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ASSESSMENT FOR POTENTIAL RADIONUCLIDE EMISSIONS FROM STACKS
AND DIFFUSE AND FUGITIVE SOURCES ON THE HANFORD SITE

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ABSTRACT

On February 3, 1993, the U.S. Department of Energy, Richland Operations Office (RL) received a Compliance Order and Information Request from the U.S. Environmental Protection Agency (EPA), Region 10. The Compliance Order required RL to evaluate all radionuclide emission points at the Hanford Site to determine which points are subject to continuous emission monitoring requirements in Title 40, Code of Federal Regulations, Part 61 (40 CFR 61), Subpart H. The Information Request required 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. The Compliance Plan contained milestones for a registered stack assessment and for reaching agreement on a Federal Facility Compliance Agreement (FFCA). The FFCA was signed into force on February 7, 1994.

The Compliance Plan and the FFCA specified milestones for a dose assessment for potential emission on 124 stacks (84 registered and 40 unregistered stacks) and diffuse and fugitive sources. Stacks with potential emissions resulting in an effective dose equivalent to a maximum exposed individual $> 0.1 \text{ mrem y}^{-1}$ would be identified. Six methods were used in performing the assessments: (1) Release Fractions From Appendix D of 40

CFR 61, (2) Back Calculations Using A High Efficiency Particulate Air Filtration Factor (HEPA), (3) Nondestructive Assay of HEPA, (4) Spill Release Fraction, (5) Upstream of HEPA Filter Air Concentrations, and (6) Limiting Inventory Calculations.

Methods (1) and (2) were found to be extremely conservative for estimating releases. The third method, which used a state-of-the-art portable gamma spectrometer to determine the distribution of radionuclides on HEPA filters, yielded surprising results. All six methods are described in the paper.

Three methods were used for assessing the diffuse and fugitive emissions: (1) an annual dose assessment, (2) onsite environmental monitoring, and (3) radiological surveys. However, only the stack assessments identified sources with the potential for exceeding the 0.1 mrem y^{-1} . When an initial assessment was performed using a HEPA filtration factor for back calculations, 32 registered stacks were identified with potential emissions that would exceed 0.1 mrem y^{-1} . The other methods only identified 17 stacks. The paper discusses reasons for the overestimation. In addition, the assessment of the unregistered stacks identified three stacks with the potential for exceeding 0.1 mrem y^{-1} .

I. INTRODUCTION

On December 15, 1989, the U.S. Environmental Protection Agency (EPA) promulgated, in the Code of Federal Regulations (CFR), 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 the emissions of radionuclides from the U.S. Department of Energy (DOE), facilities shall not exceed those amounts which would cause any member of the public to receive an effective dose equivalent (EDE) of 10 mrem in a year. In addition, potential emissions of radionuclides from a facility which could cause an EDE to a maximum exposed individual (MEI) to exceed 0.1 mrem y^{-1} require continuous monitoring.

In order to determine compliance, 40 CFR 61.93 provides requirements for monitoring of radionuclide emissions from point sources. These monitoring requirements became effective upon promulgation of the regulation on December 15, 1989. DOE Richland Operations Office (RL), as defined in 40 CFR Part 61, is an "owner or operator" of a "facility" (i.e., the Hanford Site.) The Hanford Site is depicted in Figure 1.

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. The Compliance Order required RL to evaluate all radionuclide emission points at the Hanford Site to determine which are subject to continuous emission measurement requirements per 40 CFR Part 61, Subpart H. In addition, the Order required RL to continuously measure radionuclide emissions in accordance with 40 CFR 61.93. The Information Request required RL to provide a written Compliance Plan to meet the requirements of the

Figure 1. Map of the Hanford Site.

Compliance Order. A Compliance Plan was submitted to EPA, Region 10, on April 30, 1993. One of the Compliance Plan milestones was to complete assessment of the 84 registered stacks at the Hanford Site under Westinghouse Hanford Company (WHC) management by December 17, 1993.

The Compliance Plan also included reaching agreement on a Federal Facility Compliance Agreement (FFCA). This was accomplished on February 7, 1994. The FFCA listed the additional assessment of unregistered stacks with powered ventilation.

This document presents the dose assessment results for both the registered and unregistered stacks on the Hanford Site for potential emissions; i.e., emissions with no control devices in place. Further, the document identifies methods used to determine diffuse and fugitive emissions from the Hanford Site.

II. SCOPE

Both stack assessments and diffuse and fugitive emission assessment were performed for the Hanford Site. The stack assessment of potential emissions was performed on 84 registered stacks and 40 unregistered stacks on the Hanford Site. The registered stacks emission sources represent individual point sources presently registered under Washington Administrative Code (WAC) 246-247 with the Washington State Department of Health. Unfortunately, potential emissions for most stacks are not sampled. For these stacks, other methods were developed and submitted to EPA, Region 10 for approval.

The diffuse and fugitive emission assessment was performed for the Hanford Site by using data from samplers located upwind and downwind of the Hanford Site.

III. METHODS FOR CALCULATING POTENTIAL STACK EMISSIONS

Six EPA-approved methods were used to calculate potential emissions for the registered stacks:

1. Source Term Estimation based on release factors in Appendix D (40 CFR 61)
2. Back Calculations Based on a Decontamination Factor of 3000^n , where n equals the number of high efficiency particulate air (HEPA) filter banks in series
3. Nondestructive Assessment (NDA)
4. Upstream of HEPA Filter Air Concentration Measurements
5. Spill Release Fraction (296-Z-5)
6. Limiting Inventory Calculation (105-N 14-ft Decon Room).

Calculations based on methods (1) and (2) are considered extremely conservative. The last four methods should provide a realistic estimate of the actual potential releases. If the results from either method (1) or (2) indicate that the potential emissions would result in an EDE exceeding 0.1 mrem y^{-1} and one of the remaining methods results in an $\text{EDE} < 0.1 \text{ mrem y}^{-1}$, the results from the remaining methods would be accepted over those from methods (1) or (2).

III.1. SOURCE TERM ESTIMATION (Appendix D Release Factors)

The potential emissions for a system without control devices can be estimated based on factors presented in 40 CFR 61, Appendix D. For gases the release factor is 1, for liquids or particulate solids the release factor is 1×10^{-3} , and for solids the release factor is 1×10^{-6} . This method is extremely conservative, since accidents involving liquids and loose particulates have a release fraction orders of magnitude less than the specified 1×10^{-3} release fraction. In an accident condition, a spill of powder from a 1-m height of the entire inventory would have, under extremely conservative conditions, a release fraction of 4×10^{-5} . A liquid spill from the same 1-m height would have a release fraction of approximately 1×10^{-6} . A 1×10^{-3} release fraction is used for powders and liquids. For waste tank assessments, if the inventory was covered by supernate, the supernate was evaluated using the release factor for liquids. If the inventory was covered by salt cake, the salt cake was estimated using a release factor for solids.

III.2. BACK CALCULATIONS BASED ON A DECONTAMINATION FACTOR OF 3000^n

This method assumes the *Nuclear Air Cleaning Handbook* (Buchsted et al. 1976) decontamination factor (DF) of 3000 [$DF \sim 1/(1-0.9997)$] for 0.3μ by a HEPA filter. Each bank in series is assumed to act independently of a preceding bank and to remove contamination with the same 3000 DF. For a system with "n" banks of HEPA filters in series, the DF is 3000^n .

When processing no longer occurs, the resuspension of contamination downstream of the HEPA filters can dominate the airborne releases from a facility. Multiplying these releases by 3000^n will overestimate the potential

emissions by orders of magnitude. Consequently, this method can result in very conservative estimates in a contaminated system.

III.3. NONDESTRUCTIVE ASSESSMENT

In September 1992, the EPA, Region 10, concurred with a WHC proposal for a test method to measure radioactive particulate emissions (particularly gamma emitters from HEPA filters) in stack exhaust systems across the Hanford Site (Barnett 1994). An NDA (i.e., in situ) method was developed, tested, and implemented using portable low-resolution (NaI) gamma spectroscopy instrumentation (BTI 1991) to evaluate gamma emissions from operating HEPA filters. Guidance for the developed method comes from 40 CFR 61, Subpart H, and Appendix B, Method 114.

III.4. UPSTREAM OF HEPA FILTER AIR CONCENTRATION MEASUREMENTS

The upstream air concentrations provide direct information on the potential emissions from a facility. This method can be applied by using any of the following procedures:

1. Continuous Air Monitoring (CAM) data
2. Inserting an air sample probe for upstream measurements
3. Radiological analysis of removed HEPA filters.

CAM data (procedure 1) can be used if the data are taken from the process area containing the radionuclide inventory. Air measurements may also be collected in the ventilation system upstream of the HEPA filters (procedure 2). In this case, a sampling port is selected, a probe inserted, and air concentrations are measured. Procedure 3 is the sampling of the furthest upstream HEPA filters for the facility. In this case, one or more HEPA filters are removed

and the radiological content is analyzed either by destructive assay or by a gamma spectrometer. The airflow during the time the HEPA filter is online is used to determine the annual release rate. All of these procedures are technically based in that the measurements represent the potential concentrations emitted from a facility without control devices.

III.5. SPILL RELEASE FRACTION (296-Z-5)

In the facility venting to the 296-Z-5 stack, the only potential emissions occur when a canister of PuO_2 powder is repackaged. No emissions are expected from contamination in the ventilation system for the facility since it is essentially uncontaminated. When a canister is to be repackaged, the double canisters containing 1,500 g of PuO_2 are opened in a hood and the powder is poured into another canister. The canister is sealed and put into another canister, which is also sealed. The pouring could cause a release of PuO_2 to the air. To estimate the potential maximum release, observed spill release fractions for depleted UO_2 oxide spills were used (Sutter et al. 1981). A maximum release fraction value of 4.0×10^{-5} was used. This number is extremely conservative since it represents a release fraction for a 1-m release height for the spill. The actual release height is a maximum of 0.15 m. The spill release fraction was only used for the 296-Z-5 stack.

III.6. LIMITING INVENTORY CALCULATION (105-N 14-ft Decon Room)

The method uses the measured radionuclides emitted from the stack and back calculates the dose rates within the facility needed to produce a 0.1 mrem y^{-1} to the MEI. First the EDE to the MEI is calculated using the

measured release in the CAP88 dose model (Parks 1992). Next, a factor is formed using the calculated EDE and 0.1 mrem y^{-1} : $\text{factor} = 0.1/\text{calculated EDE}$. This factor is multiplied by each of the measured radionuclides emitted to yield the limiting potential emissions from within the facility which would be equal to the 0.1 mrem y^{-1} .

A release factor of 1×10^{-3} for particulates and liquids (no solids were assumed) from 40 CFR 61, Appendix D, was applied to determine the limiting inventory for the facility. The limiting inventory was compared to the actual inventory; the inventory used was the compacted waste drums. Low-level waste is received in the facility in drums and cardboard cartons. The waste is opened under a hood and is sorted and placed in 208-L (55-gal) drums for compaction. When filled, the drum is sealed and radiologically surveyed before release. The radiological survey must be $< 50 \text{ mrem/hr}$ at 1 cm before the drum can be released for shipment to the burial ground.

IV. CAP88 DOSE MODELING

A potential source term was calculated for the 84 registered stacks using one of the six approved methods. Once the potential source terms were determined, the source term, location, and stack height were used with Hanford meteorology in the CAP88 computer model (Parks 1992) to predict the EDE for the MEI.

The CAP88 model incorporates plume rise from the stack based on the flow rate and stack diameter. After leaving the stack, the plume is modeled to disperse based on meteorological conditions. Modeled concentrations are

decreased based on dry deposition (dry deposition velocity = 1.8 cm/s).

However, wet deposition is ignored because of the low incident of precipitation on the Hanford Site. The modeled concentrations are used to calculate an EDE for an offsite MEI by summing the product of the EDE for each isotope with its activity.

$$\dot{H}_{total} = \sum (EDE_{(i)} \times A_{(i)}) = mrem\ y^{-1} \quad (1)$$

where:

H = potential unabated dose to the MEI
 $EDE_{(i)}$ = EDE for each radionuclide
 $A_{(i)}$ = total activity for radioisotope i
 i = radioisotope.

Normalized source terms were used in CAP88 for each of the major areas on site (100, 200, 300, 400, and 600 Areas). Five-year averaged Hanford Site meteorological data (1983-1987) taken on the Site were used to compute normalized air concentrations (i.e., X/Q , where X is the air concentration $[Ci/m^3]$ normalized by the source term Q $[Ci/s]$). Stack release heights of 89 m (200-ft stack with a 100-ft plume rise) and 10 m (33 ft) were used. To model an individual stack the following input was needed: the potential radiological source terms, the chosen stack release height, and the location of the stack in one of the major areas. Potential dose data were produced by the CAP88 model for each registered stack.

V. RESULTS OF DOSE ASSESSMENT

Of the 84 registered stacks and 40 unregistered stacks assessed, 44 stacks were assessed using release fractions from 40 CFR 61, Appendix D; 35 stacks were assessed using back calculations, 15 stacks were assessed using NDA; 26 stacks were assessed using upstream air samples; 1 stack was assessed using the powder release fraction and 1 was assessed using the limiting inventory calculation. Of the 124 stacks assessed, 21 were identified to have potential emissions which could cause an EDE $> 0.1 \text{ mrem y}^{-1}$ (Table 1). One of the original seven designated stacks, 291-T-1, was assessed by NDA and reduced to a nondesignated stack (Mizner and Barnett 1993).

To evaluate the six different methods, each method, where possible, was compared to the results of back calculations. The back calculations were performed for all registered stacks and the results indicated that emissions from 32 of the registered stacks would have caused an EDE over 0.1 mrem y^{-1} and required the stacks to provide continuous monitoring. When a stack reported a nondetectable release, the minimum detection limit was used as the release for the stack. A comparison made for a subset of 30 registered stacks

TABLE 1. DESIGNATED STACKS. (2 sheets)

Stack Number	Facility	Number of HEPA Filters
107-N	100-N	2
291-A-1	PUREX	3
296-A-1	PUREX	3
291-B-1 ^b	B Plant	2
291-Z-12	PFP	1-3

TABLE 1. DESIGNATED STACKS. (2 sheets)

Stack Number	Facility	Number of HEPA Filters
296-Z-3	PFP	2
296-A-22 ^b	Tank Farms	2
296-A-27	Tank Farms	2
296-A-29	Tank Farms	2
296-A-40	Tank Farms	2
296-P-16	Tank Farms	2
296-A-22 ^b	Tank Farms	2
296-P-23	Tank Farms	2
296-P-26	Tank Farms	2
296-P-28	Tank Farms	2
296-S-7W	ERO	2
296-S-15	Tank Farms	2
308-GL-EX	308 Building	3
340-NT-EX ^b	340 Building	2

HEPA = high efficiency particulate air

^aStacks with potential emission to cause a dose > 0.1 mrem y⁻¹.

^bOriginal seven designated stacks.

^cStages of filtration depends on exhaust pathway.

using release factors from 40 CFR 61, Appendix D, with back calculations showed no correlation between the two methods (Figure 2). Further, 21 of the 30 back calculations potential emissions exceeded the release fractions emissions. In only four comparisons did the release fractions from Appendix D identify a designated stack when the back calculation indicated a nondesignated.

Figure 2. Appendix D^(*) Versus Back Calculations^(*) Comparison.

Figure 3. Comparison of Nondestructive Assay^(*) with Back Calculations^(*).

The comparison between NDA and back calculations showed that back calculations overestimated the potential releases for nine stacks by at least four orders of magnitude (Table 2 and Figure 3). Four of the stacks (Table 3) reported nondetection of a release. For these stacks, the minimum detection

TABLE 2. NONDESTRUCTIVE ASSAY COMPARISON WITH BACK CALCULATIONS.

Stack Number	NDA (mrem y ⁻¹)	Back Calculation (mrem y ⁻¹)	Log ₁₀ (difference [mrem y ⁻¹])
291-T-1	4E-3	4E+2	5
296-T-13	3E-4	3E+1	5
296-B-13	5E-8	2E+0 ^a	8
296-G-1	3E-8	3E-1 ^a	7
296-S-2	1E-5	1.2E-1	4
296-S-16	2E-6	1.0E-1	5
296-W-3	2E-9	3E+0 ^a	9
308-ET-EX	3E-5	1E+2	7
437-MN&ST	2E-3	2E+1 ^a	4

NDA = nondestructive assay.

^aMinimum detection limit used for back calculations.

limit was used for back calculations.) If back calculations had been used instead of NDA, all nine of these stacks would have required continuous monitoring. Using the upstream air sample method for two of the stacks showed that the back calculations overestimated the emissions by three orders of magnitude. For the single stack that used the powder release fraction, the back calculations overestimated the release by four orders of magnitude.

WHC-SA-2885-FP

When upstream measurements or NDA were performed, an apparent decontamination factor was computed for the HEPA filter systems for eight nondesignated stacks having releases above the detection limit. The term "apparent" has been used since an actual DF could not be computed. An actual DF would have to be calculated for a variety of particle sizes with air concentration measurements before and after the filters. The apparent DF was

TABLE 3. APPARENT DECONTAMINATION FACTORS FOR NONDESIGNATED STACKS.

Stack Number	Method	Number of HEPA	Nuclide	Unabated (Ci)	Release (Ci)*	DF
291-T-1	NDA	Prefilter, 2 HEPAs	Sr90	1.6E-3	1.2E-5	190
			Cs137	1.7E-3	1.3E-5	130
			Pu239,240	2.0E-3	2.2E-5	110
			Am241	2.0E-4	2.0E-6	100
296-T-13	NDA	2	Pu239,240	1.7E-4	2.0E-6	90
296-T-11	upstream	2	total beta	1.5E-5	4.3E-7	30
296-S-2	NDA	2	total alpha	2.1E-6	8.4E-9	240
			total beta	3.5E-6	1.4E-8	250
296-S-7W	upstream	2	Pu239,240	3.2E-5	7.5E-7	40
			Am241	3.9E-4	4.2E-6	90
296-S-16	NDA	1	total alpha	3.1E-7	1.7E-9	185
			total beta	9.8E-6	5.3E-8	180
308-ET-EX	NDA	2	total alpha	9.3E-7	9.2E-8	10
			total beta	1.8E-7	3.4E-7	0.5
437-MN&ST	NDA	2	total alpha	2.0E-5	1.9E-7	105
			total beta	7.8E-5	7.4E-7	106

DF = decontamination factor.

HEPA = high efficiency particulate air.

NDA = nondestructive assay.

*Data taken from Environmental Releases for Calendar Year 1992, WHC-EP-0527-2, Westinghouse Hanford Company, Richland, Washington.

formed using either the estimated annual air concentration or the loading on the HEPA filters ratioed with the measured releases. The measured releases were $< 2\text{E-}5 \text{ Ci y}^{-1}$ for a radioisotope for all of the stacks. The unabated emissions for these stacks were $< 3\text{E-}3 \text{ Ci y}^{-1}$. For one stack, 308-ET-EX, a DF of 0.5 was computed; i.e., more released than was assessed on the HEPA filters. For some of the designated stacks the DFs, if measured, would produce larger DFs than noted in Table 3.

VI. DIFFUSE AND FUGITIVE EMISSION ASSESSMENT

The Hanford Site consists of semiarid shrub-steppe land, of which approximately 6% has been disturbed and actively used for processing nuclear material. This land, approximately 82.9 km^2 (32 mi^2) or 8,090 ha (20,000 acres), is divided into five operational areas: the 100, 200, 300, 400, and 600 Areas. 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).

VII. 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. These include 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 4 shows the types of waste sites and the sources of diffuse and fugitive. 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. In addition, 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 resuspension influence rates of diffuse emissions).

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 continue 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 resuspension or biological intrusion, to previously uncontaminated areas. (Approximately 80% of all areas of surface contamination are estimated to have dose rates of < 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 5 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* (Diediker et al. 1994) and in the facility effluent monitoring plans for major facilities.

TABLE 4. 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.

**VIII. 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)

TABLE 5. 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.

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 (Figure 4), as well as gamma energy analysis, uranium, plutonium, and

Figure 4. Monthly Average Gross Beta Radioactivity in Airborne Particulate Samples, 1981 through 1991.
(Woodruff and Hanf 1992)

S9501043.1

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.

IX. 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 over other 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 resuspension 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. These sources include 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 code¹³. 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.

X. 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 6 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 6 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 6

indicate that the hypothetical mean doses to individuals at these locations were 0.049 mrem y^{-1} at the Prosser Barricade location and 0.028 mrem y^{-1} 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 y^{-1} standard.

Over the past 4 years, the total dose assessment to the offsite MEI from all site sources was < 2% of the 10 mrem y^{-1} standard. Of that total, the dose from diffuse sources ranged from 0.028 to 0.12 mrem y^{-1} , whereas the dose from stack sources was between 0.0037 and 0.016 mrem y^{-1} .

XI. CONCLUSIONS

By using the six EPA-approved methods, Region 10, instead of only the original back calculation method for assessing the 84 WHC registered stacks, the number of stacks requiring continuous monitoring was reduced from 32 to 19 stacks.

The intercomparison between results showed that no correlation existed between back calculations and release fractions from 40 CFR 61, Appendix D, results. Also the NDA, upstream air samples, and powder release fraction

TABLE 6. 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 y ⁻¹) ^d	Estimated dose at location ^c (mrem y ⁻¹) ^d	Estimated dose at location ^c (mrem y ⁻¹) ^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

MEI = maximum exposed individual.

^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 resuspension 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.

method results were at least three orders of magnitude lower than the back calculations results.

The most surprising results of the assessment came from NDA. NDA was found to be an easy method for assessing potential emissions. For the nine stacks assessed by NDA, all nine of the stacks would have required continuous monitoring when assessed by back calculations. However, when NDA was applied all stacks had potential emissions that would cause an EDE below the $> 0.1 \text{ mrem y}^{-1}$ standard.

Apparent DFs for the HEPA filter systems were calculated for eight nondesignated stacks with emissions above the detection limit. These apparent DFs ranged from 0.5 to 250.

The EDE dose to the MEI was calculated to be $0.028 \text{ mrem y}^{-1}$ for diffuse and fugitive emissions from the Hanford Sited. This is well below the $> 0.1 \text{ mrem y}^{-1}$ standard.

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