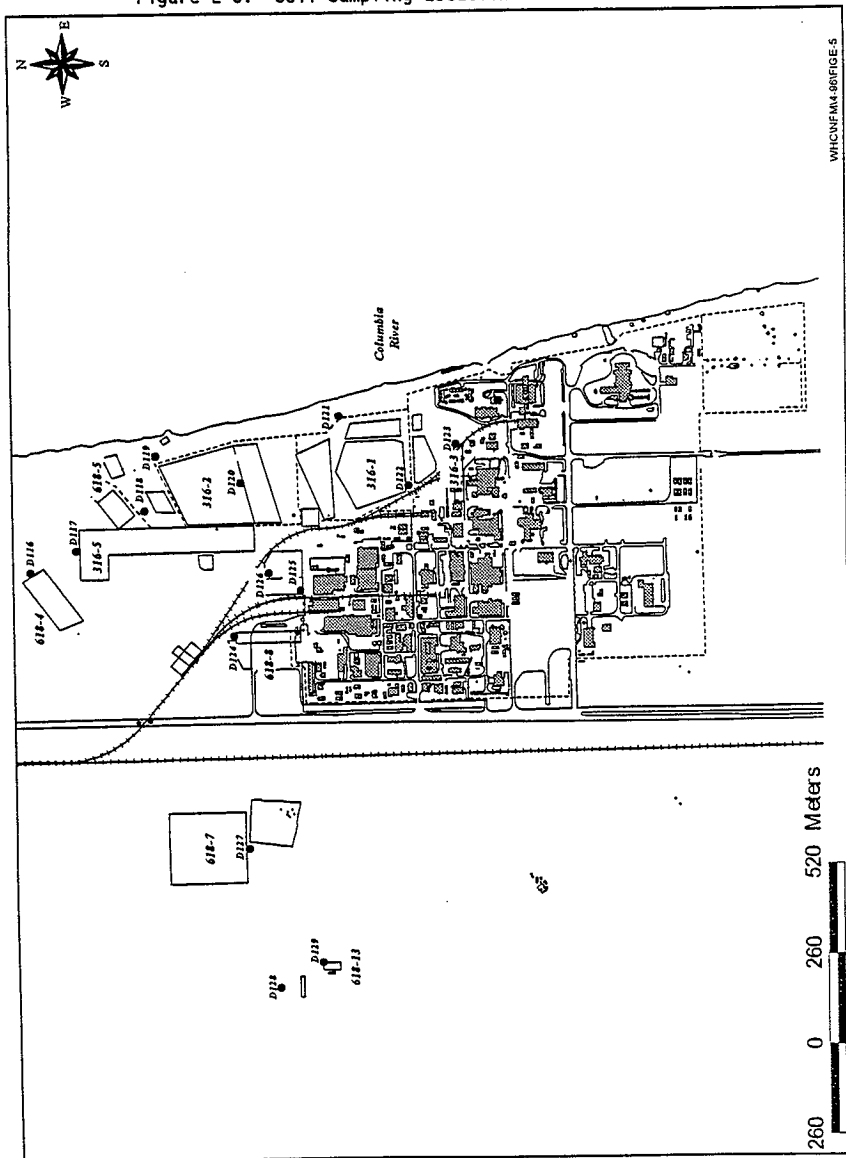
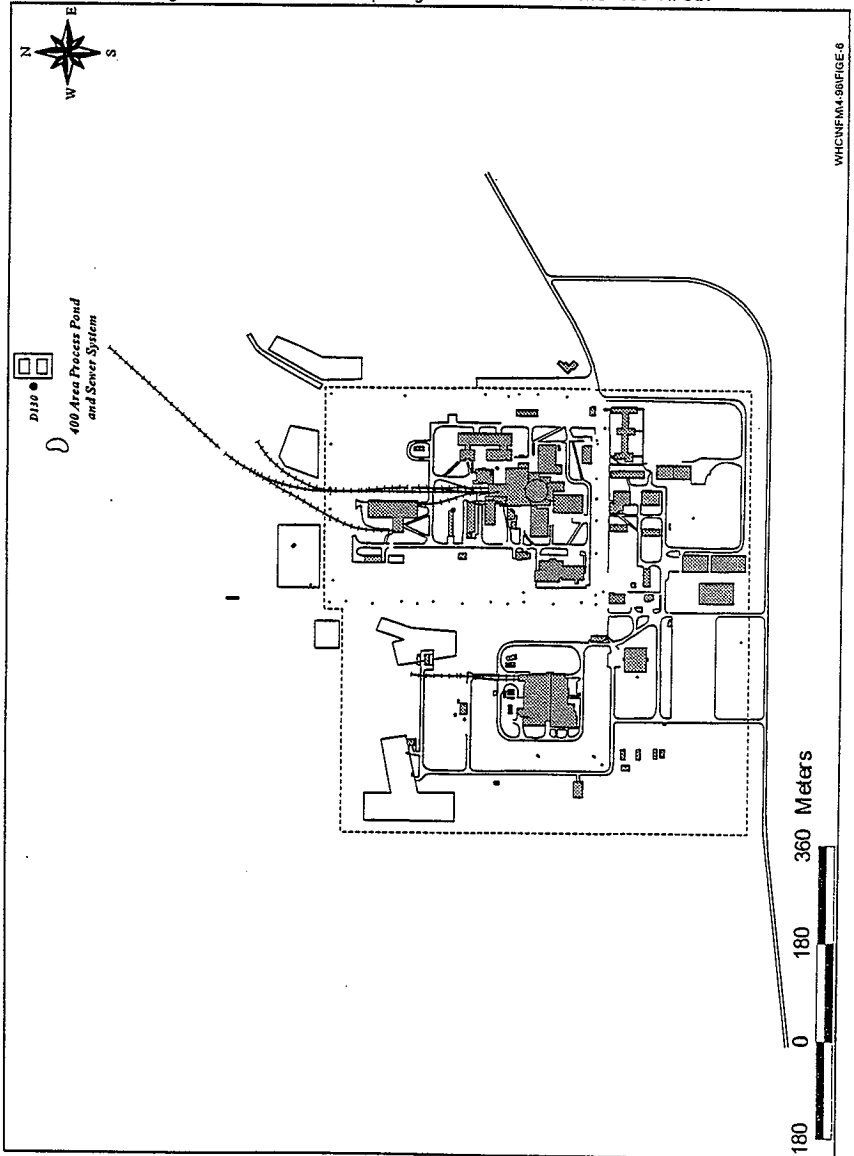


Figure E-6. Soil Sampling Locations in the 400 Area.



WHC/NF/M-4-98/FIG. 6

Figure E-7. Vegetation Sampling Locations in the 100-N Area.

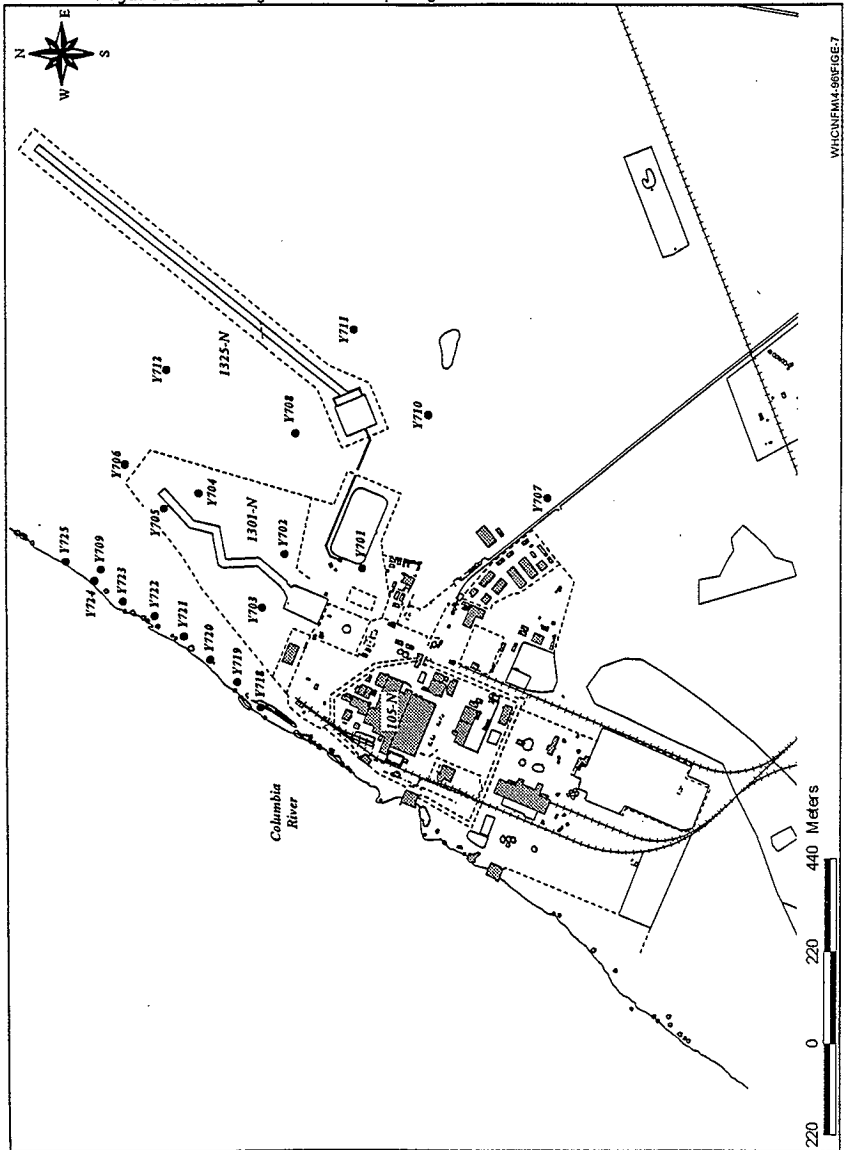
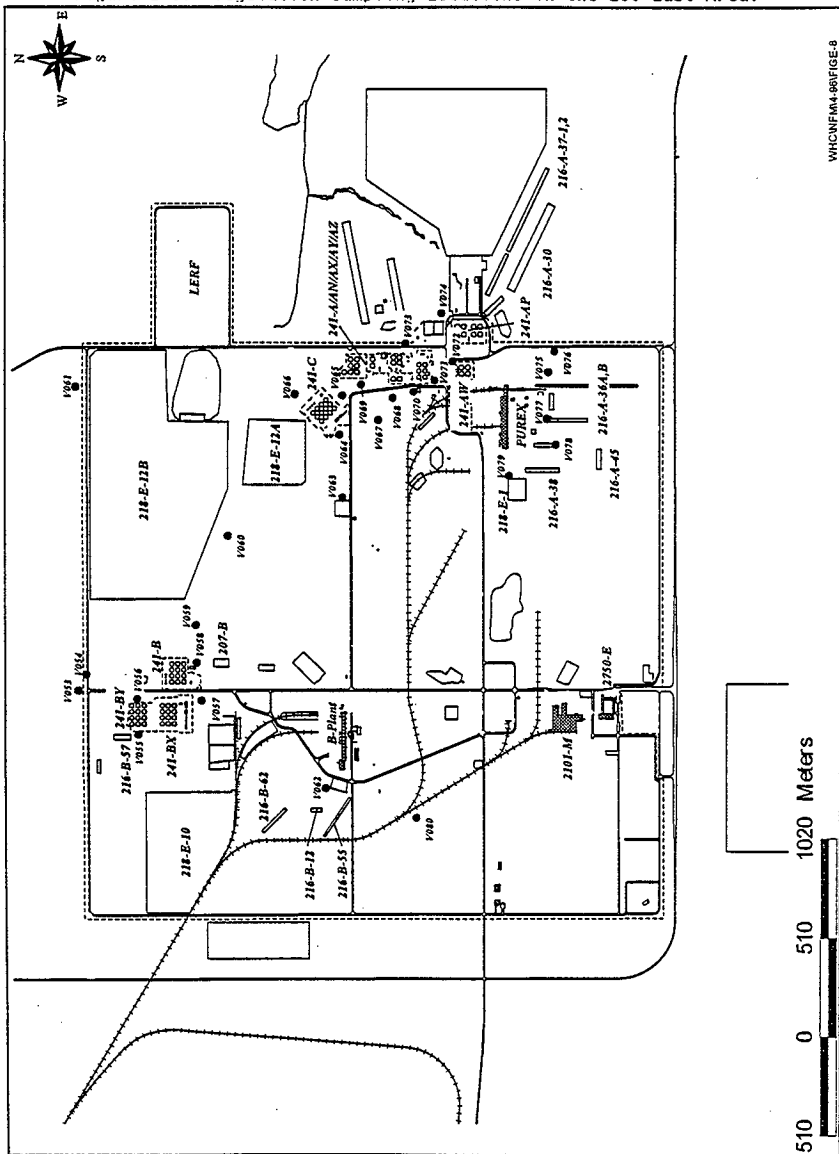


Figure E-8. Vegetation Sampling Locations in the 200 East Area.



WHC/NFRA-95/FGE-8

Figure E-9. Vegetation Sampling Locations in the 200 West Area.

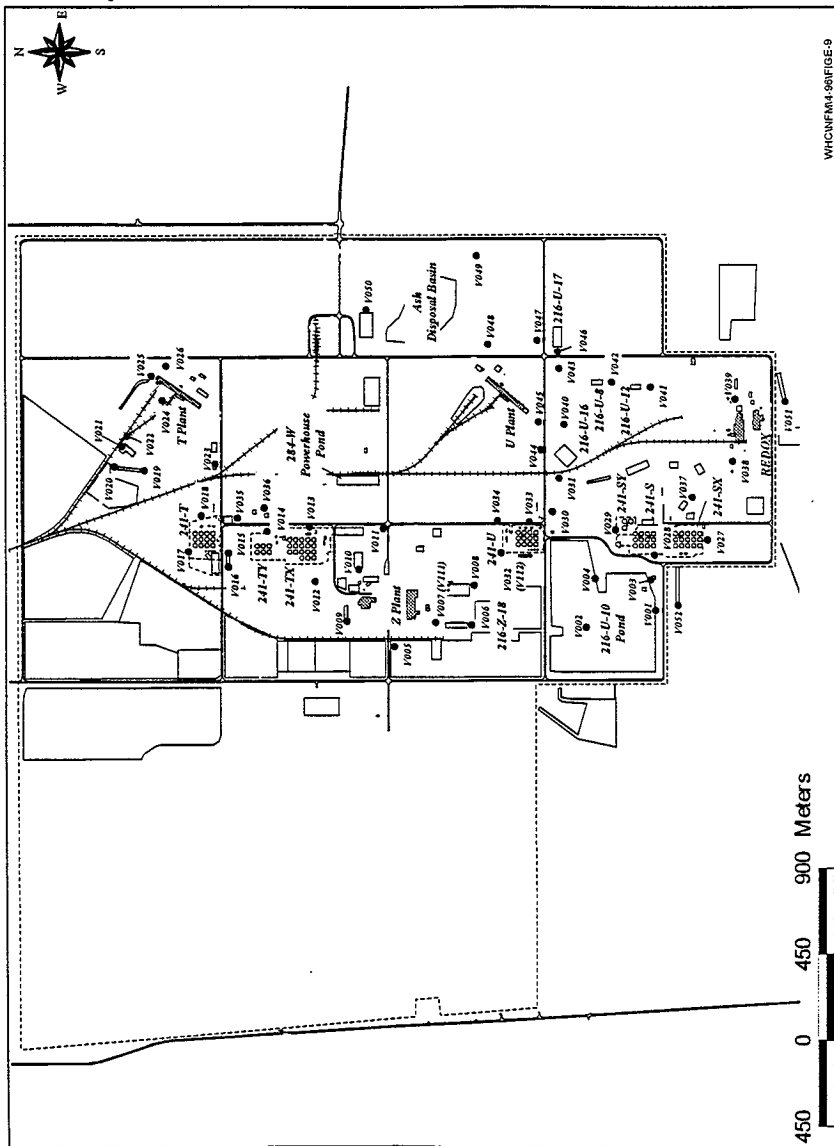
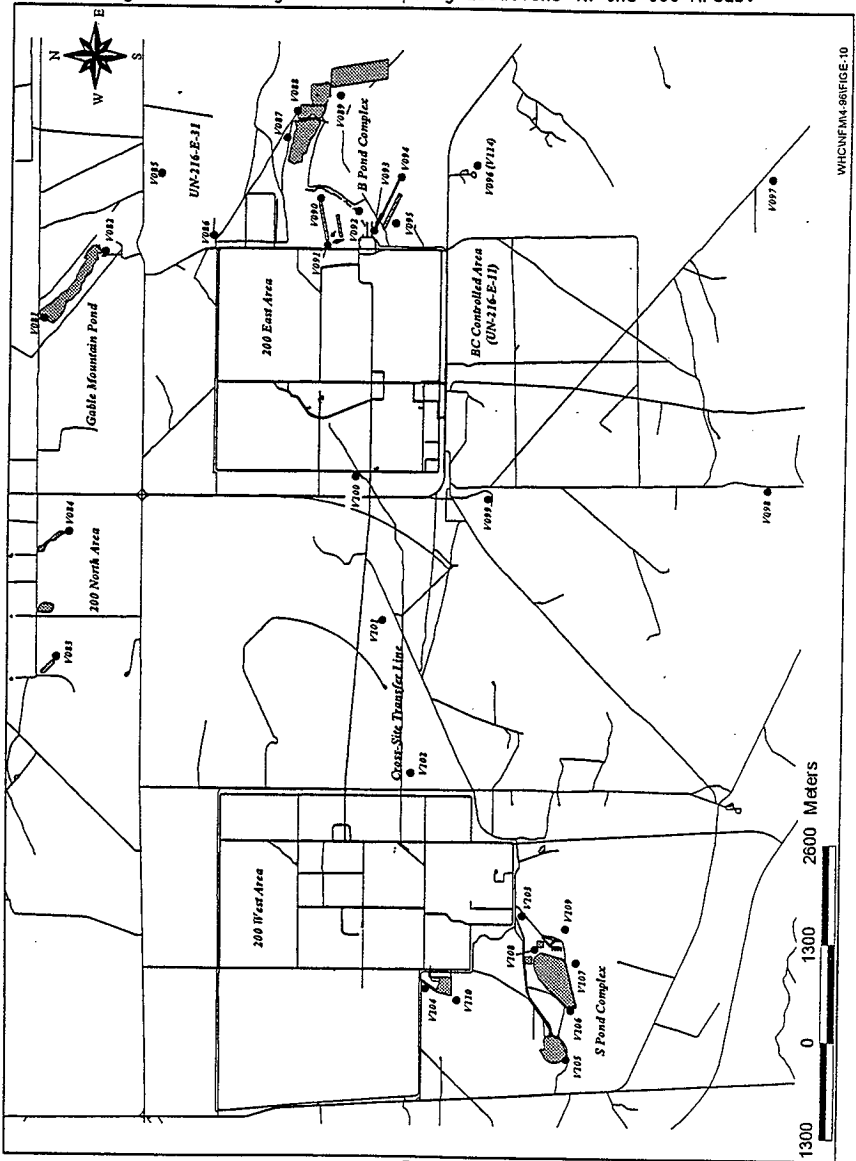
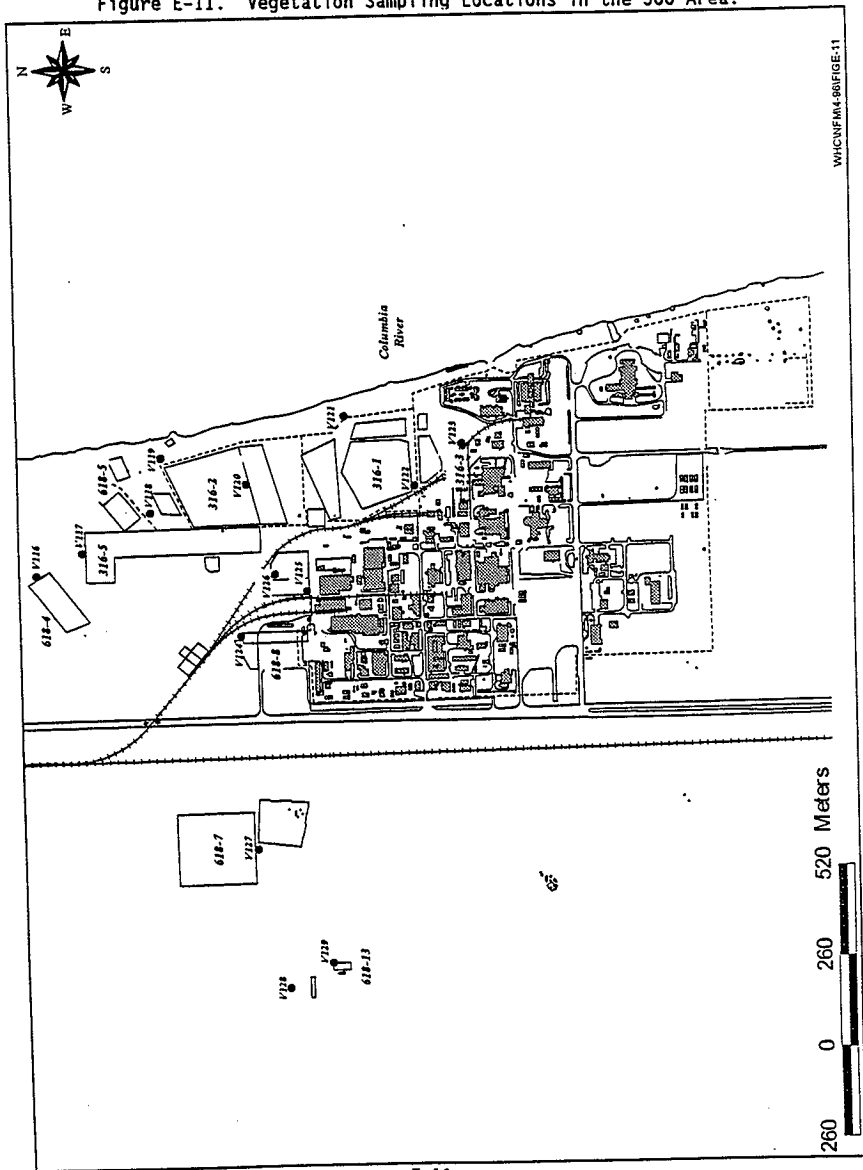


Figure E-10. Vegetation Sampling Locations in the 600 Areas.



WHC/NM-SE/FIG-E-10

Figure E-11. Vegetation Sampling Locations in the 300 Area.



WHC/NFM-4-98/FIG-E-11

Figure E-12. Vegetation Sampling Locations in the 400 Area.

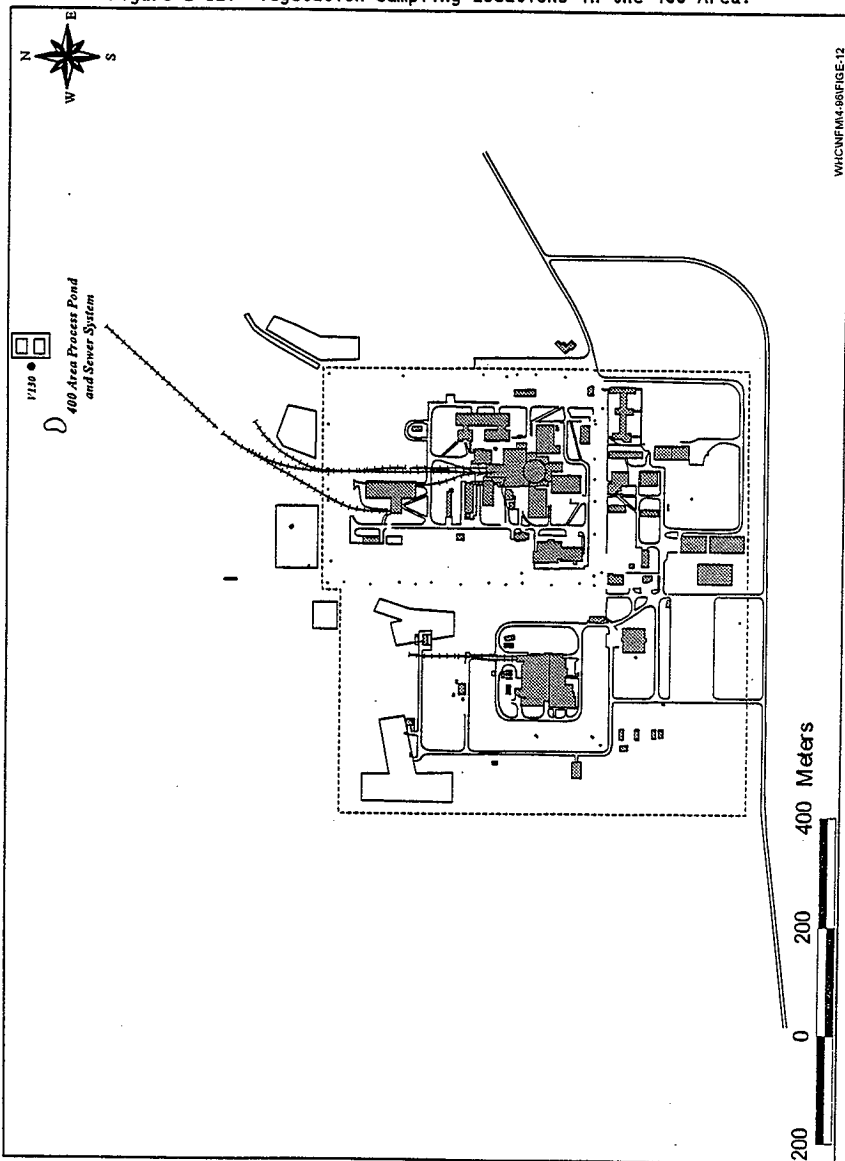


Table E-1. 100-N Area Soil Sample Results (pCi/g). (Sheet 1 of 2)

	⁴⁰ K		⁶⁰ Co		⁹⁰ Sr		¹³⁴ Cs		¹³⁷ Cs	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
Y601	1.7 E+01	11	3.6 E-01	13	5.7 E-02	23	-2.1 E-02	57	1.3 E-01	18
Y602	1.5 E+01	11	4.0 E+00	10	5.8 E-02	23	1.9 E-02	80	1.2 E+00	11
Y603	1.5 E+01	11	5.4 E+00	10	4.8 E-01	18	-5.2 E-03	330	1.5 E+00	11
Y604	1.5 E+01	11	3.6 E-01	13	1.2 E-01	20	-5.0 E-03	220	6.9 E-01	11
Y605	1.5 E+01	11	2.6 E-01	15	4.4 E-02	22	1.7 E-03	580	2.9 E-01	15
Y606	1.5 E+01	11	8.4 E-02	28	2.5 E-01	18	-2.0 E-02	52	2.5 E-01	14
Y607	1.2 E+01	11	3.5 E-02	38	1.5 E-01	20	4.1 E-04	>9999	5.1 E-01	12
Y608	1.5 E+01	11	1.4 E-01	22	1.2 E-01	20	-1.7 E-02	61	4.7 E-01	12
Y609	1.5 E+01	11	1.6 E-01	20	4.6 E-02	23	-9.1 E-03	120	2.2 E-01	16
Y610	1.5 E+01	11	2.9 E-01	14	6.1 E-02	22	-1.2 E-02	83	2.4 E-01	14
Y611	1.2 E+01	11	1.2 E-01	23	1.7 E-01	20	2.2 E-03	380	4.0 E-01	12
Y612	1.4 E+01	11	6.5 E-02	34	3.8 E-02	26	-3.6 E-03	240	1.3 E-01	20
	¹⁵⁴ Eu		¹⁵² Eu		²²⁶ Ra		²³⁴ U		²³⁵ U	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
Y601	2.1 E-02	220	6.4 E-02	61	NR	NR	7.6 E-02	15	3.1 E-03	62
Y602	-2.4 E-03	>9999	9.9 E-02	43	NR	NR	6.9 E-02	16	1.1 E-03	130
Y603	2.4 E-02	200	5.0 E-02	89	NR	NR	9.6 E-02	14	3.2 E-03	62
Y604	1.1 E-02	370	3.2 E-02	120	NR	NR	6.3 E-02	16	2.8 E-03	64
Y605	4.5 E-02	79	6.5 E-02	51	NR	NR	8.3 E-02	15	3.9 E-03	53
Y606	-2.8 E-03	>9999	4.5 E-02	78	NR	NR	9.4 E-02	14	2.6 E-03	61
Y607	-7.1 E-02	48	6.6 E-02	42	NR	NR	7.4 E-02	15	3.4 E-03	52
Y608	-2.0 E-02	200	5.5 E-02	64	NR	NR	8.8 E-02	15	4.1 E-03	50
Y609	-4.7 E-03	910	6.0 E-02	61	NR	NR	1.3 E-01	14	8.6 E-03	35
Y610	2.4 E-02	160	8.5 E-02	43	NR	NR	1.2 E-01	13	6.0 E-03	39
Y611	-2.1 E-02	160	4.8 E-02	65	NR	NR	1.1 E-01	14	5.5 E-03	45
Y612	2.9 E-02	120	5.7 E-02	50	NR	NR	9.0 E-02	14	2.9 E-03	61

Table E-1. 100-N Area Soil Sample Results
(pCi/g). Sheet 2 of 2.

	²³⁸ U		²³⁸ Pu		^{239/240} Pu	
	Result	% Error	Result	% Error	Result	% Error
Y601	8.2 E-02	15	6.5 E-04	70	3.6 E-03	30
Y602	7.2 E-02	15	5.1 E-04	69	2.6 E-03	32
Y603	9.6 E-02	14	7.1 E-03	22	3.6 E-02	15
Y604	7.1 E-02	15	7.6 E-04	58	6.0 E-03	24
Y605	8.3 E-02	15	1.0 E-03	49	2.8 E-03	30
Y606	1.0 E-01	14	7.7 E-03	23	5.6 E-02	15
Y607	7.3 E-02	15	5.6 E-04	58	1.5 E-02	16
Y608	8.8 E-02	15	1.2 E-03	48	1.3 E-02	19
Y609	1.5 E-01	13	4.7 E-04	69	3.7 E-03	27
Y610	1.3 E-01	13	1.1 E-03	47	6.1 E-03	23
Y611	1.2 E-01	14	4.8 E-04	86	1.4 E-02	20
Y612	1.0 E-01	14	1.2 E-03	48	3.2 E-03	30

Table E-2. 200/600 Areas Soil Sample Results (pCi/g). (Sheet 1 of 5)

Site I.D.	⁴⁰ K		⁶⁰ Co		⁹⁰ Sr		¹³⁴ Cs		¹³⁷ Cs	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
D001	1.4 E+01	12	1.1 E-02	230	9.3 E-02	21	-4.6 E-02	48	2.8 E-01	20
D003	1.5 E+01	12	2.3 E-02	120	3.9 E-01	19	-2.7 E-02	91	1.9 E+00	11
D005	1.3 E+01	12	1.9 E-02	110	4.4 E-01	19	1.8 E-03	>9999	6.5 E-01	14
D007	1.4 E+01	12	8.1 E-03	230	4.4 E-02	25	3.2 E-03	550	2.0 E-01	23
D009	1.4 E+01	12	6.6 E-03	320	1.5 E-01	20	NR	NR	2.5 E-01	21
D011	1.1 E+01	12	9.3 E-03	200	2.9 E-01	19	-1.0 E-02	210	4.0 E+00	10
D015	1.4 E+01	12	1.4 E-02	160	2.2 E-01	18	-2.5 E-02	90	2.4 E+00	11
D017	1.4 E+01	12	-1.9 E-03	>9999	2.3 E-01	19	-1.0 E-02	200	1.7 E+00	11
D019	1.3 E+01	12	1.0 E-02	190	2.2 E-01	18	-7.3 E-03	220	1.8 E+00	11
D021	1.5 E+01	12	4.5 E-02	49	3.2 E-01	19	2.0 E-03	>9999	3.3 E+00	11
D023	1.3 E+01	12	2.1 E-02	110	2.3 E-01	19	-2.2 E-02	100	4.1 E+00	10
D025	1.3 E+01	12	4.3 E-03	490	1.7 E-01	25	-2.7 E-02	79	8.9 E-01	12
D027	1.4 E+01	12	-5.8 E-04	>9999	4.3 E-01	25	1.1 E-02	180	3.9 E+00	11
D029	1.5 E+01	12	1.4 E-02	160	5.0 E-01	19	9.6 E-03	210	1.5 E+00	11
D031	1.3 E+01	12	1.6 E-03	>9999	1.4 E+00	24	1.2 E-02	160	6.6 E+00	10
D033	1.2 E+01	12	6.6 E-03	270	1.1 E+00	25	-7.3 E-04	>9999	8.8 E+00	10
D035	1.3 E+01	12	1.7 E-02	120	3.1 E-01	24	-2.8 E-02	91	6.5 E+00	10
D037	1.4 E+01	12	3.7 E-03	620	4.2 E-01	19	1.3 E-02	150	1.7 E+00	11
D039	1.2 E+01	12	3.8 E-03	480	8.1 E-01	23	2.3 E-02	78	2.9 E+00	11
D041	1.3 E+01	12	7.1 E-03	290	2.6 E-01	19	-2.0 E-03	930	1.2 E+00	11
D043	1.2 E+01	12	6.5 E-03	370	2.2 E-01	20	-2.7 E-02	84	3.6 E+00	10
D045	1.3 E+01	12	-6.0 E-03	370	3.8 E-01	19	1.6 E-02	130	4.7 E+00	10
D047	1.4 E+01	12	-3.7 E-02	75	8.4 E-01	20	-5.2 E-03	460	4.6 E+00	10
D049	1.3 E+01	12	6.7 E-03	270	1.6 E-01	25	-2.8 E-03	610	1.6 E+00	11
D051	1.4 E+01	12	1.7 E-03	>9999	9.1 E-02	21	-2.7 E-02	68	5.3 E-01	15
D053	1.5 E+01	12	-6.6 E-03	400	2.9 E-01	25	-1.5 E-02	180	6.6 E+00	10
D055	1.5 E+01	12	6.6 E-03	400	2.2 E-01	18	-2.6 E-03	960	8.8 E+00	10
D057	1.4 E+01	12	9.7 E-03	220	6.3 E-01	19	1.2 E-03	>9999	8.1 E+00	10
D059	1.5 E+01	12	-2.6 E-02	110	3.5 E+00	19	-9.4 E-03	250	3.1 E+00	11
D061	1.4 E+01	12	-9.3 E-03	260	2.9 E-01	19	3.6 E-02	54	7.9 E-01	13
D063	1.4 E+01	12	5.2 E-04	>9999	1.5 E+00	18	-1.1 E-02	180	6.0 E-01	14
D065	1.4 E+01	12	2.4 E-03	>9999	1.1 E+00	18	-3.4 E-02	80	3.5 E+00	11
D067	1.5 E+01	12	2.0 E-02	100	9.8 E-01	18	-1.2 E-02	170	3.5 E-01	18
D069	1.5 E+01	12	1.4 E-02	140	2.7 E-01	19	-1.2 E-03	>9999	5.1 E-01	15
D071	1.4 E+01	12	-2.8 E-02	82	4.2 E-01	19	-3.4 E-03	970	2.6 E+01	10

Table E-2. 200/600 Areas Soil Sample Results (pCi/g). (Sheet 2 of 5)

Site I.D.	⁴⁰ K		⁶⁰ Co		⁹⁰ Sr		¹³⁴ Cs		¹³⁷ Cs	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
D073	1.3 E+01	12	6.4 E-03	290	3.0 E+00	18	1.7 E-02	98	5.9 E-01	14
D075	1.2 E+01	12	-3.6 E-03	560	1.5 E-01	20	-1.7 E-02	120	3.1 E-01	17
D077	1.3 E+01	13	-5.3 E-03	420	1.4 E-01	19	-3.5 E-02	69	4.2 E-01	17
D079	1.7 E+01	12	1.3 E-02	160	1.6 E-01	20	8.8 E-04	>9999	1.1 E+00	12
D081	1.5 E+01	12	1.1 E-02	190	1.2 E-02	43	4.4 E-03	400	7.1 E-03	330
D083	1.3 E+01	13	-3.8 E-03	740	1.4 E-01	20	-1.8 E-02	150	2.6 E+00	11
D085	1.4 E+01	12	4.1 E-03	48	3.8 E-01	19	-6.6 E-04	>9999	2.5 E+00	11
D087	1.5 E+01	12	1.3 E-02	170	3.4 E-01	25	1.6 E-02	130	1.0 E+00	12
D089	1.4 E+01	12	-7.2 E-03	310	6.8 E-02	27	1.3 E-03	>9999	3.8 E-01	16
D091	1.3 E+01	12	-2.1 E-02	82	3.6 E-01	22	1.6 E-02	110	3.3 E+00	10
D093	1.5 E+01	12	-7.9 E-03	240	1.6 E-01	22	-4.5 E-02	44	3.4 E-01	17
D095	1.4 E+01	12	-5.5 E-03	360	1.3 E-01	24	-2.3 E-02	87	5.1 E-01	14
D097	1.6 E+01	12	-1.0 E-02	220	6.1 E-02	24	1.2 E-02	150	4.4 E-02	56
D099	1.3 E+01	12	1.3 E-02	150	1.6 E-01	20	4.3 E-03	370	1.2 E-01	38
D101	1.4 E+01	12	3.9 E-03	510	1.5 E+00	19	1.5 E-03	>9999	2.4 E+00	11
D103	1.2 E+01	12	1.3 E-02	120	2.4 E-02	27	6.2 E-03	240	1.1 E+00	11
D105	1.4 E+01	12	6.3 E-03	320	1.2 E-01	21	-2.1 E-02	92	2.5 E-01	17
D109	1.4 E+01	12	-5.8 E-03	410	1.3 E-01	20	1.2 E-02	160	4.4 E-01	15
Site I.D.	¹⁵² Eu		¹⁵⁴ Eu		²²⁶ Ra		²³⁴ U		²³⁵ U	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
D001	-2.8 E-02	240	5.3 E-02	130	5.9 E-01	17	7.3 E-02	15	2.5 E-03	69
D003	7.8 E-02	82	-4.6 E-03	>9999	6.3 E-01	20	9.5 E-02	14	3.1 E-03	61
D005	4.5 E-03	>9999	2.0 E-02	240	5.0 E-01	20	7.2 E-02	15	2.2 E-03	67
D007	2.7 E-02	230	7.0 E-02	74	6.4 E-01	17	7.2 E-02	15	3.1 E-03	60
D009	-3.0 E-02	220	7.2 E-02	75	6.4 E-01	16	8.6 E-02	14	3.8 E-03	53
D011	1.3 E-02	440	9.3 E-02	67	5.2 E-01	15	8.4 E-02	14	4.4 E-03	46
D015	2.1 E-02	340	5.3 E-02	130	5.8 E-01	17	1.0 E-01	13	4.7 E-03	42
D017	5.3 E-02	120	1.0 E-01	53	6.2 E-01	18	7.4 E-02	15	4.3 E-03	45
D019	4.3 E-02	140	8.0 E-02	73	6.9 E-01	15	8.0 E-02	15	2.6 E-03	64
D021	NR	NR	4.4 E-02	160	7.6 E-01	16	8.1 E-02	14	3.1 E-03	56
D023	3.1 E-02	210	8.8 E-02	77	7.2 E-01	16	1.3 E-01	13	6.2 E-03	38
D025	2.8 E-03	>9999	4.2 E-02	160	6.0 E-01	18	1.5 E-01	12	4.8 E-03	41
D027	-7.1 E-02	100	3.0 E-02	200	5.3 E-01	19	1.4 E-01	12	5.5 E-03	39
D029	-6.8 E-02	120	9.1 E-02	63	7.0 E-01	16	1.5 E-01	14	7.1 E-03	43

Table E-2. 200/600 Areas Soil Sample Results (pCi/g). (Sheet 3 of 5)

Site I.D.	¹⁵⁴ Eu		¹⁵² Eu		²²⁶ Ra		²³⁴ U		²³⁵ U	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
D031	4.2 E-03	>9999	8.8 E-02	75	7.0 E-01	15	1.6 E-01	17	9.7 E-03	48
D033	8.4 E-02	55	5.7 E-02	110	5.0 E-01	21	1.0 E-01	15	2.5 E-03	87
D035	4.7 E-02	120	5.2 E-02	140	5.7 E-01	16	6.5 E-02	17	1.7 E-03	90
D037	-3.3 E-03	>9999	4.7 E-02	110	5.5 E-01	18	8.6 E-02	14	2.6 E-03	61
D039	-1.6 E-02	410	1.2 E-02	470	5.0 E-01	21	9.3 E-02	16	5.3 E-03	56
D041	-1.1 E-01	66	8.5 E-02	68	5.8 E-01	17	1.3 E-01	15	5.3 E-03	54
D043	-2.8 E-02	240	2.0 E-02	370	5.2 E-01	18	1.8 E-01	14	6.8 E-03	47
D045	4.9 E-02	140	3.2 E-02	220	6.2 E-01	17	4.7 E-01	12	2.1 E-02	25
D047	3.1 E-02	230	3.8 E-02	170	7.1 E-01	17	2.2 E-01	12	8.2 E-03	36
D049	2.9 E-02	210	8.2 E-02	650	6.4 E-01	16	1.6 E-01	14	5.2 E-03	51
D051	-2.1 E-03	>9999	7.2 E-02	74	7.0 E-01	15	9.1 E-02	15	3.7 E-03	56
D053	8.1 E-02	90	1.4 E-02	580	8.0 E-01	15	6.9 E-02	16	3.9 E-03	54
D055	-4.9 E-02	190	1.1 E-02	710	7.5 E-01	19	7.8 E-02	14	2.5 E-03	62
D057	2.8 E-02	240	-1.5 E-02	500	6.3 E-01	21	7.1 E-02	14	3.5 E-03	49
D059	7.9 E-02	89	4.0 E-02	200	8.0 E-01	19	8.4 E-02	14	2.8 E-03	59
D061	2.2 E-02	320	5.8 E-02	940	6.3 E-01	17	5.4 E-02	16	1.7 E-03	86
D063	6.1 E-02	110	7.1 E-02	92	7.5 E-01	17	1.7 E-01	12	5.9 E-03	41
D065	-4.1 E-02	180	2.4 E-02	350	7.3 E-01	18	1.4 E-01	12	4.9 E-03	41
D067	5.3 E-02	130	2.8 E-02	250	8.4 E-01	15	1.4 E-01	13	4.4 E-03	44
D069	-5.0 E-03	>9999	4.0 E-02	140	5.1 E-01	20	8.4 E-02	14	2.7 E-03	59
D071	-7.0 E-02	110	-8.8 E-03	>9999	6.7 E-01	21	1.0 E-01	13	3.7 E-03	51
D073	-1.4 E-02	470	4.3 E-02	120	5.9 E-01	17	1.1 E-01	14	2.8 E-03	63
D075	-7.1 E-02	110	-3.6 E-02	180	6.1 E-01	17	1.6 E-01	12	6.2 E-03	40
D077	8.2 E-03	960	3.9 E-02	190	5.5 E-01	21	1.7 E-01	12	7.5 E-03	35
D079	-2.9 E-02	320	2.9 E-02	250	6.0 E-01	22	1.7 E-01	12	5.7 E-03	38
D081	-3.7 E-02	220	6.2 E-02	81	6.5 E-01	16	9.0 E-02	15	4.4 E-03	52
D083	-1.6 E-02	600	6.7 E-02	100	6.0 E-01	24	6.9 E-02	14	2.4 E-03	63
D085	1.5 E-02	490	6.9 E-02	99	7.4 E-01	16	8.4 E-02	14	2.3 E-03	65
D087	-1.2 E-02	600	4.8 E-02	120	7.0 E-01	17	1.2 E-01	14	5.4 E-03	42
D089	-1.0 E-02	610	5.1 E-02	97	7.1 E-01	15	1.0 E-01	14	4.3 E-03	48
D091	-3.4 E-02	180	4.6 E-02	110	4.7 E-01	21	9.6 E-02	14	3.7 E-03	50
D093	4.0 E-02	150	3.8 E-02	172	5.6 E-01	18	9.8 E-02	14	4.9 E-03	42
D095	-2.5 E-03	>9999	5.0 E-02	110	6.2 E-01	17	1.1 E-01	14	3.9 E-03	52
D097	-3.0 E-02	230	-1.9 E-02	350	7.5 E-01	17	9.5 E-02	14	3.2 E-03	55
D099	-1.8 E-02	360	6.2 E-02	80	5.1 E-01	18	1.6 E-01	13	8.3 E-03	33

Table E-2. 200/600 Areas Soil Sample Results (pCi/g). (Sheet 4 of 5)

Site I.D.	¹⁵⁴ Eu		¹⁵⁵ Eu		²²⁶ Ra		²³⁴ U		²³⁵ U	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
D101	1.2 E-02	570	-8.1 E-03	680	6.2 E-01	17	1.2 E-01	13	4.6 E-03	46
D103	4.1 E-02	130	3.1 E-02	160	5.5 E-01	16	1.4 E-01	13	5.6 E-03	39
D105	3.2 E-02	220	4.7 E-02	140	5.6 E-01	17	1.1 E-01	13	4.7 E-03	43
D109	3.3 E-02	190	2.0 E-02	260	4.6 E-01	22	6.9 E-02	17	2.9 E-03	70
Site I.D.	²³⁸ U		^{239,240} Pu		^{239,240} Pu					
	Result	% Error	Result	% Error	Result	% Error				
D001	7.0 E-02	15	2.7 E-04	98	9.4 E-03	19				
D003	1.0 E-01	14	2.1 E-03	32	5.6 E-02	13				
D005	7.3 E-02	15	3.5 E-03	31	2.4 E-02	17				
D007	7.3 E-02	15	1.7 E-02	18	1.4 E-01	14				
D009	8.4 E-02	14	9.8 E-04	47	3.2 E-02	15				
D011	9.9 E-02	14	2.4 E-03	25	1.2 E-01	11				
D015	1.1 E-01	13	1.4 E-03	40	2.1 E-02	15				
D017	7.5 E-02	14	1.2 E-03	52	2.4 E-02	17				
D019	8.6 E-02	14	2.2 E-03	32	4.2 E-02	14				
D021	9.5 E-02	13	3.3 E-03	33	2.5 E-01	15				
D023	1.4 E-01	12	6.3 E-04	93	5.7 E-02	19				
D025	1.6 E-01	12	9.4 E-04	60	2.3 E-02	19				
D027	1.5 E-01	12	2.3 E-03	32	5.9 E-02	14				
D029	1.7 E-01	14	9.1 E-04	63	3.6 E-02	15				
D031	1.6 E-01	17	4.3 E-03	21	1.0 E-01	12				
D033	1.1 E-01	15	2.8 E-03	23	1.3 E-01	11				
D035	9.1 E-02	15	6.3 E-04	55	1.9 E-02	15				
D037	1.0 E-01	14	5.9 E-04	71	9.3 E-03	21				
D039	1.1 E-01	16	1.6 E-02	13	4.0 E-01	11				
D041	1.3 E-01	15	2.9 E-03	28	5.9 E-02	13				
D043	1.8 E-01	14	6.9 E-03	17	3.0 E-01	11				
D045	4.4 E-01	12	4.3 E-03	22	1.8 E-01	12				
D047	2.3 E-01	12	4.8 E-03	23	2.0 E-01	12				
D049	1.5 E-01	14	2.1 E-03	27	8.5 E-02	12				

Table E-2. 200/600 Areas Soil Sample Results
(pCi/g). (Sheet 5 of 5)

Site I.D.	²³⁸ U		²³⁸ Pu		^{239,240} Pu	
	Result	% Error	Result	% Error	Result	% Error
D051	1.1 E-01	14	4.7 E-03	20	2.3 E-02	13
D053	7.6 E-02	16	4.4 E-04	66	1.2 E-02	15
D055	7.9 E-02	14	1.7 E-04	180	1.4 E-02	17
D057	7.8 E-02	14	6.4 E-04	57	1.3 E-02	17
D059	8.4 E-02	14	2.3 E-04	110	3.1 E-03	29
D061	5.9 E-02	16	1.4 E-04	150	4.1 E-03	31
D063	1.6 E-01	12	7.2 E-04	52	4.0 E-02	14
D065	1.6 E-01	12	3.2 E-04	72	4.5 E-03	21
D067	1.4 E-01	12	1.3 E-04	110	5.5 E-03	20
D069	9.0 E-02	14	4.7 E-06	>9999	1.4 E-03	32
D071	1.1 E-01	13	9.0 E-05	130	2.0 E-03	29
D073	1.2 E-01	13	6.5 E-04	50	9.9 E-03	17
D075	1.7 E-01	12	2.4 E-04	84	6.7 E-03	18
D077	1.7 E-01	12	4.6 E-04	58	1.1 E-02	15
D079	1.7 E-01	12	1.1 E-03	51	4.2 E-02	15
D081	8.3 E-02	16	-5.0 E-05	170	6.5 E-04	60
D083	7.3 E-02	14	1.0 E-03	54	4.4 E-02	16
D085	8.6 E-02	14	9.7 E-04	41	3.0 E-02	13
D087	1.3 E-01	13	6.9 E-04	52	2.3 E-02	15
D089	1.1 E-01	13	2.0 E-04	74	5.8 E-03	17
D091	1.2 E-01	13	1.3 E-03	30	9.0 E-03	15
D093	1.0 E-01	13	1.1 E-03	43	2.0 E-02	15
D095	1.1 E-01	14	5.8 E-04	41	1.4 E-02	13
D097	9.8 E-02	14	1.3 E-04	92	1.7 E-03	25
D099	1.7 E-01	12	8.0 E-05	130	2.7 E-03	24
D101	1.3 E-01	13	1.9 E-04	77	8.6 E-03	15
D103	1.5 E-01	12	8.7 E-03	15	5.3 E-01	11
D105	1.1 E-01	13	9.3 E-03	16	34 E-01	11
D109	7.3 E-02	17	2.6 E-03	21	1.4 E-01	11

Table E-3. 300/400 Areas Soil Sample Results (pCi/g). (Sheet 1 of 2)

Site I.D.	⁴⁰ K		⁶⁰ Co		⁹⁰ Sr		¹³⁴ Cs		¹³⁷ Cs	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
D116	1.6 E+01	11	7.1 E-03	150	9.3 E-02	22	-1.4 E-03	600	4.4 E-01	12
D117	1.7 E+01	11	8.7 E-03	140	3.6 E-02	22	-1.9 E-02	53	1.9 E-01	15
D118	1.7 E+01	11	-1.4 E-02	84	3.2 E-02	28	5.8 E-03	140	1.5 E-01	16
D119	1.6 E+01	11	2.5 E-03	450	1.0 E-01	21	5.6 E-03	150	4.8 E-01	12
D120	1.5 E+01	11	-2.5 E-03	440	1.4 E-02	36	1.4 E-03	530	6.2 E-02	29
D121	1.5 E+01	11	1.5 E-02	83	8.3 E-02	23	-1.4 E-03	600	4.1 E-01	12
D122	1.7 E+01	11	9.5 E-04	>9999	1.0 E-02	45	-2.2 E-02	50	1.9 E-02	90
D123	1.5 E+01	11	5.6 E-03	190	4.5 E-03	66	-6.7 E-03	120	1.6 E-02	61
D124	1.6 E+01	11	4.9 E-03	220	7.2 E-02	21	-2.8 E-03	310	4.8 E-01	12
D125	1.5 E+01	11	1.3 E-02	83	4.9 E-02	23	2.1 E-03	410	7.2 E-01	11
D126	1.7 E+01	11	-2.2 E-03	460	1.6 E-02	31	3.5 E-03	200	4.1 E-02	35
D127	1.6 E+01	10	3.9 E-03	280	1.4 E-01	21	-2.3 E-02	42	3.1 E-01	12
D128	1.5 E+01	10	3.7 E-03	260	4.7 E-02	26	-9.7 E-03	77	9.0 E-02	18
D129	1.7 E+01	11	-1.3 E-02	95	3.6 E-02	28	8.7 E-03	92	1.6 E-01	15
D130	1.5 E+01	11	-6.4 E-03	170	7.9 E-03	47	3.2 E-03	240	1.6 E-02	62
Site I.D.	¹⁵⁴ Eu		¹⁵² Eu		²²⁶ Ra		²²⁴ U		²²⁸ U	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
D116	-1.2 E-02	280	6.7 E-02	47	NR	NR	2.2 E-01	13	9.1 E-03	37
D117	-6.9 E-03	600	2.8 E-02	130	NR	NR	3.9 E+00	10	4.2 E-01	11
D118	-7.7 E-04	>9999	3.2 E-02	100	NR	NR	1.0 E+00	11	6.3 E-02	15
D119	-5.1 E-03	660	8.9 E-02	41	NR	NR	1.6 E+01	22	7.6 E-01	24
D120	3.8 E-02	85	3.0 E-02	85	NR	NR	1.3 E+00	10	1.3 E-01	13
D121	3.5 E-02	92	5.4 E-02	63	NR	NR	4.1 E+00	10	1.9 E-01	12
D122	-1.3 E-02	330	5.8 E-02	65	NR	NR	1.5 E+00	11	6.9 E-02	15
D123	3.2 E-02	98	3.6 E-02	74	NR	NR	4.1 E-01	12	1.9 E-02	27
D124	1.4 E-03	>9999	3.8 E-02	82	NR	NR	4.0 E-01	11	1.9 E-02	24
D125	1.8 E-02	190	4.8 E-02	68	NR	NR	1.3 E+00	11	5.9 E-02	16
D126	-1.7 E-02	200	4.4 E-02	61	NR	NR	3.2 E-01	12	1.3 E-02	30
D127	-1.3 E-02	260	3.8 E-02	91	NR	NR	2.5 E-01	13	1.4 E-02	30
D128	2.4 E-02	120	3.0 E-02	86	NR	NR	1.5 E-01	13	5.8 E-03	44
D129	1.8 E-02	200	4.9 E-02	57	NR	NR	2.7 E-01	12	1.2 E-02	3.0
D130	-4.9 E-04	>9999	2.9 E-02	96	NR	NR	5.6 E-01	11	1.9 E-02	23

Table E-3. 300/400 Areas Soil Sample Results
(pCi/g). (Sheet 2 of 2)

Site I.D.	²³⁸ U		²³⁸ Pu		²³⁹ , ²⁴⁰ Pu	
	Result	% Error	Result	% Error	Result	% Error
D116	2.2 E-01	13	4.5 E-04	62	1.2 E-02	16
D117	2.8 E+00	10	1.9 E-03	47	9.6 E-03	25
D118	8.6 E-01	11	3.5 E-04	74	4.3 E-03	24
D119	1.7 E+01	22	5.3 E-03	19	1.7 E-01	11
D120	1.1 E+00	11	8.4 E-04	46	3.3 E-03	24
D121	4.1 E+00	10	1.4 E-03	37	1.1 E-01	13
D122	1.5 E+00	11	2.7 E-04	82	1.4 E-02	15
D123	4.1 E-01	12	2.1 E-04	93	9.0 E-03	18
D124	3.3 E-01	11	9.6 E-04	52	9.4 E-03	20
D125	1.2 E+00	11	3.3 E-04	78	3.8 E-03	26
D126	2.9 E-01	12	2.5 E-04	93	1.3 E-03	43
D127	2.9 E-01	12	2.7 E-04	140	7.8 E-03	25
D128	1.3 E-01	13	1.4 E-04	160	2.7 E-03	31
D129	3.3 E-01	12	2.4 E-04	130	3.7 E-03	29
D130	5.6 E-01	11	-2.0 E-04	300	2.1 E-02	21

Table E-4. 100-N Area Vegetation Sample Results (pCi/g). (Sheet 1 of 2)

Site I.D.	⁴⁰ K		⁶⁰ Co		⁹⁰ Sr		¹³⁴ Cs		¹³⁷ Cs	
	Result	% Error	Result	% Error	Result	% Error	Result	% Error	Result	% Error
Y701	1.0 E+01	42	2.2 E-01	61	4.3 E-02	31	2.1 E-02	5.60	-7.8 E-02	170
Y702	2.4 E+01	21	6.9 E-02	250	6.6 E-02	26	1.2 E-01	1.10	1.3 E-01	110
Y703	7.9E+00	64	-8.0 E-02	230	9.7 E-02	21	-8.5 E-02	1.70	1.6 E-01	110
Y704	1.1 E+01	54	5.3 E-03	>9999	6.6 E-02	25	6.7 E-02	2.30	3.3 E-01	57
Y705	6.9E+00	53	5.4 E-02	220	4.9 E-02	27	4.2 E-02	2.70	5.0 E-02	230
Y706	2.2 E+01	17	8.5 E-02	110	1.1 E-02	50	-2.4 E-03	>9999	1.2 E-01	68
Y707	5.0 E+00	110	1.4 E-01	150	3.0 E-02	36	-1.0 E-01	1.60	4.6 E-02	370
Y708	2.8 E+01	20	-1.3 E-01	110	1.2 E-01	27	6.0 E-03	>9999	-4.4 E-03	>9999
Y709	1.3 E+01	28	1.0 E-02	>9999	2.1 E-02	42	5.5 E-02	170	1.8 E-02	532
Y710	1.9 E+00	240	-2.5 E-01	76	1.4 E-02	53	-1.4 E-02	960	-4.3 E-03	>9999
Y711	8.6 E+00	68	2.4 E-01	79	2.4 E-02	35	4.9 E-02	300	3.3 E-03	>9999
Y712	1.5 E+01	24	1.1 E-01	90	1.2 E-02	42	4.7 E-04	>9999	1.3 E-02	740
Y718	1.7E+01	25	-3.4 E-02	360	3.3 E+00	24	7.8 E-02	160	6.8 E-02	200
Y719	1.2E+01	31	1.2 E-01	87	1.3 E+01	21	-2.7 E-02	340	6.9 E-02	190
Y720	1.7 E+01	22	1.4 E-02	820	3.6 E+01	18	-6.4 E-02	140	5.4 E-02	200
Y721	9.6E+00	32	1.0 E-01	94	3.6 E+01	19	3.7 E-02	200	4.4 E-02	200
Y722	1.2 E+01	24	1.5 E-02	530	7.3 E+00	22	-3.2 E-02	190	2.7 E-01	45
Y723	1.0 E+01	38	-3.8 E-02	310	8.2 E+00	22	3.4 E-02	270	NR	NR
Y724	1.3 E+01	27	-2.3 E-02	450	1.1 E+00	21	2.0 E-02	420	9.6 E-02	100
Y725	1.4 E+01	23	-4.2 E-02	280	2.5 E+00	24	-8.8 E-02	120	1.5 E-01	72
Site I.D.	¹⁵⁴ Eu		¹⁵⁵ Eu		²³⁴ U		²³⁵ U		²³⁸ U	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
Y701	1.6 E-01	230	1.4 E-02	>9999	2.2 E-04	>9999	3.4 E-04	330	7.0 E-04	290
Y702	-1.1 E-01	370	1.7 E-01	160	1.2 E-03	260	-1.6 E-04	870	-6.8 E-04	260
Y703	-2.2 E-01	230	-3.4 E-02	830	7.6 E-04	360	-6.5 E-04	190	3.0 E-03	91
Y704	3.3 E-01	140	2.7 E-01	120	-3.3 E-04	790	8.1 E-05	>9999	1.4 E-03	170
Y705	3.1 E-01	110	2.3 E-01	89	3.3 E-04	840	-5.1 E-04	210	1.8 E-03	140
Y706	1.4 E-01	180	9.1 E-02	180	1.9 E-03	180	-4.2 E-04	280	4.1 E-03	83
Y707	-3.5 E-02	>9999	-2.1 E-01	180	2.2 E-03	150	-4.3 E-04	190	4.3 E-03	77
Y708	-2.2 E-01	170	-7.6 E-02	250	7.6 E-05	>9999	-4.7 E-04	180	4.8 E-04	410
Y709	-3.4 E-02	910	-1.7 E-01	100	2.0 E-03	150	1.6 E-04	660	1.5 E-03	140
Y710	-9.1 E-02	510	1.1 E-01	260	8.4 E-04	330	5.1 E-05	>9999	3.5 E-03	77

Table E-4. 100-N Area Vegetation Sample Results (pCi/g). (Sheet 2 of 2)

Site I.D.	¹⁵⁴ Eu		¹⁵² Eu		²³⁴ U		²³⁵ U		²³⁸ U	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
Y711	5.8 E-01	97	-3.3 E-01	110	1.6 E-03	180	-5.3 E-05	>9999	3.2 E-03	79
Y712	7.8 E-02	350	1.3 E-01	120	3.7 E-03	89	-5.5 E-05	>9999	2.2 E-03	110
Y718	-9.6 E-02	430	1.7 E-01	150	1.0 E-02	38	-4.5 E-04	250	8.2 E-03	39
Y719	2.9 E-02	>9999	-3.8 E-02	530	1.6 E-02	31	5.1 E-04	300	1.1 E-02	35
Y720	-1.5 E-02	>9999	5.2 E-02	350	2.3 E-02	25	4.3 E-04	330	1.9 E-02	26
Y721	-5.6 E-02	450	-6.1 E-02	270	3.1 E-02	21	3.4 E-04	370	2.4 E-02	22
Y722	-4.1 E-02	560	9.1 E-02	150	1.1 E-02	40	1.3 E-03	120	9.9 E-03	39
Y723	-4.6 E-01	79	1.1 E-01	170	4.6 E-02	19	5.5 E-05	>9999	3.5 E-02	20
Y724	-8.7 E-02	340	8.2 E-02	180	4.7 E-02	18	2.5 E-03	72	3.3 E-02	20
Y725	4.7 E-02	660	3.0 E-02	640	2.1 E-02	27	2.4 E-03	75	1.8 E-02	27
	²³⁹ Pu	% Error	^{239,240} Pu	% Error						
Y701	8.3 E-04	82	4.4 E-03	34						
Y702	5.2 E-04	120	5.4 E-03	41						
Y703	1.6 E-03	41	1.2 E-02	18						
Y704	1.4 E-03	63	1.1 E-02	26						
Y705	2.1 E-03	47	1.0 E-02	24						
Y706	1.6 E-04	130	1.6 E-04	160						
Y707	2.6 E-04	110	3.3 E-04	92						
Y708	-7.7 E-05	120	2.9 E-04	120						
Y709	-2.1 E-04	140	-1.1 E-04	310						
Y710	-1.6 E-04	180	5.0 E-05	490						
Y711	2.5 E-03	40	5.1 E-04	90						
Y712	-6.4 E-05	170	3.6 E-04	80						
Y718	5.7 E-04	79	3.7 E-03	31						
Y719	7.9 E-04	57	3.6 E-03	28						
Y720	7.6 E-04	63	3.4 E-03	32						
Y721	1.1 E-03	65	3.9 E-03	34						
Y722	1.4 E-04	130	1.2 E-03	42						
Y723	3.9 E-04	750	2.5 E-03	30						
Y724	3.9 E-04	65	1.1 E-03	37						
Y725	6.0 E-04	56	3.1 E-03	26						

Table E-5. 200/600 Areas Vegetation Sample Results (pCi/g). (Sheet 1 of 5)

Site I.D.	⁴⁰ K		⁶⁰ Co		⁹⁰ Sr		¹³⁴ Cs		¹³⁷ Cs	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
V001	1.6 E+01	22	7.6 E-02	130	1.7 E-01	22	-4.9 E-03	>9999	6.9 E-03	>9999
V003	1.3 E+01	27	-6.9 E-02	150	9.6 E-02	23	1.5 E-02	580	2.5 E-02	440
V007	2.3 E+01	15	7.6 E-02	93	2.8 E-01	20	-7.1 E-02	89	1.5 E-01	46
V009	1.4 E+01	24	3.6 E-02	290	4.0 E-01	23	-2.0 E-02	470	-1.9 E-02	490
V011	1.8 E+01	22	2.4 E-02	400	1.3 E-01	29	1.7 E-02	540	6.8 E-02	160
V015	2.6 E+01	17	7.9 E-02	110	7.2 E+00	19	3.4 E-02	260	2.0 E-01	52
V017	3.5 E+01	14	-1.9 E-02	540	8.6 E-01	25	3.2 E-02	230	2.1 E-01	44
V019	1.8 E+01	19	2.6 E-02	390	2.7 E-01	26	-6.5 E-02	120	7.0 E-02	110
V021	1.9 E+01	20	5.3 E-03	>9999	3.3 E-01	25	1.4 E-02	600	1.0 E-01	87
V023	3.2 E+01	15	-6.4 E-02	150	8.8 E-01	23	1.1 E-01	73	8.6 E-02	120
V025	4.8 E+01	12	6.1 E-02	120	5.1 E+00	18	9.6 E-02	58	3.3 E+00	11
V027	5.1 E+01	14	-7.1 E-03	>9999	2.9 E+00	24	8.0 E-02	110	2.4 E-01	48
V029	4.1 E+01	13	6.0 E-02	160	2.5 E+00	22	-6.1 E-02	120	7.7 E-03	>9999
V031	1.4 E+01	26	9.0 E-02	120	2.8 E+00	19	1.7 E-02	580	-3.5 E-02	330
V033	4.3 E+01	17	-3.0 E-01	79	9.8 E+00	19	7.4 E-02	230	3.8 E-01	52
V035	7.4 E+01	12	2.4 E-02	440	8.3 E+00	18	-7.3 E-02	110	3.4 E-01	48
V037	1.6 E+01	33	5.8 E-03	>9999	5.2 E-01	19	-5.2 E-02	290	1.9 E-01	88
V039	2.9 E+01	20	-2.6 E-02	630	7.1 E-01	20	3.9 E-02	350	1.1 E-01	140
V041	2.4 E+01	23	1.1 E-01	98	1.5 E-01	22	1.2 E-02	>9999	7.8 E-02	160
V043	2.8 E-01	19	5.1 E-04	260	2.2 E-01	30	-1.2 E-03	96	9.8 E-04	110
V045	2.9 E+01	17	1.0 E-01	120	4.6 E-01	26	6.3 E-02	170	1.1 E+00	24
V047	1.9 E+01	25	5.0 E-02	320	1.3 E-01	26	1.1 E-02	>9999	2.2 E-01	62
V049	1.5 E+01	25	-3.8 E-02	260	1.3 E-01	27	-6.3 E-03	>9999	8.5 E-02	110
V051	1.7 E+01	25	-5.2 E-02	220	1.0 E-01	22	-3.6 E-02	270	2.0 E-02	470
V053	3.7 E+01	15	-7.6 E-02	140	6.6 E-01	20	NR	NR	9.2 E-02	95
V055	1.9 E+01	20	-1.3 E-01	96	5.3 E+00	19	2.5 E-02	360	4.4 E-02	220
V057	2.0 E+01	20	-3.6 E-02	250	8.3 E-01	19	-8.9 E-02	100	3.6 E-02	260
V059	1.5 E+01	26	8.0 E-02	140	7.4 E+00	18	4.2 E-02	230	7.1 E-02	160
V061	5.3 E+01	12	8.6 E-02	95	1.3 E+00	18	-1.1 E-02	620	3.6 E-02	200
V063	7.6 E+01	11	1.2 E-02	590	1.4 E+01	18	-3.4 E-02	150	6.7 E-02	96
V065	1.6 E+01	23	4.6 E-02	200	1.1 E-01	22	-9.4 E-02	99	-6.7 E-02	140
V075	1.9 E+01	21	1.1 E-01	97	1.7 E-01	20	1.1 E-01	80	-1.7 E-01	660
V077	7.8 E+00	21	-2.6 E-02	190	1.4 E-01	26	-7.0 E-03	580	1.5 E-02	290
V079	1.9 E+01	24	4.4 E-02	290	1.7 E-01	21	8.9 E-03	>9999	1.9 E-01	62
V081	1.3 E+01	22	-6.9 E-03	>9999	1.5 E-01	21	4.8 E-02	150	3.0 E-02	270

Table E-5. 200/600 Areas Vegetation Sample Results (pCi/g). (Sheet 2 of 5)

Site I.D.	⁴⁰ K		⁶⁰ Co		⁹⁰ Sr		¹³⁴ Cs		¹³⁷ Cs	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
V083	2.0 E+01	17	1.0 E-01	78	1.4 E-01	25	-4.2 E-04	>9999	2.9 E-02	310
V085	3.1 E+01	15	-1.6 E-03	>9999	1.8 E+00	18	3.4 E-02	250	1.5 E-01	72
V087	1.6 E+01	21	1.6 E-01	74	2.0 E-01	21	2.8 E-03	>9999	4.0 E-02	220
V089	1.7 E+01	18	2.8 E-02	250	1.6 E-01	22	8.4 E-02	76	3.9 E-03	>9999
V091	6.3 E+01	12	1.1 E-02	650	4.2 E+00	18	-4.3 E-03	>9999	4.0 E-02	170
V093	1.8 E+01	22	1.0 E-01	120	4.0 E-01	19	-1.1 E-01	110	7.6 E-02	170
V095	2.2 E+01	17	2.1 E-02	340	2.7 E-01	20	4.8 E-03	>9999	-2.5 E-03	>9999
V097	3.0 E+01	14	-1.3 E-02	520	1.0 E+00	20	1.9 E-02	290	2.4 E-02	270
V099	4.8 E+01	13	8.1 E-02	120	1.8 E-01	21	4.3 E-02	180	6.0 E-02	140
V101	1.5 E+01	17	5.1 E-02	110	2.7 E+00	19	1.7 E-02	290	-2.5 E-02	210
V103	1.9 E+01	21	-1.8 E-02	650	1.7 E-01	23	-3.3 E-02	280	1.9 E-03	>9999
V105	1.9 E+01	18	-6.0 E-02	170	5.2 E-01	19	3.8 E-02	200	8.4 E-02	100
V107	1.5 E+01	24	-1.3 E-02	740	6.7 E+00	18	-2.9 E-02	290	1.3 E-01	72
V109	1.9 E+01	16	-4.0 E-02	220	4.4 E-01	20	-3.0 E-02	240	6.0 E-02	120
Site I.D.	¹⁵⁴ Eu		¹⁵⁵ Eu		²³² U		²³⁴ U		²³⁸ U	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
V001	3.4 E-01	82	2.8 E-02	690	5.6 E-03	76	1.7 E-04	190	6.6 E-03	61
V003	3.4 E-02	930	1.9 E-01	88	4.9 E-03	82	7.1 E-04	130	6.7 E-03	60
V007	6.0 E-02	350	-4.0 E-02	330	8.5 E-02	18	5.1 E-03	56	9.2 E-02	18
V009	-1.6 E-01	190	-1.5 E-02	>9999	9.8 E-03	53	-2.6 E-04	490	9.1 E-03	52
V011	5.9 E-01	53	6.1 E-02	310	6.8 E-03	68	8.4 E-05	>9999	1.0 E-02	48
V015	5.4 E-02	510	-3.5 E-02	470	1.2 E-02	46	5.5 E-04	300	1.9 E-02	34
V017	-7.9 E-02	400	3.4 E-02	490	1.9 E-02	35	2.1 E-03	110	2.4 E-02	30
V019	8.1 E-02	300	1.2 E-01	150	1.3 E-03	260	-1.2 E-03	89	2.5 E-03	120
V021	3.2 E-01	86	2.5 E-01	66	2.9 E-03	140	-3.4 E-04	550	4.6 E-03	93
V023	7.5 E-02	330	-1.6 E-01	98	2.7 E-03	130	1.9 E-04	720	4.4 E-03	74
V025	9.1 E-02	240	1.0 E-01	110	8.6 E-03	60	-2.6 E-04	500	9.7 E-03	52
V027	1.8 E-01	220	2.5 E-03	>9999	1.2 E-02	46	4.1 E-04	450	9.4 E-03	50
V029	3.4 E-03	>9999	-1.2 E-02	>9999	1.1 E-02	43	1.6 E-04	960	9.0 E-03	47
V031	2.7 E-01	130	-5.0 E-02	350	1.2 E-03	220	1.3 E-04	880	3.7 E-03	70
V033	-3.0 E-01	220	2.1 E-01	160	3.4 E-03	94	3.7 E-04	320	8.0 E-03	43
V035	-1.8 E-02	>9999	-8.2 E-02	210	7.5 E-03	49	-1.1 E-04	890	7.2 E-03	44
V037	6.5 E-01	71	1.4 E-01	210	4.8 E-03	72	-4.0 E-04	250	4.4 E-03	66
V039	2.7 E-01	160	1.1 E-01	230	1.2 E-02	47	2.7 E-05	>9999	1.5 E-02	38

Table E-5. 200/600 Areas Vegetation Sample Results (pCi/g). (Sheet 3 of 5)

Site I.D.	¹⁵⁴ Eu		¹⁵² Eu		²³⁴ U		²³⁴ U		²³⁸ U	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
V041	-4.9 E-01	93	1.3 E-01	150	4.7 E-03	92	8.7 E-04	250	9.4 E-03	50
V043	-9.6 E-04	450	3.5 E-04	610	1.2 E-02	42	-8.3 E-04	110	1.2 E-02	39
V045	3.2 E-01	99	1.5 E-01	140	2.8 E-02	26	1.4 E-03	130	2.6 E-02	26
V047	7.9 E-02	540	1.8 E-01	130	3.5 E-02	22	2.2 E-03	92	3.8 E-02	20
V049	8.4 E-02	320	1.1 E-01	140	4.1 E-03	88	-4.6 E-04	280	9.4 E-03	45
V051	-3.9 E-01	98	-1.3 E-01	140	-3.2 E-0	760	1.9 E-04	580	-5.5 E-04	300
V053	-1.9 E-01	150	4.1 E-02	320	3.1 E-03	100	-1.2 E-04	760	2.9 E-03	85
V055	2.9 E-01	92	-5.6 E-02	300	-5.1 E-04	500	1.7 E-04	780	9.0 E-04	250
V057	2.2 E-01	130	4.5 E-02	340	4.1 E-03	83	-3.4 E-04	320	3.3 E-03	80
Site I.D.	¹⁵⁴ Eu		¹⁵² Eu		²³⁴ U		²³⁴ U		²³⁸ U	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
V059	-8.6 E-03	>9999	-4.0 E-02	480	1.4 E-03	230	7.5 E-04	230	1.6 E-03	150
V061	1.7 E-01	160	-2.1 E-02	750	8.8 E-03	56	-6.3 E-04	240	3.5 E-03	97
V063	-1.1 E-01	210	-4.2 E-02	250	5.7 E-03	75	2.8 E-04	530	4.0 E-03	85
V065	3.2 E-01	82	-5.2 E-02	340	1.6 E-03	170	7.5 E-04	190	-2.2 E-04	830
V075	1.3 E-01	250	2.8 E-02	700	5.7 E-03	70	-4.7 E-04	290	3.4 E-03	91
V077	6.2 E-02	220	2.8 E-02	290	1.4 E-01	80	-1.3 E-02	130	-4.2 E-02	160
V079	6.6 E-02	580	8.0 E-02	300	2.7 E-03	140	-5.8 E-04	150	1.7 E-03	180
V081	-6.2 E-03	>9999	-3.1 E-02	440	-8.6 E-05	>9999	6.9 E-04	210	1.2 E-03	200
V083	2.8 E-01	90	8.9 E-02	160	-1.4 E-03	220	7.4 E-04	340	9.8 E-04	310
V085	1.9 E-01	150	6.0 E-04	>9999	6.7 E-03	61	2.7 E-04	580	3.3 E-03	91
V087	-1.4 E-01	220	-9.6 E-02	200	-5.3 E-04	570	-9.1 E-04	110	-4.6 E-05	>9999
V089	-1.2 E-01	190	6.0 E-02	200	3.7 E-03	98	3.5 E-04	400	2.8 E-03	100
V091	-5.9 E-02	420	1.6 E-01	66	3.7 E-03	91	4.2 E-04	320	6.7 E-03	53
V093	-2.2 E-01	180	4.0 E-02	500	3.2 E-03	1,20	-3.3 E-04	440	8.0 E-03	55
V095	-1.6 E-01	150	1.0 E-02	>9999	6.5 E-04	440	7.0 E-05	>9999	1.8 E-03	150
V097	6.9 E-03	>9999	-3.8 E-02	290	1.9 E-03	170	1.4 E-05	>9999	4.4 E-03	74
V099	-6.9 E-02	400	1.2 E-01	130	7.0 E-03	67	1.3 E-03	150	7.9 E-03	57
V101	1.6 E-01	100	-1.8 E-03	>9999	1.8 E-02	37	-4.3 E-04	300	1.2 E-02	44
V103	1.7 E-01	170	-2.3 E-02	850	9.1 E-03	58	1.6 E-03	160	4.7 E-03	80
V105	-4.1 E-02	600	7.6 E-02	190	1.4 E-02	37	1.3 E-05	>9999	6.7 E-03	55
V107	1.7 E-01	160	-8.8 E-02	170	1.3 E-02	50	2.8 E-05	>9999	7.7 E-03	63
V109	-8.0 E-02	250	1.6 E-01	83	5.1 E-03	87	6.7 E-04	270	1.8 E-03	170

Table E-5. 200/600 Areas
Vegetation Sample Results
(pCi/g). (Sheet 4 of 5)

Site I.D.	²³⁸ Pu		^{239, 240} Pu	
	Results	% Error	Results	% Error
V001	-1.2 E-04	100	6.2 E-04	100
V003	8.9 E-05	180	3.9 E-03	26
V007	8.8 E-04	46	2.2 E-02	13
V009	1.8 E-05	570	1.3 E-03	37
V011	6.2 E-04	65	1.1 E-02	17
V015	2.2 E-04	140	1.6 E-03	48
V017	3.4 E-04	89	1.3 E-02	17
V019	2.5 E-04	130	6.2 E-05	760
V021	-1.7 E-04	220	1.8 E-03	47
V023	-1.5 E-04	170	1.7 E-03	63
V025	1.7 E-04	260	2.3 E-03	49
V027	-2.4 E-04	100	5.3 E-04	140
V029	1.4 E-04	180	3.4 E-03	34
V031	7.5 E-03	29	8.1 E-04	120
V033	5.8 E-03	34	5.9 E-02	15
V035	-2.7 E-04	160	1.4 E-04	910
V037	3.5 E-04	99	2.4 E-03	35
V039	8.8 E-04	53	2.6 E-02	14
V041	-1.5 E-04	300	2.9 E-03	44
V043	1.4 E-02	44	1.9 E-03	130
V045	8.5 E-04	120	3.7 E-02	18
V047	1.1 E-04	230	5.2 E-03	25
V049	-2.4 E-05	>9999	1.6 E-03	47
V051	-1.5 E-05	>9999	5.6 E-04	69
V053	-3.1 E-04	180	3.7 E-04	1.30
V055	-3.4 E-05	>9999	4.0 E-04	1.60
V057	-1.7 E-04	290	5.2 E-04	1.10
V059	1.4 E-04	160	5.8 E-05	2.80
V061	-2.9 E-05	>9999	9.5 E-05	5.00

Table E-5. 200/600 Areas
Vegetation Sample Results
(pCi/g). (Sheet 5 of 5)

Site I.D.	²³⁸ Pu		^{239, 240} Pu	
	Results	% Error	Results	% Error
V063	5.0 E-04	230	9.6 E-04	1.40
V065	-1.5 E-05	>9999	9.2 E-05	180
V075	1.8 E-04	130	8.3 E-04	52
V077	2.9 E-04	160	1.0 E-03	74
V079	-5.9 E-05	160	1.1 E-04	300
V081	9.2 E-05	210	8.9 E-05	220
V083	6.7 E-05	560	8.4 E-04	100
V085	1.0 E-04	500	2.4 E-03	69
V087	4.1 E-04	150	6.0 E-05	620
V089	-2.1 E-05	>9999	-1.4 E-04	430
V091	2.8 E-04	270	-1.0 E-04	>9999
V093	-2.6 E-04	130	8.7 E-05	270
V095	9.2 E-05	260	-1.5 E-04	420
V097	4.4 E-04	500	4.3 E-04	300
V099	-2.2 E-04	220	4.6 E-04	160
V101	1.4 E-04	390	1.7 E-03	73
V103	-1.5 E-04	180	4.6 E-03	40
V105	4.0 E-04	85	1.2 E-02	20
V105	4.0 E-04	85	1.2 E-02	20
V107	-1.1 E-05	>9999	1.4 E-03	39
V109	2.3 E-04	150	3.0 E-03	39

Table E-6. 300/400 Areas Vegetation Sample Results (pCi/g). (Sheet 1 of 2)

Site I.D.	⁴⁰ K		⁶⁰ Co		⁹⁰ Sr		¹³⁴ Cs		¹³⁷ Cs	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
V116	1.3 E+01	25	-5.2 E-03	>9999	3.8 E-02	26	2.5 E-02	270	-4.7 E-02	160
V117	2.2 E+01	17	6.1 E-02	160	4.3 E-02	29	-1.6 E-01	53	-2.2 E-02	370
V118	1.2 E+01	28	-9.0 E-03	>9999	4.3 E-02	30	-2.2 E-02	390	6.7 E-02	140
V119	1.7 E+01	18	1.4 E-01	59	3.8 E-02	34	4.2 E-02	170	-1.9 E-02	450
V120	1.6 E+01	19	2.1 E-02	440	3.6 E-02	33	-3.4 E-03	>9999	8.4 E-02	90
V121	2.0 E+01	18	6.9 E-02	140	5.8 E-02	32	-1.1 E-01	78	1.5 E-03	>9999
V122	4.2 E+01	12	4.5 E-02	160	2.0 E-01	27	-2.3 E-02	270	6.1 E-02	110
V123	2.5 E+01	15	-6.0 E-02	120	1.7 E-02	63	-1.2 E-02	570	-7.8 E-02	90
V124	1.6 E+01	22	-1.1 E-01	100	3.2 E-02	33	-1.0 E-01	99	-1.2 E-01	97
V125	1.7 E+01	19	4.2 E-02	240	2.6 E-02	36	-1.8 E-02	430	9.1 E-03	890
V126	2.6 E+01	17	1.2 E-01	94	1.5 E-01	24	-7.9 E-02	120	-6.3 E-02	160
V127	2.0 E+01	18	8.7 E-02	110	2.5 E-02	41	7.9 E-02	98	-6.1 E-02	160
V128	1.1 E+01	21	1.1 E-02	570	5.6 E-02	26	2.1 E-02	270	5.3 E-02	110
V129	1.9 E+01	18	1.7 E-01	56	2.9 E-02	32	2.6 E-03	>9999	-7.1 E-02	130
V130	1.3 E+01	30	4.0 E-02	280	7.8 E-03	71	5.5 E-02	170	1.4 E-01	69
V132	2.0 E+01	17	2.5 E-02	310	1.5 E-02	50	-2.9 E-02	250	5.0 E-02	150
Site I.D.	¹⁵⁴ Eu		¹⁵² Eu		²³⁴ U		²³⁵ U		²³⁸ U	
	Results	% Error	Results	% Error	Results	% Error	Results	% Error	Results	% Error
V116	-1.8 E-01	140	6.9 E-04	>9999	6.4 E-03	62	6.2 E-04	260	6.0 E-03	54
V117	1.9 E-02	>9999	1.4 E-02	>9999	8.8 E-03	47	3.7 E-04	350	7.1 E-03	47
V118	-1.3 E-01	260	6.3 E-02	300	3.4 E-02	22	2.0 E-03	95	3.8 E-02	21
V119	-1.8 E-02	>9999	-7.1 E-02	220	2.7 E-01	13	1.2 E-02	34	2.7 E-01	13
V120	-7.7 E-02	280	-6.1 E-02	260	6.1 E-02	18	2.7 E-03	79	5.6 E-02	18
V121	9.0 E-02	300	-1.0 E-02	>9999	6.0 E-02	17	1.7 E-03	99	6.1 E-02	17
V122	-3.5 E-02	690	-4.4 E-02	350	2.8 E-01	12	9.2 E-03	37	2.7 E-01	13
V123	-6.2 E-02	340	1.6 E-02	850	2.5 E-02	25	-3.4 E-04	320	2.1 E-02	26
V124	4.5 E-02	670	1.2 E-01	160	8.7 E-03	50	-3.1 E-05	>9999	1.2 E-02	39
V125	-4.4 E-02	560	1.8 E-01	74	3.6 E-02	23	2.5 E-03	83	3.5 E-02	22
V126	-1.9 E-01	160	1.2 E-01	200	5.3 E-02	21	9.3 E-04	180	4.7 E-02	22
V127	1.3 E-01	230	1.1 E-01	140	3.7 E-03	88	5.9 E-05	>9999	5.5 E-03	57
V128	-2.5 E-01	77	2.8 E-02	390	1.2 E-02	35	2.3 E-04	460	1.1 E-02	35
V129	-4.3 E-02	620	1.0 E-01	180	1.0 E-02	42	9.6 E-04	150	1.0 E-02	38
V130	-1.1 E-01	270	-1.1 E-01	180	1.1 E-02	37	7.6 E-04	160	1.6 E-02	28
V132	-4.3 E-02	580	4.0 E-02	360	2.7 E-02	25	6.0 E-04	220	2.6 E-02	24

Table E-6. 300/400 Areas
Vegetation Sample Results
(pCi/g). (Sheet 2 of 2)

Site I.D.	²³⁸ Pu		^{239,240} Pu	
	Results	% Error	Results	% Error
V116	5.2 E-05	410	-1.8 E-05	740
V117	1.9 E-04	100	1.1 E-03	41
V118	9.3 E-05	260	1.4 E-04	190
V119	1.3 E-04	120	5.8 E-04	56
V120	-5.1 E-05	470	1.9 E-04	120
V121	6.7 E-05	190	2.7 E-04	84
V122	6.9 E-05	380	1.4 E-03	62
V123	-1.8 E-04	290	4.1 E-04	160
V124	-5.9 E-05	250	1.8 E-04	100
V125	6.5 E-05	270	-2.4 E-05	10
V126	-2.1 E-04	170	2.1 E-04	150
V127	8.0 E-05	250	5.2 E-04	64
V128	-1.7 E-05	>9999	2.7 E-04	270
V129	1.5 E-05	710	1.3 E-04	120
V130	-1.8 E-05	>9999	2.6 E-04	380
V132	-2.2 E-05	840	-2.8 E-05	670

APPENDIX F
EXTERNAL RADIATION MONITORING
FIGURES AND TABLES

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Figure F-1. Thermoluminescent Dosimeter Locations in the 100-K Area.

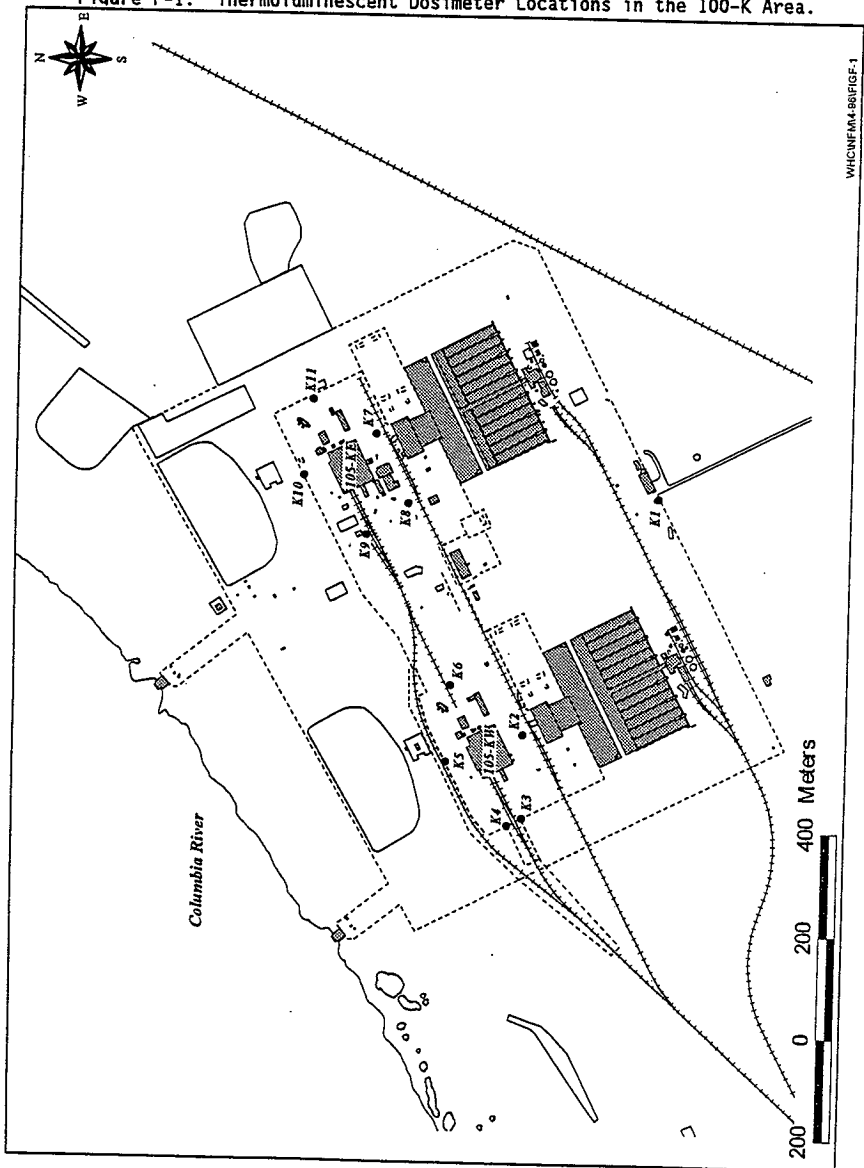


Figure F-2. Thermoluminescent Dosimeter Locations in the 100-N Area.

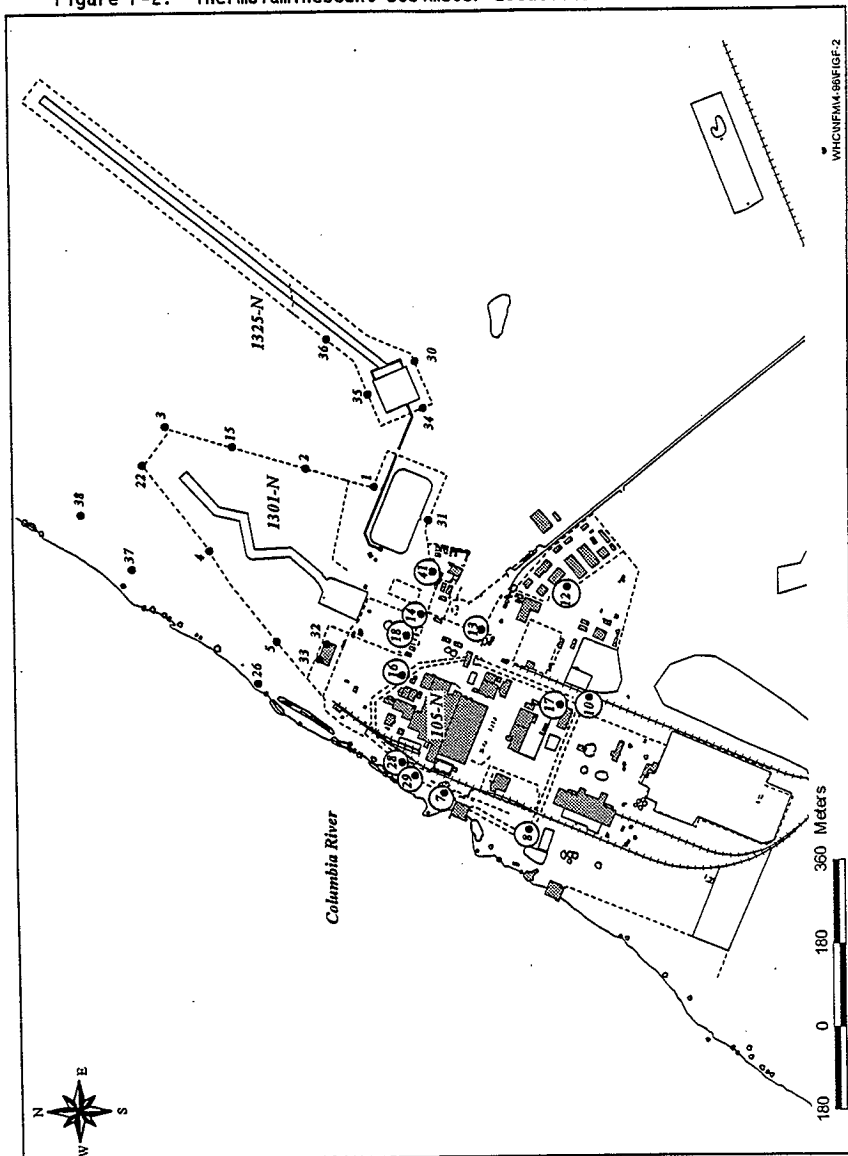


Figure F-3. Thermoluminescent Dosimeter Locations in the 200 East Area.

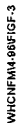
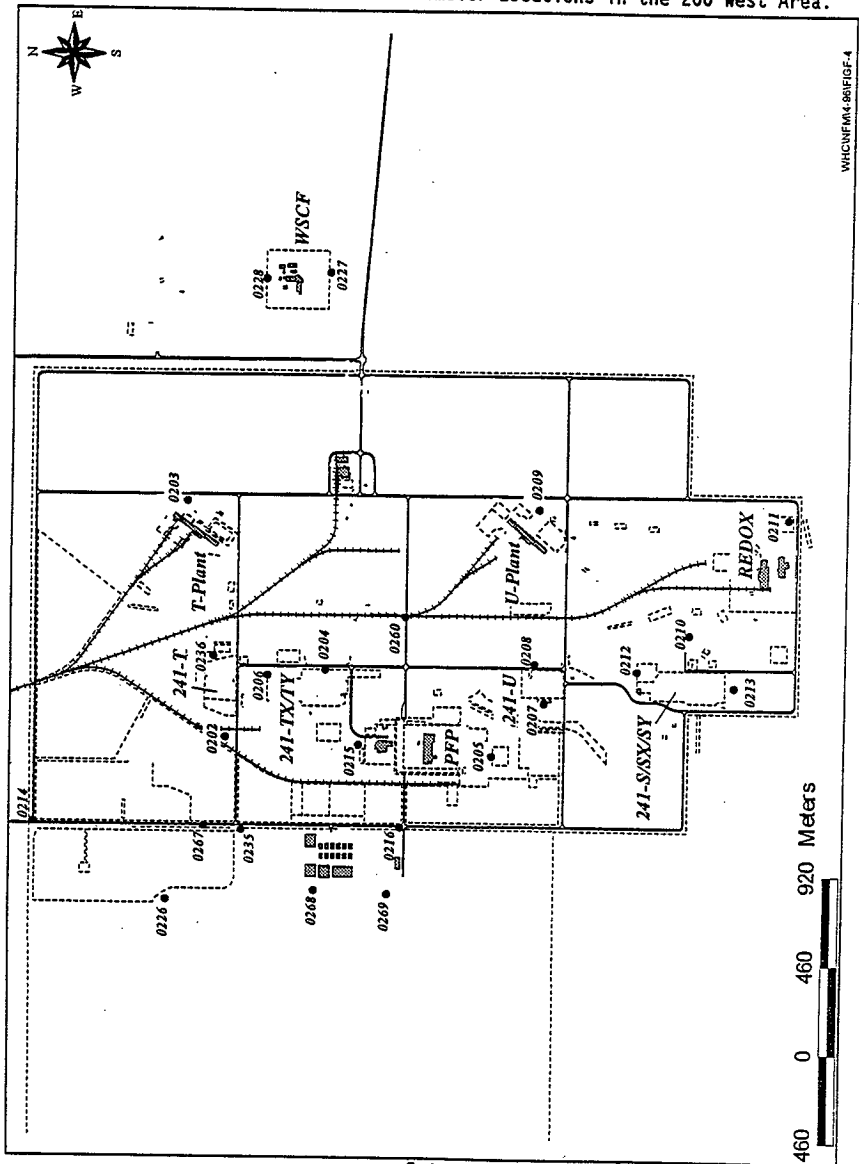


Figure F-4. Thermoluminescent Dosimeter Locations in the 200 West Area.



WHC/EM/4-85/F/G/F-4

Figure F-5. Thermoluminescent Dosimeter Locations in the 300 Area.

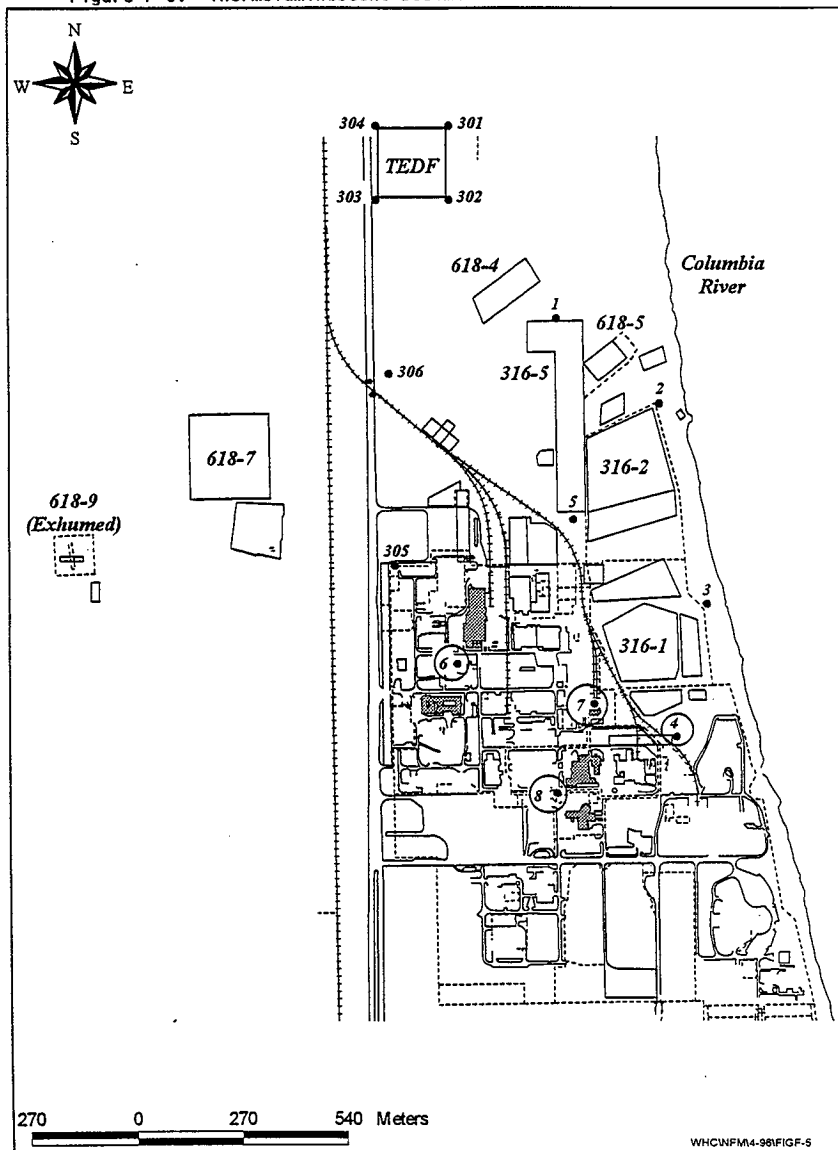
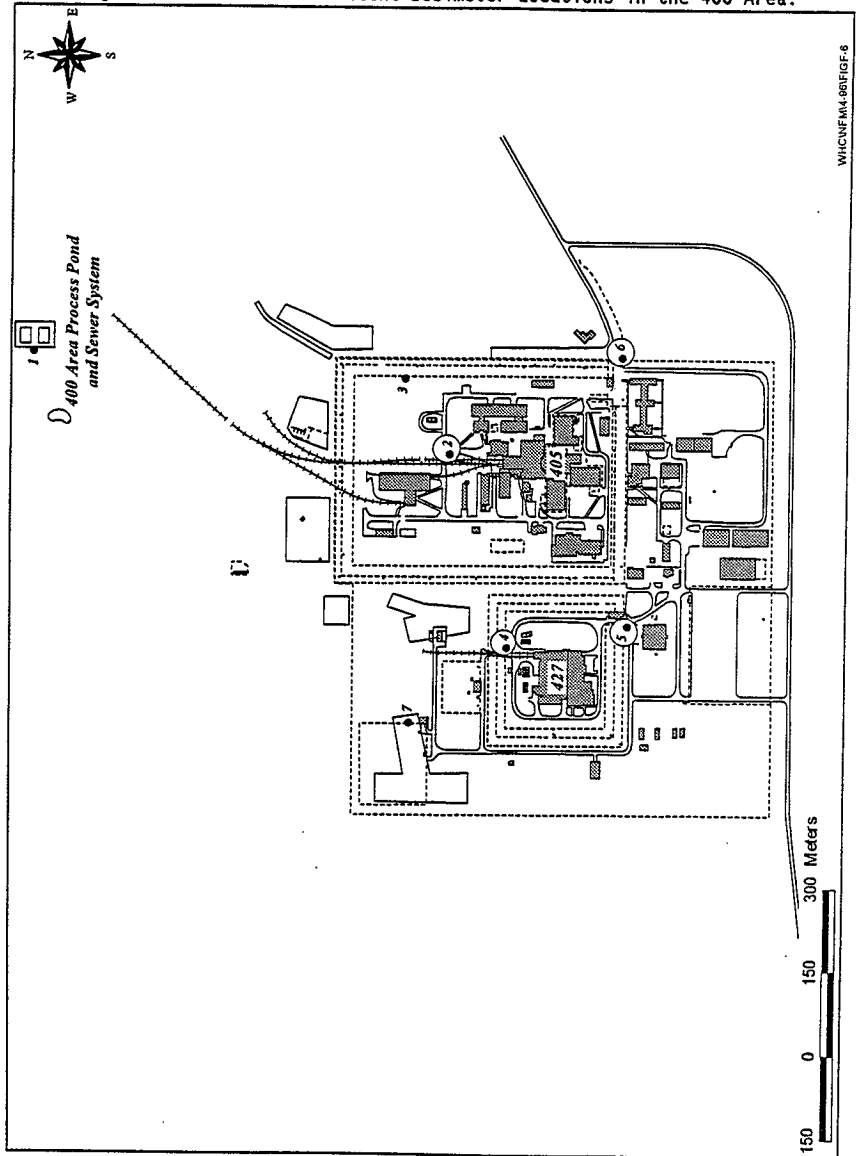


Figure F-6. Thermoluminescent Dosimeter Locations in the 400 Area.



WHC/NE/4-95/FIG. 6

Table F-1. 100-K Thermoluminescent Dosimeter Exposure Results, Calendar Year 1995.

100K Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results (mrem/yr)		
	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	Max	Min	Avg
K-1	8.6 E-03	7.5 E+01	8.2 E-03	7.2 E+01	8.3 E-03	7.3 E+01	8.5 E-03	7.4 E+01	7.5 E+01	7.2 E+01	7.4 E+01
K-2	9.1 E-03	7.9 E+01	8.8 E-03	7.7 E+01	1.0 E-02	8.9 E+01	9.7 E-03	8.5 E+01	8.9 E+01	7.7 E+01	8.2 E+01
K-3	9.0 E-03	7.9 E+01	8.4 E-03	7.4 E+01	9.1 E-03	8.0 E+01	1.5 E-02	1.3 E+02	1.3 E+02	7.4 E+01	9.0 E+01
K-4	8.9 E-03	7.8 E+01	8.4 E-03	7.3 E+01	9.1 E-03	8.0 E+01	2.2 E-02	2.0 E+02	2.0 E+02	7.3 E+01	1.1 E+02
K-5	1.0 E-02	9.1 E+01	9.8 E-03	8.6 E+01	1.0 E-02	9.1 E+01	1.1 E-02	9.4 E+01	9.4 E+01	8.6 E+01	9.0 E+01
K-6	9.2 E-03	8.1 E+01	8.0 E-03	7.0 E+01	8.5 E-03	7.4 E+01	8.9 E-03	7.8 E+01	8.1 E+01	7.0 E+01	7.6 E+01
K-7	1.0 E-02	9.1 E+01	1.0 E-02	9.2 E+01	1.2 E-02	1.0 E+02	1.2 E-02	1.1 E+02	1.1 E+02	9.1 E+01	9.8 E+01
K-8	3.6 E-02	3.2 E+02	2.6 E-02	2.3 E+02	3.1 E-02	2.7 E+02	3.2 E-02	2.8 E+02	3.2 E+02	2.3 E+02	2.7 E+02
K-9	1.7 E-01	1.5 E+03	1.5 E-01	1.3 E+03	2.1 E-01	1.8 E+03	2.3 E-01	2.0 E+03	2.0 E+03	1.3 E+03	1.7 E+03
K-10	1.9 E-01	1.6 E+03	1.7 E-01	1.5 E+03	6.4 E-02	5.6 E+02	3.2 E-01	2.8 E+03	2.8 E+03	5.6 E+02	1.6 E+03
K-11	1.2 E-02	1.1 E+02	1.1 E-02	9.7 E+01	1.2 E-02	1.0 E+02	1.2 E-02	1.0 E+02	1.1 E+02	9.7 E+01	1.0 E+02

Table F-2. 100-N Thermoluminescent Dosimeter Exposure Results, Calendar Year 1995.

100-N Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results (mrad/yr)		
	mrad/hr	mrad/yr	mrad/hr	mrad/yr	mrad/hr	mrad/yr	mrad/hr	mrad/yr	Max	Min	Avg
1	1.1 E-01	9.6 E+02	1.1 E-01	9.3 E+02	1.1 E-01	9.4 E+02	9.9 E-02	8.7 E+02	9.6 E+02	8.7 E+02	9.2 E+02
2	1.1 E-01	9.4 E+02	1.0 E-01	9.1 E+02	1.1 E-01	9.7 E+02	9.9 E-02	8.7 E+02	9.7 E+02	8.7 E+02	9.2 E+02
3	4.8 E-02	4.2 E+02	4.6 E-02	4.0 E+02	4.9 E-02	4.3 E+02	4.6 E-02	4.0 E+02	4.3 E+02	4.0 E+02	4.1 E+02
4	1.8 E-01	1.6 E+03	1.8 E-01	1.6 E+03	1.8 E-01	1.6 E+03	1.7 E-01	1.5 E+03	1.6 E+03	1.5 E+03	1.6 E+03
5	6.5 E-02	5.7 E+02	6.7 E-02	5.8 E+02	7.5 E-02	6.6 E+02	6.4 E-02	5.6 E+02	6.6 E+02	5.6 E+02	5.9 E+02
6	2.6 E-02	2.2 E+02	2.5 E-02	2.2 E+02	5.9 E-02	5.2 E+02	2.6 E-02	2.3 E+02	5.2 E+02	2.2 E+02	3.0 E+02
7	1.0 E-01	9.0 E+02	9.1 E-02	8.0 E+02	1.0 E-01	9.0 E+02	4.8 E-02	4.2 E+02	9.0 E+02	4.2 E+02	7.6 E+02
8	1.0 E-02	9.1 E+01	9.8 E-03	8.5 E+01	1.4 E-02	1.2 E+02	1.2 E-02	1.0 E+02	1.2 E+02	8.5 E+01	1.0 E+02
10	1.0 E-02	8.7 E+01	9.8 E-03	8.6 E+01	1.2 E-02	1.1 E+02	9.8 E-03	8.6 E+01	1.1 E+02	8.6 E+01	9.2 E+01
12	9.0 E-03	7.9 E+01	1.1 E-02	9.7 E+01	1.2 E-02	1.0 E+02	1.1 E-02	9.6 E+01	1.0 E+02	7.9 E+01	9.4 E+01
13	1.7 E-02	1.5 E+02	1.7 E-02	1.5 E+02	2.1 E-02	1.8 E+02	1.7 E-02	1.5 E+02	1.8 E+02	1.5 E+02	1.6 E+02
14	4.1 E-02	3.6 E+02	4.0 E-02	3.5 E+02	4.8 E-02	4.2 E+02	4.0 E-02	3.5 E+02	4.2 E+02	3.5 E+02	3.7 E+02
15	8.4 E-02	7.3 E+02	8.3 E-02	7.2 E+02	8.1 E-02	7.1 E+02	7.8 E-02	6.8 E+02	7.3 E+02	6.8 E+02	7.1 E+02
16	2.9 E-02	2.5 E+02	2.8 E-02	2.4 E+02	1.7 E-01	1.5 E+03	3.2 E-02	2.8 E+02	1.5 E+03	2.4 E+02	5.8 E+02
17	3.4 E-02	3.0 E+02	1.8 E-02	1.6 E+02	1.4 E-02	1.2 E+02	2.3 E-02	2.0 E+02	3.0 E+02	1.2 E+02	2.0 E+02
18	4.4 E-02	3.8 E+02	4.2 E-02	3.7 E+02	6.2 E-02	5.5 E+02	8.9 E-02	7.8 E+02	7.8 E+02	3.7 E+02	5.2 E+02
22	5.5 E-02	4.8 E+02	5.5 E-02	4.8 E+02	5.5 E-02	4.8 E+02	5.3 E-02	4.6 E+02	4.8 E+02	4.6 E+02	4.8 E+02
26	2.5 E-02	2.2 E+02	2.5 E-02	2.2 E+02	2.9 E-02	2.5 E+02	2.5 E-02	2.2 E+02	2.5 E+02	2.2 E+02	2.3 E+02
28	2.6 E-02	2.3 E+02	2.6 E-02	2.2 E+02	5.5 E-01	4.8 E+03	3.0 E-02	2.6 E+02	4.8 E+03	2.2 E+02	1.4 E+03
29	1.8 E-01	1.6 E+03	1.7 E-01	1.5 E+03	1.8 E-01	1.6 E+03	8.2 E-02	7.2 E+02	1.6 E+03	7.2 E+02	1.4 E+03
30	7.0 E-01	6.1 E+03	6.1 E-01	5.3 E+03	6.8 E-01	6.0 E+03	6.4 E-01	5.6 E+03	6.1 E+03	5.3 E+03	5.8 E+03
31	4.8 E-02	4.2 E+02	4.9 E-02	4.3 E+02	5.1 E-02	4.5 E+02	4.7 E-02	4.1 E+02	4.5 E+02	4.1 E+02	4.3 E+02
32	0.0	0.0	0.0	0.0	0.0	0.0	3.5 E-02	3.1 E+02	3.1 E+02	0.0	7.6 E+01

Table F-2. 100-N Thermoluminescent Dosimeter Exposure Results, Calendar Year 1995.

100-N Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results (mrem/yr)			
	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	Max	Min	Avg	Avg
33	2.5 E-02	2.2 E+02	2.2 E-02	1.9 E+02	3.7 E-02	3.2 E+02	2.0 E-02	1.8 E+02	3.2 E+02	1.8 E+02	2.3 E+02	2.3 E+02
34	1.2 E+00	1.1 E+04	1.1 E+00	9.6 E+03	1.1 E+00	9.8 E+03	1.1 E+00	9.7 E+03	1.1 E+04	9.6 E+03	9.9 E+03	9.9 E+03
35	1.2 E+00	1.1 E+04	1.2 E+00	1.0 E+04	1.1 E+00	9.9 E+03	1.1 E+00	9.5 E+03	1.1 E+04	9.5 E+03	1.0 E+04	1.0 E+04
36	4.2 E-02	3.6 E+02	4.0 E-02	3.5 E+02	3.9 E-02	3.5 E+02	4.0 E-02	3.5 E+02	3.6 E+02	3.5 E+02	3.5 E+02	3.5 E+02
37	4.2 E-02	3.7 E+02	4.0 E-02	3.5 E+02	4.3 E-02	3.8 E+02	4.0 E-02	3.5 E+02	3.8 E+02	3.5 E+02	3.6 E+02	3.6 E+02
38	1.7 E-02	1.5 E+02	1.7 E-02	1.5 E+02	1.8 E-02	1.6 E+02	1.7 E-02	1.5 E+02	1.6 E+02	1.5 E+02	1.5 E+02	1.5 E+02
41	3.9 E-02	3.4 E+02	3.8 E-02	3.3 E+02	4.2 E-02	3.7 E+02	3.7 E-02	3.2 E+02	3.7 E+02	3.2 E+02	3.4 E+02	3.4 E+02

Table F-3. 200/600 Areas Thermoluminescent Dosimeter Exposure Results, Calendar Year 1995.

Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results (mrem/yr)		
	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	Max	Min	Avg
202	9.1 E-03	8.4 E+01	1.0 E-02	8.9 E+01	1.1 E-02	9.3 E+01	1.0 E-02	8.8 E+01	9.3 E+01	8.0 E+01	8.7 E+01
203	9.6 E-03	8.4 E+01	1.1 E-02	9.4 E+01	1.0 E-02	9.0 E+01	1.1 E-02	9.3 E+01	9.4 E+01	8.4 E+01	9.0 E+01
204	1.5 E-02	1.3 E+02	1.6 E-02	1.4 E+02	1.7 E-02	1.5 E+02	1.7 E-02	1.5 E+02	1.5 E+02	1.3 E+02	1.4 E+02
205	8.7 E-03	7.6 E+01	9.4 E-03	8.2 E+01	9.5 E-03	8.3 E+01	1.0 E-02	8.8 E+01	9.3 E+01	7.6 E+01	8.2 E+01
206	1.3 E-02	1.2 E+02	1.4 E-02	1.3 E+02	1.5 E-02	1.3 E+02	1.4 E-02	1.3 E+02	1.3 E+02	1.2 E+02	1.2 E+02
207	1.1 E-02	9.2 E+01	1.1 E-02	9.3 E+01	1.1 E-02	9.7 E+01	1.1 E-02	1.0 E+02	1.0 E+02	9.2 E+01	9.5 E+01
208	1.6 E-02	1.4 E+02	1.7 E-02	1.5 E+02	2.0 E-02	1.7 E+02	1.9 E-02	1.6 E+02	1.7 E+02	1.4 E+02	1.6 E+02
209	8.9 E-03	7.8 E+01	9.5 E-03	8.4 E+01	9.6 E-03	8.4 E+01	1.0 E-02	8.7 E+01	9.3 E+01	7.8 E+01	8.3 E+01
210	1.0 E-02	8.9 E+01	1.1 E-02	9.7 E+01	1.2 E-02	1.0 E+02	1.2 E-02	1.0 E+02	1.0 E+02	8.9 E+01	9.8 E+01
211	8.7 E-03	7.6 E+01	1.0 E-02	9.0 E+01	1.0 E-02	9.0 E+01	1.0 E-02	9.1 E+01	9.3 E+01	7.6 E+01	8.7 E+01
212	1.2 E-02	1.1 E+02	1.3 E-02	1.1 E+02	1.4 E-02	1.2 E+02	1.4 E-02	1.2 E+02	1.2 E+02	1.1 E+02	1.2 E+02
213	2.1 E-02	1.8 E+02	2.2 E-02	1.9 E+02	2.4 E-02	2.1 E+02	2.3 E-02	2.0 E+02	2.1 E+02	1.8 E+02	2.0 E+02
214	8.2 E-03	7.2 E+01	8.8 E-03	7.7 E+01	9.3 E-03	8.2 E+01	9.4 E-03	8.2 E+01	9.3 E+01	7.2 E+01	7.8 E+01
215	9.8 E-03	8.5 E+01	9.9 E-03	8.7 E+01	1.1 E-02	9.6 E+01	1.1 E-02	9.2 E+01	9.6 E+01	8.5 E+01	9.0 E+01
216	1.1 E-02	9.4 E+01	1.1 E-02	9.6 E+01	1.1 E-02	9.9 E+01	1.1 E-02	9.8 E+01	9.9 E+01	9.4 E+01	9.7 E+01
217	8.9 E-03	7.8 E+01	9.5 E-03	8.3 E+01	9.7 E-03	8.5 E+01	1.0 E-02	8.8 E+01	9.3 E+01	7.8 E+01	8.3 E+01
218	8.3 E-03	7.2 E+01	8.7 E-03	7.6 E+01	9.2 E-03	8.0 E+01	9.0 E-03	7.9 E+01	9.3 E+01	7.2 E+01	7.7 E+01
219	9.3 E-03	8.2 E+01	1.0 E-02	9.1 E+01	1.1 E-02	9.9 E+01	1.1 E-02	9.7 E+01	9.9 E+01	8.2 E+01	9.2 E+01
220	9.6 E-03	8.4 E+01	1.1 E-02	9.3 E+01	1.1 E-02	9.5 E+01	1.1 E-02	9.5 E+01	9.5 E+01	8.4 E+01	9.2 E+01
221	9.2 E-03	8.1 E+01	9.9 E-03	8.7 E+01	1.0 E-02	8.8 E+01	1.1 E-02	9.2 E+01	9.3 E+01	8.1 E+01	8.7 E+01
222	1.2 E-02	1.1 E+02	1.3 E-02	1.1 E+02	1.3 E-02	1.1 E+02	1.3 E-02	1.2 E+02	1.2 E+02	1.1 E+02	1.1 E+02
223	1.5 E-02	1.3 E+02	1.6 E-02	1.4 E+02	1.8 E-02	1.5 E+02	1.6 E-02	1.4 E+02	1.5 E+02	1.3 E+02	1.4 E+02
224	8.5 E-03	7.4 E+01	9.5 E-03	8.3 E+01	9.8 E-03	8.5 E+01	9.5 E-03	8.3 E+01	9.3 E+01	7.4 E+01	8.1 E+01

Table F-3. 200/600 Areas ThermoLuminescent Dosimeter Exposure Results, Calendar Year 1995.

Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results Calendar Year			
	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	Max	Min	Avg	
226	8.8 E-03	7.7 E+01	9.3 E-03	8.2 E+01	1.0 E-02	8.8 E+01	9.9 E-03	8.7 E+01	9.3 E+01	7.7 E+01	8.3 E+01	
227	8.4 E-03	7.3 E+01	9.4 E-03	8.2 E+01	9.5 E-03	8.4 E+01	9.2 E-03	8.0 E+01	9.3 E+01	7.3 E+01	8.0 E+01	
228	8.7 E-03	7.6 E+01	9.5 E-03	8.3 E+01	9.4 E-03	8.2 E+01	1.0 E-02	8.9 E+01	9.3 E+01	7.6 E+01	8.2 E+01	
229	9.5 E-03	8.3 E+01	1.0 E-02	9.1 E+01	1.2 E-02	1.0 E+02	1.1 E-02	9.3 E+01	1.0 E+02	8.3 E+01	9.2 E+01	
230	1.3 E-02	1.1 E+02	1.4 E-02	1.2 E+02	1.5 E-02	1.3 E+02	1.4 E-02	1.2 E+02	1.3 E+02	1.1 E+02	1.2 E+02	
231	9.7 E-03	8.5 E+01	1.0 E-02	8.8 E+01	1.1 E-02	9.4 E+01	1.1 E-02	9.3 E+01	9.4 E+01	8.5 E+01	9.0 E+01	
232	1.4 E-02	1.2 E+02	1.5 E-02	1.3 E+02	1.6 E-02	1.4 E+02	1.6 E-02	1.4 E+02	1.4 E+02	1.2 E+02	1.3 E+02	
233	9.1 E-03	8.0 E+01	1.0 E-02	8.8 E+01	1.0 E-02	9.1 E+01	1.0 E-02	9.1 E+01	9.3 E+01	8.0 E+01	8.7 E+01	
234	1.2 E-02	1.0 E+02	1.2 E-02	1.1 E+02	1.8 E-02	1.6 E+02	1.4 E-02	1.2 E+02	1.6 E+02	1.0 E+02	1.2 E+02	
235	8.9 E-03	7.8 E+01	NR	0.0	9.6 E-03	8.4 E+01	9.5 E-03	8.3 E+01	8.4 E+01	7.8 E+01	8.2 E+01	
236	1.0 E-02	9.0 E+01	1.1 E-02	9.9 E+01	1.1 E-02	9.6 E+01	1.1 E-02	1.0 E+02	1.0 E+02	9.0 E+01	9.6 E+01	
237	8.5 E-03	7.4 E+01	8.9 E-03	7.8 E+01	9.0 E-03	7.8 E+01	8.9 E-03	7.8 E+01	9.3 E+01	7.4 E+01	7.7 E+01	
238	1.0 E-02	8.9 E+01	9.7 E-03	8.5 E+01	1.1 E-02	9.4 E+01	9.5 E-03	8.3 E+01	9.4 E+01	8.3 E+01	8.8 E+01	
239	9.4 E-03	8.2 E+01	9.9 E-03	8.7 E+01	1.1 E-02	9.2 E+01	1.0 E-02	8.9 E+01	9.3 E+01	8.2 E+01	8.7 E+01	
240	8.5 E-03	7.4 E+01	8.8 E-03	7.7 E+01	9.1 E-03	8.0 E+01	9.2 E-03	8.1 E+01	9.3 E+01	7.4 E+01	7.8 E+01	
241	1.0 E-02	8.9 E+01	1.1 E-02	9.6 E+01	1.2 E-02	1.0 E+02	1.1 E-02	9.7 E+01	1.0 E+02	8.9 E+01	9.6 E+01	
242	9.4 E-03	8.2 E+01	9.6 E-03	8.4 E+01	1.0 E-02	9.2 E+01	1.0 E-02	8.9 E+01	9.3 E+01	8.2 E+01	8.7 E+01	
243	8.6 E-03	7.6 E+01	9.0 E-03	7.9 E+01	9.5 E-03	8.3 E+01	9.5 E-03	8.3 E+01	9.3 E+01	7.6 E+01	8.0 E+01	
244	1.2 E-02	1.0 E+02	1.3 E-02	1.2 E+02	1.3 E-02	1.2 E+02	1.4 E-02	1.2 E+02	1.2 E+02	1.0 E+02	1.1 E+02	
245	8.6 E-03	7.6 E+01	9.3 E-03	8.1 E+01	9.8 E-03	8.6 E+01	9.6 E-03	8.4 E+01	9.3 E+01	7.6 E+01	8.2 E+01	
246	8.9 E-03	7.8 E+01	9.3 E-03	8.1 E+01	9.7 E-03	8.5 E+01	9.6 E-03	8.4 E+01	9.3 E+01	7.8 E+01	8.2 E+01	
247	8.7 E-03	7.6 E+01	9.1 E-03	8.0 E+01	1.0 E-02	9.0 E+01	9.4 E-03	8.2 E+01	9.3 E+01	7.6 E+01	8.2 E+01	
249	1.3 E-02	1.1 E+02	1.3 E-02	1.1 E+02	2.5 E-02	2.2 E+02	1.7 E-02	1.5 E+02	2.2 E+02	1.1 E+02	1.5 E+02	

Table F-3. 200/600 Areas Thermoluminescent Dosimeter Exposure Results, Calendar Year 1995.

Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results (arcem/yr)		
	mrem/hr	arcem/yr	mrem/hr	arcem/yr	mrem/hr	arcem/yr	mrem/hr	arcem/yr	Max	Min	Avg
250	1.3 E-02	1.2 E+02	1.4 E-02	1.3 E+02	1.6 E-02	1.4 E+02	1.7 E-02	1.5 E+02	1.5 E+02	1.2 E+02	1.3 E+02
251	1.6 E-02	1.4 E+02	1.6 E-02	1.4 E+02	3.0 E-02	2.6 E+02	2.0 E-02	1.7 E+02	2.6 E+02	1.4 E+02	1.8 E+02
252	1.2 E-02	1.1 E+02	1.2 E-02	1.0 E+02	2.1 E-02	1.8 E+02	1.7 E-02	1.5 E+02	1.8 E+02	1.0 E+02	1.4 E+02
253	1.0 E-02	8.7 E+01	1.0 E-02	8.9 E+01	1.5 E-02	1.3 E+02	1.3 E-02	1.1 E+02	1.3 E+02	8.7 E+01	1.0 E+02
254	2.5 E-02	2.1 E+02	2.0 E-02	1.7 E+02	5.2 E-02	4.6 E+02	3.1 E-02	2.7 E+02	4.6 E+02	1.7 E+02	2.8 E+02
255	1.1 E-02	9.3 E+01	1.2 E-02	1.0 E+02	1.7 E-02	1.5 E+02	1.4 E-02	1.2 E+02	1.5 E+02	9.3 E+01	1.2 E+02
256	4.9 E-02	4.3 E+02	4.6 E-02	4.0 E+02	5.4 E-02	4.7 E+02	5.1 E-02	4.5 E+02	4.7 E+02	4.0 E+02	4.4 E+02
258	7.0 E-02	6.1 E+02	8.4 E-02	7.3 E+02	8.7 E-02	7.6 E+02	7.8 E-02	6.8 E+02	7.6 E+02	6.1 E+02	7.0 E+02
259	1.3 E-02	1.1 E+02	1.4 E-02	1.2 E+02	1.4 E-02	1.2 E+02	4.0 E-02	3.5 E+02	3.5 E+02	1.1 E+02	1.8 E+02
260	8.3 E-03	7.2 E+01	9.2 E-03	8.0 E+01	9.7 E-03	8.5 E+01	9.0 E-03	7.9 E+01	9.3 E+01	7.2 E+01	7.9 E+01
261	1.2 E-02	1.0 E+02	1.2 E-02	1.0 E+02	1.2 E-02	1.0 E+02	1.2 E-02	1.0 E+02	1.0 E+02	1.0 E+02	1.0 E+02
262	8.7 E-03	7.6 E+01	9.3 E-03	8.1 E+01	9.9 E-03	8.7 E+01	9.7 E-03	8.5 E+01	9.3 E+01	7.6 E+01	8.2 E+01
263	8.0 E-03	7.0 E+01	9.0 E-03	7.9 E+01	9.1 E-03	8.0 E+01	8.7 E-03	7.6 E+01	9.3 E+01	7.0 E+01	7.6 E+01
264	8.7 E-03	7.6 E+01	9.6 E-03	8.4 E+01	9.8 E-03	8.6 E+01	9.3 E-03	8.1 E+01	9.3 E+01	7.6 E+01	8.2 E+01
267	5.9 E-03	5.2 E+01	9.6 E-03	8.4 E+01	9.6 E-03	8.4 E+01	9.9 E-03	8.7 E+01	9.3 E+01	5.2 E+01	7.7 E+01
268	6.1 E-03	5.4 E+01	1.0 E-02	8.8 E+01	1.1 E-02	9.6 E+01	1.2 E-02	1.0 E+02	1.0 E+02	5.4 E+01	8.5 E+01
269	6.5 E-03	5.7 E+01	1.0 E-02	9.0 E+01	1.1 E-02	9.9 E+01	1.1 E-02	9.5 E+01	9.9 E+01	5.7 E+01	8.5 E+01

Table F-4. 300/300 TEDE/400 Areas ThermoLuminescent Dosimeter Exposure Results, Calendar Year 1995.

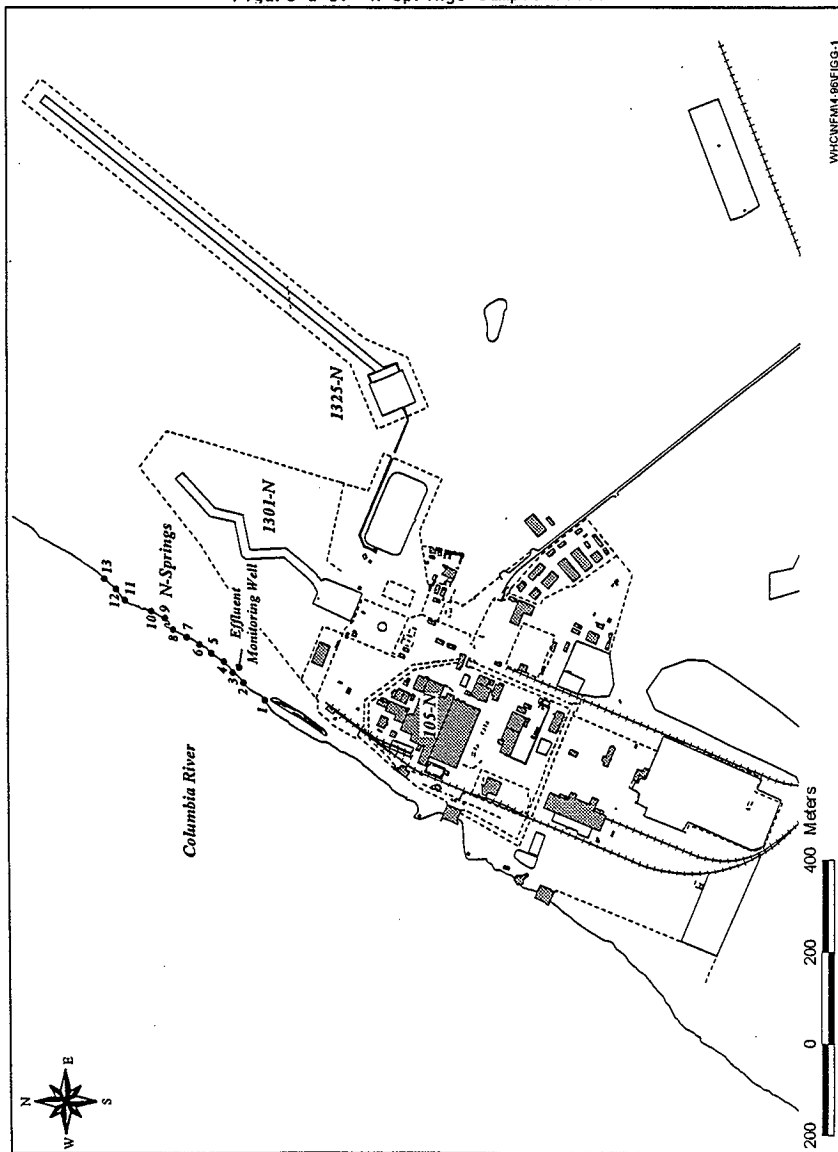
300 Area Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results (mrem/yr)		
	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	Max	Min	Avg
1	9.1 E-03	8.0 E+01	8.9 E-03	7.8 E+01	9.3 E-03	8.1 E+01	9.3 E-03	8.1 E+01	8.1 E+01	7.8 E+01	8.0 E+01
2	9.7 E-03	8.5 E+01	9.6 E-03	8.4 E+01	1.0 E-02	8.8 E+01	1.0 E-02	8.8 E+01	8.8 E+01	8.4 E+01	8.6 E+01
3	9.6 E-03	8.4 E+01	9.2 E-03	8.0 E+01	1.0 E-02	8.7 E+01	1.0 E-02	8.7 E+01	8.7 E+01	8.0 E+01	8.5 E+01
4	2.4 E-02	2.1 E+02	2.6 E-02	2.3 E+02	2.9 E-02	2.5 E+02	NR	NR	2.5 E+02	2.1 E+02	2.3 E+02
5	9.1 E-03	8.0 E+01	9.3 E-03	8.1 E+01	9.4 E-03	8.2 E+01	9.4 E-03	8.2 E+01	8.2 E+01	8.0 E+01	8.1 E+01
6	1.1 E-02	9.3 E+01	1.1 E-02	9.3 E+01	1.1 E-02	9.8 E+01	1.1 E-02	9.8 E+01	9.8 E+01	9.3 E+01	9.6 E+01
7	5.1 E-02	4.5 E+02	2.8 E-02	2.5 E+02	3.2 E-02	2.8 E+02	3.2 E-02	2.8 E+02	4.5 E+02	2.5 E+02	3.1 E+02
8	1.4 E-02	1.3 E+02	1.5 E-02	1.3 E+02	1.6 E-02	1.4 E+02	1.6 E-02	1.4 E+02	1.4 E+02	1.3 E+02	1.3 E+02
300 TEDE Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results (mrem/yr)		
	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	Max	Min	Avg
301	9.4 E-03	8.2 E+01	8.8 E-03	7.7 E+01	9.3 E-03	8.2 E+01	9.3 E-03	8.2 E+01	8.2 E+01	7.7 E+01	8.1 E+01
302	9.2 E-03	8.1 E+01	8.8 E-03	7.7 E+01	8.9 E-03	7.8 E+01	8.9 E-03	8.1 E+01	8.1 E+01	7.7 E+01	7.8 E+01
303	9.3 E-03	8.1 E+01	9.1 E-03	8.0 E+01	9.5 E-03	8.3 E+01	9.5 E-03	8.3 E+01	8.3 E+01	8.0 E+01	8.2 E+01
304	9.0 E-03	7.9 E+01	8.7 E-03	7.6 E+01	9.1 E-03	8.0 E+01	9.1 E-03	8.0 E+01	8.0 E+01	7.6 E+01	7.9 E+01
305	9.5 E-03	8.3 E+01	8.5 E-03	7.4 E+01	1.0 E-02	9.1 E+01	1.0 E-02	9.1 E+01	9.1 E+01	7.4 E+01	8.4 E+01
306	9.1 E-03	8.0 E+01	8.7 E-03	7.6 E+01	9.3 E-03	8.1 E+01	9.3 E-03	8.1 E+01	8.1 E+01	7.6 E+01	7.9 E+01
400 Area Site I.D.	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Annual Results (mrem/yr)		
	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	mrem/hr	mrem/yr	Max	Min	Avg
1	8.8 E-03	7.7 E+01	9.2 E-03	8.0 E+01	9.1 E-03	8.0 E+01	9.1 E-03	8.0 E+01	8.0 E+01	7.7 E+01	7.9 E+01
2	9.1 E-03	8.0 E+01	8.2 E-03	7.2 E+01	8.3 E-03	7.3 E+01	8.3 E-03	7.7 E+01	8.0 E+01	7.2 E+01	7.4 E+01
3	1.0 E-02	9.1 E+01	8.9 E-03	7.8 E+01	8.8 E-03	7.7 E+01	8.8 E-03	7.7 E+01	9.1 E+01	7.7 E+01	8.1 E+01
4	8.6 E-03	7.6 E+01	8.3 E-03	7.3 E+01	8.8 E-03	7.7 E+01	8.8 E-03	7.7 E+01	7.7 E+01	7.3 E+01	7.5 E+01
5	8.9 E-03	7.8 E+01	8.3 E-03	7.3 E+01	8.4 E-03	7.4 E+01	8.4 E-03	7.4 E+01	7.8 E+01	7.3 E+01	7.5 E+01
6	9.5 E-03	8.3 E+01	8.6 E-03	7.6 E+01	8.7 E-03	7.6 E+01	8.7 E-03	7.6 E+01	8.3 E+01	7.6 E+01	7.8 E+01
7	9.2 E-03	8.1 E+01	8.4 E-03	7.4 E+01	8.7 E-03	7.6 E+01	8.7 E-03	7.6 E+01	8.1 E+01	7.4 E+01	7.7 E+01

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APPENDIX G
SURFACE WATER DISPOSAL UNIT (POND AND DITCH)
MONITORING FIGURES AND TABLES

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Figure G-1. N Springs Sample Sites.



WHC/NFW/4.56/FIG.1

Figure G-2. 200 East and West Areas Liquid Waste Disposal Facilities.

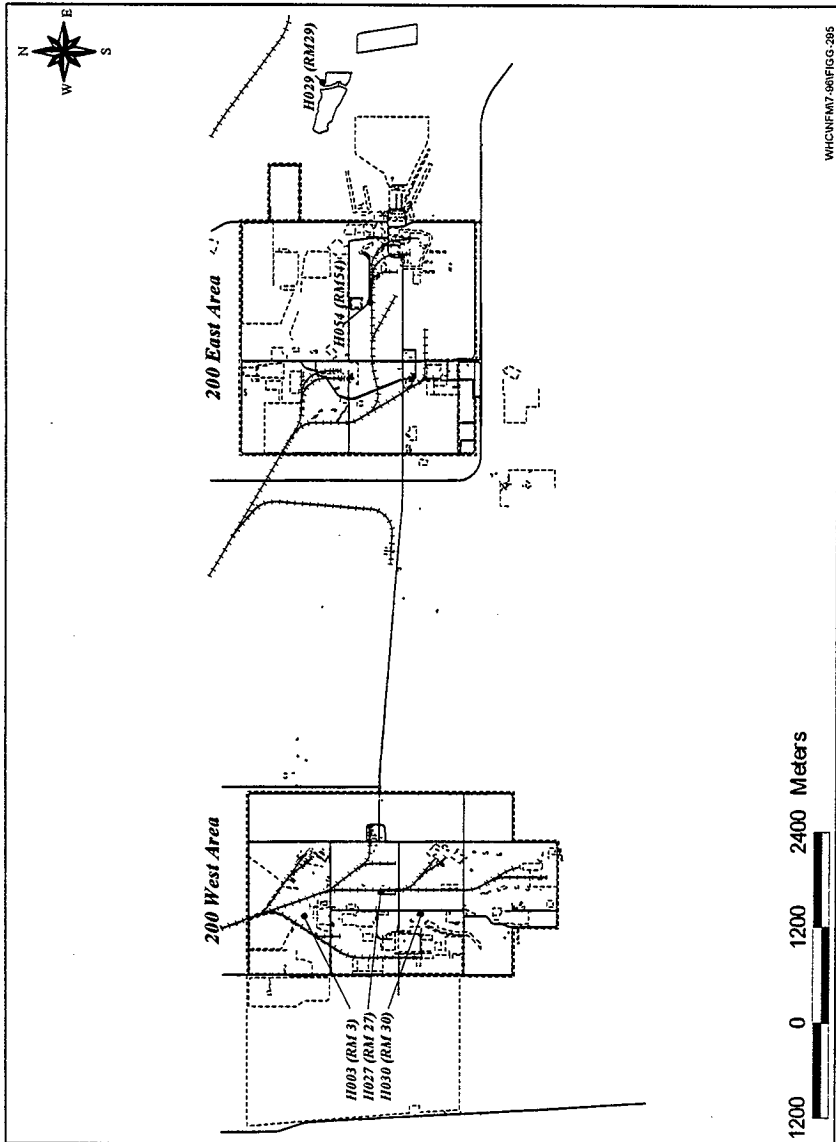


Table G-1. Radiological Results for Liquid Samples from Surface Water Disposal Units
200 Areas, 1995 (pCi/L).

Sample Location	Number of Samples		^{238}Pu	$^{239,240}\text{Pu}$	^{241}Pu	^{137}Cs	^{90}Sr	^3H
216-T-4 Ditch	3	Mean	1.7 E-02	3.6 E-03	2.1 E-05	1.4 E+01	1.9 E+01	<450
		Max	6.0 E-02	4.1 E-02	8.2 E-05	1.8 E+01	2.7 E+01	<450
		Min	-1.7 E-02	-4.0 E-02	-1.0 E-04	6.2 E+00	1.4 E+01	<450
200 East Powerhouse Ditch	12	Mean	1.4 E-02	4.2 E-02	1.9 E-04	-9.7 E-01	9.0 E-01	<450
		Max	2.3 E-01	1.5 E-01	2.6 E-04	2.8 E+00	1.9 E+01	<450
		Min	-4.1 E-02	-2.6 E-02	8.2 E-05	-5.8 E+00	-7.3 E+00	<450
216-Z-21 Basin	5	Mean	-4.4 E-03	1.2 E-01	4.9 E-05	1.5 E-01	-8.0 E-01	<450
		Max	6.7 E-07	1.8 E-01	8.2 E-05	1.3 E+00	2.5 E+00	<450
		Min	-1.1 E-02	-2.1 E-02	-8.3 E-05	-8.4 E-01	-7.2 E+00	<450
216-B-3 3rd Overflow	12	Mean	1.2 E-01	1.1 E+00	2.2 E-04	1.5 E-01	-6.8 E+13	<450
		Max	1.1 E+00	1.3 E+01	2.7 E-04	3.0 E+00	2.3 E+00	<450
		Min	-8.0 E-03	-2.5 E-02	8.2 E-05	-3.2 E+00	-9.0 E+00	<450
200 West Powerhouse Pond	5	Mean	5.0 E-03	2.6 E-02	7.1 E-05	-5.2 E-01	2.3 E+00	<450
		Max	3.2 E-02	4.5 E-02	1.6 E-04	5.4 E-01	6.0 E+00	<450
		Min	-3.2 E-02	2.5 E-03	-1.1 E-04	-2.6 E+00	-1.0 E-01	<450

Notes: Negative values indicate results at or near background levels of radioactivity
* ^3H analyses are performed quarterly

Table G-2. Nonradiological Results for Liquid Samples from Surface Water Disposal Units, 200 Areas, 1995.

Sample Locations	pH				Nitrate (NO ₃ mg/L)			
	No. of Samples	Mean	Max	Min	No. of Samples	Mean	Max	Min
216-T-4 Ditch	12	6.3	6.7	5.9	1	1.30	1.30	1.30
216-Z-21 Basin	20	8.0	8.5	7.6	1	3.50	3.50	3.50
200W Powerhouse Pond	20	8.0	9.0	7.3	1	3.70	3.70	3.70
200E Powerhouse Ditch	52	8.5	9.6	6.7	4	0.62	1.30	0.06
216-B-3C Pond	52	7.4	8.0	6.4	4	0.34	0.91	0.05

Table G-3. Radiological Results for Aquatic Vegetation from Surface Water Disposal Units, 200/600 Areas, 1995 (pCi/g dry weight).

Location	¹³⁷ Cs	⁹⁰ Sr	^{239,240} Pu	total U (g/g)
200W Powerhouse Pond	3.7 E+00	3.6 E+00	4.2 E+00	8.6 E-08
216-B-3C Pond	4.0 E+00	5.6 E-01	9.1 E-01	1.0 E-08
216-Z-21 Basin	3.8 E-01	1.2 E+00	4.7 E+00	1.5 E-09
200E Powerhouse Ditch	2.3 E+00	1.6 E+00	2.9 E+00	4.9 E-09

Table G-4. Radiological Results for Sediment (Surface) Samples from Surface Water Disposal Units, 200/600 Areas (pCi/g dry weight), 1995.

Sample Location	^{137}Cs	^{90}Sr	$^{239,240}\text{Pu}$	total U (g/g)
200W Powerhouse Pond	8.0 E-02	1.2 E+00	3.9 E-01	2.7 E-08
216-B-3C Pond	6.6 E+00	5.7 E-01	2.0 E+00	1.6 E-07
216-Z-21 Basin	NR	3.9E-01	1.7 E-01	3.2 E-07
200E Powerhouse Ditch	NR	4.1 E-01	5.2 E-01	3.8 E-08

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APPENDIX H
RADIOLOGICAL SURVEYS FIGURES
AND TABLES

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Figure H-1. Radiological Survey Locations in the 100-B/C Area.

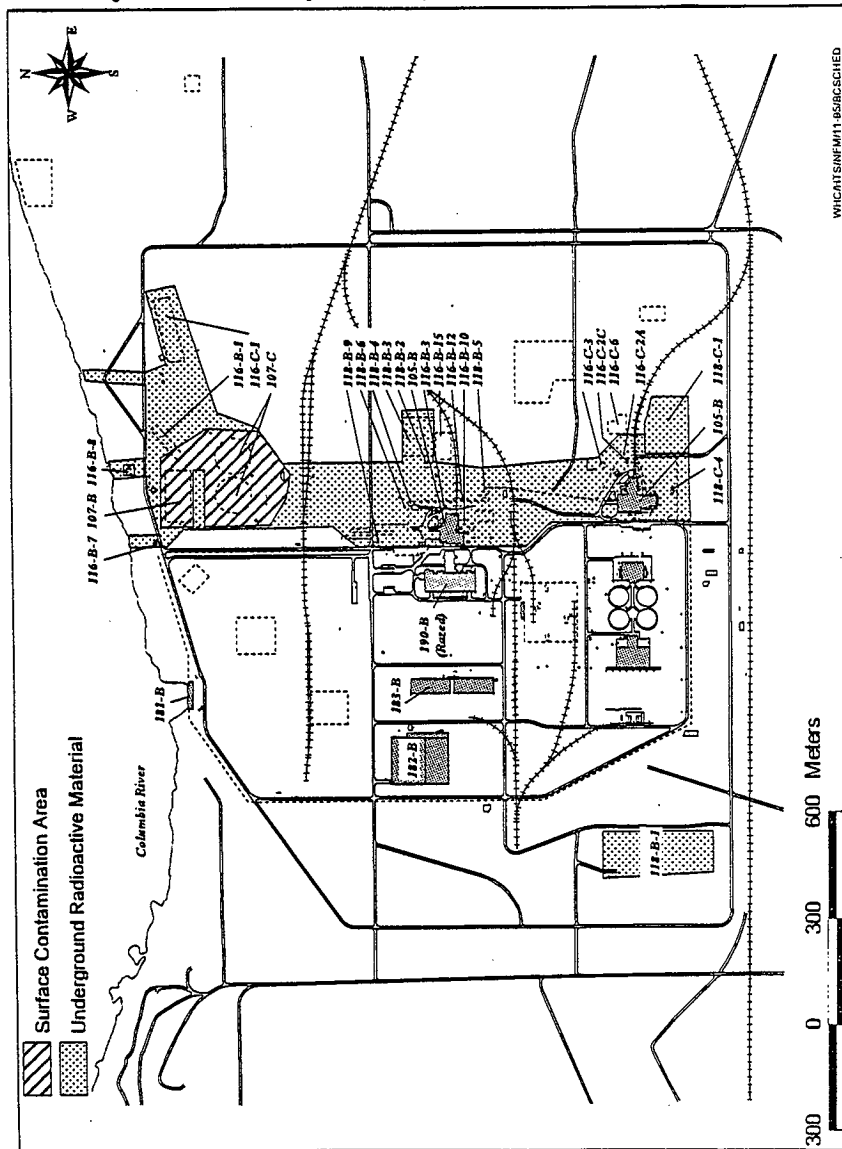
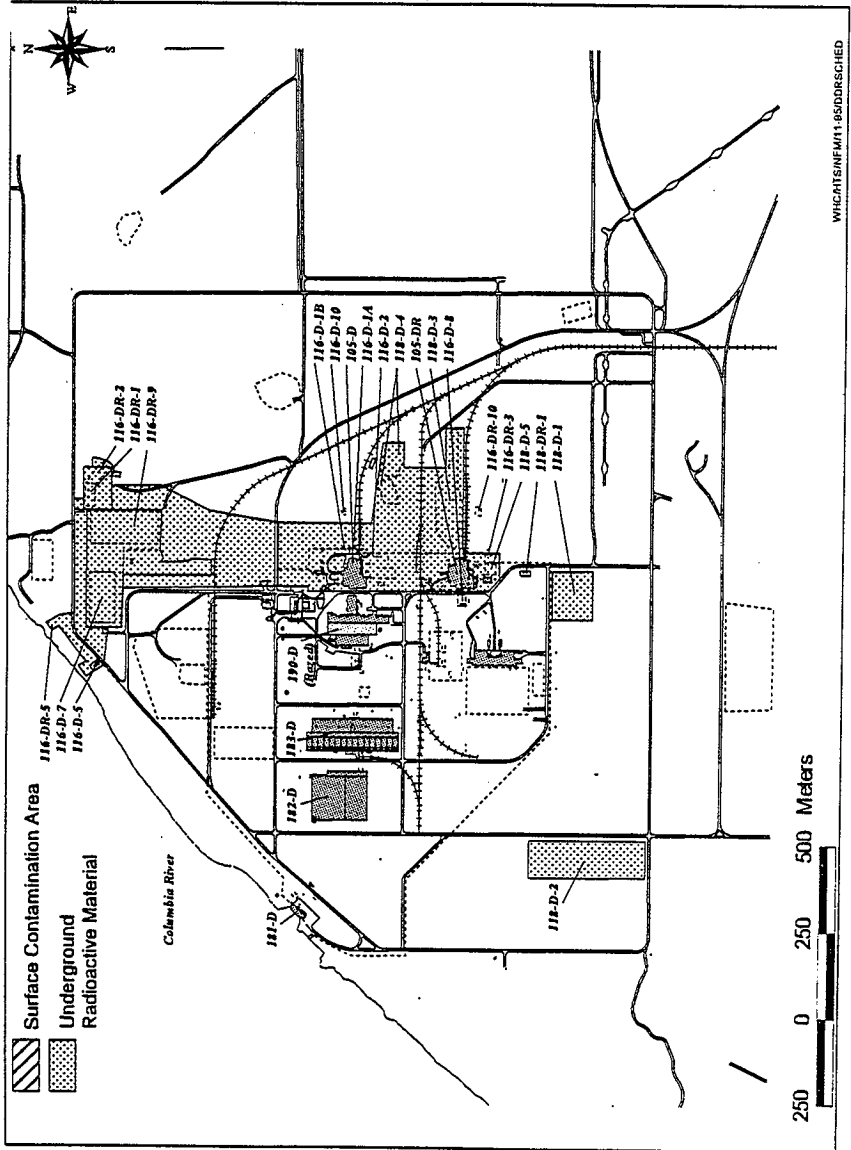


Figure H-2. Radiological Survey Locations in the 100-D/DR Area.



WHC/ATE/INF-M11-95DDRSCHIED

Figure H-3. Radiological Survey Locations in the 100-F Area.

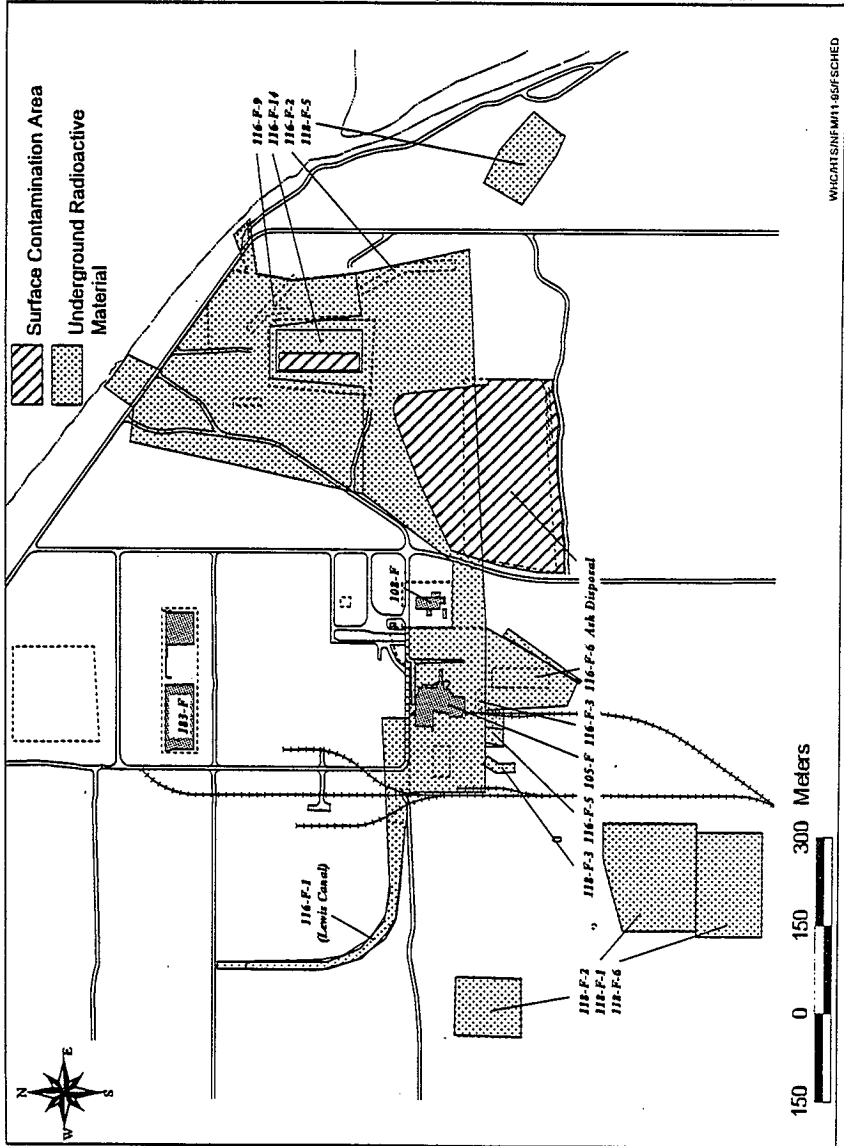
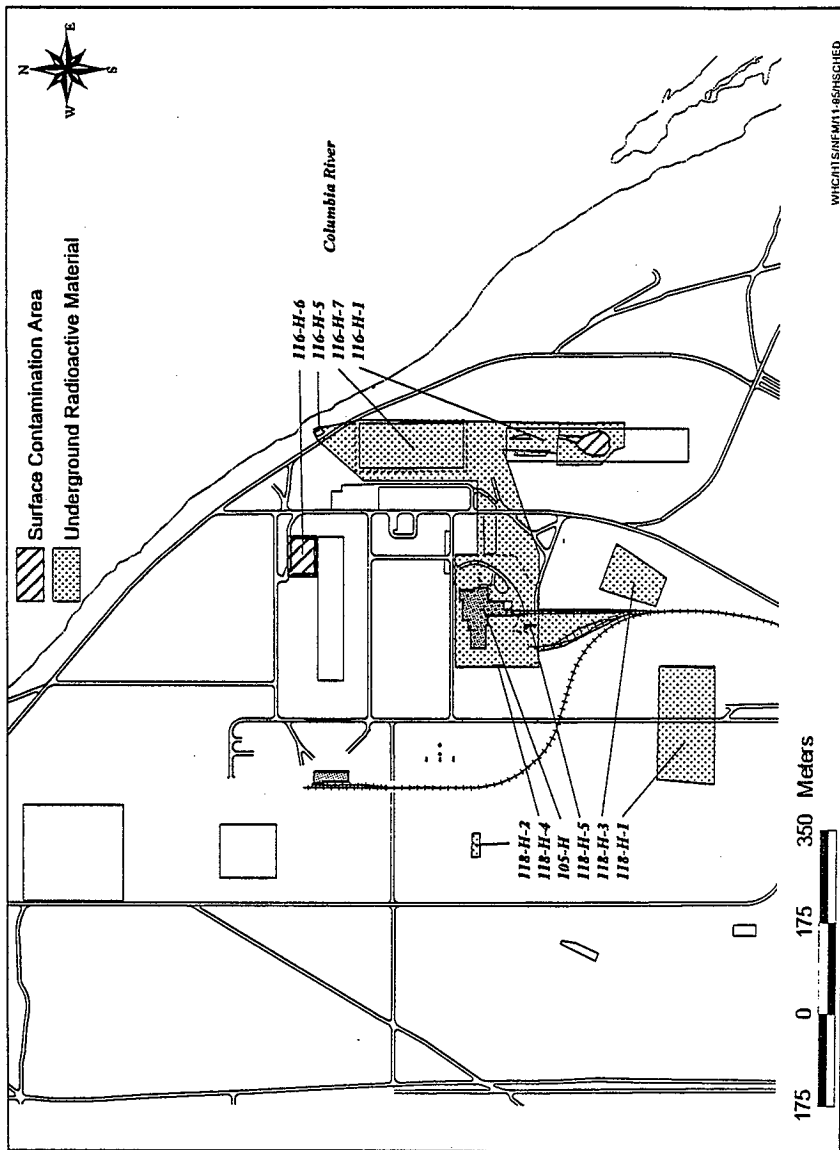


Figure H-4. Radiological Survey Locations in the 100-H Area.



WHC(1)S/NF/M11-6/UNSCHED

Figure H-5. Radiological Survey Locations in the 100-KE/KW Area.

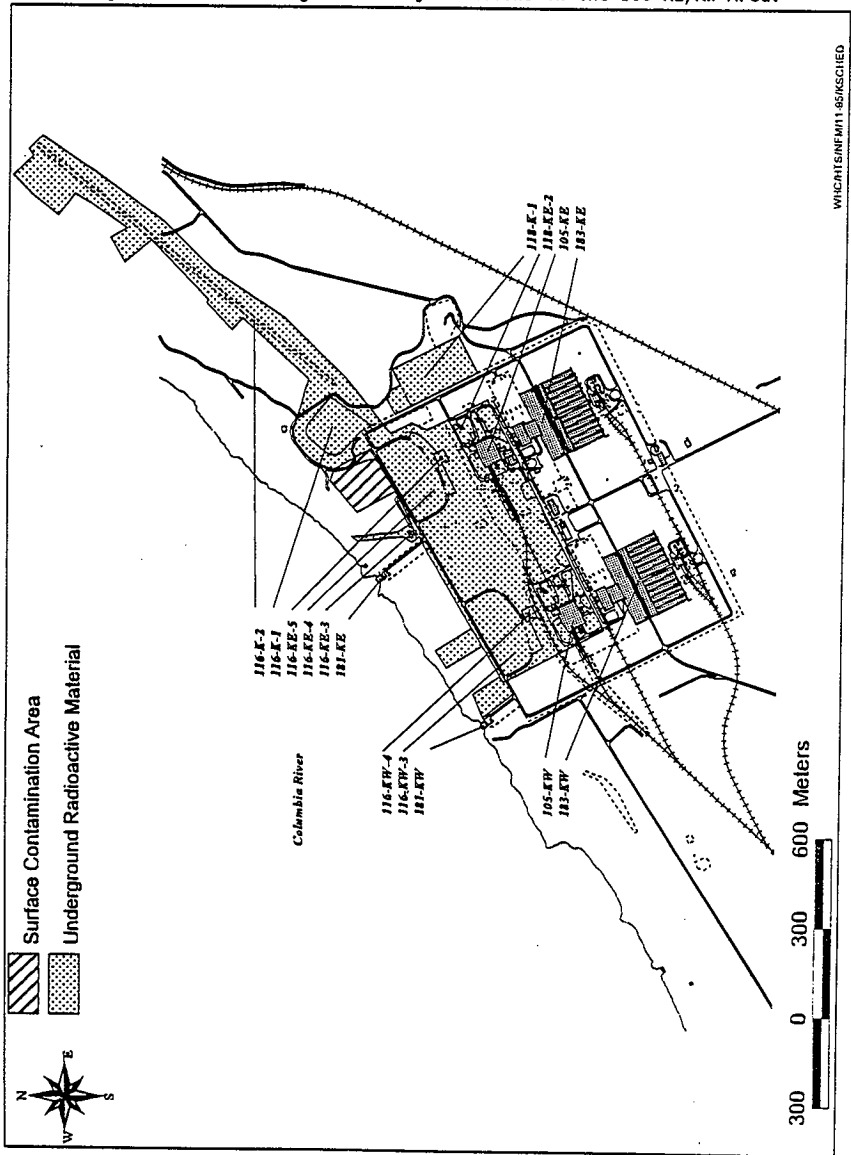


Figure H-6. Radiological Survey Locations in the 100-N Area.

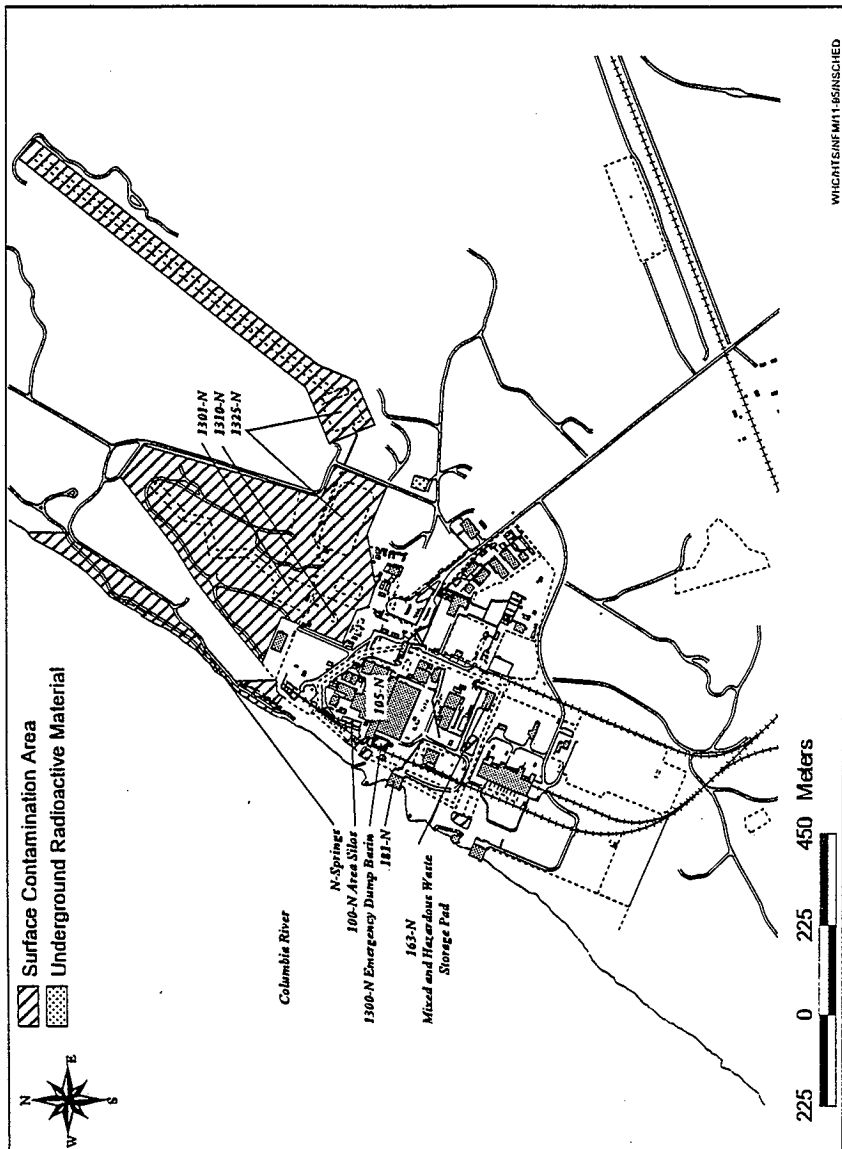


Figure H-7. Radiological Survey Locations in the 200 East Area.

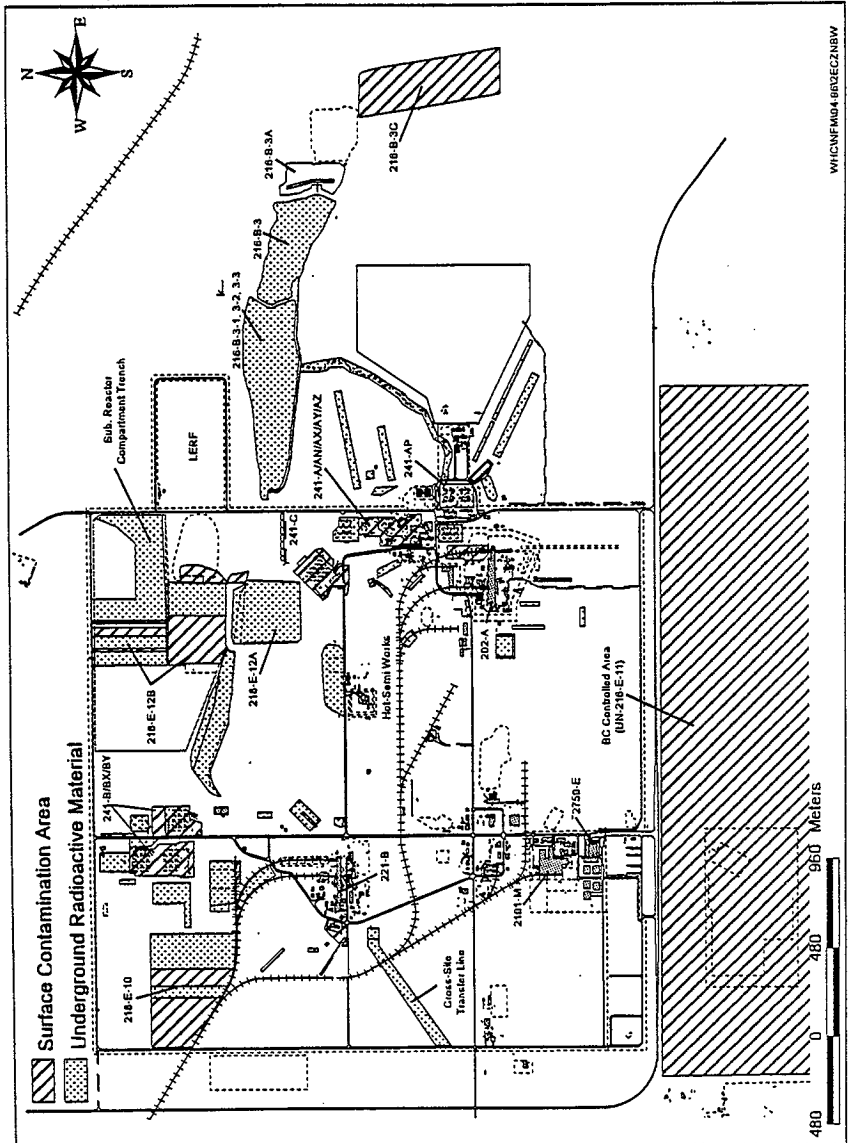


Figure H-8. Radiological Survey Locations in the 200 West Area.

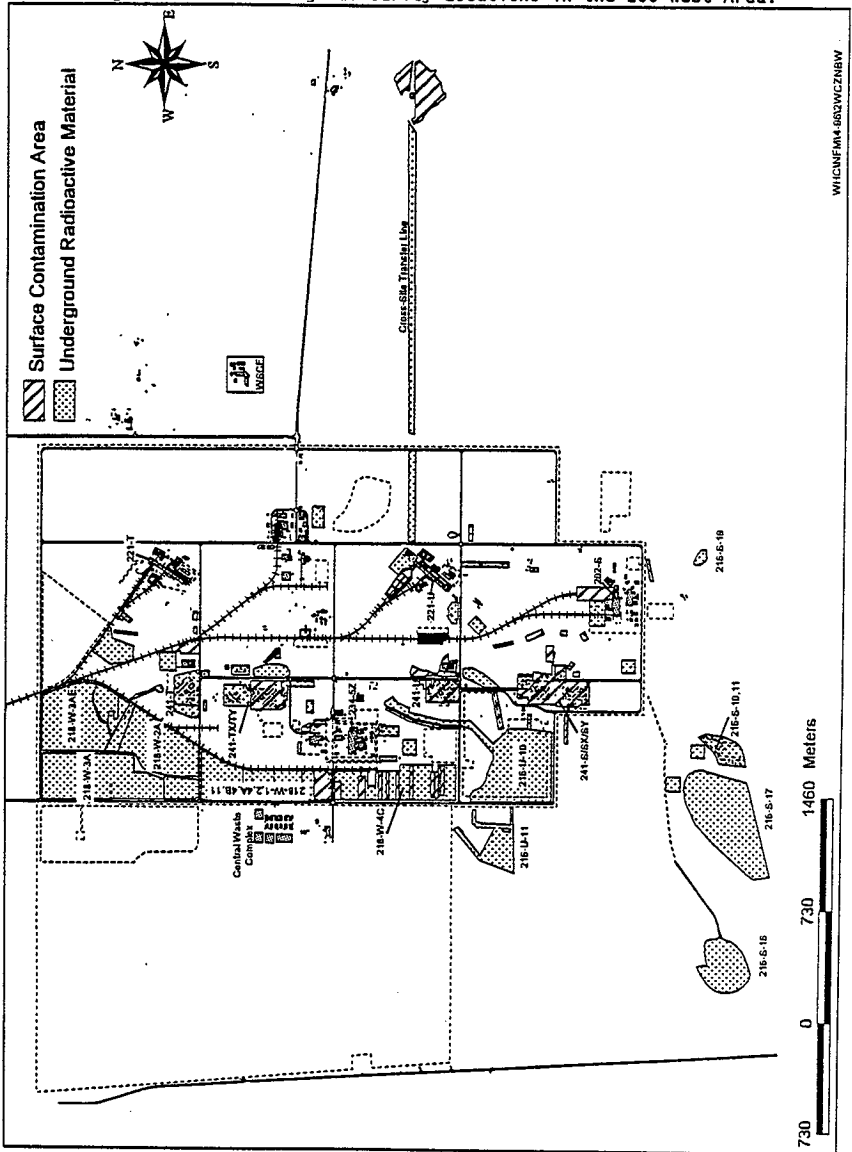


Figure H-9. Radiological Survey Locations in the 600 Area.

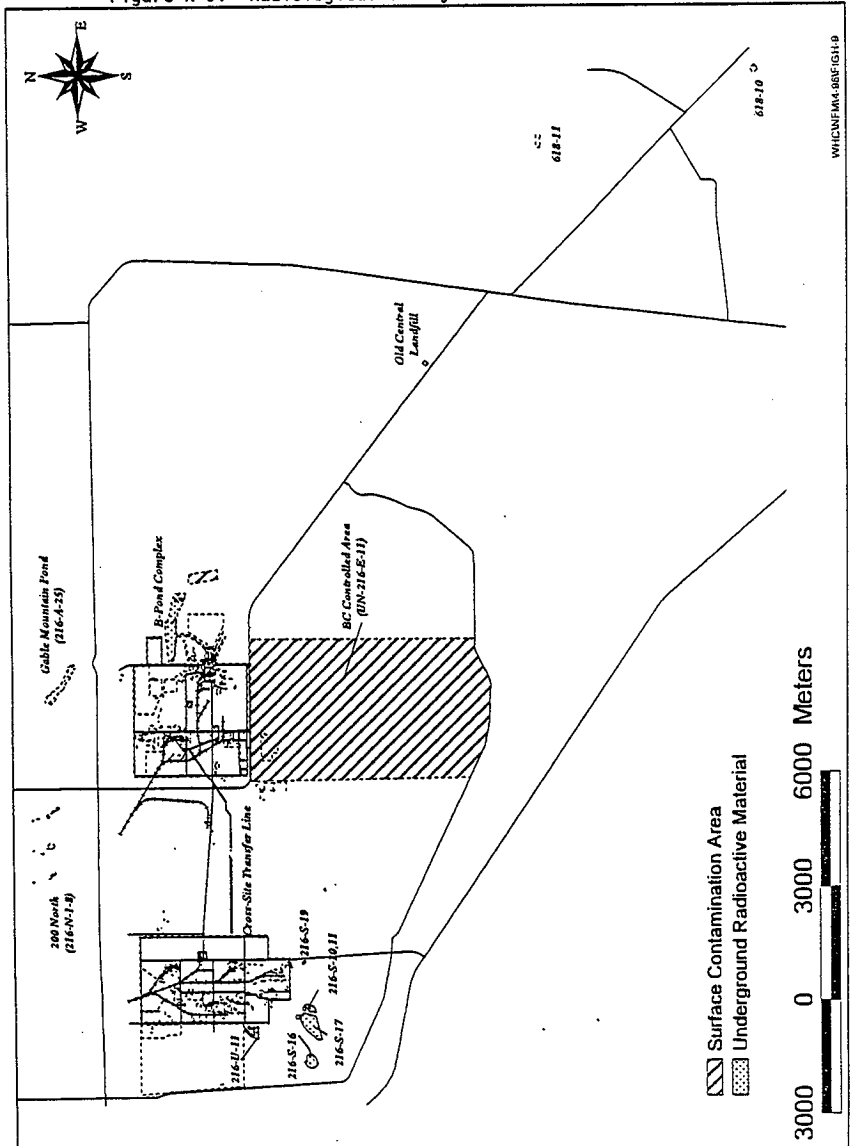


Figure H-10. Radiological Survey Locations in the 300 Area.

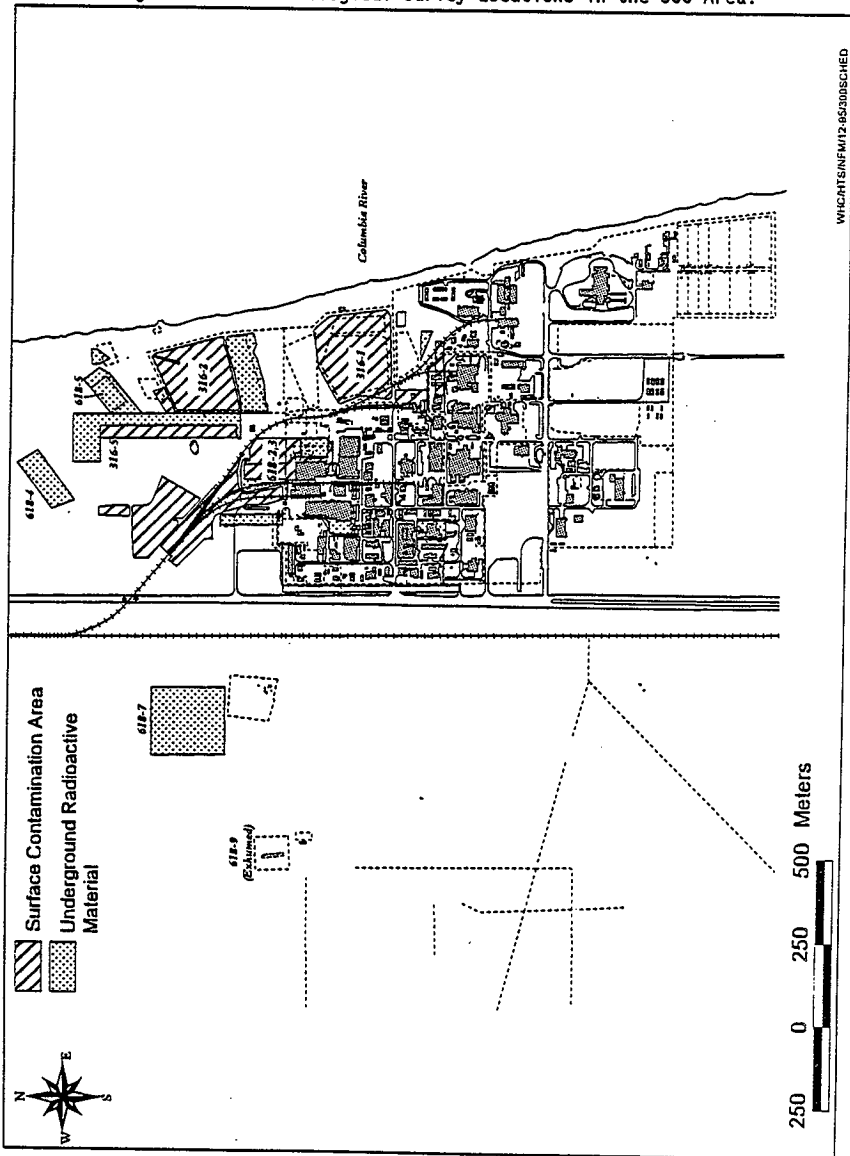


Table H-1. 100-N Area Shoreline Radiation Surveys
($\mu\text{R/hr}$).

Location	1990	1991	1992	1993	1994	1995*
1	14	11	12	11	10	10
	14	15	13	13	11	9
	16	14	14	14	13	9
	18	17	18	17	14	10
	22	18	18	18	15	10
	27	17	20	20	14	11
	36	20	28	27	23	12
	46	33	37	35	33	14
	55	46	46	45	44	16
	64	59	55	50	50	17
10	74	72	65	55	55	16
	83	85	70	60	60	15
	90	100	75	70	70	14
	120	110	100	80	75	13
	150	120	105	100	85	12
	160	140	110	90	85	13
	140	130	120	75	75	10
	90	100	100	60	60	9
	80	80	70	40	40	8
	70	70	50	40	40	11
20	60	50	45	35	35	12
	50	50	50	30	35	11
	50	50	40	30	35	11
	50	40	40	35	35	12
	50	50	50	35	35	11
	50	50	50	30	35	11
	60	50	50	30	40	12
	60	50	60	30	40	11
	60	50	60	35	45	12
	60	50	70	45	45	13
30	70	50	80	55	50	11
	80	50	80	50	60	11
	90	70	80	60	60	12
	100	80	100	65	65	11
	120	90	100	60	65	13

Table H-1. 100-N Area Shoreline Radiation Surveys
($\mu\text{R/hr}$).

Location	1990	1991	1992	1993	1994	1995*
	110	90	100	70	70	16
	130	90	110	70	70	16
	130	100	110	70	75	14
	150	110	120	80	75	18
40	150	110	120	80	80	22
	150	110	120	90	80	21
	170	120	130	80	85	19
	170	130	140	80	90	20
	180	130	145	80	95	20
	210	140	150	90	100	19
	230	140	150	90	110	18
	240	150	160	95	110	18
	230	180	170	110	115	20
	270	170	160	110	120	22
50	250	180	160	95	120	19
	270	180	160	100	120	18
	250	170	160	100	115	19
	250	170	170	110	115	18
	240	190	160	115	110	18
	240	180	160	100	110	16
	220	170	150	95	110	17
	210	170	140	90	105	18
	210	170	130	90	100	18
	200	150	120	90	85	16
60	200	160	120	80	80	15
	170	140	110	75	80	12
	150	140	100	70	75	12
	150	130	90	70	65	11
	140	120	80	55	60	10
	120	120	80	45	55	10
	90	110	70	45	50	11
	110	90	60	40	45	11
	100	90	60	45	45	10
	90	80	60	35	40	11
70	80	70	50	40	40	10

Table H-1. 100-N Area Shoreline Radiation Surveys
($\mu\text{R/hr}$).

Location	1990	1991	1992	1993	1994	1995*
	70	70	40	35	35	10
	70	60	40	30	35	11
	60	50	40	30	30	10
	60	50	30	30	25	10
	50	50	30	25	24	10
	40	50	27	30	23	11
	40	40	26	30	19	8
	30	40	22	25	19	10
	30	30	21	20	19	7
80	30	30	20	20	17	9
	25	30	19	25	15	9
	24	30	17	20	17	8
	24	30	17	18	14	7
	20	30	16	18	13	8
	18	30	14	18	12	7
	18	20	13	18	12	8
	19	20	14	15	11	7
	17	15	14	15	11	4
	15	15	12	18	11	5
90	15	15	12	15	11	4
	13	14	11	10	12	5
	13	13	10	10	11	5
	13	12	9	12	10	5

*This survey used alternate field instrument.

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APPENDIX I
INVESTIGATIVE SAMPLES

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Table I-1. Investigative Samples Collected from the Operations Areas, 1995 (pCi/m³).

Sample Type	Location	Radionuclides	Concentration
Air	116-B-4 Crib, 100-BC Area	⁶⁰ Co ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu ⁹⁰ Sr Total U	-8.5 E-06 1.2 E-04 -2.4 E-07 -6.5 E-04 5.3 E-05
	116-B-5 Crib, 100-BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	1.1 E-04 -2.0 E-03 2.3 E-06 3.6 E-06 1.8 E-04
	116-B-5 Crib, 100-BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	-1.1 E-04 -2.3 E-03 5.6 E-04 -1.6 E-05 1.8 E-04
	116-B-5 Crib, 100-BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	1.4 E-04 -2.1 E-03 2.9 E-04 1.4 E-05 2.2 E-04
	116-C-1 Trench/100 BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	5.2 E-05 -9.5 E-05 9.7 E-05 -9.7 E-06 6.1 E-05
	116-C-1 Trench/100 BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	1.1 E-04 -8.6 E-04 7.1 E-06 1.5 E-05 4.7 E-05
	116-C-1 Trench/100 BC Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	-6.2 E-05 -6.8 E-04 9.0 E-05 7.0 E-07 4.7 E-05
	183-H Burial Ground/100 H Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	4.5 E-05 -3.3 E-05 2.4 E-05 -5.4 E-06 1.4 E-04
	183-H/100 H Area	⁶⁰ Co ⁹⁰ Sr ¹³⁷ Cs ²³⁹ , ²⁴⁰ Pu Total U	1.1 E-04 -2.7 E-04 8.0 E-05 7.4 E-06 9.5 E-05

Table I-1. Investigative Samples Collected from the Operations Areas, 1995 (pCi/m³).

Sample Type	Location	Radionuclides	Concentration
Air (cont)	183-H Burial Ground/100 H Area	⁶⁰ Co	-9.9 E-05
		⁹⁰ Sr	3.2 E-04
		¹³⁷ Cs	1.1 E-04
		²³⁹ , ²⁴⁰ Pu	-1.2 E-06
		Total U	1.2 E-04

Table I-2. Investigative Water Samples Collected from the Operations Areas in 1995 (pCi/L).

Sample Type	Location	Radionuclides	Concentration
Water	West of 241-AN and south of 17th St.	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	<5.9 E+01 <5.9 E+00 <8.3 E+00 5.0 E-01
	East of 241-BX and west of Baltimore	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	<5.8 E+01 <7.8 E+00 4.7 E+01 5.0 E-01

Table I-3. Investigative Soil Samples Collected from the Operations Areas in 1995 (pCi/g). (2 sheets)

Sample Type	Location	Radionuclides	Concentration
Soil	199-K-109A/ 100-K Area	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	<3.1 E-01 <3.7 E-01 7.9 E-05 9.7 E-07
Soil	TLD Location 65/100-N	¹³⁷ Cs ^{239/240} Pu ²¹² Bi ⁹⁰ Sr Total U	2.1 E+01 <2.9 E-01 1.2 E+00 1.9 E+00 5.8 E-07
Soil	TLD Location 67/100-N	¹³⁷ Cs ²¹² Pb ²¹⁴ Pb ²²⁸ Ac ^{239/240} Pu ⁹⁰ Sr Total U	1.5 E-01 1.0 E+00 1.4 E+00 1.1 E+00 <2.8 E-01 2.1 E+01 5.4 E-07
Soil	TLD Location 69/100-N	²¹² Pb ²¹⁴ Pb ²²⁴ Ra ^{239/240} Pu ⁹⁰ Sr Total U	7.3 E-01 1.2 E+00 2.4 E+00 <3.0 E-01 6.1 E-01 4.2 E-07
Soil	UN-216-E-7/200 East	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	3.8 E+01 2.4 E+00 1.8 E+01 2.0 E-07
Soil	241-SY tank farm/200 West	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	2.9 E+02 <2.0 E-01 8.7 E-01 1.4 E-08
Soil	UN-216-E-6/200 East	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	<1.9 E+00 <1.1 E+01 1.9 E+03 3.5 E-07
Soil (green)	N side of 241-B/200 East	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	6.8 E+01 3.6 E-01 2.9 E+02 1.3 E-07
Soil	200 West portion of E/W vent station	¹³⁷ Cs ²¹⁴ Bi ²²⁸ Ac ^{239/240} Pu ⁹⁰ Sr Total U	6.3 E+02 6.5 E-01 6.7 E-01 <2.1 E-01 1.9 E+01 4.6 E-07

Table I-3. Investigative Soil Samples Collected from the Operations Areas in 1995 (pCi/g). (2 sheets)

Sample Type	Location	Radionuclides	Concentration
Soil (ant mound)	241-C/200 East Area	¹³⁷ Cs ^{239/240} Pu ¹³⁴ Cs Total ¹³⁷ Cs	1.2 E+01 2.2 E+03 8.0 E+02 7.5 E-10
Soil (Ant Mound)	0.3 mile east of vent station/ 600 Area	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total ¹³⁷ Cs	7.9 E+03 <4.2 E-01 8.2 E-04 5.1 E-07

Table I-4. Radiologically Contaminated Soil Disposed of from the Operations Areas in 1995 (counts per minute). (3 sheets)

Sample Type	Location	External Radioactivity
Soil speck	UN-216-E-26, 200 East	30,000
Soil specks	UN-216-E-26, 200 East	35,000
Soil	Rod rack W. of 105-KW, 100-K	25,000
Soil speck	241-EW-151 Vent Station, 600 Area (300 m east)	20,000
Soil	241-EW-151 Vent Station, 600 Area (300 m west)	20,000
Soil specks	216-S-1/2, 200 West	600,000
Soil speck (rust)	E/W Transfer Line, 600 Area	150,000
Soil	244-A Lift Station, 200 East	30,000
Soil specks	216-T-5, 200 West	600,000
Soil speck	216-T-5, 200 West	20,000
Soil specks	216-U-1/2, 200 West	6,000
Soil speck	218-W-2A, 200 West	25,000
Soil speck	218-W-2A, 200 West	80,000
Soil specks	218-W-2A, 200 West	8,000
Soil speck	241-SX, SE side, 200 West	80,000
Soil specks	241-TX/TY, SW corner, 200 West	250,000
Soil speck	241-U, N side, 200 West	150,000
Soil specks	241-U, N side, 200 West	60,000

Table I-4. Radiologically Contaminated Soil Disposed of from the Operations Areas in 1995 (counts per minute). (3 sheets)

Sample Type	Location	External Radioactivity
Soil speck	241-SX, W side (decon dome), 200 West	400,000
Soil specks	105-KE, E side (near bunker), 100-K	350,000
Soil speck	216-T-4-1, 200 West	350,000
Soil speck	216-T-4-2, 200 West	6,000
Soil speck	218-W-11, 200 West	20,000
Soil	207-B (100 m SW), 200 East	50,000
Soil specks	216-B-61, 200 East	30,000
Soil speck	Camden Ave. E of 241-U Tank Farm, 200 West	10,000
Soil	S. of 202-A, 200 East	85,000
Soil speck	218-E-8, 200 East	>1,000,000
Soil (plastic in)	216-T-4-2, 200 West	2,000
Soil specks	241-TX-152, 155 Diversion Box, 200 West	100,000
Soil speck	218-E-4, 200 East	30,000
Soil	618-11, 200 West	2,500
Soil	UN-216-E-41 Vent Station to Rt. 4 S.	600,000
Soil	241-BX/BY Tank Farm perimeter	6,000
Soil speck	216-B-14 through B-19	15,000
Soil specks	B-C Controlled Zone roads	6,000
Soil specks	116-H-3, 100-H	500,000
Soil specks	116-H-4, 100-H	500,000
Soil specks	118-H-4, 100-H	500,000
Soil specks	118-H-5, 100-H	500,000
Soil specks	116-H-9, 100-H	400,000
Soil speck	118-D-3, 100-D	300,000
Soil	216-A-24 Crib, W of, 200 East	20,000
Soil speck	116-KW-1, 100-KW	700,000
Soil specks	UN-216-E-23, 200 East	10,000

Table I-4. Radiologically Contaminated Soil Disposed of from the Operations Areas in 1995 (counts per minute). (3 sheets)

Sample Type	Location	External Radioactivity
Soil	UN-216-E-44, 200 East	75,000
Soil	216-S-4 and S-21, 200 West	5,000
Soil	241-B Tank Farm, N side, 200 East	300,000
Soil specks	241-BY, NE perimeter, 200 East	200,000
Soil speck	W of 241-S Fence Line, 200 West	200,000
Soil/specks	W of 241-EW-151 at TR-31-EW and TR-32-EW, 600 Area	40,000
Soil speck	241-AZ, base of slope on E side, 200 East	>1,000,000
Soil speck	241-AN, E of, 5 ft W of Canton Ave, 200 East	35,000
Soil speck	244-A Lift Station, 200 East	7,000
Soil specks	218-W-5, 200 West	>1,000,000
Soil speck	107-KE, 100-K	12,000
Soil speck	116-K-1, 100-K	20,000
Soil	241-Z, S of Gate 8 on E side, 200 West	950,000
Soil specks	218-E-10, 200 East	70,000
Soil speck	241-C Tank Farm, E side, 200 East	50,000
Soil speck	241-C Tank Farm, NW corner, 200 East	400,000
Soil speck	241-C Tank Farm, W side, 200 East	20,000

Table I-5. Investigative Vegetation Samples Collected from the Operations Areas in 1995 (pCi/g).

Sample Type	Sample Location	Radionuclides	Concentration
Tumbleweed (assoc. soil)	216-A-3/200 East	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	9.0 E-01 2.0 E+01 7.9 E+01 1.1 E-07

Tumbleweed	Cross-Site transfer line/ 600 Area	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	2.6 E+00 <7.3 E-01 1.8 E+02 7.7 E-09
Tumbleweed	UN-216-E-44/ 200 East	^{137}Cs ^{214}Pb $^{239/240}\text{Pu}$ ^{90}Sr Total U	1.4 E+01 4.5 E+00 <1.8 E-01 3.9 E+02 1.6 E-08

Table I-6. Radiologically Contaminated Vegetation Disposed of from the Operations Areas in 1995 (counts per minute). (3 sheets)

Sample Type	Location	External Radioactivity
Tumbleweed fragments	Outside 202-A, 200 East	not recorded
Tumbleweed fragments	216-C-4 Crib, 200 East	100,000
Tumbleweed fragments	218 E-12B, 200 East	>1,000,000
Tumbleweed fragments	221-T, E side at R-7, 200 East	6,000
Tumbleweed fragments	216-B-55, 200 East	8,000
Tumbleweed fragments	216-B-52, S of, 200 East	Not recorded
Tumbleweed	B-Plant at R-13, 200 East	Not recorded
Tumbleweed	200 West Interior Fence	8,000
Tumbleweed fragments	UN-216-E-8, R3 section at 221-B, 200 East	100,000
Tumbleweed	241-EW-151 Vent Station, 3/4 mi? W of, 600 Area	15,000
Tumbleweed	216-U-10, 200 West	250,000
Tumbleweed	218-W-2A, 200 West	25,000
Tumbleweed fragments	241-B Tank Farm perimeter, 200 East	10,000
Tumbleweeds	216-U-11, 200 West	15,000
Tumbleweed	216-U-10, 200 West	6,000
Tumbleweed	221-T, door R-3, 200 West	20,000

Table I-6. Radiologically Contaminated Vegetation Disposed of from the Operations Areas in 1995 (counts per minute). (3 sheets)

Sample Type	Location	External Radioactivity
Tumbleweed	221-T, E of at shotcreted URM area, 200 West	20,000
Tumbleweed	202-A, exclusion area S of, 200 East	20,000
Tumbleweed	221-B, S of, 200 East	8,000
Tumbleweed fragment	221-B and Baltimore St, 200 East	30,000
Tumbleweed fragments	221-B Tile Field, E of, 200 East	100,000
Vegetation	218-W-3A, 200 West	70,000
Tumbleweed fragments	241-BX/BY, 200 East	200,000
Tumbleweeds	200 East Fence, 1.5 mi S of gate 810, 200 East	20,000
Vegetation fragments	241-SY Fence, 300 ft E of, 200 West	250,000
Vegetation	218-W-3A Burial Ground, 200 West	3,000
Tumbleweed seeds	216-S-4 Crib, 50 ft E of, 200 West	20,000
Tumbleweed seeds	216-S-4 and 21 Cribs, E side of, 200 West	20,000
Tumbleweed	216-S-4 and 21 Cribs, E side of, 200 West	5,000
Tumbleweeds	241-BX/BY, NE of, 200 East	140,000
Tumbleweeds	221-BA, 200 East	Not recorded
Tumbleweed fragments	216-B-64 Basin, 200 East	40,000
Tumbleweeds	Cooper and 13th Sts, NW of, 200 West	2,000
Tumbleweed fragments	202-A, 200 East	>100,000 (50 mRad/u)
Tumbleweeds	202-A, 200 East	20,000
Tumbleweed fragments	221-T at R-3, E of, 200 West	2,500

Table I-7. Investigative Wildlife Samples Collected from the Operations Area in 1995 (pCi/g). (3 sheets)

Sample Type	Location	Radionuclides	Concentration
Mouse	105-KE/100-K	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	3.7 E+02 1.3 E+00 2.2 E+02 1.2 E-08
Mouse	272-U/200 West	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	<4.5 E+00 6.5 E-01 1.0 E+01 2.6 E-08
Bat	190-D/100-D	^{137}Cs ^{60}Co $^{239/240}\text{Pu}$ ^{90}Sr Total U	2.2 E+02 1.6 E+03 <7.6 E+00 1.1 E+04 6.8 E-06
Mouse	DACS Trailer/200 West	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	1.2 E+03 5.5 E-01 1.6 E+03 8.3 E-09
Mouse	241-C Laundry Shack/200 East	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	<1.5 E+01 1.5 E+00 9.0 E+00 4.2 E-08
Wasp Nest	1301-N/100-N	^{137}Cs ^{60}Co	4.8 E+02 2.5 E+03
Mouse	2713 WB/200 West	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	1.2 E+00 2.4 E-01 5.8 E+01 7.7 E-08
Mouse	KEH Trailer near 241-A/200 East	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	2.2 E+00 1.5 E-01 3.1 E+02 9.7 E-09
Coyote Feces	East of B Plant, S of 207-B/ 200 East	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	6.2 E+00 <2.1 E-01 3.3 E+02 2.6 E-07
Mouse	202-A Purex/ 200 East	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	<1.4 E+01 <2.8 E+00 <2.9 E+00 1.4 E-07

Table I-7. Investigative Wildlife Samples Collected from the Operations Area in 1995 (pCi/g). (3 sheets)

Sample Type	Location	Radionuclides	Concentration
Pigeons	105-N/100-N	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	<3.2 E-02 <5.0 E-02 5.1 E-02 9.3 E-08
Pigeons	221-U/200 West	^{137}Cs $^{239/240}\text{Pu}$ ^{234}Th ^{90}Sr Total U	3.4 E-01 <1.4 E-01 9.4 E+00 <3.1 E-01 2.4 E-05
Coyote Jaw	202-A/200 East	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	<1.2 E+01 <1.0 E+01 1.3 E+02 2.2 E-08
Snake	200 West Area	^{137}Cs $^{239/240}\text{Pu}$ ^{134}Cs ^{90}Sr	9.6 E+05 <2.8 E+00 1.4 E+02 3.5 E+04
Deer Mouse	2247-B/200 East	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	<4.2 E+00 <2.3 E+00 3.4 E+00 8.4 E-08
Rattlesnake	105-N/100-N	^{137}Cs ^{60}Co $^{239/240}\text{Pu}$ ^{90}Sr Total U	1.2 E+02 2.0 E+02 1.6 E+00 1.4 E+01 1.6 E-09
Mouse	241-AY/200 East	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	<1.9 E+00 <2.2 E+00 9.3 E+02 4.0 E-09
Bullsnake	Camden & 19th ICF/KEH Complex/200 West	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	2.0 E+00 2.6 E-01 3.1 E+02 2.4 E-08
Bullsnake	20 meters west of 241-AZ/200 East	^{137}Cs ^{214}Bi $^{239/240}\text{Pu}$ ^{90}Sr Total U	5.4 E+02 1.9 E+00 <1.1 E+00 9.9 E+01 1.6 E-08
Mouse	2707-SX lunchroom/200 West	^{137}Cs $^{239/240}\text{Pu}$ ^{90}Sr Total U	2.7 E+02 <3.2 E+00 4.8 E+03 5.1 E-09

Table I-7. Investigative Wildlife Samples Collected from the Operations Area in 1995 (pCi/g). (3 sheets)

Sample Type	Location	Radionuclides	Concentration
House Finch	271-U/200 West	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr	5.4 E+00 3.5 E+01 2.3 E+02
Mouse	200 Areas	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	8.3 E+02 7.5 E+00 1.4 E+03 1.0 E-02
Pigeon	200 Areas	⁶⁰ Co ¹⁵⁴ Eu ^{239/240} Pu ⁹⁰ Sr Total U	2.0 E+01 1.4 E+00 <1.5 E-01 1.3 E-01 5.4 E-04
Coyote feces	200 Areas	¹³⁷ Cs ¹⁵⁴ Eu ¹⁵⁵ Eu ⁶⁰ Co ^{239/240} Pu ⁹⁰ Sr Total U	1.6 E+02 1.5 E+01 1.5 E+01 1.3 E+00 <5.7 E+01 5.0 E+02 8.9 E-02
Mouse	200 Areas	¹³⁷ Cs ^{239/240} Pu ⁹⁰ Sr Total U	<3.4 E+00 <4.0 E+00 6.9 E+02 8.4 E-03

Table I-8. Radiologically Contaminated Wildlife Disposed of from the Operations Areas in 1995 (counts per minute).

Sample Type	Location	External Radioactivity
Mouse feces	242-S Change Trailer, 200 West	150,000
Mouse	242-S Change Trailer, 200 West	2,000
Coyote feces	E of B Plant and S of 207-B, 200 East	5,000
Ant mound	241-EW-151, 600 Area	100,000
Insect nests	300 Area Laydown Yard, 300 Area	20,000
Mouse urine	244-A Lift Station, 200 East	30,000
Snake	218-W-4A, 200 West	500,000

Starlings	Unknown	2,000
Mouse	105-KE Women's Change Rm, 100 KE	150,000
Mouse feces	WSCF Conex Box #K3, 200 West	90,000
Mouse feces	Cross-Site Transter Line, 200 West	>1,000,000
Ant Mound	URM pipelines, 200 West	20,000
Mouse feces	216-S-4 and S-21 Cribs, E side, 200 West	300,000
Animal urine	218-W-5, 200 West	>20,000 (10 mRad/hr)

Table I-9. Investigative Samples Collected at the Vegetation Die-Off West of 221-T Parking Lot. (2 Sheets)

Sample type	Sample Location	Chemical Constituent	Concentration
Soil (loose sandy soil with little organic matter)	West of 221-T Parking Lot	organics (%)	< MQL
		pesticides (ppm)	< MQL
		metallic salts (ppm)	< MQL
		anions (ppm):	
		flouride	< MQL
		chloride	< MQL
		nitrate	331.3
		phosphate	< MQL
		sulfate	< MQL
		conductivity (ms/cm)	0.168
		pH (units)	7.3
	West of 221-T Parking Lot	organics (%)	< MQL
		pesticides (ppm)	< MQL
		metallic salts (ppm)	< MQL
		anions (ppm):	
		flouride	< MQL
		chloride	< MQL
		nitrate	288.5
		phosphate	< MQL
		sulfate	< MQL
		conductivity (ms/cm)	0.158
		pH (units)	7.6
	West of 221-T Parking Lot	organics (%)	< MQL
		pesticides (ppm)	< MQL
		metallic salts (ppm)	< MQL
		anions (ppm):	
		flouride	< MQL
		chloride	< MQL
		nitrate	55.7
		phosphate	161.0
		sulfate	121.1
		conductivity (ms/cm)	0.206
		pH (units)	7.7
	West of 221-T Parking Lot	organics (%)	< MQL
		pesticides (ppm)	< MQL
		metallic salts (ppm)	< MQL
		anions (ppm):	
		flouride	< MQL
		chloride	< MQL
		nitrate	308.0
		phosphate	120.7
		sulfate	< MQL
		conductivity (ms/cm)	0.151
		pH (units)	8.0

Table I-9. Investigative Samples Collected at the Vegetation
Die-Off West of 221-T Parking Lot. (2 Sheets)

Sample type	Sample Location	Chemical Constituent	Concentration
Vegetation (rabbitbrush and sagebrush stems and leaves)	West of 221-T Parking Lot	organics (%) pesticides (ppm) metallic salts (ppm) anions (ppm): fluoride chloride nitrate phosphate sulfate conductivity (ms/cm) pH (units)	< MQL < MQL < MQL < MQL < MQL < MQL 292.1 < MQL 0.182 7.0
	West of 221-T Parking Lot	organics (%) pesticides (ppm) metallic salts (ppm) anions (ppm): fluoride chloride nitrate phosphate sulfate conductivity (ms/cm) pH (units)	< MQL < MQL < MQL < MQL < MQL < MQL 112.6 325.5 298.8 0.201 6.6

MQL = method quantitation limit

ppm = parts per million

ms/cm = milliseconds per centimeter

APPENDIX J
CONCENTRATION GUIDES

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Table J-1. Airborne Derived Concentration Guides.

Radionuclide	DCG ^a (pCi/m ³)
⁹⁰ Sr	9
¹³⁷ Cs	400
¹⁰⁶ Ru	30
²³⁹ Pu	0.02

^aDerived Concentration Guides.

Table J-2. Derived Concentration Guides for Water (pCi/L).

Radionuclide	DCG ^a
³ H	2.0 E+05
⁶⁰ Co	5.0 E+03
⁹⁰ Sr	1.0 E+03
⁹⁹ Tc	1.0 E+05
¹⁰⁶ Ru	6.0 E+03
¹²⁹ I	5.0 E+02
¹³⁷ Cs	3.0 E+03
²³⁴ U	5.0 E+02
²³⁵ U, ²³⁸ U	6.0 E+02
²³⁸ Pu	4.0 E+01
²³⁹ Pu, ²⁴⁰ Pu	3.0 E+01

^aDerived Concentration Guides.

Table J-3. Inaccessible Soil Concentration Limits, pCi/g. (2 sheets)

Radionuclide	100-BDN	100-F, H	200-W	200-E	300 Area	400 Area
^3H	1.4 E+08	7.4 E+07	3.7 E+08	2.0 E+08	9.5 E+06	1.4 E+07
^{14}C	6.2 E+05	6.2 E+05	6.2 E+05	6.2 E+05	6.2 E+05	6.2 E+05
^{55}Fe	9.7 E+06	9.7 E+06	3.6 E+10	1.9 E+10	1.0 E+07	1.4 E+09
^{58}Co	9.8 E+06	9.8 E+06	8.1 E+09	4.3 E+09	1.2 E+07	3.1 E+08
^{60}Co	9.9 E+05	9.9 E+05	5.7 E+08	3.0 E+08	1.0 E+06	9.9 E+06
^{63}Ni	1.5 E+08	1.5 E+08	6.9 E+09	6.9 E+09	1.5 E+08	2.2 E+08
$^{90}\text{Sr}^*$	8.3 E+05	8.3 E+05	2.2 E+08	1.2 E+08	8.3 E+05	8.4 E+06
^{99}Tc	1.3 E+07	1.3 E+07	1.3 E+07	1.3 E+07	1.3 E+07	1.3 E+07
$^{106}\text{Ru}^*$	2.0 E+07	2.0 E+07	5.7 E+08	3.0 E+08	1.5 E+07	2.2 E+07
$^{125}\text{Sb}^*$	9.1 E+06	9.1 E+06	5.7 E+09	3.0 E+09	9.2 E+06	1.1 E+08
^{129}I	2.8 E+05	2.8 E+05	2.8 E+05	2.8 E+05	2.2 E+05	2.8 E+05
^{134}Cs	1.7 E+04	1.7 E+04	2.5 E+08	1.4 E+08	2.4 E+04	9.7 E+06
$^{137}\text{Cs}^*$	1.7 E+04	1.7 E+04	3.5 E+08	1.8 E+08	1.7 E+04	1.3 E+07
$^{144}\text{Cs}^*$	1.4 E+06	1.4 E+06	7.4 E+08	4.0 E+08	1.9 E+06	2.8 E+07
^{147}Pm	3.4 E+07	3.4 E+07	7.4 E+09	4.0 E+09	3.5 E+07	2.8 E+08
^{152}Eu	4.5 E+06	4.5 E+06	1.2 E+09	6.2 E+08	4.6 E+06	4.5 E+07
^{154}Eu	3.3 E+06	3.3 E+06	8.8 E+08	4.7 E+08	3.3 E+06	3.4 E+07
^{159}Eu	2.3 E+07	2.3 E+07	6.9 E+09	3.7 E+09	2.4 E+07	2.6 E+08
$^{226}\text{Ra}^*$	1.3 E+05	1.3 E+05	2.1 E+05	2.1 E+05	1.3 E+05	1.4 E+05
$^{227}\text{Ac}^*$	2.4 E+03	2.4 E+03	5.4 E+04	2.9 E+04	1.4 E+03	2.1 E+03
$^{232}\text{Th}^*$	2.0 E+04	2.0 E+04	2.0 E+04	2.0 E+04	4.7 E+03	7.1 E+03
$^{235}\text{U}^*$	5.5 E+04	5.5 E+04	1.4 E+05	1.4 E+05	9.9 E+03	1.5 E+04
^{238}U	4.5 E+05	4.5 E+05	4.5 E+05	4.5 E+05	6.7 E+04	1.0 E+05
^{239}U	4.6 E+05	4.6 E+05	4.6 E+05	4.6 E+05	6.9 E+04	1.0 E+05
$^{239}\text{U}^*$	4.9 E+05	4.9 E+05	4.9 E+05	4.9 E+05	7.3 E+04	1.1 E+05
^{235}U	4.9 E+05	4.9 E+05	4.9 E+05	4.9 E+05	7.1 E+04	1.1 E+05
$^{238}\text{U}^*$	4.7 E+05	4.7 E+05	4.7 E+05	4.7 E+05	7.7 E+04	1.2 E+05

Table J-3. Inaccessible Soil Concentration Limits, pCi/g. (2 sheets)

Radionuclide	100-BDKN	100-F, H	200-W	200-E	300 Area	400 Area
²³⁸ U*	4.7 E+05	4.7 E+05	4.7 E+05	4.7 E+05	7.7 E+04	1.2 E+05
²³⁷ Np*	8.9 E+02	8.9 E+02	8.9 E+02	8.9 E+02	8.9 E+02	8.9 E+02
²³⁸ Pu	1.3 E+04	1.3 E+04	8.8 E+05	4.7 E+05	1.3 E+04	3.4 E+04
²³⁹ Pu	1.2 E+04	1.2 E+04	1.2 E+04	1.2 E+04	1.2 E+04	1.2 E+04
²⁴⁰ Pu	1.2 E+04	1.2 E+04	1.4 E+04	1.4 E+04	1.2 E+04	1.2 E+04
²⁴¹ Pu	6.1 E+05	6.1 E+05	4.2 E+07	2.2 E+07	6.1 E+05	1.2 E+06
²⁴¹ Am	2.5 E+04	2.5 E+04	7.4 E+05	4.0 E+05	1.9 E+04	2.8 E+04

Note: Asterisks mark nuclides with progeny that are assumed to be present in equilibrium amounts. However, ²³⁴U was not included in the ²³⁸U limits. For supporting references see WHC-SD-EN-TI-070.

Table J-4. Accessible Soil Concentration Limits, pCi/g. (2 sheets)

Radionuclide	100-BDKN	100-F, H	200-W	200-E	300 Area	400 Area
² H	1.4 E+08	7.4 E+07	3.7 E+08	2.0 E+08	9.5 E+06	1.4 E+07
¹⁴ C	6.2 E+05	6.2 E+05	6.2 E+05	6.2 E+05	6.2 E+05	6.2 E+05
⁵⁵ Fe	5.3 E+05	5.3 E+05	5.3 E+05	5.3 E+05	5.3 E+05	5.3 E+05
⁵⁸ Co	1.8 E+01	1.8 E+01	1.8 E+01	1.8 E+01	1.8 E+01	1.8 E+01
⁶⁰ Co	7.1 E+00	7.1 E+00	7.1 E+00	7.1 E+00	7.1 E+00	7.1 E+00
⁶³ Ni	2.5 E+07	2.5 E+07	2.5 E+07	2.5 E+07	2.5 E+07	2.5 E+07
⁹⁰ Sr*	2.8 E+03	2.8 E+03	2.8 E+03	2.8 E+03	2.8 E+03	2.8 E+03
⁹⁹ Tc	1.0 E+06	1.0 E+06	1.0 E+06	1.0 E+06	1.0 E+06	1.0 E+06
¹⁰⁶ Ru*	7.7 E+01	7.7 E+01	7.7 E+01	7.7 E+01	7.7 E+01	7.7 E+01
¹²⁵ Sb*	3.7 E+01	3.7 E+01	3.7 E+01	3.7 E+01	3.7 E+01	3.7 E+01
¹²⁹ I	1.0 E+04	1.0 E+04	1.0 E+04	1.0 E+04	1.0 E+04	1.0 E+04
¹³⁴ Cs	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01
¹³⁷ Cs*	3.0 E+01	3.0 E+01	3.0 E+01	3.0 E+01	3.0 E+01	3.0 E+01

Table J-4. Accessible Soil Concentration Limits, pCi/g. (2 sheets)

Radionuclide	100-BKN	100-F, H	200-W	200-E	300 Area	400 Area
¹⁴⁴ Ce*	3.3 E+02	3.3 E+02	3.3 E+02	3.3 E+02	3.3 E+02	3.3 E+02
¹⁴⁷ Pm	1.1 E+06	1.1 E+06	1.1 E+06	1.1 E+06	1.1 E+06	1.1 E+06
¹⁵² Eu	1.5 E+01	1.5 E+01	1.5 E+01	1.5 E+01	1.5 E+01	1.5 E+01
¹⁵⁴ Eu	1.4 E+01	1.4 E+01	1.4 E+01	1.4 E+01	1.4 E+01	1.4 E+01
¹⁵⁵ Eu	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02
²²⁶ Ra*	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01
²²⁷ Ac*	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01
²³² Th*	5.9 E+00	5.9 E+00	5.9 E+00	5.9 E+00	5.9 E+00	5.9 E+00
²³² U*	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01	1.0 E+01
²³⁵ U	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02
²³⁵ U	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02	6.3 E+02
²³⁵ U*	1.7 E+02	1.7 E+02	1.7 E+02	1.7 E+02	1.7 E+02	1.7 E+02
²³⁶ U	6.7 E+02	6.7 E+02	6.7 E+02	6.7 E+02	6.7 E+02	6.7 E+02
²³⁸ U*	3.7 E+02	3.7 E+02	3.7 E+02	3.7 E+02	3.7 E+02	3.7 E+02
²³⁷ Np*	4.8 E+01	4.8 E+01	4.8 E+01	4.8 E+01	4.8 E+01	4.8 E+01
²³⁸ Pu	2.1 E+02	2.1 E+02	2.1 E+02	2.1 E+02	2.1 E+02	2.1 E+02
²³⁹ Pu	1.9 E+02	1.9 E+02	1.9 E+02	1.9 E+02	1.9 E+02	1.9 E+02
²⁴⁰ Pu	1.9 E+02	1.9 E+02	1.9 E+02	1.9 E+02	1.9 E+02	1.9 E+02
²⁴¹ Pu	1.0 E+04	1.0 E+04	1.0 E+04	1.0 E+04	1.0 E+04	1.0 E+04
²⁴¹ Am	1.8 E+02	1.8 E+02	1.8 E+02	1.8 E+02	1.8 E+02	1.8 E+02

Note: Asterisks mark nuclides with progeny that are assumed to be present in equilibrium amounts. However, ²³⁴U was not included in the ²³⁸U limits. For supporting references see WHC-SD-EN-TI-070.

APPENDIX K
DATA SUMMARY METHODS

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Measuring any physical quantity has some degree of inherent uncertainty. This uncertainty results from the combination of all possible inaccuracies in the measurements process, including such factors as the reading of the result, the calibration of the measuring device, and numerical rounding errors. In this report, individual radioactive measurements are accompanied by a plus or minus ($\pm$) value, which is the uncertainty term known as a two-sigma counting error.

The two-sigma counting error gives information on what the measurement might be if the same sample were counted again under identical conditions. The two-sigma counting error implies that approximately 95 percent of the time, a recount of the same sample would give a value within plus or minus the two-sigma counting error at the value reported.

Values in the tables that are less than the minimum detectable activity indicate that the reported result might have come from a sample with no radioactivity. Such values are considered below the detection limits of the measuring instrument. Also note that each radioactive measurement must have the random background radioactivity of the measuring instrument subtracted; therefore, negative results are possible, especially when the sample has very little radioactivity.

Reported averages also are accompanied by two standard errors of the mean. If the data fluctuate randomly, the standard error is a measure of the uncertainty in the estimated average of the data because of this randomness. If trends of periodic fluctuation are present, the standard error is primarily a measure of the variability in the trends and fluctuations about the average of the data, rather than a measure of the uncertainty of the estimated average because of random fluctuations in the data.

The mean, $\bar{X}$, is computed as:

$$\bar{X} = \frac{1}{n} \sum_{i=1}^n X_i$$

where X_i is the i th measurement and n is the number of measurements.

The standard error of $\bar{X}$ was computed as:

$$SEM = \sqrt{\left(\frac{S^2}{M} \right)}$$

where $S^2_M^n$, the variance of the n measurements, was computed as:

$$S^2_M^n = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$$

This estimator, $S^2_M^n$, includes the variance among the samples and the counting variance. The estimated $S^2_M^n$ occasionally may be less than the average counting variance.

APPENDIX L
SUBSURFACE MONITORING REPORTS

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APPENDIX L

SUBSURFACE MONITORING REPORTS

This appendix lists site-specific vadose zone monitoring and characterization reports and RCRA/Operational (ROM) groundwater monitoring project and assessment reports. Vadose monitoring reports consist primarily of the borehole gamma logging data reports prepared by Rust Geotech, Inc. for individual tanks in the SX tank farm. Borehole gamma logging results for work conducted by Westinghouse Hanford Company are recorded in Tank Waste Remediation System (TWRS) internal files and or as part of project reports for other customers.

The following document list consists of three parts.

- Vadose monitoring and characterization reports
- RCRA groundwater monitoring annual reports
- Non-RCRA/operational groundwater project reports.

VADOSE MONITORING AND CHARACTERIZATION REPORTS

- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-101*, GJ-HAN-5, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-102*, GJ-HAN-6, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-103*, GJ-HAN-4, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-104*, GJ-HAN-3, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-105*, GJ-HAN-7, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-106*, GJ-HAN-8, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-107*, GJ-HAN-9, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-108*, GJ-HAN-10, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.

- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-109*, GJ-HAN-11, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-110*, GJ-HAN-12, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-111*, GJ-HAN-13, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank T-107*, GJ-HAN-2, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1995, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank T-110*, GJ-HAN-1, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1996, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-112*, GJ-HAN-14, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1996, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-113*, GJ-HAN-15, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1996, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-114*, GJ-HAN-16, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.
- Rust, 1996, *Vadose Zone Characterization Project at the Hanford Tank Farms, Tank Summary Data Report for Tank SX-115*, GJ-HAN-17, prepared by Rust Geotech for the Grand Junction Projects Office, Grand Junction, Colorado.

RCRA GROUNDWATER MONITORING REPORTS

Both quarterly and annual reports are produced for the RCRA groundwater monitoring projects. However, only the annual reports are listed here. Report numbers for the quarterly reports are included in each annual report for the respective report year. The quarterly reports are primarily data reports; the annual reports include interpretive analysis of the data. The annual reports for the last five years are as follows:

- DOE-RL, 1991, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1990*, DOE/RL-91-03, U.S. Department of Energy, Richland Operations Office, Richland, Washington.
- DOE-RL, 1992, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1991*, DOE/RL-92-03, U.S. Department of Energy, Richland Operations Office, Richland Washington.

DOE-RL, 1993, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1992*, DOE/RL-93-09, U.S. Department of Energy, Richland Operations Office, Richland Washington.

DOE-RL, 1994, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1993*, DOE/RL-93-88, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1994*, DOE/RL-94-136, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Annual Report for RCRA Groundwater Monitoring Projects at Hanford Site Facilities for 1995*, DOE/RL-96-01, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

NON-RCRA/OPERATIONAL REPORTS

Groundwater monitoring at active non-RCRA waste water disposal facilities intensified beginning in 1989 and resulted in several site-specific monitoring and assessment project reports and annual reports. All operational groundwater monitoring and related reports generated from 1990 to the present are listed in chronological order as follows:

Johnson, V. G. and B. F. Ford, 1990, *Liquid Effluent Study: Groundwater Characterization Report*, WHC-EP-0366, Westinghouse Hanford Co., Richland Washington.

Rohay, V. J., V. G. Johnson, A. G. Law, B. H. Ford, and K. R. Fecht, 1990, *Liquid Effluent Study Final Project Report*, WHC-EP-0367, Westinghouse Hanford Company, Richland, Washington.

Tyler, D. K., 1991, *A Methodology for Assessing Impacts to Groundwater from Disposal of Liquid Effluent to the Soil at the Hanford Site*, WHC-SD-EN-EV-008, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Peterson, R. E. and V. G. Johnson, 1992, *Riverbank Seepage of Groundwater Along the 100 Areas Shoreline, Hanford Site*, WHC-EP-0609, Westinghouse Hanford Company, Richland, Washington.

Tyler, D. K., 1992, *Assessment of Potential Environmental Impacts from Continued Discharge to the 300 Area Process Trenches at Hanford*, WHC-SD-WM-EE-005, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Tyler, D. K., 1992, *Groundwater Impact Assessment Report for the 400 Area Ponds*, WHC-EP-0587, Westinghouse Hanford Company, Richland Washington.

Reidel, S. P., V. G. Johnson, and N. W. Kline, 1993, *Groundwater Impact Assessment Report for the 216-U-17 Crib, 200 West Area*, WHC-EP-0664, Westinghouse Hanford Company, Richland, Washington.

- Alexander, D. J., 1993, *Groundwater Impact Assessment Report for the 100-D Ponds*, WHC-EP-0666, Westinghouse Hanford Company, Richland, Washington.
- Alexander, D. J. and V. G. Johnson, 1993, *Groundwater Impact Assessment Report for the 1325-N Liquid Waste Disposal Facility*, WHC-EP-0675, Westinghouse Hanford Company, Richland Washington.
- Alexander, D. J., V. G. Johnson, and K. A. Lindsey, 1993, *Groundwater Impact Assessment Report for the 284-WB Powerplant Ponds*, WHC-EP-0679, Westinghouse Hanford Company, Richland, Washington.
- Johnson, V. G., 1993, *Groundwater Impact Assessment Report for the 216-Z-20 Crib, 200 West Area*, WHC-EP-0674, Westinghouse Hanford Company, Richland, Washington.
- Lindberg, J. W., S. D. Evelo, and D. J. Alexander, 1993, *Groundwater Impact Assessment Report for the 216-S-26 Crib*, WHC-EP-0690, Westinghouse Hanford Company, Richland, Washington.
- Chou, C. J., V. G. Johnson, and F. N. Hodges, 1993, *Statistical Application of Groundwater Monitoring Data at the Hanford Site*, WHC-SA-1792-FP, Westinghouse Hanford Company, Richland, Washington.
- Lindsey, K. A. and V. G. Johnson, 1993, *Hydrogeologic Characterization Plan: I. Principal Recharge Zone for the Hanford Site 200 Areas Waste Storage and Disposal Sites, Cold Creek Valley Area, Western Hanford Site*, WHC-SD-EN-AP-133, Westinghouse Hanford Company, Richland, Washington.
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