Diffuse and Fugitive Emission Dose Assessment on the Hanford Site

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EXECUTIVE SUMMARY

On February 3, 1993, the U.S. Department of Energy, Richland Operations Office (RL), received a Compliance Order and Information Request from the Director of the Air and Toxics Division of the U.S. Environmental Protection Agency (EPA), Region 10. The Compliance Order requires RL to (1) evaluate all radionuclide emission points at the Hanford Site to determine which are subject to continuous emission measurement requirements in 40 Code of Federal Regulations (CFR) 61, Subpart H, and (2) continuously measure radionuclide emissions in accordance with 40 CFR 61.93. The Information Request requires RL to provide a written Compliance Plan to meet the requirements of the Compliance Order. RL submitted a Compliance Plan to the EPA, Region 10, on April 30, 1993.

§ The RL Compliance Plan included as one of its milestones the requirement to develop a Federal Facility Compliance Agreement (FFCA). An FFCA was negotiated between RL and the EPA, Region 10, and was entered into on February 7, 1994. One of the milestones was to provide EPA, Region 10, with a copy of the Federal Clean Air Act Title V operating air permit application and Air Emission Inventory (AEI) concurrent with its submission to the Washington State Department of Ecology (FFCA, Appendix A, Section V). The AEI will include an assessment of the diffuse and fugitive emissions from the Hanford Site. This assessment does not identify any diffuse or fugitive emission source that would cause an effective dose equivalent greater than 0.1 mrem/yr.

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DIFFUSE AND FUGITIVE EMISSION DOSE ASSESSMENT ON THE HANFORD SITE

1.0 INTRODUCTION

On December 15, 1989, the U.S. Environmental Protection Agency (EPA) promulgated in the "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities" (40 CFR Part 61, Subpart H). Subpart H requires that the emissions of radionuclides from U.S. Department of Energy (DOE) facilities shall not exceed those amounts that would cause any member of the public to receive an effective dose equivalent (EDE) of 10 mrem/yr. In addition, continuous effluent monitoring is required at facilities that have potential emissions which could result in a dose of greater than 0.1 mrem/yr to a maximally exposed individual (MEI).

To determine compliance, 40 CFR 61.93 provides requirements for monitoring radionuclide emissions from point sources. These monitoring requirements became effective upon promulgation of the regulation on December 15, 1989. Also, the U.S. Department of Energy, Richland Operations Office (RL), as defined in 40 CFR 61, is an "owner or operator" of a "facility," i.e., the Hanford Site. At present, the continuous effluent monitoring systems at some existing facilities on the Hanford Site do not use EPA-approved methods as specified in the regulations.

On February 3, 1993, RL received a Compliance Order and Information Request from the Director of the Air and Toxics Division of the EPA, Region 10 (McCormick 1993). The Compliance Order requires RL to evaluate all radionuclide emission points at the Hanford Site to (1) determine which are subject to continuous emission measurement requirements in 40 CFR 61, Subpart H, and (2) continuously measure radionuclide emissions in accordance with 40 CFR 61.93. The Information Request requires RL to provide a written Compliance Plan to meet the requirements of the Compliance Order. A Compliance Plan was submitted to EPA, Region 10, on April 30, 1993 (Bauer 1993). The Compliance Plan called for developing a Federal Facility Compliance Agreement (FFCA). An FFCA was negotiated between RL and EPA, Region 10, and was entered into on February 7, 1994. The milestones in the FFCA were set to assess all radionuclide emissions. However, the schedule established a priority for the assessments. All stacks registered with the Washington State Department of Health (DOH) were assessed by December 17, 1993 (Davis and Barnett 1994). The unregistered stacks with powered exhaust and the potential to emit radionuclides were assessed by August 31, 1994. The assessment of diffuse and fugitive emissions of radionuclides are to be covered in the Title V air permit application to the Washington State Department of Ecology (Ecology).

This document presents the dose assessment results for the diffuse and fugitive emissions on the Hanford Site. The document does not address passive emissions from point sources with control devices in place. The document also discusses the potential for any diffuse or fugitive emission source to produce an EDE greater than 0.1 mrem/yr to the offsite MEI.

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2.0 SCOPE

The diffuse and fugitive dose assessment of radionuclide emissions was performed for more than 600 sources throughout the entire Hanford Site. In addition, additional air concentration measurements were performed for four of the more heavily contaminated areas (see Schmidt et al. 1995).

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3.0 DIFFUSE AND FUGITIVE EMISSIONS

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 6 percent of land, about 82.9 km² (32 mi²) or 8,090 ha (20,000 acres), is divided into five operational areas: the 100, 200, 300, 400, and 1100 Areas. Radioactive emissions from the Hanford Site are grouped into two categories for regulatory purposes: (1) point source emissions and (2) diffuse and fugitive emissions. Point sources are from stacks with powered exhaust with monitoring systems while the diffuse and fugitive sources are monitored onsite through the Operational (Near-Field) Environmental Monitoring Program (OEMP). Almost all point and diffuse sources of radionuclide emissions are within the five operational areas. The 600 Area designates the land outside these operational areas (two minor point sources are in the 600 Area).

3.1 DIFFUSE AND FUGITIVE EMISSION SOURCES

Among the sources that could contribute diffuse and fugitive radionuclide emissions are waste handling and disposal facilities used at the Hanford Site: cribs, ponds, ditches, trenches, retention basins, valve pits, French drains, reverse wells, tanks, contaminated surfaces, and burial grounds. Operating facilities or facilities on standby or that are inactive also contribute to the diffuse emissions. Table 3-1 shows the types of waste sites and the sources of diffuse and fugitive emissions. A disk containing the Waste Information Data System (WIDS) data base from 1993 is included in this report package. Each site or facility may include structures such as passive vents, risers, equipment access doors, and one personnel access door. Undetected leaks, unburied waste, or an absence of intrusion barriers may contribute to the diffuse sources. Various environmental conditions will affect the diffuse and fugitive emission source term (e.g., changing atmospheric pressures, wind speed, erosion, evaporation, percolation, biotic intrusion, and/or suspension influence rates of diffuse emissions). Appendix A includes an air monitoring study of four of these emission sources.

3.2 TYPES OF SOURCES

Sections 3.2.1 through 3.2.12 briefly describe general types of sites and facilities and the potential primary sources of diffuse and fugitive emissions.

3.2.1 Crib

Cribs are generally subsurface systems, similar to sanitary drain fields, that allow the liquids to percolate into the soil. Low-level radioactive liquid waste is discharged to the ground via these structures. The natural 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 engineered structures such as 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 suspension.

3.2.2 Pond

Ponds are used to manage the large quantities of liquids (i.e., cooling water and chemical-sewer waste water) associated with chemical processing operations. Normally, these liquids are nonradioactive. The ponds allow percolation of the liquids into the soil. Diffuse emissions from ponds are primarily by wind-caused suspension. The only active pond is 216-B-3C.

Table 3-1. Sources of Diffuse Emissions (1993).

Types of diffuse emissions	Total
Cribs*	119
Ponds	29
Ditches	23
Trenches*	96
Retention Basins	17
Diversion Boxes	87
Valve Pits	11
Reverse wells	4
French drains	44
Tanks	151
Burial grounds	42
Total	623

*Cribs and trenches that are located in a contiguous complex, such as those within the BC Cribs and Trenches Area, were recorded as one site, rather than as individual sources.

3.2.3 Ditch

Ditches are open, unlined excavations used for disposing of liquid effluents or for transporting liquid effluents to ponds for disposal. The primary route for diffuse emissions from ditches is wind-caused suspension. The only active ditches are 216-T-1, 216-T-4, and 216-U-14.

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 later replaced with cribs. Diffuse emissions from trenches are primarily the result of erosion, biotic uptake, or intrusion followed by wind-caused suspension.

3.2.5 Retention Basin

Retention basins generally were lined with concrete and used to hold liquids before routing them to ditches, ponds, trenches, or the Columbia River. Diffuse emissions from retention basins are primarily by wind-caused suspension.

3.2.6 Diversion Box

A diversion box is usually an underground, concrete structure formed around a junction of transfer lines carrying liquid effluent. Diffuse emissions from diversion boxes may occur when they are opened for maintenance.

3.2.7 Valve Pit

A valve pit is similar in structure to a diversion box but contains piping valves. The primary source of diffuse emissions from valve pits is when the pit is opened for maintenance.

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 radionuclides from effluent water. Diffuse airborne emissions from French drains and reverse wells could occur from erosion, biotic uptake, or intrusion followed by wind-caused suspension.

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 are typically arrayed in clusters called tank farms. Sources of diffuse emissions from tanks include vents and exhausters that release gaseous effluents directly to the atmosphere, in addition to deposition and suspension of contaminated surface soil in the vicinity of the tanks. A significant proportion of surface soil contamination incidents have common boundaries with the tank farms and associated transfer systems.

3.2.10 Burial Ground

A burial ground is a trench in which contaminated solid waste, generated by various activities on the Hanford Site, is buried. Waste packaging procedures and burial practices depend on the type of waste. Sources of diffuse emissions from burial grounds include direct emission to the atmosphere until the waste is buried, then erosion, biotic uptake, or intrusion followed by wind-caused suspension.

3.2.11 Decontamination and Decommissioning Activities

Westinghouse Hanford Company (WHC) activities also involve decontaminating and decommissioning (D&D) of 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; however, steps to isolate contamination and reduce its spread are taken as the contamination is identified. Sources of diffuse emissions are primarily the result of exposing certain mated contaminated surfaces such as walls and floors; however, planning and procedures minimize these exposures. Monitoring is also increased during decontamination and demolition to detect any increased radioactivity. To date there have been no significant increases in radioactivity as a result of these activities.

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 areas varies. The number is not fixed because there is a continuing effort to clean, stabilize, or remediate known contaminated areas while new areas of contamination are continuing to be identified. Newly identified contamination may be because of preexisting contamination that has migrated to the surface or to surrounding surfaces, by way of wind-caused suspension or biological intrusion, to previously uncontaminated areas. Appendix B contains more information on the OEMP. These areas classified as contaminated may increase if the radiological criteria become more stringent. Approximately 80 percent of all areas of surface contamination are estimated to have dose rates of less than 1 mrem/hr.

Contaminated areas are posted as Surface Contaminated Areas or Radiologically Controlled Areas. Radiologically controlled areas are large areas with a potential for speck contamination (i.e., single grains of soil, rust particles, feces, or pieces of vegetation). Surface contaminated areas include large and small areas with identified contamination. Table 3-3 shows the general location (by area) and the approximate area of surface contamination.

A more detailed description of specific sites and facilities can be found in *Radionuclide Air Emissions Report for the Hanford Site, Calendar Year 1993*, DOE/RL-93-36 (Diediker et al. 1994) and in the facility effluent monitoring plans for major facilities.

Table 3-2. Hanford Site Surface Contamination.

Hanford Site area	Surface contamination ^a , ha (acres)
100 Areas	65 (160)
200 Areas	129 (318)
600 Area	1,063 (2,627) ^b
300 Area (north)	18 (45)
Total	1,275 (3,150)

^aIncludes areas posted as Surface Contaminated Areas or Radiologically Controlled Areas.

^bIncludes BC Radiologically Controlled Area south of the 200 East Area.

4.0 ANNUAL DOSE ESTIMATES FOR DIFFUSE AND FUGITIVE EMISSIONS FOR THE HANFORD SITE

Estimated doses to the public, related to radioactive emissions from both point and diffuse and fugitive sources, were included in the 1993 annual emission report for the Hanford Site (Diediker et al. 1994). Data on diffuse and fugitive emissions were contained in the onsite OEMP results. However, the results were too low to support meaningful dose estimates. Instead, onsite environmental monitoring data were reported simply as the activity of radionuclides detected rather than converting the activity to doses.

In the past, when the Hanford Site was operating at or near full capacity, point source emissions were easily detected. Now, however, emissions from point sources have diminished in most instances to near background levels. The relative importance of diffuse and fugitive emissions has increased with the decrease in the point source emissions. Methodologies for modeling diffuse sources are more difficult than modeling point sources because of complicating factors such as (1) unknown source terms, (2) complex terrain, (3) interference from naturally occurring radionuclides and radionuclides from nuclear fallout (see Figure 4-1), and (4) low detection levels required to measure the sources.

In the annual air emissions report to EPA (Diediker et al. 1994), doses were estimated for emissions from both point and diffuse sources. Dose calculations for each type of emission were provided separately.

4.1 ESTIMATED RADIONUCLIDE AIR EMISSION RELEASES AND RESULTING DOSE TO ANY MEMBER OF THE PUBLIC FROM DIFFUSE AND FUGITIVE EMISSIONS

The potential dose to an offsite individual and the potential releases from diffuse and fugitive emissions were estimated using ambient air monitoring data from locations around the Hanford Site perimeter. The Hanford Site air monitoring network operated by Pacific Northwest Laboratory (PNL) consists of 39 sampling stations: 20 stations located on the site, 10 stations located at the site perimeter, 7 stations in nearby communities, and 2 stations in distant communities (Dirkes et al. 1994). The data used for this analysis were taken during 1993 at six of the perimeter sampling stations located in generally downwind directions (northeast to south) from the Hanford Site and at the distant community stations, which are assumed to be unaffected by airborne effluents from the Hanford Site (Bisping 1994). In addition, WHC operates and maintains an OEMP. As part of that program, radiological ambient air quality measurements for parameters such as gross alpha and gross beta, as well as gamma energy analysis, uranium, plutonium, and strontium on composited filters are performed at 45 additional onsite monitoring stations. With the exception of the one background station, all of the air stations are located in close proximity to waste sites or facilities. In most instances a single air station or group of stations monitors several facilities and waste sites simultaneously. Biweekly gross alpha and gross beta analyses are performed as a screening for contamination before offsite shipment for laboratory analysis, as well as an early indication of unexpected emissions from a source upwind of the sampler. All other analyses are conducted by International Technology (IT) Corporation - Richland Laboratory.

4.1.1 Methods for Assessing Diffuse and Fugitive Emissions

The Hanford Site has elected to use environmental monitoring data collected at the Hanford Site perimeter to estimate the dose from diffuse and fugitive emissions. This method was chosen in preference to other possible methods because Hanford Site perimeter data most accurately represent the actual dose to an offsite individual and because information about the extent and levels of soil contamination on the Hanford Site is currently insufficient to use suspension and dispersion models. The ambient air sampling results consisted of annual average air concentrations for radionuclides that may be released from Hanford Site operations and diffuse sources, including tritium, iodine (^{129}I , ^{131}I), and particulates (^{90}Sr , ^{60}Co , $^{106}\text{Ru}/^{106}\text{Rh}$, ^{134}Cs , $^{137}\text{Cs}/^{137\text{m}}\text{Ba}$,

^{238}Pu , $^{239,240}\text{Pu}$, and uranium isotopes). The naturally occurring radionuclides ^7Be and ^{40}K were also analyzed in particulate samples. Tritium, iodine, and uranium were only sampled at selected locations, and in one case particulate samples for two perimeter stations in the same general vicinity were composited for radioanalysis in order to obtain more accurate counting statistics. Air concentrations measured for composite samples were assigned to the location that would be expected to have the lowest concentration to avoid underpredicting estimated releases from diffuse sources.

Radionuclide air concentrations resulting from 1993 stack emissions were calculated for each of the selected perimeter sample locations using the CAP88-PC code (Parks 1992). The combined contributions to airborne radionuclide levels from all operating areas were subtracted from the ambient monitoring results. The reference regional background level of each radionuclide was assumed to be equal to the average air concentration measured at distant community sampling stations in Yakima and Sunnyside, Washington. The average background concentration at these stations was also subtracted from the ambient monitoring results at perimeter stations in order to estimate the potential contribution from diffuse source emissions.

4.1.2 Results of Diffuse-Source Evaluation

During 1993, the annual average ambient air concentrations at downwind perimeter sampling stations were found to be numerically greater than the combined contributions from monitored stack releases and background for several radionuclides, including ^{90}Sr , ^{106}Ru , ^{129}I , ^{137}Cs , ^{235}U , ^{238}U , ^{238}Pu , $^{239,240}\text{Pu}$, and ^{241}Am . However, these perimeter concentrations are not statistically different from those measured at the distant community stations that are unaffected by Hanford Site effluents (Dirkes et al. 1994). Although concentrations of other radionuclides were greater than would be expected from stack releases and background at one or more individual monitoring stations, the average corrected concentrations for those nuclides over all evaluated perimeter stations were less than zero.

Releases from diffuse and unmonitored sources were estimated from the corrected average air concentrations by performing a back calculation using CAP88-PC (Parks 1992). The 200 West Area was assumed to be the source of diffuse emissions for all radionuclides, which results in the highest release estimate. The diffuse source releases reported in Table 4-1 represent the mean of the release estimates for each of the selected downwind perimeter locations at which a particular radionuclide was sampled. In accordance with guidance from DOE headquarters, the average release estimates for diffuse sources were calculated using air concentrations that were both positive and negative with respect to the regional background and stack emission estimates. Where the resulting mean release estimate reported in Table 4-1 for an individual radionuclide is less than zero, it indicates that the average of the monitored air concentrations at the downwind perimeter stations was numerically smaller than the combined concentrations expected as a result of stack emissions and regional background. For these cases, the diffuse sources did not contribute significantly to the offsite measured air concentrations.

During the past 4 years, no radionuclide detected by the offsite monitoring system exceeded the concentration expected from monitored point sources and natural background. However, results for several radionuclides indicated potential emissions from diffuse sources during 3 of the 4 years, including tritium, ^{90}Sr , ^{106}Ru , ^{137}Cs , and total uranium.

The estimated diffuse source releases for the sampled radionuclides were also used to estimate the dose at the Prosser Barricade station, the downwind perimeter sampling station with the highest air concentrations, and at the Byers Landing station, which is closest to the Sagemore Road location selected for the Hanford Site's MEI from stack emissions. The 1993 results in Table 4-1 indicate that the hypothetical mean doses to individuals at these locations were .049 mrem/yr at the Prosser Barricade location and 0.028 mrem/yr at the Byers Landing location. Where the release estimate for a particular radionuclide was numerically less than zero, the dose estimate for that nuclide was set equal to zero before summing the contributions of all radionuclides to obtain the total dose at each location. Although the estimated dose from diffuse sources at the Sagemore Road location is somewhat higher than the dose from point sources, the combined dose from stack emissions and diffuse and unmonitored sources during 1993 was substantially below the 10 mrem/yr standard.

Figure 4-1. Monthly Average Gross Beta Radioactivity in Airborne Particulate Samples, 1981 through 1991 (Woodruff et al. 1992).

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Over the past 4 years, the total dose assessment to the offsite MEI from all site sources was less than 2 percent of the 10 mrem/yr standard. Of that total, the dose from diffuse sources ranged from 0.028 to 0.12 mrem/yr, whereas the dose from stack sources was between 0.0037 and 0.016 mrem/yr.

4.1.3 Estimate of Uncertainty in Dose from Diffuse Sources

In order to estimate the uncertainty in dose estimates at the Hanford Site perimeter, the reported 1993 air concentrations at the Byers Landing sampling station and at the distant community stations were used to estimate the mean and 95 percent confidence intervals for each location. This analysis employed the uncorrected air concentrations at the reference locations, including the contributions from stack releases, diffuse sources, and regional background. The Byers Landing station was selected for this analysis because it is closest to the location of the Hanford Site MEI at the Sagemore Road farm and also was the only perimeter station at which all radionuclides were reported. The calculation was performed using the GENII-S computer code (Leigh et al. 1992) to produce a stochastic analysis of the environmental radiation doses. The mean values of the measured air concentrations were input as basic concentrations along with the maximum and minimum sample values to define a triangular distribution for each radionuclide. To obtain the dose distribution for each location, the code used a Latin hypercube sampling routine to select random values for each radionuclide concentration in 100 trials.

The estimated mean dose at the Byers Landing station was 0.14 mrem/yr for artificially produced radionuclides sampled at that location, with a 95 percent confidence interval of 0.095 to 0.19 mrem/yr. The corresponding result for the distant community monitoring stations was 0.072 mrem/yr with 95 percent confidence limits of 0.0 to 0.17 mrem/yr. Although the mean dose estimate at the site perimeter was somewhat higher than that at the distant community stations, the upper 95 percent confidence limits are similar. These results are consistent with those from the previous 3 years, when the estimated mean dose to the offsite MEI was between 0.083 and 0.17 mrem/yr (95 percent upper confidence limits 0.13 to 0.23 mrem/yr) and the mean

dose at the reference background location was 0.03 to 1.2 mrem/yr (95 percent confidence limits 0.11 to 2.5 mrem/yr). Because the measured dose at perimeter stations was almost entirely a result of background radioactive materials (naturally occurring radionuclides and fallout), the estimated diffuse source component was a relatively small fraction of the total. The 95 percent confidence interval for the dose from diffuse sources would therefore be a fraction of that for the total dose at these locations.

4.2 DISCUSSION

Release estimates for diffuse and fugitive emissions in Table 4-1 were obtained using the CAP88-PC code package (Parks 1992). This code incorporates a continuous release gaussian plume dispersion model. Releases from diffuse sources would be expected to occur primarily under conditions that are very different from the annual average assumptions used in the CAP88-PC model. This is particularly true for suspension of contaminated soil and, to some extent, for emissions from sources such as evaporation ponds, which are a function of the wind speed. Because release rates from such sources are greatest under conditions that favor atmospheric dispersion, use of an annual average continuous release model to back calculate the release quantities may introduce a significant bias in these estimates. The dose estimates for sources of this type may also be affected by seasonal variation in the suspension rates due to prevalence of strong winds during certain seasons of the year. If these episodes occur primarily during times when crop production is minimal, some of the exposure pathways incorporated into the CAP88-PC code (e.g., direct deposition on human and animal food crops) would not be applicable. The release and dose estimates reported for diffuse sources in this evaluation should therefore be viewed as approximations whose accuracy is limited by a number of factors inherent in the sampling and modeling process.

Table 4-1. Estimated 1993 Hanford Site Diffuse Emissions and Resulting Dose.^a

Location		Byers Landing (closest to MEI location)	Prosser Barricade (highest air concentrations)
Radionuclide	Diffuse source estimated release from 200 Areas ^b (Ci/yr) ^d	Estimated dose at location ^c (mrem/yr) ^d	Estimated dose at location ^c (mrem/yr) ^d
³ H	-9.3E+01	0.0E+00	0.0E+00
⁶⁰ Co	-7.8E-02	0.0E+00	0.0E+00
⁹⁰ Sr	6.2E-03	2.6E-04	4.4E-04
¹⁰⁶ Ru	8.5E-01	4.8E-03	8.3E-03
¹²⁹ I	3.3E-02	6.6E-04	1.4E-03
¹³¹ I	-6.2E+01	0.0E+00	0.0E+00
¹³⁴ Cs	-1.2E-01	0.0E+00	0.0E+00
¹³⁷ Cs/ ^{137m} Ba	9.7E-02	8.5E-03	1.4E-02
²³⁴ U	-1.3E-04	0.0E+00	0.0E+00
²³⁵ U	2.1E-03	2.3E-03	4.0E-03
²³⁸ U	6.9E-03	7.0E-03	1.2E-02
²³⁸ Pu	2.8E-05	7.9E-05	1.4E-04
^{239,240} Pu	2.3E-04	6.9E-04	1.2E-03
²⁴¹ Am	8.3E-04	3.9E-03	6.7E-03
Total		2.8E-02	4.9E-02

^aDose factor includes ingestion, inhalation, air submersion, and external exposure to radionuclides on ground.

^bEmissions from diffuse sources assumed to originate in the Hanford Site 200 Areas, except for uranium. The 300 Area also has potential sources for suspension of uranium from soil, in addition to naturally occurring uranium isotopes found throughout the area. Because it was not possible to determine the source of uranium isotopes detected at offsite sample stations, the releases were modeled as if the total inventory were from the 200 Areas.

^cDose is based on air monitoring results for sample stations downwind, generally east and south, of the Hanford Site. The measured air concentrations for these locations are corrected for estimated contributions from stack releases and regional background levels of monitored radionuclides. Doses that are reported as being <0 result from air monitoring results that are below the detection limit or for which the monitoring results are lower than the contributions from stack releases and background.

^d1 Ci = 3.7E+10 Bq; 1 mrem = 1.0E-02 mSv.

MEI = maximally exposed individual.

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5.0 DISCUSSION OF RESULTS

The results of the diffuse and fugitive emission assessment based on an annual assessment has shown the dose from all sources to be less than 0.1 mrem/yr. In addition, the operational environmental monitoring stations on site provides an early detection of increased emissions on the Hanford Site. Finally, radiological surveys provide periodic confirmatory measurements for determining the spread of surface radiological contamination.

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6.0 REFERENCES

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APPENDIX A

**DIFFUSE AND FUGITIVE EMISSIONS FROM
FOUR SOURCES ON THE HANFORD SITE**

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DIFFUSE AND FUGITIVE EMISSIONS FROM FOUR SOURCES ON THE HANFORD SITE

Four diffuse and fugitive emission sources were studied during 1994: 234-5Z, 241-BY, 1301-N, and 316-5 Trenches and 316-2 Pond. These sites were selected from the more than 1,000 source points identified in the Waste Information Data System (WIDS) data base. The four sites were identified among the highest areas of surface contamination on the Hanford Site (see Schmidt et al. 1995).

A.1 SITE DESCRIPTIONS

The sites were chosen as being representative of most of the Hanford Site waste sites, which are known to be diffuse emission sites. The sites were evaluated on the following criteria: physical size, surface contamination levels, geology, vegetation density, surface cover, potential for occupational exposure, and potential for public exposure. The selected sites vary greatly with the selection criteria parameters and as a result should provide representative data for most of the Hanford Site waste sites (see Table A-1).

Air samples were collected during the months of June, July, and August. All ambient samples were submitted to the 222-S Analytical Laboratory's routine air filter sample analysis program for an initial nondestructive analysis. The 222-S Analytical Laboratory performed nondestructive gross alpha and gross beta analyses on all samples. The wind data taken near the sites were used to determine which samples are downwind and upwind samples.

When sampling at a specific waste site or facility was completed, the ambient air samples were composited as deemed necessary and submitted to International Technology (IT) Corporation - Richland Laboratory for isotopic analyses. Upon receipt of the analyses the airborne concentrations of radionuclides will then be calculated for each sampling period and location.

The test locations are predominately contaminated with isotopes of ^{60}Co , ^{137}Cs , and ^{90}Sr . Other radiological contaminants may include: ^{134}Cs , ^{154}Eu , ^{155}Eu , ^{129}I , ^{210}Pb , ^{212}Pb , ^{214}Pb , ^{238}Pu , $^{239/240}\text{Pu}$, ^{226}Ra , ^{106}Ru , ^{125}Sb , ^{235}U , and ^{238}U . Contamination levels at several locations within some of the waste sites exceed 1×10^6 dpm/100 cm^2 for beta and gamma emissions as indicated by the most recent radiological surveys.

A.1.1 234-5Z FACILITY (PLUTONIUM FINISHING PLANT)

The Plutonium Finishing Plant (PFP) is located in the western end of the 200 West Area. This facility is used to recover, stabilize, and store plutonium and has been on standby since 1992. Plutonium nitrate solutions from the PUREX Plant are reduced to plutonium oxide or plutonium metal. Radionuclides primarily associated with PFP include $^{239,240}\text{Pu}$, ^{241}Pu , and ^{241}Am . Potential diffuse emission release points from PFP include inlet-exhaust ventilation systems, access doors, and outdoor contamination areas.

In addition to the main structure, 234-5Z, PFP comprises many small support structures. 234-5Z and most of its support structures have potential for diffuse emissions. Figure A-1 contains a detailed map of PFP with its support structures. Sparse vegetation surrounds the plant and its support structures. Surface contaminated soil is covered by gravel.

Table A-1. Sites Selected to Evaluate Emissions from Diffuse Sources.

Site	Size	Contamination	Geological Description	Vegetation Density	Surface Cover	Population Exposure Occupational ¹	Population Exposure Public ¹
Plutonium Finishing Plant	M	Low	Flat	Low	Sand/grass/brush/cobble	Low	Low
241-BY Tank Farm	S	High	Flat	None	Medium gravel	High	Low
1301-N Trench	M	High	Hilly	High	Sand/grass/little brush	Medium	Medium
316-5 Trenches and 316-2 Pond	XL	Medium (isolated high)	Partially below grade	Medium/high	Sand/grass/brush/cobble	Medium	Medium/high

¹These comparisons are relative to other waste sites existing on the Hanford Site. The dose to the public due to all of the waste sites combined is very low (0.05 mrem/yr).

Figure A-1. Plutonium Finishing Plant Detailed Map.

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Air sampling results are shown in Table A-2. Meteorological data taken during the air sampling were analyzed for the 357 hours of sample and the results are shown in Table A-3. An analysis of the wind data indicated that sampler N190 was downwind approximately 22.6 percent of the time while the upwind sampler N191 was upwind 92 percent of the time. $^{239/40}\text{Pu}$ data indicated that the downwind sampler had a higher air concentration. CAP88-PC modeling indicated that the measured air concentrations were two orders of magnitude below air concentrations needed to cause an offsite dose of 0.1 mrem/yr to the MEI.

Figure A-2 shows the wind roses of the winds during the study.

Table A-2. Plutonium Finishing Plant Air Concentrations (pCi/m³)*.

Site	^{238}Pu	$^{239/240}\text{Pu}$
N190	8.8E-7 (5.7E-6)	2.0E-4 (4.2E-5)
N191	4.5E-7 (5.4E-6)	3.6E-5 (1.5E-5)
N190-N191	4.3E-7	1.6E-4

*The values in parenthesis represent the $\pm 95\%$ confidence limits.

A.1.2 241-BY TANK FARM

The 241-BY Tank Farm is located inside the northern boundary of the 200 East Area. The underground tanks contain liquid wastes from chemical processing operations, which contain high concentrations of radionuclides. Surface contamination levels in the 241-BY Tank Farm range into the millions of dpm/100 cm² gross beta/gamma. The predominant isotopes in 241-BY include ^3H , ^{14}C , ^{90}Sr , ^{125}Sb , ^{137}Cs , $^{239,240}\text{Pu}$, and ^{241}Am . Diffuse emission release locations include surface contamination areas, vents, risers, access hole covers, inlet-exhaust ventilation systems, diversion boxes, transfer lines, and storage vaults.

The surfaces of the 241-BY Tank Farm are generally flat. The surface contamination area is vegetation free, has many small obstructions, and a few buildings. The entire tank farm surface is covered with stone, which is partially mixed with sand. Figure A-3 provides a detailed map of the 241-BY Tank Farm.

The 241-BY Tank Farm was selected because of the documented levels of surface contamination with cesium. Five samplers were used to monitor diffuse emissions from the farm (see Figure A-3.) Samples were taken over a period of 8 days. Vegetation at the tank farm is nonexistent with gravel covering the areas of surface contamination.

The air sampling results are shown in Table A-4. Meteorological data were analyzed for the 216 hours of sampling (Table A-5 and wind rose in Figure A-4). The wind data indicated that N413 and N414 were downwind approximately 60 percent of the time while N416 and N417 were upwind approximately 84 percent of the time. N416 and N417 samples were chosen to represent the upwind samplers. An examination of the air concentrations compared to the combined error revealed two samples slightly higher than background for ^{137}Cs : N414 and N416. CAP88-PC modeling indicates the measured air concentrations are 4 orders of magnitude below what is needed to produce an offsite dose of 0.1 mrem/yr to the MEI for both ^{137}Cs and ^{90}Sr .

Table A-3. Wind Direction and Speeds During Measurements.

Station: (19) PFP

Begin: 5/24/94

End: 6/7/94

Total Hours: 357

DIRECTION																		
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	SSW	W	WNW	NW	NNW	CALM	TOTAL
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.1
1-3	1.6	0.8	0.4	0.4	0.5	0.9	1.2	0.4	0.6	0.8	1.4	2.6	3.6	3.6	3.5	0.4	0.0	22.7
4-7	3.2	1.3	1.6	1.2	1.6	0.7	2.7	0.4	0.3	0.5	2.3	2.7	4.1	7.8	6.8	3.6	0.0	40.9
8-12	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.7	0.3	0.5	4.2	6.8	5.0	1.3	6.3	2.0	0.0	27.5
13-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.2	3.0	0.3	0.0	2.6	0.4	0.0	7.8
19-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32-38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39-46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	5.0	2.1	2.0	1.6	2.1	1.6	3.9	1.6	1.2	2.1	9.1	15.1	13.1	12.7	19.2	6.4	1.1	100.0

Figure A-2. Wind Rose.

Wind Rose

Period: 5/24/94 - 6/7/94

A.1.3 1301-N TRENCH

The 1301-N Trench is located at the northeast corner of the 100-N Area. The trench received radioactive water containing activation and fission products along with small quantities of corrosive liquids and laboratory chemicals. The trench received radioactive effluent streams from 105-N and 109-N at an average flow rate of 1,500 gal/min (950 l/s). These effluents to the trench ceased in 1985. Potential diffuse emissions are produced solely from suspension.

The 1301-N Trench is a 1,725-ft long (525 m) and 50-ft wide (15 m) rectangular basin covered with concrete slabs. The surrounding terrain is extremely uneven and hilly. Figure A-5 provides a detailed map of the 1301-N Trench. The 1301-N Trench was selected for two reasons. The first is that the contamination of ^{60}Co is the highest on the site for this radionuclide, and it is closest to general public access to the Columbia River. Five samplers were used to monitor diffuse emissions from the ditch (see Figure A-5.) Samples were taken from July 4 to July 18, 1994. The vegetation near the ditch is sparse grass and sagebrush.

The air monitoring results are shown in Table A-6. Meteorological data were analyzed for the 360-hours sample period and the results are shown in Table A-7 (wind rose is shown in Figure A-6). The mean winds indicated that the upwind sampler, N422, was upwind approximately 85 percent of the time. The rest of the samplers were assumed to be downwind samplers ranging up to 50 percent of the time downwind. The sampler N418 ^{137}Cs air concentration was approximately twice the combined error but only slightly higher than background. The air concentrations for ^{60}Co for N419 and N420 were also above the combined error and only slightly above background. Sampler N420 air concentration for ^{134}Cs was also slightly higher than background. CAP88-PC modeling of the average air concentrations required to produce a dose of 0.1 mrem/yr to the MEI indicates that the air concentrations measured are 2 orders of magnitude less than what is needed.

Figure A-3. 241-BY Tank Farm Samplers.

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Table A-4. 241-BY Tank Farm Air Concentrations (pCi/m³).*

Site	¹³⁷ Cs	^{239/40} Pu	²³⁸ Pu	⁹⁰ Sr	²³⁴ U	²³⁵ U	²³⁸ U
N412	5.8E-4 (2.6E-3)	-3.3E-7 (1.5E-5)	-1.3E-5 (1.4E-5)	5.8E-6 (4.8E-4)	2.3E-6 (8.9E-5)	2.0E-5 (4.4E-5)	-7.3E-5 (4.7E-5)
N413	1.7E-3 (2.2E-3)	-1.3E-5 (1.6E-5)	-2.7E-6 (1.3E-5)	9.5E-5 (5.1E-4)	-5.6E-5 (7.7E-5)	-1.1E-5 (1.3E-5)	-6.8E-5 (5.8E-5)
N414	6.0E-3 (4E-3)	2.3E-6 (9.9E-6)	-6.2E-6 (5.4E-6)	1.3E-4 (5.3E-4)	3.1E-5 (1.0E-4)	1.1E-6 (4.9E-5)	1.4E-5 (8.5E-5)
N415	2.4E-3 (2.7E-3)	1.1E-5 (1.6E-5)	-4.5E-6 (4.2E-6)	-1.2E-4 (4.7E-4)	-8.4E-5 (7.5E-5)	3.9E-5 (6.4E-5)	-5.5E-5 (6.4E-5)
N416	2.9E-3 (2.5E-3)	3.6E-6 (8.4E-6)	-6.6E-6 (8.1E-6)	3.2E-5 (5.1E-4)	-6.3E-5 (7.0E-5)	1.9E-5 (4.3E-5)	-6.9E-5 (4.5E-5)
N417	1.8E-3 (2.9E-3)	-3.3E-7 (1.5E-5)	-7.6E-6 (1.0E-5)	-1.6E-4 (4.5E-4)	-2.4E-5 (8.0E-5)	-1.2E-5 (1.2E-5)	-3.9E-5 (6.4E-5)

The values in parenthesis represent the $\pm 95\%$ confidence limits.

Figure A-4. Wind Rose.

Wind Rose

Period: 6/13/94 - 6/21/94

Table A-5. Wind Direction and Speeds During Measurements.

Station: (6) 200E
Begin: 6/13/94

End: 6/21/94

Total Hours: 216

DIRECTION																			Total Hours: 216	
	N	NNE	NE	NNE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	TOTAL		
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
1-3	0.3	0.6	1.1	1.3	1.3	0.0	0.0	0.5	0.5	0.4	1.0	0.6	1.5	1.2	0.9	0.5	0.0	11.6		
4-7	3.3	1.1	3.0	1.5	0.6	1.0	1.0	0.5	0.9	0.0	0.7	1.8	1.1	5.9	4.5	4.2	0.0	31.0		
8-12	0.6	0.8	0.1	0.0	0.0	1.7	0.2	1.0	0.6	0.6	0.4	4.9	6.9	8.8	3.2	2.5	0.0	32.4		
13-18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.8	0.0	1.0	0.8	0.8	10.2	2.9	0.0	0.0	17.1		
19-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.1	0.6	0.0	0.0	0.0	2.8		
25-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	4.4	0.6	0.0	0.0	0.0	0.0	5.1		
32-38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
39-46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
> 46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
TOTAL	4.2	2.5	4.2	2.8	1.9	2.7	1.2	2.5	2.8	1.0	3.3	13.5	11.9	26.8	11.5	7.1	0.0	100.0		

Figure A-5. 1301-N Trench Samplers.

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Table A-6. 1301-N Trench Air Concentrations (pCi/m³).*

Site	⁶⁰ Co	¹³⁴ Cs	¹³⁷ Cs	⁹⁰ Sr
N418	-2.2E-4 (1.4E-3)	-9.6E-4 (1.5E-3)	3.0E-3 (1.6E-3)	2.4E-5 (3.3E-4)
N419	1.6E-3 (1.3E-3)	-6.7E-4 (1.8E-3)	-1.1E-3 (1.9E-3)	1.4E-4 (3.0E-4)
N420	2.7E-3 (1.9E-3)	2.3E-3 (1.9E-3)	7.9E-4 (2.0E-3)	-1.3E-4 (3.6E-4)
N421	1.7E-3 (2.1E-3)	5.3E-4 (1.6E-3)	-1.4E-3 (1.7E-3)	4.4E-5 (3.1E-4)
N422	-3.5E-3 (3.5E-3)	-3.5E-4 (1.9E-3)	6.5E-4 (2.1E-3)	1.6E-4 (3.6E-4)

*The values in parenthesis represent the $\pm 95\%$ confidence limits.

A.1.4 316-5 TRENCHES AND 316-2 NORTH PROCESS POND

The 316-5 Trenches and 316-2 North Process Pond are part of operable unit 300-FF-1 and are located at the north end of the 300 Area. The 316-5 Trenches received wastes containing radioactive material from the 300 Area Process Sewer System. The 316-2 North Process Pond received low-level radioactive wastes and cooling water from the 3706 and 321 Buildings, along with aqueous wastes containing unirradiated uranium from the Hot Semi-Works Laboratory and 303 Building. Potential diffuse emissions are produced solely from suspension.

The 316-5 Trenches are two north and south oriented trenches, which are 1.8 m (6 ft) apart. Each trench is 468 m (1,535 ft) long, 3 m (10 ft) wide, and 3.7 m (12 ft) deep, with a side slope of 1:1.5.

The 316-2 North Process Pond consists of seven different subsections separated by 3.7-m (12-ft) wide dikes. The pond occupies an area of approximately 40,000 m² (10 acres) and is surrounded by a 3-m (10-ft) high and 4.6-m (15-ft) wide dike.

The area around the 316-5 Trenches and 316-2 North Process Pond is partially below grade and contains a medium to high vegetation density. The soil in the area consists of a sand and cobble mixture. Figure A-7 provides a detailed map of the 316-5 Trenches and 316-2 North Process Pond.

The 316-5 Trenches and the 316-2 North Process Pond were selected for two reasons: the presence of uranium tailings from the 300 Area fuel fabrication facilities and the proximity of the trenches and pond to the general public. Five samplers were used to monitor diffuse emissions from the ditch (see Figure A-7). Samples were taken over a period of 358 hours. The vegetation in and near the trenches and pond is sparse grass and sagebrush.

The air monitoring results are shown in Table A-8. Meteorological data were analyzed for the period of sample and the results are shown in Table A-9 (wind rose is provided in Figure A-8). The mean winds indicated that the downwind samplers (N428, N429, and N430) were downwind approximately 60 percent of the time. CAP88-PC modeling of the air concentrations required to produce a 0.1 mrem/yr dose to the offsite MEI are approximately 2 orders of magnitude larger than the measured air concentrations.

Table A-7. Wind Direction and Speeds During Measurements.

Station: (13) 100N

Begin: 7/4/94

End: 7/18/94

Total Hours: 360

DIRECTION																		
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	TOTAL
CALM	.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
1-3	2.4	0.9	2.2	1.6	2.8	1.8	0.3	1.0	0.9	0.3	0.6	0.8	0.8	1.7	1.4	2.6	0.0	21.9
4-7	1.8	1.8	1.4	1.2	1.6	1.9	3.2	0.1	1.1	1.5	1.7	4.8	7.9	3.6	3.4	3.6	0.0	40.6
8-12	0.0	0.3	1.8	0.2	0.3	2.1	1.9	0.2	0.0	0.0	0.2	4.6	5.9	4.8	2.9	0.0	0.0	25.0
13-18	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.0	0.0	0.0	0.0	0.0	1.0	5.3	1.0	0.0	0.0	8.3
19-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	1.7	0.0	0.0	3.6
25-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3
32-38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39-46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
> 46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	4.2	2.9	5.3	3.0	4.6	6.3	6.0	1.3	2.1	1.8	2.6	10.1	15.4	17.5	10.4	6.2	0.3	100.0

Figure A-6. Wind Rose.

Wind Rose

Period: 7/4/94 - 7/18/94

When the mean winds were analyzed, N423 and N431 were upwind between 85 percent and 90 percent of the time. Analysis of the data only revealed two samples slightly above the combined error: N424 for ^{234}U and N429 for ^{238}U . Both of these samples were at background levels.

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Figure A-7. 316-5 Trenches and 316-2 North Process Pond Detailed Map.

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Table A-8. 316-5 Trenches and 316-2 North Process Pond
Air Concentrations (pCi/m³).*

Site	²³⁴ U	²³⁵ U	²³⁸ U
N423	6.1E-5 (8.2E-5)	1.7E-6 (3.6E-5)	1.2E-5 (5.8E-5)
N424	8.0E-5 (7.9E-5)	2.2E-5 (4.3E-5)	4.1E-5 (6.4E-5)
N425	2.5E-5 (6.9E-5)	2.0E-5 (3.4E-5)	2.8E-5 (5.8E-5)
N426	2.7E-6 (6.2E-5)	-2.4E-6 (2.1E-5)	3.8E-5 (6.5E-5)
N427	-1.8E-5 (4.7E-5)	2.7E-5 (3.1E-5)	-9.0E-6 (4.3E-5)
N428	-4.2E-6 (5.5E-5)	2.1E-5 (3.7E-5)	1.1E-6 (4.9E-5)
N429	3.7E-5 (5.7E-5)	4.0E-6 (2.1E-5)	5.9E-5 (5.6E-5)
N430	6.0E-5 (6.5E-5)	1.6E-5 (2.6E-5)	2.8E-5 (5.0E-5)
N431	1.8E-5 (5.4E-5)	2.6E-6 (1.4E-5)	4.6E-5 (5.6E-5)
N432	3.0E-6 (4.3E-5)	3.5E-7 (1.1E-5)	1.0E-5 (4.1E-5)

*The values in parenthesis represent the $\pm 95\%$
confidence limits.

Table A-9. Wind Direction and Speeds During Measurements.

Station: (11) 300A
Begin: 7/25/94

Total Hours: 358

End: 8/8/94

DIRECTION																		
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	CALM	TOTAL
CALM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
1-3	0.3	0.3	0.7	0.9	1.3	0.9	1.0	0.6	0.2	0.5	1.4	0.3	0.6	1.6	0.4	1.3	0.0	12.3
4-7	0.4	0.6	0.4	2.8	4.5	7.9	10.9	4.7	6.2	4.1	1.1	1.0	0.4	0.7	0.1	1.1	0.0	46.9
8-12	1.6	1.6	0.9	1.0	1.6	2.0	4.7	0.8	3.1	5.2	4.1	1.6	0.4	0.3	0.8	0.1	0.0	29.9
13-18	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.4	3.2	1.5	0.7	0.9	0.2	0.7	0.4	0.0	8.7
19-24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.2	0.0	0.0	0.0	0.0	0.0	0.0	2.0
25-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32-38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39-46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	2.5	2.7	2.1	4.7	7.4	10.8	16.6	6.1	9.9	13.7	9.2	3.6	2.4	2.8	2.1	3.0	0.3	100.0

Figure A-8. Wind Rose.

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APPENDIX B**OPERATIONAL (NEAR-FACILITY) ENVIRONMENTAL MONITORING**

Several types of environmental media are sampled near nuclear facilities to monitor the effectiveness of waste management and effluent treatment and control practices. These media include air, surface water and seeps, surface contamination, soil and vegetation, investigative sampling (which can include wildlife), and external radiation.

B.1 NEAR-FACILITY ENVIRONMENTAL MONITORING AT THE HANFORD SITE

Near-facility environmental monitoring is defined principally as routine monitoring near facilities that discharge, or have discharged, radioactive or hazardous contaminants. The monitoring locations are associated mostly with major nuclear facilities, such as the PUREX Plant and N Reactor, and waste disposal facilities (e.g., burial grounds, tank farms, ponds, cribs, trenches, and ditches).

Much of the 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, 5484.1, 5400.5, and 5820.2A, and 10 CFR 835.

Monitoring activities routinely include sampling and monitoring near-facility ambient air, water from surface-water disposal units, external radiation dose, soil, sediment (both surface and core), vegetation, and animals. Some of the parameters typically monitored are pH, radionuclide concentrations, external radiation exposure rates, and concentrations of other potentially hazardous constituents. Samples are collected in known or expected effluent pathways, which generally are downwind of potential or actual airborne releases and downgradient of liquid discharges.

Waste disposal sites and the terrain surrounding them are surveyed to detect and characterize any radioactive surface contamination. The location of these surveys include cribs, trenches, retention basin perimeters, pond perimeters, ditch banks, solid waste disposal sites (e.g., burial grounds and trenches), unplanned release sites, tank farm perimeters, stabilized waste disposal sites, roads, and firebreaks in and around the Hanford Site operational areas. In 1993, radiological surveys were conducted at 411 sites in the operational areas (100 surveys in the 100 Areas; 297 surveys in the 200 and 600 Areas; and 14 surveys in the 300 and 400 Areas).

B.2 AIR MONITORING

Near-facility air sampling monitors 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. In 1994, radioactivity in air was sampled by a network of continuously operated samplers at 45 locations near nuclear facilities: 4 samplers in the 100-K Area, 4 samplers in the 100-N Area, 35 samplers in the 200/600 Areas, 2 background stations collocated with samplers operated by the Surface Environmental Surveillance Project and the Washington Department of Health at the Wye and Yakima Barricades, and 1 background station collocated with a sampler operated by the Washington Department of Health at the old Hanford townsite. To avoid duplication of sampling, the near-facility environmental monitoring program used existing Surface Environmental Surveillance Project air samplers in the 300 and 400 Areas.

Air samplers were primarily located at or near (approximately 500 m or ~1600 ft) sites and/or facilities having the potential for, or history of, release, with an emphasis on the prevailing downwind directions.

Samples were collected according to a schedule established before the monitoring year. Airborne particles were sampled at each of these stations 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, and 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 a biannual composite for each location. Each biannual composite was then sent to International Technology (IT) Corporation, Inc. (Richland, Washington) to be analyzed for strontium, plutonium, uranium, and gamma-emitting radionuclides.

B.3 SURFACE-WATER DISPOSAL UNITS AND SEEP MONITORING

Surface-water disposal units (open ponds and ditches) used by the operating facilities, and seeps, are monitored to assess the effectiveness of effluent and contamination controls.

Sample Collection and Analysis. Samples from surface-water disposal units and Columbia River shoreline seeps were collected from various locations in the operational areas. Sampling of surface-water disposal units included water, sediment, and aquatic vegetation. Samples taken at river shoreline seeps included water only. The sampling methods are discussed in detail in the *Operational Environmental Monitoring* manual (WHC 1991b). To avoid duplication of sampling, the near-facility environmental monitoring program used surface-water sample data collected by the Surface Environmental Surveillance Project for the 400 Area.

Radiological analysis of water samples from surface-water disposal units included total alpha, total beta, ^3H , $^{239,240}\text{Pu}$, and gamma-emitting radionuclides. Alpha and beta measurements provided a general indication of radionuclide contamination. Radiological analysis of sediment and aquatic vegetation included ^{90}Sr , $^{239,240}\text{Pu}$, uranium, and gamma-emitting radionuclides. Nonradiological analysis performed included 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.

B.4 RADIOLOGICAL SURVEYS

Another aspect of the near-facility environmental monitoring program is radiological surveying, which monitors and helps direct the reduction of the radiologically controlled areas on the Hanford Site. Facilities also perform periodic surveys of their facilities as directed by 10 CFR 835 and maintain the records and results of these surveys.

Two types of posted radiological controlled areas are underground radioactive materials and surface 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 routinely surveyed (at least annually) to document the current radiological status.

Surface contamination areas may or may not have been associated with an underground radioactive material structure. A breach in the barrier of an underground radioactive materials area may have resulted in the growth of contaminated vegetation. Insects or animals might have burrowed into an underground radioactive materials area and brought contamination to the surface. Vent pipes or risers from an underground structure could have been a source of speck contamination. Fallout from stacks, or unplanned releases from previously operating facilities, may have caused an area of surface contamination that was not related to a subsurface structure. All types of surface contamination areas are susceptible to contamination migration. Surface contamination areas are routinely surveyed (at least annually) to document the current radiological status.

Approximately 1,200 ha (3,000 acres) of outdoor surface contamination areas and 400 ha (1,000 acres) of posted underground radioactive materials areas have been posted. The number of acres of surface contamination areas was three times larger than the underground radioactive materials acres primarily because of the BC Controlled Area located south of the 200 East Area. This area was posted as a Radiologically Controlled Area in 1959 because of widespread speck contamination and encompasses approximately 1,000 ha (2,500 acres). Table B-1 shows the acreage for surface contamination areas and underground radioactive material areas and the change from 1992 to 1993. Table B-2 summarizes the number of contaminated acres that changed status in 1993. Approximately 5.3 ha (13 acres) were reclassified from surface contamination areas to underground radioactive material areas, and an additional 4 ha (10 acres) were posted as surface contamination areas.

The area of posted surface contamination varied because of an ongoing effort to clean, stabilize, and remediate areas of known contamination while new areas of contamination were being identified. Table B-2 indicates the changes resulting from stabilization activities during 1993. Newly identified areas may be from contamination migration or the result of 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.

Table B-1. Zone Status Change From 1992 to 1993
by Area.

Location	Zone change	Area in ha (acres)
100 Areas	SCA to URM	0
200 East Area	SCA to URM	0.9 (2.2)
200 West Area	SCA to URM	4.5 (11.2)
300 Area	SCA to URM	0
400 Area	SCA to URM	0
600 Area	SCA to URM	0

SCA = surface contamination area.

URM = underground radioactive materials.

Table B-2 . Outdoor Contamination Status, 1993
[approximate surface area in ha (acres)].

Hanford Site Area	Surface Contamination ^a	Net Change ^b	Underground Radioactive Material ^c	Net Change
100 Areas	65 (160)	0	186 (460)	0
200 Areas	129 (318)	-5 (-11) ^d	154 (380)	6 (14)
600 Area	51 (127)	3 (7) ^d	93 (230)	0
BC Control Area	1,012 (2,500)*	0	12 (30)	0
300 Area	18 (45)	0	12 (30)	0
TOTALS	1,275 (3,150)	-2 (-4)	457 (1,130)	6 (14)

^aIncludes areas posted as "Surface Contamination Areas" or as "Radiologically Controlled Areas" and areas that had both underground and surface contamination.

^b- = decreases.

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

^dThe change reflects contamination migration to previously uncontaminated areas.

*Radiologically Controlled Area.

It was estimated that the external dose rate at 80 percent of the identified outdoor surface contamination areas was less than 1 mrem/hr, although external doses from isolated contaminated specks (less than 0.6 cm [0.25 in.]) could have been considerably higher. Contamination levels of this magnitude would not contribute significantly to dose rates for the public or Hanford Site workers in 1993.

B.5 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. Migration can occur as the result of suspension from radioactively contaminated surface areas, absorption of radionuclides by the roots of vegetation growing on or near underground and surface-water disposal units, or waste site intrusion by animals. Special samples were also taken where physical or biological transport problems were identified.

Sample Collection and Analysis. The sampling methods and locations used are discussed in detail in the *Operational Environmental Monitoring* manual (WHC 1991b). Radiological analysis of soil and vegetation samples included ⁹⁰Sr, ^{239,240}Pu, uranium, and gamma-emitting radionuclides.

B.6 INVESTIGATIVE SAMPLING

The purpose of investigative sampling is to determine whether effluent controls and waste containment measures are adequate. An important part of the near-facility program, investigative sampling was conducted in the operations areas to confirm the absence of or to detect the presence of radioactive contaminants. This

investigative sampling takes place near facilities such as storage and disposal sites for at least one of the following reasons.

- Because radiological surface surveys had indicated that radioactive contamination was present.
- To quantify the radiological condition of 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) had created a potential for the spread of contaminants.
- To determine the integrity of waste containment systems.

Generally speaking, the predominant radionuclides are activation products (i.e., gamma emitters) in the 100 Areas, fission products in the 200/600 Areas, and uranium in the 300 Area.

Sample Collection and Analysis. Types of investigative samples collected over the years have included air; water; snow; sediments; soil; vegetation such as grasses, tumbleweeds (also known as Russian thistle), sagebrush, trees, and fruits; and various organisms such as spiders, termites, ants, fish, toads, snakes, birds, mice, rabbits, coyotes, and bobcats.

Methods for collecting or otherwise obtaining investigative samples are found in the *Operational Environmental Monitoring* manual (WHC 1991b). Field monitoring was conducted to detect radioactivity before collecting samples.

B.7 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 of measurement were employed, one being hand-held μ R meters used to survey multiple survey points and the other being thermoluminescent dosimeters (TLDs). The measurement methods used for external radiation measurements and sample locations are discussed in detail in the *Operational Environmental Monitoring* manual (WHC 1991b).

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APPENDIX C

WASTE INFORMATION DATA SYSTEM

The information in the report is extracted from the Waste Information Data System (WIDS) as of January 1995. The WIDS provides additional information concerning the waste management units contained in this report and is maintained current with changes to these waste management units. For the latest information concerning this data, contact:

Bechtel Hanford, Inc.
P.O. Box 969
450 Hills
Richland, Washington 99352

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