

E90-089



 **EG&G ROCKY FLATS**

ROCKY FLATS PLANT SITE ENVIRONMENTAL REPORT



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J443
1990

JANUARY THROUGH DECEMBER 1990

ADMIN RECORD
SW-A-004784

Best Available Copy



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METRIC FRACTIONS

Multiple	Decimal Equivalent	Prefix	Symbol
10 ⁶	1,000,000	mega-	M
10 ³	1,000	kilo-	k
10 ²	100	hecto-	h
10	10	deka-	da
10 ⁻¹	0.1	deci-	d
10 ⁻²	0.01	centi-	c
10 ⁻³	0.001	milli-	m
10 ⁻⁶	0.000001	micro-	μ
10 ⁻⁹	0.000000001	nano-	n
10 ⁻¹²	0.000000000001	pico-	p
10 ⁻¹⁵	0.000000000000001	femto-	f
10 ⁻¹⁸	0.000000000000000001	atto-	a

METRIC CONVERSION TABLE

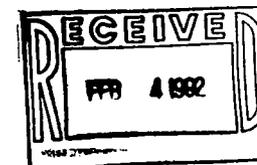
Multiply	By	Equals	Multiply	By	Equals
in	2.54	cm	cm	0.394	in.
ft	0.305	m	m	3.28	ft
ac	0.404	ha	ha	2.47	ac
mi	1.61	km	km	0.621	mi
lb	0.4536	kg	kg	2.205	lb
liq. qt. - U.S.	0.946	l	l	1.057	liq. qt. - U.S.
ft ²	0.093	m ²	m ²	10.764	ft ²
mi ²	2.59	km ²	km ²	0.386	mi ²
ft ³	0.028	m ³	m ³	35.31	ft ³
d/m	0.450	pCi	pCi	2.22	d/m
pCi (water)	10 ⁻⁹	μCi/ml (water)	μCi/ml (water)	10 ⁹	pCi/l (water)
pCi/m ³ (air)	10 ⁻¹²	μCi/cc (air)	μCi/cc (air)	10 ¹²	pCi/m ³ (air)

TRADITIONAL AND INTERNATIONAL SYSTEMS OF RADIOLOGICAL UNITS

(Traditional units are in parentheses.)

Quantity	Name	Symbol	Expression in Terms of Other Units
absorbed dose	Gray (rad)	Gy rad	J/Kg ⁻¹ 10 ⁻² Gy
activity	Becquerel (curie)	Bq Ci	1 dps 3.7 x 10 ¹⁰ Bq
dose equivalent	Sievert (rem)	Sv rem	J/Kg ⁻¹ 10 ⁻² Sv
exposure	Coulomb per kilogram (roentgen)	R	C/Kg ⁻¹ 2.58 x 10 ⁻⁴ C/Kg ⁻¹

ROCKY FLATS PLANT SITE ENVIRONMENTAL REPORT FOR 1990



David B. Costain, Editor/Program Manager
 Dianna A. Cirrincione, Technical Editor/
 Production Coordinator
 Rodd W. Ladman, Computer Graphics
 Noelle R. Stallcup, Desktop Publisher
 Debra R. Stanton, Graphic Designer



Rocky Flats Plant
 P.O. Box 464
 Golden, CO 80402

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We wish to extend particular appreciation for the effort of the authors of this report; their names are included on each section's introductory page.

Valuable assistance was given in the preparation and review of this report by the following persons: Robyn S. Almquist, Craig E. Armstrong, Michael B. Arndt, Wanda S. Busby, John R. Dick, Farrel D. Hobbs, William A. Hunt, Gary J. Magno, David R. Maxwell, Larry L. McInroy, Stephen M. Nesta, William E. Osborne, Carol A. Patnoe, Bonnie J. Pauley, Karen S. Schoendaller, Daniel L. Shain, and Dennis M. Smith, of Environmental Management; Scott A. Anderson, Robert C. Baker, Pamela W. Edrich of Waste Programs; Conrad Trice of the H&S Laboratories; Edward A. Brovsky, Merrill W. Hume, Duane I. Hunter of the General Laboratories.

ABOUT OUR COVER...

The employees of the Rocky Flats Plant are concerned with the environment -- its preservation, its protection, its future. The monitoring programs conducted at and surrounding the plantsite provide a self-assessment of the Rocky Flats Plant effect on its environment. The Rocky Flats Plant employees and families of employees, as well as others who live in the surrounding communities, are affected by how well our goals are accomplished.

Our present consideration for the environment will have a momentous effect on the future of today's children. Therefore, we judged it to be appropriate that since they are fundamental to the intent of this report, they should also be a part of its design.

Our profound thanks to the following children of Environmental Management Department employees, whose drawings appear on the cover of this report: Morgan Cloud, 1st Grade; David Greengard, 2nd Grade; Rachel Greengard, 5th Grade; Alison Magno, 1st Grade; Mary Reiman, 2nd Grade; Robert Reiman, 6th Grade; Theresa Reiman, 3rd Grade; Brandi Romano, 1st Grade; Andy Wolaver, 1st Grade.

We sincerely appreciate the efforts of the following children who also submitted pictures: Krystal Spurr, 2nd Grade; Scottlyn Spurr, Kindergarten.

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PREFACE

This report provides information to the public about the impact of the Rocky Flats Plant on the environment and public health. The report contains a compliance summary, a description of environmental monitoring programs, and radiation dose estimates for the surrounding population for the period January 1 through December 31, 1990. General content and format for this report are specified by Department of Energy Order 5400.1.

An environmental surveillance program has been ongoing at the Rocky Flats Plant since the 1950s. Early programs focused on radiological impacts to the environment. The current program examines potential impacts to air, surface water, groundwater, and soils from radiological and nonradiological sources.

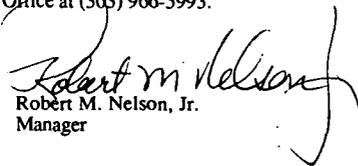
Environmental operations at Rocky Flats Plant are under the jurisdiction of several local, state, and federal agencies, most notably the Colorado Department of Health, Environmental Protection Agency, and Department of Energy. A variety of reports are prepared at different intervals for these and other agencies in addition to the annual environmental report. A list of these reports is given in Section 3, Table 3-1.

U.S. DEPARTMENT OF ENERGY/ROCKY FLATS PLANT SITE ENVIRONMENTAL REPORT FOR 1990 (RFP-ENV-90)

Attached for your information is the 1990 Site Environmental Report for the Rocky Flats Plant. In addition to summaries of radiological and nonradiological monitoring in the vicinity of and on the Rocky Flats Plant (RFP), the report includes summaries of environmental activities on the site, a listing of the major environmental permits along with the compliance status of each, and a description of National Environmental Policy Act activities.

We have also attached an environmental compliance self assessment covering the period of January 1, 1991, to August 31, 1991. This is representative of our ongoing program to place greater emphasis on identifying potential environmental compliance issues at RFP and developing solutions to those problems.

If you have any questions about the report, or would like to discuss particular items within the report, please contact the DOE-Rocky Flats Office at (303) 966-5993.


Robert M. Nelson, Jr.
Manager

Attachment

EXECUTIVE SUMMARY



David B. Costain

The Rocky Flats Plant Site Environmental Report for 1990 contains a compliance summary, results of environmental monitoring, and radiation dose assessments. This section is an overview of these topics and summarizes a more comprehensive discussion found in the main text of the report.

COMPLIANCE SUMMARY

National Environmental Policy Act (NEPA)

Notices of Intent (NOIs) for the Plutonium Recovery Modification Project Environmental Impact Statement (PRMP EIS) and Programmatic Environmental Impact Statement on the Integrated Environmental and Waste Management Program were published in the *Federal Register* on May 30 and October 22, 1990, respectively. An NOI for the Rocky Flats Plant (RFP) Sitewide EIS is expected to be published early in 1991.

Environmental Assessments (EAs) were completed, and Findings of No Significant Impact (FONSI) were published in the *Federal Register* for the 881 Hillside Sites Interim Remedial Action (January 10, 1990) and Supercompactor and Repackaging Facility (SARF) (August 10, 1990). Development of EAs were initiated for seven additional facilities/operations in 1990.

Clean Air Act (CAA)

Radionuclide air emissions from RFP were within the Environmental Protection Agency's (EPA) National Emissions Standards for Hazardous Air Pollutants (NESHAP). NESHAPs set a yearly limit of 10 millirem per year (mrem/yr) effective dose equivalent (EDE) to any member of the public.

The calculated beryllium discharged from RFP in 1990 was 8.2 grams (g) compared to the daily limit of 10 g over a 24-hr period set by Colorado Air Quality Control Regulation #8.

RFP submitted Air Pollution Emission Notices (APENs) to the Colorado Department of Health (CDH) for 25 process and support buildings. APENs are required by Colorado Air Quality Control Regulation #3 as part of an application for a new or modified emissions source releasing any contaminant classified as odorous, hazardous, or toxic.

A Notice of Violation (NOV) was received on April 11, 1990, for failure to have air emission permits or APENs for two spray paint booths and a shot blaster in Building 333. RFP subsequently filed the required documents for this facility.

Clean Water Act (CWA)

The National Pollutant Discharge Elimination System (NPDES) permit for RFP expired in 1989 but was extended

administratively until renewed. An application was filed in a timely fashion with the EPA and is pending final approval. No NOV's were received in 1990 for violation of NPDES standards.

An NPDES Federal Facilities Compliance Agreement (FFCA) was drafted in 1990 between the Department of Energy (DOE) and the EPA. This agreement includes requirements for upgrading the sewage treatment plant, a groundwater monitoring plan for the sewage sludge drying beds, a corrective action plan to address a 1989 unplanned release of chromic acid from Building 444, and quarterly progress reports.

Revised use classifications and water quality standards for Woman Creek and Walnut Creek tributaries to Standley Lake and Great Western Reservoir and resegmentation of Big Dry Creek became effective on March 30, 1990. This action by the Colorado Water Quality Control Commission (CWQCC) established goal stream standards for Segment 5 of Big Dry Creek (tributaries from source to Ponds A-4, B-5, and C-2) and final stream standards for Segment 4 of Big Dry Creek (from pond outlets to Standley Lake and Great Western Reservoir).

Toxic Substances Control Act (TSCA)

Sixteen 55-gallon drums of nonradioactivity-contaminated polychlorinated biphenyl (PCB) capacitors were shipped offsite for disposal in 1990. Radioactivity-contaminated PCB wastes and friable and radioactivity-contaminated asbestos are being stored at RFP until disposal can be arranged at suitable locations. Non-friable asbestos is disposed of in the RFP landfill.

Resource Conservation and Recovery Act (RCRA)

The RCRA Part A permit application for hazardous and low-level mixed waste was revised twice in 1990 through changes to interim status to allow operation of the Pondercrete Remix facilities on the 750 and 904 Pads and operation of a low-level mixed waste baler and nearby storage area in Building 889. A revision to the RCRA Part A permit application for transuranic (TRU) mixed waste was pending approval from CDH to allow operation under interim status of the Supercompactor and Repackaging Facility and the TRU Waste Shredder. RCRA Part B permit applications for hazardous and low-level mixed waste and TRU mixed waste also were pending CDH approval.

The Inter-Agency Agreement (IAG) requires RCRA Facility Investigations/Remedial Investigations (RFI/RI) work plans

to characterize the source of contamination and the soils of an interim status closure unit. Draft Phase I RFI/RI work plans were submitted to CDH and EPA for the Solar Evaporation Ponds, Present Landfill, Original Process Waste Lines, and West Spray Field in 1990.

Production of TRU waste declined from 1,342 cubic yards (yd³) in 1989 to 307 yd³ in 1990, and low-level waste production declined from 7,417 yd³ in 1989 to 2,555 yd³ in 1990. Hazardous waste generation decreased from 108 yd³ in 1989 to 89 yd³ in 1990. RFP recycled 141 tons of paper in 1990, an increase of 26 tons from 1989.

A Mixed Residues Compliance Plan was prepared under requirements of the Residue Compliance Agreement in 1990. This plan included actions to bring residues into compliance with State of Colorado standards and methods to minimize generation and reduce the storage of RCRA-regulated wastes.

The FFCA for Land Disposal Restricted Wastes was extended twice in 1990 with the second expiration date of February 15, 1991. During 1990, 13 formal reports were submitted (pursuant to this agreement) that identified all available and/or feasible options being pursued in the areas of waste minimization, waste characterization, and treatment technology implementation.

Inter-Agency Agreement (IAG)

The IAG was renegotiated early in 1990 following receipt of public and agency comments. The final agreement, reached in January 1991, was revised to increase the number and priority of Operable Units (OUs).

Emergency Planning and Community Right-to-Know Act (EPCRA)

The RFP submitted the "Tier II Emergency and Hazardous Chemical Inventory Forms" report to emergency planning agencies for the State of Colorado, Jefferson and Boulder counties, and the RFP Fire Department in 1990. This report is required under Section 312 of EPCRA and lists quantities and locations of hazardous chemicals.

The RFP submitted the "Toxic Chemical Release Inventory" to EPA as required under Section 313 of EPCRA. This report contains information on routine and accidental releases of chemicals in 1990, maximum amount of chemicals stored, and amount of chemicals contained in wastes transferred offsite.

Governor's Scientific Advisory Panel

The Governor's Scientific Advisory Panel on Rocky Flats Monitoring Systems completed its final report in 1990. Major recommendations in this report concerned development of environmental information and computerized data management systems, mass balance tabulation of materials entering and exiting RFP, and ambient air monitoring for six nonradioactive hazardous substances.

ENVIRONMENTAL MONITORING

A Special Assignment Team was mobilized in 1989 by DOE to provide an independent evaluation of operations and practices at RFP. The environmental portion of the audit focused on determining whether RFP activities created an imminent threat to the public or environment, whether operations were conducted in accordance with environmental requirements and best management practices, and the status of previously identified environmental concerns. Findings of this evaluation were addressed in 93 action plans that described corrective measures. During 1990, 16 action plans were completed, 21 additional plans were undergoing internal verification, and 56 plans were in various stages of implementation.

METEOROLOGICAL MONITORING

Mean wind speeds at RFP in 1990 were 9.0 miles per hour (mph). The maximum wind speed was 88.6 mph. Winds, as categorized by Pasquill stability classes, were 50.1 percent neutral, 42.5 percent stable, and 7.37 percent unstable. The mean temperature in 1990 was 48.7 °F and the minimum and maximum temperatures were -24.0 °F and 96 °F, respectively. RFP recorded 12.8 inches (in.) of precipitation in 1990.

AIR MONITORING**Effluent Air Monitoring**

Plutonium and uranium discharges totaled 1.067 microcuries (μCi) (3.95×10^4 becquerels [Bq]) and 0.606 μCi (2.24×10^4 Bq), respectively. Maximum sample concentration for plutonium was 0.0078×10^{-12} microcuries per milliliter ($\mu\text{Ci/ml}$) (2.89×10^{-4} becquerels per cubic meter [Bq/m^3]) and for uranium was 0.00026×10^{-12} $\mu\text{Ci/ml}$ (9.62×10^{-6} Bq/m^3). Americium discharges totaled 0.396 μCi (1.47×10^4 Bq) and the maximum concentration was 0.00144×10^{-12} $\mu\text{Ci/ml}$ (0.0391 Bq/m^3). Total amount of tritium discharged

was 0.0039 curies (Ci) (1.44×10^8 Bq). Maximum tritium concentration was 88×10^{-12} $\mu\text{Ci/ml}$ (3.26 Bq/m^3). Beryllium was not significantly above background levels. Radionuclide releases did not exceed NESHAP limits based on computer modeling using the AIRDOS/PC computer code.

Nonradioactive Ambient Air Monitoring

The maximum total suspended particulate (TSP) value (24-hour [hr] sample) was 134 micrograms per cubic meter ($\mu\text{g/m}^3$) and the annual geometric mean value was 31.4 $\mu\text{g/m}^3$. The maximum Particulate Matter-10 (PM-10) value (24-hr sample) was 26 $\mu\text{g/m}^3$ and the annual arithmetic mean was 9.8 $\mu\text{g/m}^3$. The annual geometric mean for TSP and arithmetic mean for PM-10 samplers were 12 percent and 20 percent, respectively, of the National Ambient Air Quality Standards (NAAQS).

Radioactive Ambient Air Monitoring

Overall mean plutonium concentration measured for onsite samplers was 0.072×10^{-15} $\mu\text{Ci/ml}$ (2.7×10^{-6} Bq/m^3), equal to 0.36 percent of the Derived Concentration Guide (DCG). Overall mean plutonium concentrations for perimeter and community locations were 0.003×10^{-15} $\mu\text{Ci/ml}$ (1.1×10^{-7} Bq/m^3) and 0.001×10^{-15} $\mu\text{Ci/ml}$ (3.7×10^{-8} Bq/m^3), respectively. These values were 0.015 percent (perimeter) and 0.005 percent (community) of the DCG.

SURFACE WATER MONITORING**Rocky Flats Plant Site Surface Water Monitoring**

Maximum volume-weighted average concentrations and percent of DCG for plutonium, uranium, americium, and tritium of sampled effluents from North and South Walnut Creeks and Woman Creek were:

	Surface Water Effluents Average Concentrations ($\times 10^{-9}$ $\mu\text{Ci/ml}$)	Percent of DCG
Plutonium (Pond C-1)	0.011 \pm 0.005	0.04
Uranium-233, 234 (Pond C-2)	1.89 \pm 0.17	0.38
Uranium-238 (Pond C-2)	2.40 \pm 0.16	0.40
Americium (Pond A-4)	0.008 \pm 0.009	0.03
Tritium (Ponds B-5, C-2)	30 \pm 10 30 \pm 200.0	0.0

EXECUTIVE SUMMARY

Mean concentrations and percent of DCG for plutonium, uranium, americium, and tritium for samples of raw water taken from Ralston Reservoir and South Boulder Diversion Canal were:

	Raw Water Supply Average Concentrations (x 10 ⁻⁹ uCi/ml)	Percent of DCG
Plutonium	0.00 ± 0.014	0.0
Uranium-233, 234	0.54 ± 0.29	0.11
Uranium-238	0.45 ± 0.20	0.09
Americium	0.004 ± 0.005	0.01
Tritium	-10 ± 30	0.0

Community Surface Water
Monitoring

Maximum average reservoir/canal concentrations and percent of DCG for plutonium, uranium, americium, and tritium from samples of public water supplies from several surrounding communities were:

	Maximum Average Reservoir Concentrations (x 10 ⁻⁹ uCi/ml)	Percent of DCG
Plutonium (Ralston)	0.011 ± 0.037	0.04
Uranium-233, 234 (Boulder)	1.87 ± 0.52	0.37
Uranium-238 (Standley)	0.71 ± 0.12	0.12
Americium (Dillon)	0.031 ± 0.049	0.10
Tritium (Ralston)	190 ± 120	0.01

Maximum average drinking water concentrations and percent of DCGs for plutonium, uranium, americium, and tritium

from samples of drinking water from several surrounding communities were:

	Maximum Average Drinking Water Concentrations (x 10 ⁻⁹ uCi/ml)	Percent of DCG
Plutonium (Golden)	0.006 ± 0.013	0.02
Uranium-233, 234 (Denver)	0.67 ± 0.57	0.13
Uranium-238 (Golden)	0.52 ± 0.30	0.09
Americium (Arvada)	0.008 ± 0.008	0.03
Tritium (Louisville)	50 ± 70	0.0

GROUNDWATER
MONITORING

The uppermost hydrostratigraphic unit within OU 1 (881 Hillside) that includes alluvial and subcropping bedrock material is contaminated with volatile organic compounds (VOCs), inorganics (including some metals), and elevated levels of uranium. Maximum concentrations of organic contaminants, trichloroethene (TCE), 1,1-dichloroethene, and 1,1,1-trichloroethane (TCA), were 13,000 micrograms per liter (µg/l), 16,000 µg/l, and 19,000 µg/l, respectively. Concentrations of VOCs diminish rapidly downgradient, becoming equal to or below detection limits (5 µg/l) within 200 feet (ft) of the suspected origin of contamination.

Groundwater in the alluvial materials and interconnected groundwater in the shallow subcropping sandstone bodies within OU 2 (903 Pad, Mound, and East Trenches Area) is contaminated with VOCs, inorganics (including some metals), elevated Total Dissolved Solids (TDSs), and radionuclides. Maximum concentrations of VOCs were: tetrachloroethene (PCE) - 20,000 µg/l, and TCE - 96,000 µg/l. Concentrations of these magnitudes represented one-time sampling events and were limited spatially. The majority of radionuclide contamination was uranium-238. Wells screened in surficial materials and subcropping bedrock immediately north, east, and southwest (downgradient) of the Solar Ponds (OU 4) detected elevated levels of nitrate/nitrite, sodium, TDS, sulfate, dissolved

EXECUTIVE SUMMARY

radionuclides, and VOCs. Nitrate/nitrite concentrations ranged up to 880 milligrams per liter (mg/l), and TDS ranged up to 6,700 mg/l. Maximum concentrations of uranium -233/-234, -235, and -238 were 900, 9, and 190 picocuries per liter (pCi/l), respectively. Tritium and americium ranged up to 940 pCi/l and 0.02 pCi/l, respectively. Concentrations of VOCs, specifically, vinyl chloride, ranged up to 950 µg/l. Wells located upgradient of the Solar Ponds were contaminated by TDS, nitrate/nitrite, calcium, magnesium, bicarbonate, chloride, and radionuclides (uranium, tritium, americium, and cesium-137).

Groundwater in the uppermost hydrostratigraphic unit and adjacent to the Present Landfill (OU 7) exhibits concentrations above background levels of inorganic ions, dissolved metals, dissolved radionuclides, and VOCs.

Water quality data from alluvial wells within and adjacent to the West Spray Field (OU 11) showed elevated levels of nitrate/nitrite, sodium, TDS, sulfate, dissolved radionuclides, and VOCs. Upgradient from the West Spray Field, groundwater quality was impacted by TDS, and nitrate/nitrite were elevated.

SOIL MONITORING

Plutonium concentrations from samples taken at a 1-mile (mi) radius from RFP ranged from 0.03 picocuries per gram (pCi/g) to 9.14 pCi/g in 1990. Soils sampled at a 2-mi radius exhibited plutonium concentrations of 0.00 pCi/g to 3.94 pCi/g. Soils at locations south and east of the 903 Pad recorded the highest plutonium concentrations.

**EXTERNAL GAMMA
RADIATION DOSE
MONITORING**

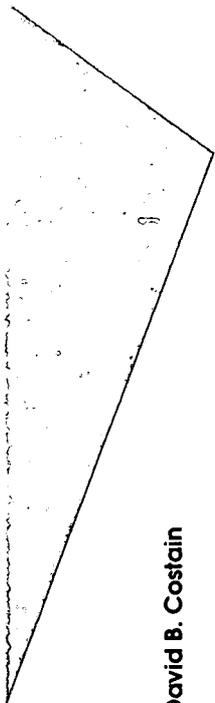
Average annual dose equivalents measured onsite, in perimeter environs, and in nearby communities were 154, 157, and 159 millirem (mrem), respectively. These values are indicative of background gamma radiation in the area.

**RADIATION DOSE
ASSESSMENT**

Maximum radiation dose from all pathways to a hypothetical individual continuously present at the site boundary was 0.52 mrem 50-year (yr) committed EDE or 0.52 percent of

the DOE standard for all pathways. The maximum radiation dose to an individual from RFP air emissions of radioactive materials, as determined by the AIRDOS-PC meteorological dispersion/radiation dose computer code, was 4.3×10^{-5} mrem from measured building air emissions and 0.21 mrem from estimated soil resuspension. Collective population dose to a distance of 50 mi was estimated as 2×10^1 person-rem 50-yr committed EDE.

1. INTRODUCTION



David B. Costain

The Rocky Flats Plant (RFP) is part of a nationwide nuclear weapons research, development, and production complex administered by the Rocky Flats Office (RFO) of the United States Department of Energy (DOE). The primary mission of RFP is the fabrication of nuclear weapons components. EG&G Rocky Flats, Inc., was the prime operating contractor for RFP in 1990. This section includes information on the RFP site environment and operations.

**ROCKY FLATS SITE
ENVIRONMENT**

The Rocky Flats Plant (RFP) occupies an area of 6,550 acres in northern Jefferson County, Colorado, approximately 16 miles (mi) northwest of Denver (Figure 1-1). Main production facilities are located near the center of RFP within a fenced security area of 384 acres. The remaining plant area contains limited support facilities and serves as a buffer zone to major production areas (DOE80). (Note: Literature citations abbreviated within this report are alphabetically listed in the References section, page 149.)

Approximately two million people live within a 50-mi radius of RFP. Adjacent land use is a mixture of agriculture, open space, industry, and low-density residential housing.

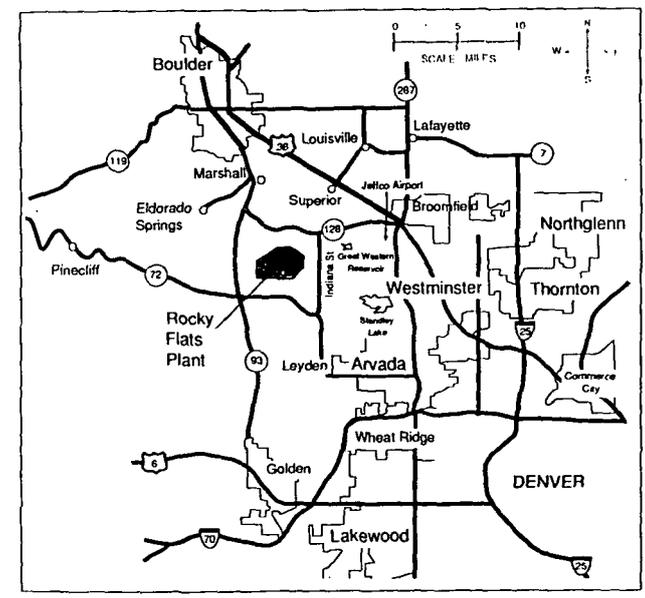


Figure 1-1. Area Map of RFP and Surrounding Communities

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Climate

The climate at RFP is characterized by dry, cool winters and warm summers. Elevation and major topographical features significantly influence climate and meteorological dispersion characteristics of the site. Winds, though variable, are predominantly northwesterly. Annual precipitation averages slightly greater than 15 inches (in.) with more than 80 percent occurring between April and September. Maximum and minimum temperatures average 76 degrees Fahrenheit (°F) and 22 °F, respectively (DOE80). Meteorological and climatological information for 1990 is given in Section 3.1.

Topography

RFP is situated at an elevation of about 6,000 feet (ft) on the eastern edge of a geological bench known locally as Rocky Flats. This bench, approximately 5 miles (mi) wide in an east-west direction, flanks the eastern edge of the abruptly rising foothills of the Front Range of the Rocky Mountains. To the east, topography slopes gradually at an average down-grade of 95 ft per mi. Approximately 20 mi to the west, the continental divide rises to elevations exceeding 14,000 ft.

Geology

RFP is situated on the Rocky Flats Alluvium, an alluvial fan deposit, varying in thickness from 0 to 100 ft, providing a gravely cover over bedrock. Underlying bedrock formations consist primarily of claystone with some siltstones. Seismic activity of the area is low, and potentials for landslides and subsidence are not considered likely at RFP (DOE80). Additional information on the geology of RFP is contained in *Draft Geologic Characterization of the Rocky Flats Plant* (EG90a).

Hydrology

Surface drainage generally occurs in a west to east pattern along five ephemeral streams within RFP. North Walnut Creek, South Walnut Creek, and Woman Creek drain the main plant facilities area. Water from Woman Creek drains into Standley Lake, which is used as a municipal water supply. Surface run-off from RFP is collected in an interceptor ditch before it enters Woman Creek, diverted to a temporary holding pond, and piped into the Broomfield diversion ditch, bypassing Great Western Reservoir. Water from North and South Walnut Creek discharges into the Broomfield diversion ditch.

Groundwater systems consist of a shallow, unconfined system in the Rocky Flats Alluvium and a confined system in deeper sandstone units within the underlying bedrock. The flow of groundwater is locally controlled by the topography

ROCKY FLATS SITE
OPERATIONS

and subsorpting sandstone channels (refer to page 85, Figure 3.4-1, Generalized Cross Section of the Stratigraphy Underlying the RFP).

The United States Atomic Energy Commission (AEC) was the responsible government agency when construction began at RFP. In 1974, the United States Energy Research and Development Administration (ERDA) succeeded the AEC. The ERDA was in turn succeeded by the Department of Energy (DOE) in 1977. Within DOE, administrative responsibility was delegated to the Albuquerque Operations Office, which established the Rocky Flats Area Office for day-to-day contact at RFP. In 1989, the Rocky Flats Area Office was upgraded to the Rocky Flats Office (RFO). Office was accountable directly to DOE Headquarters (HQ) in Washington, D.C.

The Dow Chemical Company was the first prime contractor for operations at RFP. Rockwell International replaced The Dow Chemical Company in 1975 and operated RFP through 1989. EG&G Rocky Flats, Inc., replaced Rockwell International in 1990.

The RFP fabricates nuclear weapons components from plutonium, uranium, beryllium, and stainless steel. Production activities include metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions. Approximately 140 structures contain nearly 2.76 million ft² of floor space. Of this space, major manufacturing, chemical processing, plutonium recovery, and waste treatment facilities occupy about 1.6 million ft². EG&G Rocky Flats, Inc., employed 6,289 people in December 1990.

RADIATION AT THE ROCKY FLATS PLANT

The RFP uses radioactive materials and radiation-producing equipment. Radiation-producing equipment includes X-ray machines and linear accelerators. Important radioactive materials include plutonium, americium, uranium, and tritium. The potential exists for these materials to be handled in sufficient quantities to pose an offsite hazard. The most important potential contributor to radiation dose from these materials is the alpha radiation emitted by plutonium, americium, and uranium.

Because of the low penetrating ability of alpha radiation, these materials are primarily a potential internal radiation dose hazard; that is, the radioactive material must be taken into the body for the alpha radiation to be harmful. For this reason, environmental protection at RFP focuses on minimizing release of radioactive materials to the environment. Environmental monitoring focuses on pathways by which the materials could enter the body such as air inhalation and water ingestion. A pathway is a potential route for exposure to radioactive or hazardous materials.

Appendix A, "Perspective on Radiation," describes the basic concepts of radiation. Readers unfamiliar with the types and sources of ionizing radiation are encouraged to read Appendix A for a better understanding of environmental monitoring data and radiation dose assessment at RFP. A detailed assessment of radiation dose to the public from RFP is presented in Section 4, "Radiation Dose Assessment."

2. COMPLIANCE SUMMARY



David B. Costain
Pamela S. Goode

Monitoring data are obtained from routine sampling to measure environmental impacts resulting from RFP activities. Results from this monitoring are reported to local, state, and federal agencies including the Environmental Protection Agency (EPA), DOE, and Colorado Department of Health (CDH), who are responsible for enforcing environmental regulations at RFP. These agencies oversee compliance with applicable standards, issue permits, participate in joint monitoring programs, and inspect facilities. This section covers RFP compliance with environmental regulations.

**NATIONAL
ENVIRONMENTAL
POLICY ACT (NEPA)**

The National Environmental Policy Act (NEPA) is the nation's most widely applied federal environmental statute. Federal regulations administered by the Council on Environmental Quality (CEQ), Washington, D.C., require NEPA documentation as an administrative record showing that agencies have considered environmental impacts and public commentary, and that this information is included in federal decision-making. NEPA documentation can include either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS).

In 1989, Admiral Watkins, Secretary of Energy, issued a ten-point initiative that renewed emphasis by DOE on the letter and spirit of environmental statutes and regulations. Secretary of Energy Notice SEN-15-90 was the fourth point in the initiative, becoming effective on February 5, 1990. The notice called for a revision of DOE Order 5440.1C, *National Environmental Policy Act*, by streamlining and centralizing the DOE line organizations. The responsibilities of the DOE Secretarial Officers were redefined, and in states where DOE facilities are located, the state governors are now able to work more closely with their local DOE representatives.

In 1990, the NEPA Compliance Committee (NCC) at RFP provided information and recommendations on approximately 220 projects concerned with constructing, refurbishing, or upgrading activities at RFP.

The Notice of Intent (NOI) for the Plutonium Recovery Modification Project Environmental Impact Statement (PRMP EIS) was published in the *Federal Register* on May 30, 1990. Public scoping meetings were held on June 18 and 20, followed by a 45-day comment period.

The NOI for the Programmatic Environmental Impact Statement (PEIS) on the Integrated Environmental and Waste Management Program, proposed by the DOE, was issued in the *Federal Register* on October 22, 1990. The PEIS will consider programmatic issues (for all DOE-operated facilities) and integrated approaches to the program, and will include national, program-wide alternatives.

In September 1990, the Secretary of Energy made a commitment to initiate preparation of the RFP Sitewide EIS. The NOI for the Sitewide EIS was published in the *Federal Register* during the first quarter of 1991 and underwent public scoping and comments. A preliminary work plan and a statement of work for the RFP Sitewide EIS were completed on December 21, 1990.

Environmental Assessments

During 1990, development of EAs for the following proposed actions were initiated:

- Building 374 Liquid Waste Treatment Facility Upgrades
- Construction and Use of a Residue Drum Storage Facility
- Dewatering and Resource Conservation and Recovery Act (RCRA) Partial Closure Action on Solar Evaporation Ponds
- Mixed Waste Disposal Operations at the Nevada Test Site
- New Sanitary Landfill
- Process Waste Transfer System
- Proposed Surface Water Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document for the South Walnut Creek Basin

The EA for 881 Hillside Sites Interim Remedial Action, DOE/EA-0413, was approved by the DOE; a Finding of No Significant Impact (FONSI) was published in the *Federal Register* on January 10, 1990. An EA of the Supercompactor and Repackaging Facility (SARF), DOE/EA-0432, was published in July; the DOE issued a FONSI in the *Federal Register* on August 10, 1990.

Mitigation Action Plans

The implementation of NEPA focuses on the pre-decisional aspects of an action. Mitigation is part of the post-decisional phase of NEPA. The Secretary of Energy Notice SEN-15-90, Section H, requires the publication of a Mitigation Action Plan (MAP) before an EIS or EA/FONSI is completed. The MAP documents environmental commitments made in an EIS/Record of Decision (ROD) or an EA/FONSI and reports implementation of those commitments. The MAP for the SARF is expected to be issued in the spring of 1991.

CLEAN AIR ACT (CAA)

The Clean Air Act (CAA) sets standards for ambient air quality and hazardous air pollutants. At RFP, the emphasis is on radioactive hazardous emissions.

National Emission Standards for Hazardous Air Pollutants (NESHAPs)

National Emission Standards for Hazardous Air Pollutants (NESHAPs) govern both radioactive and nonradioactive pollutants and are administered by the Environmental Protection Agency (EPA) or the Colorado Department of Health (CDH). CDH has been granted authority by the EPA to regulate several hazardous pollutants including beryllium, mercury, vinyl chloride, and asbestos; however, authority to regulate radionuclides currently lies with the EPA. Under regulations promulgated in 1989, NESHAPs limited the radiation dose from airborne radionuclide emissions from DOE facilities to 10 millirem per year (mrem/yr) effective dose equivalent (EDE) to any member of the public. A compliance report with dose calculations is due to EPA by June 30 of each year for the previous calendar year. RFP submitted the required Air Compliance Report and dose calculations for the calendar year 1989 to the EPA in June 1990. This report showed a calculated whole body dose equivalent to the maximally exposed individual from air pathway only of 0.23 mrem. Dose calculations for the 1990 calendar year are given in Section 4, "Radiation Dose Assessment."

Colorado Air Quality Control Regulation #8

Regulation #8 implements NESHAPs for nonradioactive pollutants in Colorado. Work standards, emission limitations, and ambient air standards for hazardous air pollutants including asbestos, beryllium, mercury, benzene, vinyl chloride, lead, and hydrogen sulfide are specified in this regulation. Potential hazardous air pollutants at RFP include asbestos and beryllium. Asbestos was used as insulation in the older facilities and is handled according to NESHAPs regulations during demolition, renovation, or disposal. Beryllium is machined at RFP. The emissions standard is 10 grams (g) of beryllium over a 24-hr period. Beryllium emissions did not exceed this standard in 1990.

Beryllium compliance testing will be conducted on five air ducts that have the highest potential beryllium emissions upon resumption of process operations at RFP. Process operations were suspended in 1989 and did not resume in 1990. The testing will measure beryllium emissions for 24-hr periods in accordance with EPA standards and will serve as the basis of an application for a waiver of emission testing and daily sampling requirements.

Section 2. COMPLIANCE SUMMARY

Compliance Issues

Notices Of Violation (NOVs). On April 11, 1990, NOVs were received from CDH for (1) failure to have a submerged fill tube and vapor control system for an underground gasoline storage tank at Building 331, and (2) failure to have air emission permits or Air Pollutant Emission Notices (APENs) for two spray paint booths and a shot blaster in Building 333. A following inspection by CDH revealed that facilities at Building 331 were not in violation. The NOV for these facilities expired without further action by CDH or DOE. CDH issued an Order for Compliance on May 1, 1990, respective to facilities at Building 333, that required submittal of air emissions permits and APEN forms. These documents were submitted on March 29, 1991.

Radioactive Stack Sampling Protocol. Several studies were initiated in 1990 (and will be completed in 1991-1992) to determine RFP's compliance with EPA's radioactive stack sampling protocol, Code of Federal Regulations (CFR) Title 40, Part 61, Subpart H, which was promulgated on December 15, 1989, and made effective that same date. These studies involve preparing "as built" duct drawings, duct effluent characterization, effluent particle size and composition, and isokinetic stack sampling. Air monitoring systems that do not meet EPA protocol will be reviewed for exemption under "alternative methods," provisions of EPA 40 CFR 61, Subpart H, 61.93(b) 3. Nonexempt systems will be upgraded to meet EPA standards. A Federal Facilities Compliance Agreement (FFCA) between DOE and EPA Region VIII is expected to be signed in 1991 to establish a schedule for applicable sources to meet the requirements of 40 CFR 61, Subpart H.

Colorado Air Quality Control Regulation #3. Regulation #3 implements information gathering and permitting processes of air pollution control requirements listed under Code of Colorado Regulations, Title 5 - Department of Health, Chapter 1001, Air Quality Control Commission (AQCC) Regulations, Articles 2-13, 15, and 16. The APEN form allows CDH to track air pollution sources, determine their impacts, and issue appropriate air emission permits. APENs are required for most sources emitting air pollutants as defined in the Common Provisions of the AQCC Regulations.

Preparation of an air emissions inventory for RFP was outlined in the DOE/CDH Agreement in Principle (AIP) of June 1989. An APEN is required for any process or activity that has the potential of (1) an uncontrolled emission greater than 1 pound per day for any hazardous or toxic air pollutant, (2) an uncontrolled emission greater than 1 ton per year for any pollutant, or (3) emissions arising from storage and transfer facilities and surface coating processes as defined under AQCC Regulation #7. In 1990, RFP initiated a vent survey and chemical usage analysis of 104 process and support buildings to determine which facilities require APEN documentation and/or air emission permits. Process and support buildings for which APEN documents were submitted to CDH in 1990 are listed in Table 2-1.

Table 2-1
Buildings for Which Air Pollution Emission Notices Were Submitted in 1990

Building #	Building Description	Date Submitted to CDH
886	Uranium Solution Evaporator	01-18-90
--	11 Pondercrete Shelters	01-18-90
729	Filter Plenum Building	03-26-90
779	Research & Development	03-26-90
782	Filter Plenum Building	03-26-90
701	Microwave Verification Process	05-07-90
219	Landfill	09-25-90
559	Plutonium Analytical Laboratory	09-25-90
561	Filter Plenum Building	09-25-90
952	Isolated Gas Storage	10-18-90
964	Storage Building	10-18-90
T452F	Health Effects Laboratory/Industrial Hygiene	10-18-90
T707S	Oil Storage	10-18-90
371	Plutonium Recovery	11-07-90
707	Manufacturing Building	11-20-90
771-	Plutonium Recovery	11-30-90
549	Alarm Systems	12-07-90
552	Gas Storage	12-07-90
553	Welding Shop	12-07-90
776	Manufacturing Building	12-17-90
777	Assembly Building	12-17-90
447	Manufacturing Building	12-17-90
448	Storage Building	12-17-90
451	Filter Plenum Building	12-17-90
443	Heating Plant	12-28-90

**CLEAN WATER ACT
(CWA)**

The Clean Water Act (CWA) requires the EPA to set national effluent limitations and water quality standards and establishes a regulatory program to ensure enforcement. In Colorado, discharge permits for federal facilities such as RFP are issued by the EPA. The State of Colorado sets water quality standards for receiving streams and bodies of water. These standards are applied through National Pollution Discharge Elimination System (NPDES) permits issued by the EPA. Table 2-2 lists current RFP environmental permits and permit applications.

**National Pollutant
Discharge Elimination
System (NPDES)**

The NPDES permit program controls the release of pollutants into United States waters and requires routine monitoring and reporting of results. The NPDES permit for RFP (#CO-0001333) identifies seven monitoring points for control of discharge; three of these discharge points, Ponds A-4, B-5, and C-2, are capable of discharging water from RFP. The current permit expired in 1989, but was administratively extended until renewed. An application for renewal was filed in a timely fashion with EPA. No NOV's were received in 1990 for violation of NPDES requirements. NPDES permit exceedances are summarized in Section 3.3, "Surface Water Monitoring." RFP terminated spray irrigation from Pond B-3 in March 1990 until regulatory issues could be resolved regarding conditions under which spray irrigation would begin again.

An informal agreement (between CDH and DOE) was reached requiring consent from CDH before discharging Ponds A-4, B-5, and C-2. Samples are taken and split for analysis by CDH, EG&G Rocky Flats, Inc., and independent EPA registered laboratories. Once concurrence is received from CDH, pond waters are passed through filter systems and carbon adsorption facilities to reduce contaminants. The NPDES permit requires the operation of ponds at a spill capacity of 90 percent or greater. However, because of inherent delays caused by concurrent sampling and analysis before CDH consent for discharges and the continuing storage of inflows, Ponds A-4, B-5, and C-2 have been operated with less than 90 percent spill capacity.

Table 2-2
Environmental Permits and Permit Applications

Permit/ Application	Number	Medium	Issuing Agency	Status
NPDES (12/26/84)	CO-0001333	Water	EPA	Application for revision pending
Building 122 Incinerator (3/25/82)	C-12,931	Air	CDH	Active permit (inactive source)
Building 771 Incinerator (8/28/85)	12JE932	Air	CDH	Active permit (inactive source)
Building 776 Incinerator (3/25/82)	C-13,022	Air	CDH	Active permit (inactive source)
Fugitive Dust Renewed (12/28/89)	87JE084L	Air	CDH	Active permit
Pondcrete Shelter #5 Pad #750	90JE045-1	Air	CDH	Initial approval
Pondcrete Shelter #6 Pad #750	90JE045-2	Air	CDH	Initial approval
Pondcrete Shelter #10 Pad #904	90JE045-3	Air	CDH	Initial approval
Pondcrete Shelter #11 Pad #904	90JE045-4	Air	CDH	Initial approval
Urinalysis Laboratory Fume Hood - Bldg. 123	86JE018	Air	CDH	Active permit
RCRA Part A Revision 5.0	CO-7890010526	Hazardous, low-level mixed waste	CDH	Interim status approved for operation of Pondcrete Remix facilities
RCRA Part A Revision 6.0	CO-7890010526	Hazardous, low-level mixed waste	CDH	Interim status, conditional approval for operation of Bldg. 886 Baler
RCRA Part B	CO-7890010526	Hazardous, low-level mixed waste	CDH	Application revised, submitted March 1991, permit pending
RCRA Part B	CO-7890010526	Transuranic mixed waste	CDH	Application submitted, permit pending

plants' sewage treatment facility, where an estimated 4.3 kg (9.5 lb) was discharged to Pond B-3 and then onto spray irrigation fields. Run-off from these fields reached Pond B-5.

The Spill Prevention Control and Countermeasures/Best Management Practices Plan (SPCC/BMP) addresses facility improvements, operational procedures, policies, and requirements for reporting hazardous substances and oil spills to appropriate regulatory authorities. Periodic revisions of the plan are required in order to stay current with respect to NPDES monitoring and reporting because of FPCA changes and NPDES permit revisions. The SPCC/BMP is currently being revised to be available to DOE for submittal to EPA when NPDES permit renewal activities begin. No modifications were made to the SPCC/BMP during 1990.

Resegmentation of Big Dry Creek and revised use classifications and water quality standards for Woman Creek and Walnut Creek tributaries to Standley Lake and Great Western Reservoir became effective on March 30, 1990. This action by the Colorado Water Quality Control Commission (CWQCC) established goal stream standards for Segment 5 of Big Dry Creek (tributaries from source to Ponds A-4, B-5, and C-2) and stream standards for Segment 4 of Big Dry Creek (from pond outlets to Standley Lake and Great Western Reservoir). Goal standards differ from stream standards in that the term "goal" is a qualifier indicating that the waters are presently not fully suitable but are intended to become fully suitable for the classified use. Goal is used to indicate that a temporary modification for one or more of the underlying numeric standards has been granted. Goal standards will be reviewed in 1993 against the classified stream use designated in 1990.

A Compliance Sampling Inspection of the RFP STP was conducted by the EPA on February 27 and 28, 1990. Findings include: (1) the exceedances column of the discharge monitoring report was not completed properly; (2) no approved 30-minute air packs were available in the chlorination room; (3) no chlorine repair kit was available; and (4) no warning signs were observed on the chlorine room door. Corresponding corrective actions were completed in 1990.

**Spill Prevention Control
and Countermeasures/
Best Management
Practices Plan
(SPCC/BMP)**

**Colorado Water Quality
Control Commission
(CWQCC) Water Quality
Standards**

Compliance Issues

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, specifies radionuclide concentration guides for water discharged from RFP as follows: "Implementation of the Best Available Technology (BAT) process for liquid radioactive wastes are not required where radionuclides are already at low levels, i.e., the annual average concentration is less than the Derived Concentration Guide (DCG) level. In that case, the cost consideration component of BAT analysis precludes the need for additional treatment, since any additional treatment would be unjustifiable on a cost-benefit basis." Impounded waters at RFP met these DCG standards; therefore, per DOE Order 5400.5, further treatment is unjustifiable on a cost-benefit basis. Nevertheless, RFP used activated carbon treatment systems to process approximately 135 million gallons discharged in 1990 as an added level of protection.

The NPDES FPCA between DOE and EPA was drafted in 1990. In accordance with this draft agreement, RFP submitted the following documents: (1) a groundwater monitoring plan for the sewage sludge drying beds; (2) a compliance plan for upgrading the sewage treatment plant (STP); (3) an implementation plan in response to recommendations made following a DOE investigation of the chromic acid spill in 1989; and (4) quarterly progress reports. The FPCA was awaiting approval by DOE HQ as of the end of 1990.

FPCA STP Upgrades. A sewage sludge drying bed improvement project was initiated in 1990 to increase the STP ability to process sludge. This project includes a belt filter press and an indirect-heat dryer to achieve a dried sludge content of 60 percent solids. The project is expected to be completed in 1991.

Chromic Acid Incident Plan and Implementation Schedule. This plan was prepared in response to a finding by DOE of an unplanned release of chromic acid solution from Building 444 in 1989. The plan addresses physical and administrative changes to reduce the likelihood of spill events and reduce the opportunity for contaminants to reach the environment if a spill event were to occur. The chromic acid originated from a waste tank in a production area, breached secondary containment, and leaked undetected to footing drains on February 22, 1989. Groundwater contaminated by the acid was automatically pumped to the

**TOXIC SUBSTANCES
CONTROL ACT (TSCA)**

The Toxic Substances Control Act (TSCA), administered by the EPA, authorizes testing and regulation of chemical substances entering the environment. TSCA supplements sections of the CAA, the CWA, and the Occupational Safety and Health Act (OSHA). Compliance with TSCA at RFP is directed at management of polychlorinated biphenyls (PCBs) and asbestos.

Compliance Issues

In 1990, sixteen 55-gallon drums of nonradioactivity-contaminated PCB capacitors were shipped offsite for disposal. Disposal sites for radioactivity-contaminated PCB wastes are unable to receive RFP waste at this time. RFP is storing radioactivity-contaminated PCB waste beyond the 1-year storage limit imposed by TSCA. DOE notified EPA that storage would be necessary until a commercial or DOE treatment and disposal facility capable of receiving this waste was identified.

Nonradioactivity-contaminated, nonfriable asbestos waste is disposed of in a designated area of the RFP landfill. Nonradioactivity-contaminated, friable asbestos waste is presently being held in storage until disposal issues with the CDH can be resolved. Radioactivity-contaminated asbestos waste is being stored onsite until disposal at the Nevada Test Site is approved.

**RESOURCE
CONSERVATION AND
RECOVERY ACT (RCRA)**

The Resource Conservation and Recovery Act (RCRA) provides cradle-to-grave control of hazardous waste by imposing management requirements on generators and transporters of hazardous wastes and on owners and operators of treatment, storage, and disposal facilities. The State of Colorado, under authority of EPA, regulates hazardous waste and the hazardous component of radioactive mixed waste at RFP, although EPA retains authority for certain regulatory provisions such as land disposal restrictions. Solely radioactive wastes are regulated by the Atomic Energy Act of 1954 as administered through DOE orders.

Part A and Part B Permit

The RCRA Part A permit application identifies (1) facility location, (2) owner and operator, (3) hazardous and mixed

wastes to be managed, and (4) hazardous waste management methods. A facility that has submitted a RCRA Part A permit application is allowed to manage hazardous wastes under transitional regulations known as the Interim Status Requirements pending issuance of a RCRA Operating Permit. The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous waste management.

RCRA Parts A and B permit applications for RFP cover hazardous waste treatment and storage operations. RFP does not practice hazardous waste disposal. Since the early 1980s, a series of RCRA Part A permit applications have been submitted to the CDH. During 1990, the Part A permit application for hazardous and low-level mixed waste was revised twice. Revision 5.0 was submitted to CDH in January 1990 requesting a change to interim status to allow operation of the Pondcrete Remix facilities on 750 and 904 Pads; this change was approved by CDH in April 1990. Revision 6.0 of the RCRA Part A application for hazardous and low-level mixed waste was submitted in June 1990 requesting a change to interim status to allow operation of a low-level mixed waste baler and a nearby storage area in Building 889; this request was approved by CDH, with certain conditions, in December 1990.

The RCRA Part A permit application for transuranic (TRU) mixed waste was last revised in November 1989 (Revision 3) to request a change to interim status to allow operation of the SARF and the TRU Waste Shredder. Additional information covering the Supercompactor and Shredder was submitted to CDH in May 1990 at their request. CDH conducted a public comment period to review the application in November and December 1990. The change to interim status is pending CDH approval. Several other minor and temporary changes to interim status were requested in various 1990 memoranda, including changes to interim status for four enhanced evaporation techniques at the Solar Evaporation Ponds.

Separate RCRA Part B permit applications have been submitted previously for hazardous and low-level mixed waste (December 1989) and TRU mixed waste (July 1988). CDH has prepared a draft RCRA permit for 9 of 20 hazardous and low-level mixed waste units at RFP and a Notice of Intent to Deny (NOID) for the remaining 11 units in October 1989. RFP submitted comments on the draft RCRA permit in December, 1989 and submitted a revised

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RFP continued monitoring of interim status closure units in 1990. Efforts were focused on priority areas, specifically the Solar Ponds, Present Landfill, and the West Spray Field. Major activities included groundwater and surface water monitoring and installation of new groundwater monitoring wells. The annual groundwater monitoring report for these high-priority areas was submitted to CDH and EPA on March 1, 1991 (EG91h).

RCCA Contingency Plan

The RCCA Contingency Plan (Section G of the RCCA Part B Permit) is designed to minimize hazards to human health or the environment from fires, explosions, or any unplanned sudden or non-sudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water. RFP reports releases if:

- A hazardous waste incident results in an injury requiring more than first-aid
- A spill, leak, or other release of hazardous waste to the air, soil, or surface water (i.e., outside the building) is greater than 1 pint or 1 pound
- A spill, leak, or other release of hazardous waste inside a building results in:
 - A release that exceeds a reportable quantity equivalent volume as defined in Title 40 CFR Part 302
 - A spilled material from a hazardous waste tank system not removed from secondary containment within 24 hours
- A fire and/or explosion involves a hazardous waste release or an active hazardous waste management unit

In 1990, RFP filed nine RCCA Contingency Plan Implementation Reports with the CDH. The reports describe the nature and magnitude of releases, actions to remediate contaminated areas, and measures to prevent future, similar incidents. Three spills were contained within Building 374 and did not endanger the environment. Two incidents involved fires at waste management units. Both were controlled and did not result in any release of hazardous waste to the air or soil. Of the three releases occurring outside, only one involved remediation of the contaminated area. A total of 2.75 pounds of mercury were spilled onto

Part B permit application to address the 11 waste units included in the NOID in March 1990. This additional information is under review by CDH. Likewise, the Part B permit application for TRU mixed waste continues to be under review by CDH.

RCCA Closure Plans

The RCCA closure plans identify procedures for removing hazardous waste management units from service and programs to prevent both short- and long-term threats to human health and the environment. These plans describe initial measures to minimize maintenance of hazardous waste management units, to control and limit release of hazardous constituents, and to close units with monitoring during the post-closure period.

Hazardous waste management facilities that operate under interim status (40 CFR 265) and facilities that will operate under a permit (40 CFR 264) must be addressed in RCCA closure plans (40 CFR, Parts 264 and 265, Subpart G). Closure plans for facilities that begin or continue operation following the interim status period must be addressed in the RCCA Part B permit. Hazardous waste management facilities that discontinue operation during the interim status period must be addressed by a separate RCCA Part B post-closure permit for interim status units. These are units that have been removed from service but require post-closure monitoring and maintenance. RFP has submitted closure plans as part of the RCCA Part B permit applications for all currently operating hazardous waste management facilities.

Closure plans for facilities that have ceased operations during the interim status period (i.e., through December 31, 1989) were submitted between 1986 and January 1991 Inter-Agency Agreement (IAG). The IAG requires all interim status closure units to use a combination of RCCA and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) criteria. The IAG requires RCCA Facility Investigations/Remedial Investigations (RFI/RI) work plans as a function of characterizing the source of the contamination and the soils of an interim status closure unit. Draft Phase I RFI/RI work plans have been submitted to CDH and EPA (June 8, 1990) for the following operable units (OUs): Solar Evaporation Ponds, Present Landfill, Original Process Waste Lines, and West Spray Field. An RFI/RI work plan for the Other Outside Closures OU will be submitted to CDH and EPA in 1991.

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the ground and onto the concrete pad surrounding the valve vault south of Building 124. Special vacuuming was used to remove the mercury from the concrete, and contaminated soils were excavated to return the area to normal operating conditions. The final incident involved an injury on the 904 Pad that was directly attributable to high winds.

Waste Operations

Radioactive and Mixed Waste. Radioactive waste and radioactive mixed waste generation decreased in 1990, primarily because of the suspension of operations in the plutonium and uranium manufacturing areas. TRU waste production declined from 1,342 cubic yards (yd³) in 1989 to 307 yd³ in 1990. Similarly, low-level waste (LLW) production declined from 7,417 yd³ in 1989 to 2,555 yd³ in 1990.

Evaluation and implementation of alternatives in the Waste Minimization Opportunity Assessment (RFP Waste Minimization Assessment Report and Amendments, December 1989 and March 1990, respectively) continued in 1990. In December 1990, the feasibility of a carbon dioxide pellet-blasting system to remove uranium contamination from surplus equipment and other metal objects was demonstrated. This system was tested as an alternative to size reduction and disposal practices for low-level metal waste streams currently used at RFP.

Hazardous Wastes. Hazardous waste generation decreased 17 percent from 108 yd³ in 1989 to 89 yd³ in 1990. Spent solvents, solvent-contaminated combustibles, waste oils, and paint products accounted for more than 50 percent of the hazardous waste generated at RFP. Equipment and tooling changes were implemented to eliminate a chromium-bearing sludge in Building 460. This waste stream was previously generated by an electrochemical milling process.

Solid (Nonhazardous) Wastes. The amount of recycled paper increased 23 percent, from 115 tons in 1989 to 141 tons in 1990. Scrap metal sales in 1990 were as follows:

- Stainless steel (machine turnings and assorted solids) - 29,283 lb
- Mild steel - 456,883 lb
- Aluminum - 1,833 lb

- Copper - 10,000 lb
- Lead - 41,380 lb

In an effort to decrease solid waste generation in RFP cafeterias, a project that involves using washable dishware and utensils instead of disposable items was initiated in 1990.

Compliance Issues

Settlement Agreement and Compliance Order on Consent No. 89-10-30-01 (commonly referred to as "Residue Compliance Agreement"). The DOE and CDH signed the Settlement Agreement and Compliance Order on Consent No. 89-10-30-01 on November 3, 1989, regarding alleged violations of the RCRA hazardous waste regulations pertaining to proper waste management of residues. RFP submitted the following reports to CDH in late 1989 and in 1990 in accordance with this agreement.

- Residue Inventory Report (December 15, 1989)
- Draft Compliance Framework Report (December 15, 1989)
- Residue Classification Plan (January 31, 1990)
- Descriptions of all processes used to recycle residues (February 1, 1990)
- Compliance Evaluation Report and Interim Compliance Plan (March 2, 1990)
- Residue Characterization Plan (March 30, 1990)
- Residue Classification Report (June 1, 1990)
- Mixed Residues Compliance Plan (September 28, 1990)

The Mixed Residues Compliance Plan was prepared to meet the requirements of the Settlement Agreement and Compliance Order on Consent, as well as to provide a schedule for compliance with the conclusions of the United States District Court for the District of Colorado in the Civil Action No. 89-B-181, Sierra Club, Plaintiff, vs. United States Department of Energy and Rockwell International Corporation, a Delaware Corporation, Defendants. The Mixed Residues Compliance Plan included the following actions to bring residues into compliance with the Colorado Hazardous Waste Regulations found in 6 Colorado Code of Regulations (CCR) 1007-3 Parts 100, 262, and 265; methods to minimize generation of RCRA-regulated residues; and actions to reduce the amount of RCRA-regulated residues in storage.

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- Treatment Report #1 - identifies potential treatment technologies and capacities available for the radioactive mixed waste streams identified in the Storage Report.
- Treatment Plan #1 - an evaluation of those treatment technologies described in Treatment Report #1 as to applicability and availability for actually processing RFP wastes.
- Treatment Report #2 - identifies potential treatment technologies and capacities available for the radioactive mixed waste streams identified in the LDR Determination Report.
- Treatment Plan #2 - identifies selected technologies for treating those prohibited wastes not previously covered in Treatment Plan #1.
- National Report on Prohibited Wastes and Treatment Options - issued by DOE HQ and provides a national assessment of radioactive mixed wastes being stored and accumulated throughout the DOE complex.
- LDR Determination Report - an assessment of the applicability of the LDR prohibitions to the 20 radioactive mixed waste streams listed in the Inventory Report.
- Waste Minimization Report Amendments - information on how waste minimization would affect generation and storage of those wastes covered in the Storage Report and Inventory Report.
- Waste Stream Characterization Report - The Waste Stream and Residue Identification and Characterization (WSRIC) Program was designed to meet the need for waste characterization for the RFP. The primary objective of the overall WSRIC Program is to provide a complete and accurate characterization of all nonhazardous wastes, hazardous wastes, low-level radioactive wastes, TRU wastes, low-level radioactive mixed wastes, TRU mixed wastes, and residues at RFP in sufficient detail to comply with all applicable regulations, and to effectively manage and minimize wastes and residues.

Federal Facility Compliance Agreement (FFCA) for Land Disposal Restricted Waste. A compliance order on consent was signed on September 19, 1989, by DOE, EPA Region VIII, and the State of Colorado to provide a 1-yr period for DOE to work towards compliance with the land disposal restrictions (LDR) of the Hazardous and Solid Waste Amendments of 1984 for mixed wastes. The original FFCA has been extended several times to allow time for the parties to renegotiate a new agreement; the FFCA currently expires on May 10, 1991. The FFCA covers radioactive wastes that were prohibited as of the FFCA effective date, which includes wastes containing solvents, dioxins, or California list of hazardous constituents above the applicable allowable levels for land disposal.

- During the period of the original agreement, DOE was to take all feasible steps to ensure the accurate identification, safe storage, and minimization of restricted waste prohibited from land disposal. Toward that end, the following formal reports that identified all available and/or feasible options being pursued in the areas of waste minimization, waste characterization, and treatment technology implementation were submitted to the EPA and the State of Colorado.
- Storage Report - addresses characterization, storage, and generation rates, and provides a basis for which an LDR determination was made for each of 18 mixed waste streams determined to be prohibited wastes under the LDR regulations.
 - Revised Storage Report - a revision to the original Storage Report (based on the Waste Minimization Report), and includes updated information on generation rates, storage capacities, and time to fill available storage.
 - Inventory Report - identifies an additional 20 radioactive mixed waste streams determined to be LDR prohibited and not included in the Storage Report, and includes information on generation history and storage information.
 - Waste Minimization Report - an assessment of RFP efforts to reduce the generation of radioactive mixed wastes covered in the Storage Report.

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- One-Year Report - describes all efforts undertaken by the DOE since the date of the agreement to achieve compliance with the RCRA LDR storage prohibition at RFP, including statutory and regulatory initiatives pursued at the DOE-HQ level. The One-Year Report describes specific actions that RFP has taken to develop LDR-compliant treatment for its mixed waste streams. It also describes actions DOE-HQ has taken to address concerns related to the LDR storage prohibition for mixed wastes for the entire DOE complex.

Copies of these reports are available in the RFP Public Reading Room at the Front Range Community College in Westminster, Colorado.

COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)

The CERCLA and its major amendments (Superfund Amendment and Reauthorization Act [SARA]) provide funding and enforcement authority for restoration of hazardous waste sites and for responding to hazardous substance spills. Sites contaminated by past waste activities must be investigated and remediation plans developed and implemented. The intent of these actions is to minimize the release of hazardous waste or other hazardous materials, thereby protecting human health and the environment. CERCLA requirements are addressed in a series of sequential phases designed to identify, design, and complete restoration of contaminated sites. CERCLA activities at RFP are dictated by the IAG.

INTER-AGENCY AGREEMENT (IAG)

The IAG was renegotiated early in 1990 following receipt of public and agency comments on the draft agreement submitted for review in December 1989. A revised agreement

was published on August 17, 1990. The final agreement, reached in January 1991 and signed by EPA, CDH, and DOE, included the following revisions:

- Operable Units were re-ordered to emphasize priority of offsite areas (i.e., areas located east of Indiana Street).
- The number of OUs was increased from 10 to 16 to better focus on the unique characteristics of different restoration areas (Table 2-3).

Table 2-3
Former and Current Prioritization of Operable Units
by the Inter-Agency Agreement

Former Operable Unit (OU) Number	OU Number Under Final IAG (effective 1-11-91)	Description
01	01	881 Hillside Area
02	02	903 Pad Area
10	03	Offsite Areas
03 Solar Ponds	04	Solar Ponds
04 Woman Creek	05	Woman Creek
04 Walnut Creek	06	Walnut Creek
03 Present Landfill	07	Present Landfill
05	08	700 Area
03 OPWL	09	Original Process Waste Lines
03 OOC	10	Other Outside Closures
03 West Spray Field	11	West Spray Field
06	12	400/800 Area
07	13	100 Area
09	14	Radioactive Sites
03 Inside Building Closures	15	Inside Building Closures
08	16	Low-Priority Sites

The IAG clarifies EPA, CDH, and DOE regulatory roles, coordinates oversight efforts and corrective actions, standardizes requirements, and ensures compliance with orders and permits. The agreement also specifies delivery of major reports, project management activities and milestones, and includes community involvement and decision making responsibilities. The IAG establishes a procedural framework and schedule through which response actions are developed, implemented, and monitored in accordance with CERCLA, RCRA, and the Colorado Hazardous Waste Act.

Remediation Goals

The CERCLA requires that remediation goals comply with applicable or relevant and appropriate requirements (ARARs) of federal laws or more stringent promulgated state laws in relation to cleanup standards. ARARs are generally dynamic in nature in that they evolve from general to very specific during the CERCLA Remedial Investigation/Facilities Study (RI/FS) process. Final remediation objectives are comprised of both ARARs and risk assessment information and will be determined in the ROD. The development of cleanup standards at RFP follow the general procedures described below.

Initially, during the RI/RI work plan stage, potential chemical-specific ARARs are identified, usually based on a limited amount of data. Chemical-specific ARARs at this point have meaning only in that they may be used to establish appropriate detection limits so that data collected during the RI/RI may be compared to ARAR standards. As more information becomes available during the RI/RI stage, chemical-specific ARARs may become more refined as constituents are added or deleted. Detailed location-specific ARARs are proposed in the RI/RI report as the result of the RI/RI process. This is followed by action-specific ARARs and remediation goals that are identified through the Corrective Measures Study/Feasibility Study (CMS/FS). A discussion is provided in the CMS/FS report (ARAR determinations. Once a preferred remedial action alternative is formally selected in the ROD, all chemical, location-, and action-specific ARARs are also defined in final form. CERCLA requires that remediation programs attain ARARs and are protective of human health and the environment.

**EMERGENCY PLANNING
AND COMMUNITY
RIGHT-TO-KNOW ACT
(EPCRA)**

The Emergency Planning and Community Right-To-Know Act (EPCRA) was enacted as a free-standing provision of the SARA in 1986. EPCRA, also known as SARA Title III, requires facilities to notify local and state emergency planning entities of the presence of potentially hazardous substances in their facilities and to report the inventories and environmental releases of those substances. The intent of

Documents prepared in accordance with the IAG cover a range of topics including remedial investigation work plans, interim remedial action decisions, community survey plans, project management plans, and health and safety plans. Table 2-4 lists IAG milestones completed in 1990. A series of monthly and quarterly Environmental Compliance Action reports document progress against IAG milestones (DOE90b, DOE91).

**Table 2-4
IAG Milestones Completed in 1990**

Operable Unit*	IAG Milestones
01	Final IM/RA Decision Document
01	Begin Phase 1-A IM/RA Construction
00*	Draft Community Survey Plan
01	Draft Community Survey Plan
00	Final Community Survey Plan
00	Final Phase II RFI/RI Work Plan (Alluvial)
02	Draft Phase II RFI/RI Work Plan
04	Draft Phase I RFI/RI Work Plan
07	Draft Phase I RFI/RI Work Plan
09	Draft Phase I RFI/RI Work Plan
11	Draft Phase I RFI/RI Work Plan
02	Draft Proposed IM/RA Decision Document
00	Draft Health and Safety Plan
00	Draft Quality Assurance Project Plan
00	Draft Standard Operating Procedures
02	Proposed Plan IM/RA Decision Document
00	Draft Plan for Prevention of Contaminant Dispersion
00	Draft Treatability Study Plan
01	Begin Phase I-B IM/RA Construction
03	Draft Fast Remedy Report
01	Draft Community Relations Plan
00	Draft Historical Information Summary & Preliminary Health Risk Assessment Report
03	Final Health and Safety Plan
00	Revised Background Study Report
00	Draft Response Summary and Final IM/RA
02	

- a. Interim Measures/Inform Remedial Action
- b. RCRA Facility Investigation/Remedial Investigation
- c. Operable Units designated under January 1991 IAG
- d. Sitewide (all) Operable Units

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these requirements is to provide the public with information on hazardous chemicals in their communities, enhancing public awareness of chemical hazards, and facilitating development of local and state emergency response plans.

Sections 301, 302, and 304

Under Sections 301 and 302, the EPA requires the establishment of State Emergency Response Commissions (SERCs), which are responsible for the formation of emergency planning districts and local emergency planning committees. Also under these requirements, facilities that produce, use, or store listed, extremely hazardous substances above the threshold planning quantity, must notify the SERC and the Local Planning Committees (LEPCs). RFP participates in the activities of the LEPCs established under these sections for emergency planning at the county level of government. RFP also maintains an emergency preparedness document for the plant and conducts annual mock emergency response scenarios to determine the effectiveness of the plan and the ability of plant directorates to respond.

Section 304 requires facilities to provide emergency release notification for any release of a reportable quantity of an extremely hazardous substance (as defined under Section 302) or a CERCLA hazardous substance that extends beyond a facility's boundaries. A facility reporting such a release must first give notice by telephone with written follow-up as soon as practical to the community emergency coordinator, State Emergency Response Commission, and the National Response Center (for CERCLA hazardous substances). RFP's Waste Programs Department makes these notifications if such releases occur.

Section 311

Under Section 311, facilities must submit to the SERC, local committees, and the RFP Fire Department (FD), copies of Material Safety Data Sheets (MSDSs) or a list of all chemicals above certain thresholds that are defined as hazardous by the OSHA Hazard Communication Standard. After the initial submittal, Section 311 requires the submittal of updates within 3 months for new chemicals that become subject to the OSHA Hazard Communication Standard or after discovering new information. This information was provided to the SERC, LEPC, and the RFP FD by RFP's Industrial Hygiene Department in 1987 to meet the original requirements, and MSDS updates have been provided to these agencies when required.

Section 312

Section 312 of EPCRA requires facilities to prepare an annual report titled, "Tier II Emergency and Hazardous Chemical Inventory Forms," listing the quantities and locations of hazardous chemicals. Section 312 covers hazardous chemicals under OSHA's Hazard Communication Standard (with limited exceptions). Any facility that is required to prepare or have available an MSDS for a hazardous chemical under OSHA's Hazard Communication Standard must submit Tier I information on a form or, if requested or in lieu of Tier I submittal, Tier II information to SERC, LEPC and the RFP FD. The Tier I or Tier II information must be submitted annually, beginning on March 1, 1988. RFP submitted this report to the following agencies in 1990: Colorado Emergency Planning Commission, Jefferson County Emergency Planning Committee, Boulder County Emergency Planning Committee, and the RFP FD (jurisdictional fire department).

Section 313

Section 313 of EPCRA requires facilities to prepare an annual report titled "Toxic Chemical Release Inventory, Form R," if annual usage quantities of listed toxic chemicals exceed certain thresholds. In 1990, threshold chemical usage quantities were (1) 25,000 lb for listed chemicals either manufactured or processed, and (2) 10,000 lb for listed chemicals otherwise used.

Facilities must report quantities of both routine and accidental releases of listed chemicals, maximum amount of the listed chemical stored onsite during the calendar year, and amount contained in waste transferred offsite. The owner or operator of the facility on the reporting date, July 1 of each year, is primarily responsible for reporting the data for the previous year's operations at that facility. Any other owner or operator of the facility from January 1 of the data generation year to June 30 of the reporting year may also be held liable. RFP submitted a report to the EPA and to the State of Colorado in 1990, detailing the following chemicals used in 1989.

Chemical	Annual Use (lb)
Nitric acid	223,387
Sulfuric acid	58,300
Carbon tetrachloride	48,212
1,1,1-trichloroethane	45,634
Phosphoric acid	44,194
Hydrochloric acid	27,575
Ethylene glycol	13,423
Freon 113	12,545

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AGREEMENT IN PRINCIPLE (AIP)

An Agreement in Principle (AIP) was executed between DOE and the State of Colorado on June 28, 1989. This agreement identified additional technical and financial support by DOE to Colorado for environmental oversight, monitoring, remediation, emergency response, and health-related initiatives associated with the RFP. The agreement also addressed RFP environmental monitoring initiatives and accelerated cleanup where contamination may present an imminent threat to health or the environment. The agreement is designed to ensure citizens of Colorado that public health, safety, and the environment are being protected through accelerated existing programs and substantial new commitments by DOE, and through vigorous programs of independent monitoring and oversight by Colorado officials. The programs put into place under this agreement have continued through 1990 and remain on schedule.

GOVERNOR'S SCIENTIFIC ADVISORY PANEL

The Honorable Roy Romer, Governor of Colorado, created a Governor's Scientific Advisory Panel on Rocky Flats Monitoring Systems on July 7, 1989. The council provides information regarding environmental restoration, waste management, and monitoring. Monthly public meetings are held, and a bimonthly newsletter is published.

The final report of the Panel was completed in 1990; major recommendations were:

- Development of a total environmental information system for RFP.
- Development of a computerized data management system for data analysis and graphic display.
- A mass balance tabulation for materials going into and out of RFP to identify likely releases to the environment.
- Ambient air monitoring for six nonradioactive hazardous substances.

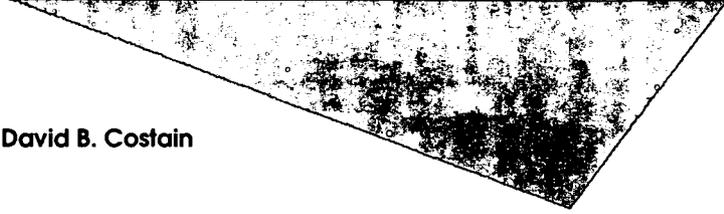
Other recommendations were grouped in categories of quality assurance and control, monitoring of ground and surface water, soil, vegetation, and meteorologic monitoring. Efforts are underway by EG&G Rocky Flats, Inc., DOE, and CDH to address these recommendations.

SETTLEMENT AGREEMENT (Church vs. DOE et al.)

A settlement agreement among DOE, The Dow Chemical Company, Rockwell International, local governments, and private landowners was reached in July 1985, requiring remediation actions to reduce plutonium contamination on areas adjacent to the eastern boundary of RFP. Contamination originated from the area now designated as the 903 Pad and occurred through airborne dispersion of plutonium particles. Soils analyses revealed offsite plutonium levels exceeding the Colorado standard of 2 disintegrations per minute per gram (dpm/g) (0.9 picocuries per gram [0.9 pCi/g]) though the EPA screening level of 44.4 dpm/g (20.0 pCi/g) was not exceeded. Court-ordered remedial action was designated for 350 acres through plowing and revegetation to prevent resuspension of the plutonium. Legal ownership of these contaminated lands was transferred to Jefferson County and the City of Broomfield for reservoir expansion and open space (no public access is permitted).

Approximately 120 acres of Jefferson County land have been treated by plowing, tilling, and seeding. Plutonium levels for these areas are now within state limits. Revegetation measures have been successful on a portion of this area (EG91a).

3. ENVIRONMENTAL MONITORING PROGRAMS



David B. Costain



The objectives of environmental management at RFP are to minimize and, where practical, eliminate the discharge of radioactive and nonradioactive hazardous effluents and to restore and enhance the environment in and around RFP. Performance of these objectives has been measured by monitoring programs designed to quantify potential impacts to the public and the environment. This section is an overview of these programs, while Section 3 subsections describe them in greater detail.

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OVERVIEW

RFP conducts operations that involve or produce liquids, solids, and gases containing radioactive and nonradioactive potentially hazardous materials. RFP environmental programs monitor penetrating ionizing radiation and pertinent radioactive, chemical, and biological pollutants. Data on air, surface water, drinking water, groundwater, and soils provide information to assess immediate and long-term environmental consequences of normal and unplanned effluent discharges and actual or potential exposures to critical populations. Site-specific data are used to evaluate risk to humans and to assist in the warning of unusual or unforeseen conditions when special environmental monitoring programs might be activated. Routine reports to local, state, and federal agencies and to the public provide information on the performance of these programs in maintaining and improving environmental quality and public health and safety at RFP. Table 3-1 is a list of these reports. Table 3-2 lists the primary environmental compliance standards for environmental monitoring programs at RFP. Additional compliance standards for air, surface water, and groundwater programs are given under references EG91k, EG91f, and EG90e, respectively.

The Catalogue of Monitoring Activities at Rocky Flats (R189), together with groundwater reports (EG90c, EG91h, EG91i, EG91j), describe routine RFP environmental monitoring programs. These programs provide current and historical perspectives on the impacts of RFP on the environment. Sections 3.1 through 3.6 of this report summarize results of routine environmental monitoring programs at RFP in 1990. Appendix D gives a detailed explanation of the sampling procedures used by laboratories and defines detection limits and error term propagation. Results are commonly compared to appropriate guides and standards that establish limits for radioactive and nonradioactive effluents. Readers unfamiliar with these standards are encouraged to review Appendix B, "Applicable Guides and Standards."

Sitewide monitoring programs are described, and results for 1989 are presented, in draft documents titled, *1989 Surface Water and Sediment Geochemical Characterization Report (EG91d)* and *Background Geochemical Characterization Report for 1989 (EG90f)*. Sitewide monitoring programs characterize and contrast environmental degradation at sites throughout RFP based on analyses of surface water, stream

Table 3-1
RFP Environmental Reports

Regulatory Report ^a	Agency ^b	Frequency
Air Compliance Report (40 CFR 61.94)	EPA	Annual
Effluent Information System/Onsite Discharge Information System	DOE	Annual
Environmental Protection Implementation Plan	DOE	Annual
Emergency and Hazardous Chemical Inventory Forms (Tier II)	c	Annual
Toxic Chemical Release Inventory (Form R)	EPA	Annual
National Pollution Discharge Elimination System/Discharge Monitoring Report	EPA	Monthly/ Annual
Polychlorinated Biphenyls (PCB) Inventory	EPA	Annual
Resource Conservation and Recovery Act Groundwater Monitoring Report	EPA/CDH	Annual
Rocky Flats Environmental Monitoring Report	DOE/EPA/CDH/ County/City	Monthly
Rocky Flats Plant Site Environmental Report	DOE	Annual
Environmental Monitoring Plan ^d	DOE	Annual
Air Quality Management Plan ^d	DOE	Annual
Surface Water Management Plan ^d	DOE	Annual
Groundwater Protection and Monitoring Program Plan ^d	DOE	Annual

- a. Reports on major environmental programs prepared on a periodic basis
 b. EPA - Environmental Protection Agency; DOE - Department of Energy; CDH - Colorado Department of Health; County - Jefferson
 Cities - Arvada, Broomfield, Westminster, Denver, Boulder, Northglenn, Fort Collins
 c. Colorado Emergency Planning Commission
 Jefferson County Emergency Planning Committee
 Boulder County Emergency Planning Committee
 Rocky Flats Fire Department
 d. Reviewed annually, updated every 3 years

Table 3-2
Primary Compliance Standards for Environmental Monitoring Programs

Monitoring Program	Compliance Standards
AIR	
Effluent Air	<ul style="list-style-type: none"> NESHAP (Title 40 CFR 61)^a Colorado Air Quality Control Regulation #8 (Title 5 CCR 1001) General Environmental Protection Program (DOE Order 5400.1) Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Nonradioactive Ambient Air	<ul style="list-style-type: none"> NAAQs (Title 40 CFR 50)^b Colorado Air Quality Control Regulations #1, #2, and #3 (Title 5CCR1001) General Environmental Protection Program (DOE Order 5400.1) Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Radioactive Ambient Air	<ul style="list-style-type: none"> General Environmental Protection Program (DOE Order 5400.1) Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
SURFACE WATER	
Surface Water	<ul style="list-style-type: none"> NPDES^c (Title 40 CFR 122, 125) Colorado Water Quality Control Commission Surface Water Standards (Title 5 CCR 1000) General Environmental Protection Program (DOE Order 5400.1) Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
Community Water	<ul style="list-style-type: none"> National Interim Primary Drinking Water Regulations (Title 40 CFR 141) Colorado Primary Drinking Water Regulations (Title 5 CCR 1002) General Environmental Protection Program (DOE Order 5400.1) Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
GROUNDWATER	
	<ul style="list-style-type: none"> CERCLA (Title 42 U.S.C. 9601)^d RCRA (Title 42 U.S.C. 6901)^e Colorado Hazardous Waste Management Act (Title 25 CRS, Article 15) General Environmental Protection Program (DOE Order 5400.1) Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B) Colorado Water Quality Control Commission Groundwater Standards
SOILS	
	<ul style="list-style-type: none"> USAEC Rocky Flats Plant, 1973 Environmental Surveillance Summary Report General Environmental Protection Program (DOE Order 5400.1) Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)
RADIATION DOSE	
	<ul style="list-style-type: none"> Radiation Protection of the Public and the Environment (DOE Order 5400.5) General Environmental Protection Program (DOE Order 5400.1) Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B)

- a. National Emission Standards for Hazardous Air Pollutants
 b. National Ambient Air Quality Standards
 c. National Pollution Discharge Elimination System
 d. Comprehensive Environmental Response, Compensation and Liability Act
 e. Resource Conservation and Recovery Act

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sediments, groundwater, and borehole materials. Results of these monitoring programs, together with results of routine groundwater monitoring, are used to identify contaminated sites and to design and monitor restoration activities.

In addition to environmental programs performed by EG&G Rocky Flats, Inc., several local, state, and federal governmental agencies conduct independent audits and environmental surveys within and adjacent to RFP. CDH, DOE, and the cities of Broomfield and Westminster conduct various air, water, and soil monitoring programs. Data are reported collectively at monthly Environmental Monitoring Information Exchange Meetings. RFP provides monthly environmental monitoring summaries at these meetings, which are open to the public and have been ongoing since the early 1970s.

SPECIAL ASSIGNMENT TEAM

On June 6, 1989, DOE mobilized a Special Assignment Team (Tiger Team) to provide an independent evaluation of operations and practices at RFP. This followed initiation of a search warrant by EPA based on an affidavit alleging regulatory and criminal violations of environmental law at RFP. The United States Department of Justice is conducting the investigation, and a federal grand jury has been convened to review RFP compliance with applicable environmental laws.

The environmental audit was completed on July 21, 1989, and results were reported in the document, *Assessment of Environmental Conditions at the Rocky Flats Plant* (DOE89). EG&G Rocky Flats, Inc., responded to findings of the Special Assignment Team through a series of documents, the most recent of which is titled, *Corrective Action Plan in Response to the August 1989 Assessment of Environmental Conditions at the Rocky Flats Plant* (EG90d). This document outlines 93 separate action plans that contain descriptions of measures to be taken by RFP to address findings and includes schedules, milestones, associated costs, and parties responsible for implementing planned actions. Many of the activities described in this plan overlap or are similar to actions specified in the AIP and IAG described in Section 2, "Compliance Summary" and to

the RFP Five-Year Plan (FYP) for environmental and waste programs (EG91b). Progress concerning this action plan has been described in reports dated September and December 1990 titled, *Quarterly Report to the Secretary of Energy on Tiger Team Corrective Actions* (DOE90c). As of December 1990, EG&G Rocky Flats, Inc., had completed all requirements contained in 16 action plans. Work had been completed and was undergoing internal verification for an additional 21 action plans. The remaining 56 plans were in various stages of implementation.

THE FIVE-YEAR PLAN (FYP) AND THE SITE- SPECIFIC PLAN (SSP)

The purpose of the FYP is to establish an agenda for compliance and cleanup against which progress will be measured. The plan is revised annually, with a 5-year planning horizon, and supports an annual national plan that is issued under the same title. A draft plan for fiscal years 1993-1997 was prepared in January 1991 and is titled *Rocky Flats Plant FY93-97 Five-Year Plan* (EG91b). The FYP encompasses total program activities and costs for DOE Corrective Activities, Environmental Restoration, Waste Management, and Applied Research and Development. Hazardous, radioactive, mixed (hazardous and radioactive), and sanitary wastes are addressed, along with facilities and sites that are either contaminated with wastes or used in the management of those wastes.

To describe how activities shown in the FYP would be implemented at RFP, a Site-Specific Plan (SSP) is prepared. This plan is revised annually and emphasizes near-term activities, primarily those to be accomplished in a fiscal year. A final plan for 1990 (EG90b) and a draft plan for 1991 (EG91c) have been prepared.

3. ENVIRONMENTAL MONITORING PROGRAMS

3.1 METEOROROLOGY AND CLIMATOLOGY

Ralph G. Porter

This section concerns meteorological data collected at RFP from January 1 through December 31, 1990, from instrumentation installed on a 61-m (200-ft) tower located in the west buffer zone. The tower is instrumented at 10, 25, and 60 meters to measure horizontal wind speed, direction, vertical wind speed, and temperature. Dew point measurements are made at the 10-m level. Solar radiation measurements are taken by a radiometer mounted on an unobstructed platform at 1.5 m above ground level. Ground-level precipitation and pressure are also measured.

RESULTS

Meteorological information in this report represents 95 percent data recovery from instrumentation located at the RFP 61-Meter Meteorological Tower (Figure 3.1-1). Table 3.1-1 is the 1990 annual summary of the percent frequency of wind directions (16 compass points) divided into four wind speed categories.

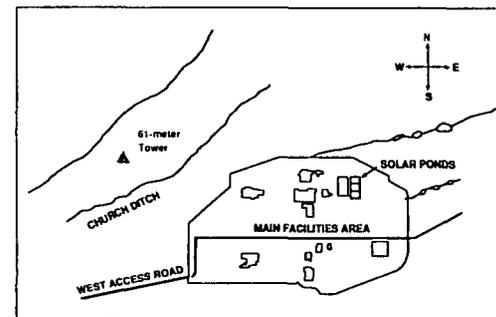


Figure 3.1-1. Location of the RFP 61-Meter Meteorological Tower

Table 3.1-1
Wind Direction Frequency (Percent)
by Four Wind-Speed Classes

(Fifteen-Minute Averages - 1990 Annual)

	Calm	1-3 (meters/sec)	3-7 (meters/sec)	7-15 (meters/sec)	>15 (meters/sec)	TOTAL
-	4.64					4.64
N	-	2.59	3.92	0.62	0.01	7.14
NNE	-	2.91	3.25	0.30	0.01	6.47
NE	-	2.91	2.01	0.04	0.00	4.96
ENE	-	2.23	0.95	0.01	0.00	3.19
E	-	2.44	0.41	0.00	0.00	2.85
ESE	-	2.35	0.87	0.00	0.00	3.22
SE	-	2.27	2.08	0.00	0.00	4.35
SSE	-	2.71	2.77	0.08	0.00	5.56
S	-	2.47	2.20	0.15	0.00	4.82
SSW	-	2.58	2.45	0.09	0.00	5.12
SW	-	2.21	2.18	0.11	0.00	4.50
WSW	-	2.25	4.05	0.39	0.00	6.69
W	-	2.82	3.37	1.45	0.11	7.75
WNW	-	3.06	3.44	3.84	0.65	10.99
NW	-	2.88	4.68	2.98	0.15	10.69
NNW	-	2.56	3.92	0.58	0.00	7.06
TOTALS	4.64	41.24	42.55	10.64	0.93	100.0

Compass point designations indicate the true bearing when facing against the wind as do wind rose vectors shown in Figure 3.1-2 (i.e., wind along each vector blows toward the center). The predominance of northwesterly winds and low frequency of winds greater than 7 meters per second (m/s) (15.6 miles per hour (mph)) with easterly components is typical at RFP.

The mean wind speed for 1990 was 4.0 m/s (9.0 mph). The highest wind speed was 39.6 m/s (88.6 mph) on December 14, 1990. The mean temperature during 1990 was 9.3 °C (48.7 °F). The maximum temperature was 34.7 °C (96 °F) on July 2, 1990, and the minimum temperature was -31.1 °C (-24.0 °F) on December 21, 1990.

Atmospheric stability at RFP was calculated using the sigma phi technique. The data collected during 1990 and presented in Pasquill stability classes showed 50.1 percent neutral stability cases (Class D), 42.5 percent stable cases (Classes E and F), and 7.37 percent unstable cases (Classes A, B, and C) (Table 3.1-2). Classes A through F represent six stability categories, from most unstable (A) to very stable conditions (F). Stability Class D represents neutral conditions. Frequency distributions of wind speed within the stability categories are presented in Appendix C.

During 1990, RFP recorded 32.4 centimeters (cm) (12.8 in.) of precipitation. The maximum precipitation for a 15-minute period was 1.30 cm (0.51 in.) occurring on July 4, 1990. The most precipitation recorded on a single day was 2.26 cm (0.89 in.) on March 6, 1990. Table 3.1-3 presents the monthly precipitation for 1990.

Meteorology of RFP is strongly influenced by the diurnal cycle of mountain and valley breezes. The Front Range of the Rocky Mountains west of the RFP is broken by several canyons that run generally east-west.

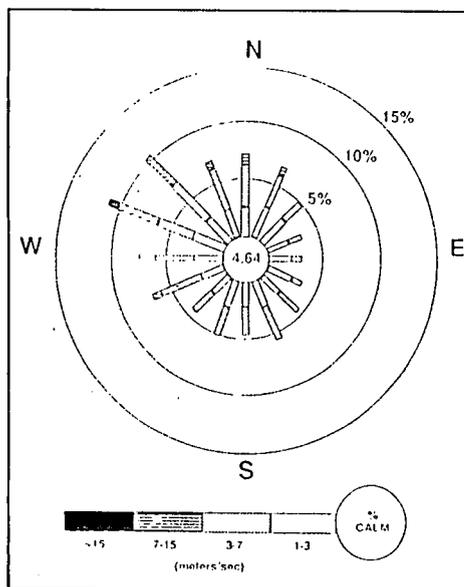


Figure 3.1-2. RFP 1990 Wind Rose

Table 3.1-2
Percent Occurrence of Winds
by Stability Class

Stability Class	Percent Occurrence
A	2.58
B	1.33
C	3.46
D	50.08
E	30.03
F	12.51

Table 3.1-3
Monthly Precipitation

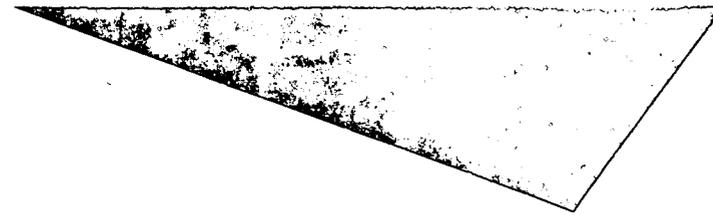
Month	Precipitation (cm)
January	0.71
February	0.43
March	6.58
April	3.38
May	4.62
June	0.30
July	8.03
August	0.58
September	5.08
October	1.22
November	1.45
December	0.02
Total	32.40

These canyons channel airflow especially when there is strong atmospheric stability. Two dominant flow patterns exist, one during daytime conditions and one at night. During daytime hours, as the earth heats, the mountains receive more direct sunlight than the plains and valleys, causing air to heat and rise. The result is a general trend for the airflow to travel toward the higher elevations (upslope condition). The general airflow pattern during upslope conditions for the Denver area is typically north to south with the flow moving up the South Platte River Valley and entering the canyons into the Front Range. After sunset, air against mountainsides cools and begins to flow toward the lower elevations (downslope conditions). The airflow pattern for the Denver area during downslope conditions is down the canyons of the Front Range onto the plains. This flow converges with the South Platte River Valley flow moving toward the north-northeast.

Strong convective activity and thunderstorms are common in the area during summer. This activity can produce severe anomalies on the normal airflow patterns because of strong inflow regions or outflow microbursts caused by the accompanying rain shafts. During late winter and spring the meteorology can be influenced by chinook windstorms. The chinook phenomenon is characterized by strong winds moving from the west to the east over the continental divide. These winds often reach 70-80 mph and have been recorded in excess of 120 mph at RFP.

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3. ENVIRONMENTAL MONITORING PROGRAMS



3.2 AIR MONITORING

Thomas G. Kalivas
Luther C. Pauley

Production and research buildings at RFP are equipped with ventilation exhaust systems. Particulate materials generated by production and research activities are removed from the air stream in each exhaust system by means of High Efficiency Particulate Air (HEPA) filters. Residual particulate materials in each of these systems are continuously sampled downstream from the final stage of HEPA filters. This section includes results of monitoring effluent air, nonradioactive ambient air, and radioactive ambient air.

EFFLUENT AIR MONITORING

Overview

For immediate detection of abnormal conditions, RFP building ventilation systems that service areas containing plutonium are equipped with Selective Alpha Air Monitors (SAAMs). SAAMs are sensitive to specific alpha particle energies and are set to detect plutonium-239 and -240. These detectors are subjected to daily operational checks, monthly performance testing and calibration for airflow, and an annual radioactive source calibration to maintain sensitivity and reliability. Monitors alarm automatically if out-of-tolerance conditions are experienced. No such condition occurred during 1990.

At regular intervals, particulate material samples from a continuous sampling system are removed from each exhaust system and radiometrically analyzed for long-lived alpha emitters. The concentration of long-lived alpha emitters is indicative of effluent quality and overall performance of the High Efficiency Particulate Air (HEPA) filtration system. If the total long-lived alpha concentration for an effluent sample exceeds the RFP actions value of 0.020×10^{-12} microcuries per milliliter ($\mu\text{Ci/ml}$) (7.4×10^{-4} Becquerels per cubic meter [Bq/m^3]), a follow-up investigation is conducted to determine the cause and to evaluate the need for corrective action. The action guide value is equal to the most restrictive offsite DCG for plutonium activity in air. (See Appendix B for guide explanations.)

At the end of each month, individual samples from each exhaust system are composited into larger samples by location. An aliquot of each dissolved composite sample is analyzed for beryllium particulate materials. The remainder of the dissolved sample is subjected to radiochemical separation and alpha spectral analysis that quantifies specific alpha-emitting radionuclides. Analyses for uranium isotopes are conducted for each composite sample.

Forty-one of the ventilation exhaust systems are located in buildings where plutonium processing is conducted. Particulate material samples from these exhaust systems are analyzed for specific isotopes of plutonium and americium. Typically, americium contributes only a small fraction of the total alpha activity release from RFP.

Results

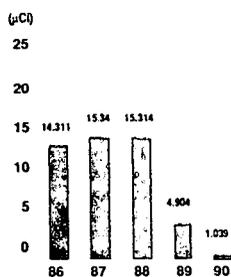


Figure 3.2-1 Plutonium-239, -240

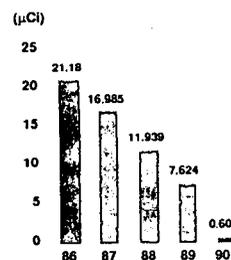


Figure 3.2-2 Uranium-233, -234, -238

Processes that are ventilated from several exhaust systems potentially exhibit trace quantities of tritium contamination. Bubble-type samplers are used to collect samples three times each week from the monitored locations. Tritium concentrations in the sample are measured using a liquid scintillation photospectrometer.

Projected doses to the public from radionuclide emissions were within the NESHAP limits of 10 mrem/year EDE. Section 4, "Radiation Dose Assessment," includes a discussion on radiation dose estimates from air emissions.

Plutonium and Uranium. During 1990, total quantities of plutonium and uranium discharged to the atmosphere from RFP processing and support buildings were 1.067 µCi (3.95×10^4 Bq) and 0.606 µCi (2.24×10^4 Bq), respectively (Tables 3.2-1 and 3.2-2). These values were corrected for background radiation. Annual plutonium-239, -240 and uranium -233, -234, -238 emissions for the 1986-1990 period are given in Figures 3.2-1 and 3.2-2, respectively.

In September 1989, operations of RFP's primary plutonium recovery facility were suspended. Operations for the remainder of the plant were suspended following the December 1989 plant inventory; these operations did not resume in 1990. Consequently, overall decreases in radionuclide emissions during 1990 are a reflection of reduced production activities.

For the period July 30 to August 2, 1990, the total long-lived alpha activity concentration for one of three sampling devices used to monitor the Building 771 main air effluent was 0.03 pCi/m³. Concentrations for the other two sampling devices were -0.001 and 0.001 pCi/m³. The RFP internal screening guide for air effluent alpha activity is 0.02 pCi/m³. An investigation was initiated to determine the cause of the above-normal alpha activity concentration. In addition the sample filter for this sampling period was analyzed separately for individual isotopes of plutonium, uranium, and americium, rather than the filter being included in the monthly composite for that location. The above-normal alpha activity concentration was caused by damage to some of the air effluent HEPA filters during maintenance work in the plenum. The plutonium-239, -240 analysis for the sample filter of interest showed a plutonium air effluent concentration of 0.0078 ± 0.0018 pCi/m³ for the July 30 to

Table 3.2-1
Plutonium in Effluent Air

Month	Number of Analyses	Plutonium-238		Plutonium-239, -240	
		Total Discharge (µCi)	C maximum ^a ($\times 10^{-12}$ µCi/ml)	Total Discharge (µCi)	C maximum ^a ($\times 10^{-12}$ µCi/ml)
January	47	0.01	0.00004 ± 0.00003	0.29	0.00082 ± 0.00021
February	46	-0.00	0.00003 ± 0.00011	0.07	0.00010 ± 0.00021
March	46	0.00	0.00003 ± 0.00003	0.06	0.00126 ± 0.00033
April	46	0.00	0.00008 ± 0.00008	0.09	0.00078 ± 0.00015
May	46	0.00	0.00014 ± 0.00003	0.08	0.00385 ± 0.00045
June	46	0.01	0.00004 ± 0.00003	0.12	0.00293 ± 0.00044
July	46	0.00	0.00002 ± 0.00002	0.04	0.00010 ± 0.00003
August	49	0.01	0.00016 ± 0.00002	0.13	0.00780 ± 0.00175
September	46	-0.00	0.00003 ± 0.00004	0.03	0.00043 ± 0.00014
October	46	0.005	0.00002 ± 0.00003	0.050	0.00066 ± 0.00015
November	45	0.002	0.00001 ± 0.00001	0.024	0.00007 ± 0.00005
December	46	-0.002	0.00002 ± 0.00003	0.060	0.00055 ± 0.00016
Overall	555	0.028 ^{b,c}	0.00016 ± 0.00020	1.039 ^{b,c}	0.00780 ± 0.00175

- a. Maximum sample concentration.
- b. Minor discrepancies in total discharge values result from rounding errors in calculations.
- c. One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

Table 3.2-2
Uranium in Effluent Air

Month	Number of Analyses	Uranium-233, -234		Uranium-238	
		Total Discharge (µCi)	C maximum ^a ($\times 10^{-12}$ µCi/ml)	Total Discharge (µCi)	C maximum ^a ($\times 10^{-12}$ µCi/ml)
January	55	0.05	0.00258 ± 0.00052	0.04	0.00014 ± 0.00012
February	54	-0.01	0.00004 ± 0.00010	0.05	0.00014 ± 0.00012
March	54	-0.00	0.00016 ± 0.00012	0.00	0.00007 ± 0.00009
April	54	-0.02	0.00204 ± 0.00030	0.04	0.00018 ± 0.00006
May	55	0.05	0.00027 ± 0.00189	0.04	0.00026 ± 0.00008
June	54	-0.03	0.00012 ± 0.00011	0.05	0.00016 ± 0.00006
July	54	0.00	0.00008 ± 0.00012	0.05	0.00016 ± 0.00006
August	57	0.02	0.00008 ± 0.00009	0.07	0.00013 ± 0.00004
September	54	-0.00	0.00028 ± 0.00015	0.02	0.00012 ± 0.00006
October	54	-0.002	0.00009 ± 0.00008	0.037	0.00017 ± 0.00007
November	53	0.015	0.00009 ± 0.00007	0.059	0.00010 ± 0.00003
December	54	0.029	0.00013 ± 0.00010	0.062	0.00018 ± 0.00007
Overall	652	0.098 ^{b,c}	0.00258 ± 0.00052	0.508 ^{b,c}	0.00026 ± 0.00008

- a. Maximum sample concentration.
- b. Minor discrepancies in total discharge values result from rounding errors in calculations.
- c. One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

August 2 period. Plutonium concentrations for the other two sampling devices were 0.00023 ± 0.00036 and -0.00008 ± 0.00011 pCi/m³. Continuous inhalation of 0.0078 pCi/m³ plutonium for 4 days at 20 liters per minute would result in a calculated effective dose equivalent of about 0.6 millirem (mrem). This would represent the maximum radiation dose from inhalation at the point the air effluent leaves the building. No person would actually be at that location, and actual dose to any individual, particularly any member of the public, from this release would be much less than 0.6 mrem. Under adverse meteorological conditions, the maximum dose at the RFP boundary would be less than 0.005 mrem. These doses can be compared to the radiation standards for protection of the public of 100 mrem per year for all pathways and 10 mrem per year for the air pathway only. Americium-241 concentration from July 30 to August 2 was 0.000879 ± 0.00686 pCi/m³. Total activity released for this location and period was 0.00624 μ Ci. Samples collected prior to and following this 3-day period were within the range typically measured in this exhaust system.

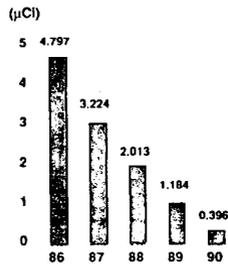


Figure 3.2-3 Americium-241

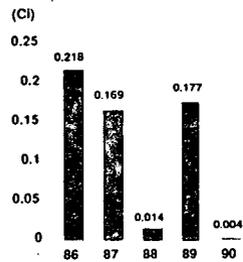


Figure 3.2-4 Tritium

Values reported for total quantities of plutonium and uranium discharged in 1990 vary from the monthly environmental monitoring reports because of rounding in calculations and because the annual report includes plutonium-238, -239, and -240. Plutonium-238 represents 2.6 percent of the total plutonium discharged in 1990.

Americium. Total americium discharged in 1990 was 0.396 μ Ci (1.47×10^4 Bq) (Table 3.2-3). Maximum concentration was 0.00144×10^{-12} μ Ci/ml, observed in samples taken in April. Americium values were corrected for background radiation. Annual americium emissions for 1989 and 1990 are shown in Figure 3.2-3.

Tritium. Total tritium discharged in 1990 from ventilation systems in which tritium is routinely measured was 0.0039 Ci (1.44×10^8 Bq) (Table 3.2-4). The maximum tritium concentration of 88×10^{-12} μ Ci/ml (3.26 Bq/m³) was observed during February from routine operations in a plutonium production building. Each month is divided into a series of individual sampling periods. The sum of discharge for these sampling periods is the total tritium discharge for the month. Tritium values include a small, unquantified contribution attributed to natural background (i.e., non-plant) sources. Annual tritium emissions for the period 1986-1990 are given in Figure 3.2-4.

Table 3.2-3
Americium In Effluent Air

Americium-241			
Month	Number of Analyses	Total Discharge (μ Ci)	C maximum* ($\times 10^{-12}$ μ Ci/ml)
January	55	0.11	0.00027 ± 0.00006
February	54	0.01	0.00003 ± 0.00003
March	54	0.01	0.00019 ± 0.00007
April	54	0.20	0.00144 ± 0.00018
May	55	0.00	0.00021 ± 0.00004
June	54	0.03	0.00057 ± 0.00012
July	54	0.00	0.00005 ± 0.00004
August	57	0.01	0.00088 ± 0.00069
September	54	0.011	0.00006 ± 0.00003
October	54	0.007	0.00006 ± 0.00004
November	53	0.007	0.00004 ± 0.00002
December	54	0.005	0.00022 ± 0.00005
Overall	652	0.396^b	0.00144 ± 0.00018

- Maximum sample concentration.
- Minor discrepancies in total discharge values result from rounding errors in calculations.
- One or more values contributing to this total are based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

Table 3.2-4
Tritium In Effluent Air

Tritium			
Month	Number of Analyses	Total Discharge (Ci)	C maximum* ($\times 10^{-12}$ μ Ci/ml)
January	57	0.0004	35 ± 6
February	51	0.0005	88 ± 7
March	50	0.0004	72 ± 13
April	63	0.0004	68 ± 19
May	67	0.0005	64 ± 5
June	69	0.0005	37 ± 7
July	50	0.0004	33 ± 2
August	66	0.0004	44 ± 4
September	27	0.0002	6 ± 8
October	41	0.0001	5 ± 5
November	35	0.0001	13 ± 6
December	35	0.0001	29 ± 4
Overall	611	0.0039^b	88 ± 7

- Maximum sample concentration.
- Minor discrepancies in total discharge values result from rounding errors in calculations.

**NONRADIOACTIVE
AMBIENT AIR
MONITORING**

Overview

Nonradioactive ambient air monitoring was conducted in 1990 for total suspended particulates (TSP) and respirable particulates (less than or equal to 10 micrometers (μm) in diameter. Ambient particulates are regulated by EPA and CDH under Clean Air Act Amendments of 1970 and 1977, as defined by the National Ambient Air Quality Standards (NAAQS) and Colorado Air Quality Control Commission Ambient Air Standards. Regulation is based on regional rather than site-specific air quality parameters. Formerly, EPA particulate standards (NAAQS) were based on TSP, a measure of total particulate recovery, regardless of particulate size. The present EPA standard, referred to as Particulate Matter-10 or PM-10, is based on respirable particulates, those particles less than or equal to 10 μm in diameter. Final EPA respirable particulate standards were issued on July 1, 1987 (EPA87a), and reference methods were issued on October 6 and December 1, 1987. PM-10 samplers at RFP were procured to meet EPA design specifications.

Ambient air monitoring at RFP provides baseline information on particulate levels. Table 3.2-6 identifies sampling equipment used for measuring particulates. RFP monitors ambient air with both TSP and PM-10 samplers. CDH has requested concurrent TSP sampling until changes have been made in state regulations to reflect PM-10 changes in federal regulations. TSP and PM-10 samplers are collocated near the east entrance to RFP. This location is unobscured by structures, near a traffic zone, and generally downwind from plant buildings. Samplers are operated on an EPA sampling schedule of one day per every sixth day. TSP is measured by the EPA-referenced, high-volume air sampling method.

Particulate data are shown in Table 3.2-7; current (PM-10) and former (TSP NAAQS) standards are given in Appendix B. The highest TSP value recorded in 1990 (24-hr sample) was 134 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) (51 percent of the former TSP 24-hr primary standard), and the annual geometric mean value was 31.4 $\mu\text{g}/\text{m}^3$ (12 percent of former TSP primary annual geometric mean standard). The observed 24-hr maximum for the PM-10 sampler was 26 $\mu\text{g}/\text{m}^3$ (17 percent of the primary 24-hr standard) and the

Results

Beryllium. The total quantity of beryllium discharged from ventilation exhaust systems was 8.219 g and the maximum concentration was 0.00371 $\mu\text{g}/\text{m}^3$ observed in September. The beryllium stationary-source emission standard is 10 g over a 24-hr period. Table 3.2-5 presents the beryllium airborne effluent data for 1990. RFP stopped using analytical blanks in laboratory analysis to correct sample beryllium concentrations in September 1989. Consequently, reported beryllium values measure both background and actual emission levels.

The total quantity of beryllium discharged in 1990 varies from the monthly environmental monitoring reports because the annual report includes values for all 49 exhaust systems, whereas the monthly report gave discharges for six exhaust systems on buildings where beryllium is processed. Beryllium discharges are monitored monthly at the remaining 43 locations but are only given in monthly reports if they exceed a screening level of 0.1 g. Annual beryllium emissions for the period 1986-1990 are shown in Figure 3.2-5.

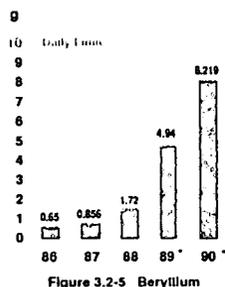


Figure 3.2-5 Beryllium

* These values are not corrected for background levels

**Table 3.2-5
Beryllium in Effluent Air**

Beryllium ^{a, b}			
Month	Number of Analyses	Total Discharge ^c (g)	C maximum ^d ($\mu\text{g}/\text{m}^3$)
January	55	0.475	0.00080
February	54	0.472	0.00068
March	54	0.413	0.00083
April	54	0.349	0.00051
May	55	0.426	0.00136
June	54	0.929	0.00091
July	54	1.048	0.00150
August	57	0.372	0.00146
September	54	1.056	0.00371
October	54	1.016	0.00143
November	53	0.994	0.00063
December	54	0.670	0.00093
Overall	652	8.219	0.00371

- a. The beryllium stationary-source is no more than 10 grams of beryllium over a 24-hour period under the provisions of subpart C of 40 CFR 61.32(a).
- b. Beginning in June 1989, concentrations and emission values were not corrected for background contribution.
- c. These values are not significantly different from the background associated with the analysis.
- d. Maximum sample concentration.

Table 3.2-6
Ambient Air Monitoring Detection Methods

Parameter	Detection Methods
Particulate Matter less than 10 micrometers in diameter (PM-10)	Wedding PM-10 Sampler
Total Suspended Particulates (TSP)	Reference Method (Hi Volume) 24-Hour sampling (6h-day scheduling)

Table 3.2-7
Ambient Air Quality Data for Nonradioactive Particulates

Total Suspended Particulates	$\mu\text{g}/\text{m}^3$
Total Number of Samples ^a	56.0
Total Number of Samples ^b	59.0
Annual Geometric Mean ^a	31.4
Annual Geometric Mean ^b	27.7
Standard Deviation ^a	20.3
Standard Deviation ^b	18.2
Observed 24-Hour Maximum ^a	134.4
Observed 24-Hour Maximum ^b	119.0
Second Highest Maximum ^a	74.0
Second Highest Maximum ^b	69.0
Lowest Observed Value ^a	8.0
Lowest Observed Value ^b	2.9
Respirable Particulates (PM-10)	
Total Number of Samples ^c	45.0
Total Number of Samples ^d	49.0
Annual Arithmetic Mean ^c	9.8
Annual Arithmetic Mean ^d	11.2
Observed 24-Hour Maximum ^c	26.0
Observed 24-Hour Maximum ^d	29.7
Second Highest Maximum ^c	19.0
Second Highest Maximum ^d	26.0

- a. Primary ambient air TSP particulate sampler; reporting unit.
b. Collocated duplicate TSP sampler.
c. Primary ambient air PM-10 sampler.
d. Collocated duplicate PM-10 sampler.

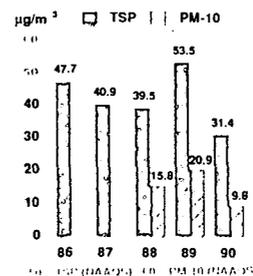


Figure 3.2-6 TSP and PM-10

annual arithmetic mean was $9.8 \mu\text{g}/\text{m}^3$ (20 percent of the primary annual arithmetic mean standard). Mean annual concentrations of particulates for onsite ambient TSP samplers (1986-1990) and PM-10 samplers (1988-1990) are shown in Figure 3.2-6.

RADIOACTIVE AMBIENT AIR MONITORING

Overview

Radioactive ambient air samplers monitor airborne dispersion of radioactive materials from RFP into the surrounding environment. Samplers are designated in three categories by their proximity to the main facilities area. Twenty-five onsite samplers are located within RFP, concentrated near the main facilities area. Fourteen perimeter samplers border RFP along major highways on the north (Highway 128), east (Indiana Street), south (Highway 72), and west (Highway 93) (Figure 3.2-7). Fourteen community samplers are located in metropolitan areas adjacent to RFP (Figure 3.2-8). Samplers operate continuously at a volumetric flow rate of approximately 12 liters per second (l/s) (25 cubic feet per minute [ft³/min]), collecting air particulates on 20 x 25-cm (8 x 10-in) fiberglass filters. Manufacturer's test specifications rate this filter media to be 99.97 percent efficient for relevant particle sizes under conditions typically encountered in routine ambient air sampling (SC 82).

Filters were collected biweekly from all RFP samplers. Each biweekly filter from the onsite samplers was analyzed separately each month except in December. Filters collected in December were composited by location into one onsite sample. Filters from perimeter and community samplers are collected biweekly, composited by location, and analyzed monthly for plutonium.

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Section 3.2 AIR MONITORING

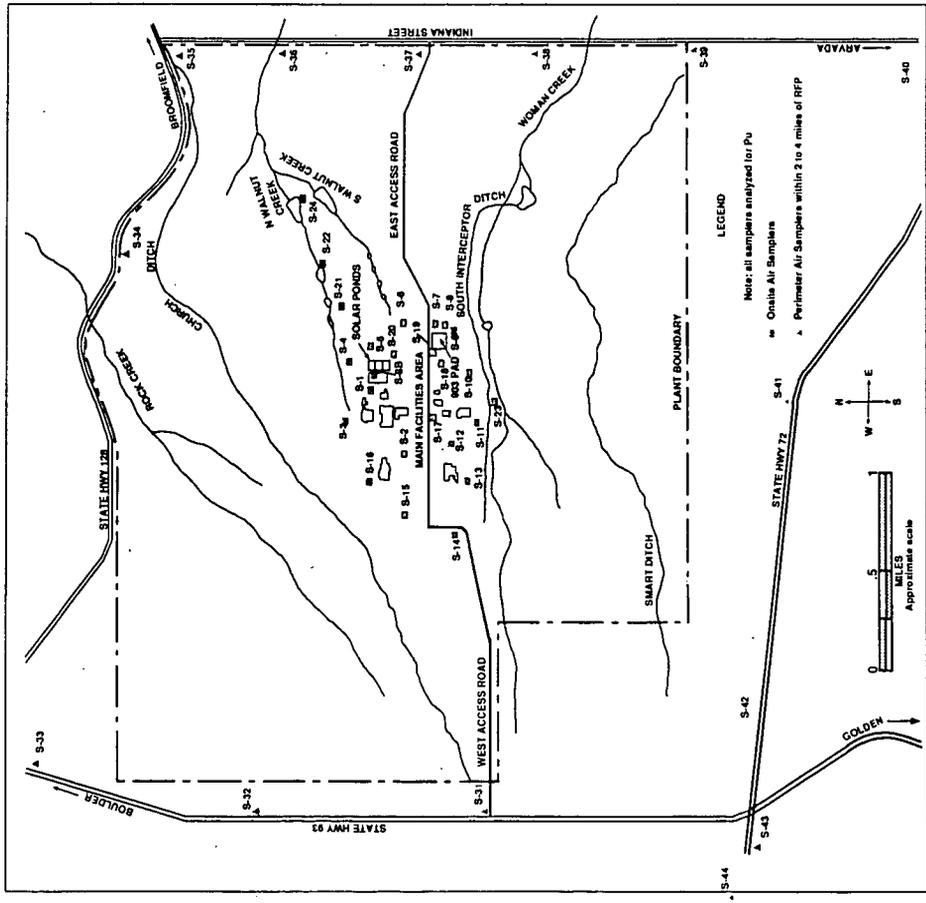


Figure 3.2-7. Onsite and Perimeter Ambient Air Samplers

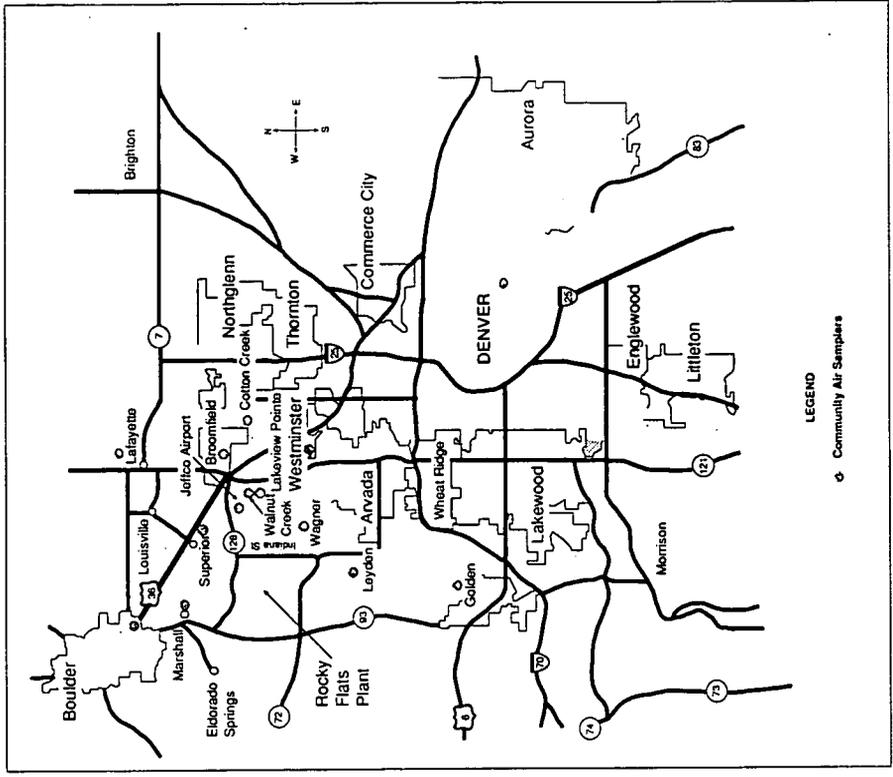


Figure 3.2-8. Community Ambient Air Samplers

Results

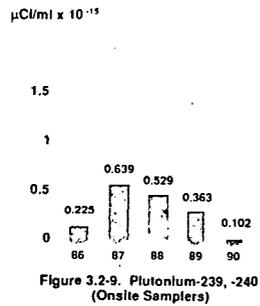


Figure 3.2-9. Plutonium-239, -240 (Onsite Samplers)

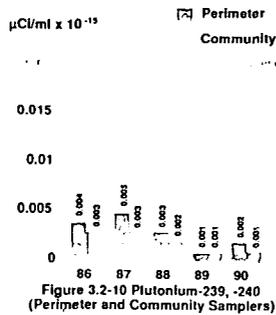


Figure 3.2-10 Plutonium-239, -240 (Perimeter and Community Samplers)

Plutonium concentrations for onsite samplers are given in Table 3.2-8. Plutonium concentrations for perimeter and community samplers are given in Table 3.2-9. Overall mean plutonium concentration for onsite samplers was $0.072 \times 10^{-15} \mu\text{Ci/ml}$ ($2.7 \times 10^{-6} \text{ Bq/m}^3$), 0.36 percent of the offsite DCG for plutonium in air (Appendix C). Overall mean plutonium concentration for perimeter samplers was $0.003 \times 10^{-15} \mu\text{Ci/ml}$ ($1.1 \times 10^{-7} \text{ Bq/m}^3$). Overall mean plutonium concentration for community samplers was $0.001 \times 10^{-15} \mu\text{Ci/ml}$ ($3.7 \times 10^{-8} \text{ Bq/m}^3$). These values are 0.013 percent and 0.005 percent, respectively, of the offsite DCG.

Mean annual concentrations of plutonium for 1986 - 1990 are shown in Figure 3.2-9 (onsite samplers) and Figure 3.2-10 (perimeter and community samplers). The onsite data are based on the mean of the annual concentrations from five locations, S-5 through S-9. Isotope-specific analyses were not reported for other onsite locations until 1990. The perimeter and community data points are the annual averages of fourteen locations within each of these areas.

Table 3.2-8
Onsite Ambient Air Sampler Plutonium Concentrations^{a,b}

Station	Number of Samples	Concentration ($\times 10^{-15} \mu\text{Ci/ml}$) ^c			Standard Deviation (C standard)	Percent of DCG ^d (C mean)
		C minimum	C maximum	C mean		
S-1	21	0.000	3.057	0.948	0.892	4.740
S-2	13	0.003	0.024	0.007	0.007	0.037
S-3	16	0.000	0.010	0.003	0.001	0.014
S-4	17	0.001	0.181	0.022	0.050	0.110
S-5	24	0.004	0.453	0.099	0.123	0.496
S-6	24	0.013	0.482	0.127	0.144	0.637
S-7	24	0.010	0.670	0.118	0.180	0.588
S-8	25	0.024	0.108	0.061	0.033	0.305
S-9	24	0.033	0.328	0.107	0.094	0.535
S-10	17	0.002	0.016	0.006	0.004	0.028
S-11	17	0.000	0.008	0.005	0.003	0.024
S-12	17	0.002	0.023	0.013	0.007	0.063
S-13	17	0.001	0.008	0.004	0.003	0.018
S-14	17	0.000	0.006	0.002	0.002	0.011
S-15*	15	-0.001	0.028	0.004	0.008	0.021
S-16	17	-0.001	0.005	0.002	0.002	0.011
S-17	17	0.005	0.022	0.011	0.005	0.053
S-18*	16	0.011	0.069	0.035	0.020	0.177
S-19	17	0.010	0.092	0.028	0.023	0.142
S-20	17	0.004	0.033	0.016	0.008	0.080
S-21	17	0.004	0.018	0.009	0.005	0.045
S-22	17	0.001	0.009	0.004	0.002	0.020
S-23	16	0.001	0.006	0.003	0.002	0.015
S-24	17	-0.002	0.010	0.002	0.003	0.012
S-8B*	13	0.051	0.356	0.161	0.123	0.806
Overall	452	-0.002	3.057	0.072	0.070	0.360

- Data provided in this table are based on various periods of sampling. The locations not marked with an asterisk are calculated on a 12-month basis. The other locations are calculated using less than 12 months of data due to mechanical malfunctions, incomplete laboratory analyses, or the installation of a new sampler (S-8B) that has not been in service for a complete year.
- Isotope-specific analyses were reported only for locations S-5 through S-9 before 1990 (see Figure 3.2-7). These five samplers are the only onsite locations included in the 5-year trending portion of this report.
- Concentrations reflect monthly composites of biweekly station concentrations; C minimum = minimum composited concentration; C maximum = maximum composited concentration; C mean = mean composited concentration.
- The DOE Derived Concentration Guide (DCG) for inhalation of class W plutonium by members of the public is $20 \times 10^{-15} \mu\text{Ci/ml}$ (Appendix B). Protection standards for members of the public are applicable for onsite locations. All locations in this table are on RFP property. DCGs for the public are presented here for comparison purposes only.

Table 3.2-9
Perimeter Ambient Air Sampler Plutonium Concentrations^a

Station	Number of Samples	Concentration (x 10 ⁻¹⁵ µCi/ml) ^b			Standard Deviation (C_standard)	Percent of DCG ^c (C_mean)
		C_minimum	C_maximum	C_mean		
S-31*	11	-0.001	0.002	0.001	0.001	0.003
S-32	12	0.000	0.003	0.001	0.001	0.007
S-33	12	-0.001	0.004	0.000	0.001	0.002
S-34	12	0.000	0.005	0.002	0.002	0.009
S-35	12	-0.001	0.003	0.001	0.001	0.004
S-36	12	0.000	0.003	0.001	0.001	0.005
S-37	12	0.000	0.007	0.003	0.002	0.014
S-38	12	0.000	0.181	0.017	0.052	0.083
S-39	12	-0.001	0.002	0.001	0.001	0.003
S-40*	11	0.000	0.032	0.004	0.009	0.019
S-41	12	0.000	0.003	0.001	0.001	0.005
S-42	12	0.000	0.004	0.001	0.001	0.005
S-43	12	-0.001	0.003	0.001	0.001	0.003
S-44	12	-0.001	0.004	0.001	0.001	0.003
Overall	166	-0.001	0.181	0.002	0.005	0.013

Community Ambient Air Sampler Plutonium Concentrations^a

Station	Number of Samples	Concentration (x 10 ⁻¹⁵ µCi/ml) ^b			Standard Deviation (C_standard)	Percent of DCG ^c (C_mean)
		C_minimum	C_maximum	C_mean		
S-51	12	0.000	0.003	0.001	0.001	0.004
S-52	12	0.001	0.018	0.004	0.005	0.019
S-53	12	-0.001	0.002	0.001	0.001	0.003
S-54	12	-0.001	0.004	0.001	0.001	0.003
S-55	12	-0.001	0.002	0.000	0.001	0.001
S-56	12	0.000	0.004	0.001	0.001	0.007
S-57	12	0.000	0.004	0.001	0.001	0.005
S-58*	10	0.000	0.003	0.001	0.001	0.006
S-59	12	0.000	0.005	0.001	0.002	0.005
S-60	12	-0.001	0.003	0.001	0.001	0.005
S-62	12	-0.001	0.002	0.000	0.001	0.001
S-68	12	-0.001	0.005	0.001	0.002	0.004
S-73	12	-0.001	0.005	0.001	0.002	0.006
Overall	154	-0.001	0.018	0.001	0.002	0.005

- a. Data provided in this table are based on an 12-month period except those marked with an asterisk.
 b. Concentrations reflect monthly composites of biweekly station concentrations; C minimum = minimum composited concentration; C maximum = maximum composited concentration; C mean = mean composited concentration.
 c. The DOE Derived Concentration Guide (DCG) for inhalation of class W plutonium by members of the public is 20 x 10⁻¹⁵ µCi/ml (Appendix B). Protection standards for members of the public are applicable for offsite locations and are based on calculated radiation dose.

3. ENVIRONMENTAL MONITORING PROGRAMS



3.3 SURFACE WATER MONITORING

William J. Burdellik
 Leslie A. Dunstan

Surface water management at RFP focuses on the North Walnut Creek, South Walnut Creek, and Woman Creek drainages. These drainages receive runoff from the main facilities area and treated sanitary waste water and contain earthen impoundments that restrict offsite discharges allowing water testing and, if necessary, treatment to meet quality standards. Additional sites throughout RFP are monitored to characterize background water quality and to evaluate potential contaminant releases from specific locations. This section reports results of RFP surface water monitoring as well as that of several of the communities that surround the RFP.

DRAINAGE SYSTEMS

North Walnut Creek

North Walnut Creek receives surface water runoff from the north side of the main facilities area (Figure 3.3-1). Ponds A-1 and A-2 are isolated from North Walnut Creek by valves that divert run-off by way of a surface pipeline into Pond A-3. In the past, these ponds were used for storage and evaporation of laundry water; this practice was discontinued in 1980. Ponds A-1 and A-2 are maintained to control possible chemical spills into the North Walnut Creek drainage basin. Run-off into these ponds is disposed of through natural evaporation and enhanced by spraying water through fog nozzles over the surface of the ponds. Excess water that does not evaporate is recollected in the ponds. Holding Pond A-3 on North Walnut Creek is used to impound surface run-off for analysis prior to discharge. Pond A-4 is located farther downstream and provides secondary monitoring and control during normal flow and flood conditions.

South Walnut Creek

South Walnut Creek receives surface water run-off from the central portion of the main facilities area (Figure 3.3-1). This water is diverted past Ponds B-1, B-2, and B-3 by way of a culvert system to Pond B-4 and then to flood control Pond B-5 where the water is impounded for analysis prior to controlled offsite discharge. Pond B-5 discharges into South Walnut Creek. Pond B-4 is a flow-through pond with no operational holding capacity.

Ponds B-1 and B-2, located in the central drainage, are reserved as backup control ponds. These ponds can be used to retain chemical spills, surface water run-off, or treated sanitary waste water.

Before 1979, treated sanitary waste water from the STP was discharged offsite through holding Ponds B-1 through B-4. From 1979 through 1989, this water was routed directly to Pond B-3 where it was held and then spray irrigated onto the RFP buffer zone areas as weather permitted. In 1990, spray irrigation of treated STP effluent from Pond B-3 was discontinued. Pond B-3 waters are now continually released to Pond B-4 and subsequently to Pond B-5. Pond B-5 serves as overflow capacity for Pond B-3 in the event of excess surface run-off. As necessary, water is transferred from Pond B-5 to Pond A-4 through a temporary pipeline to maintain Pond B-5 capacity at safe limits.

Section 3.3 SURFACE WATER MONITORING

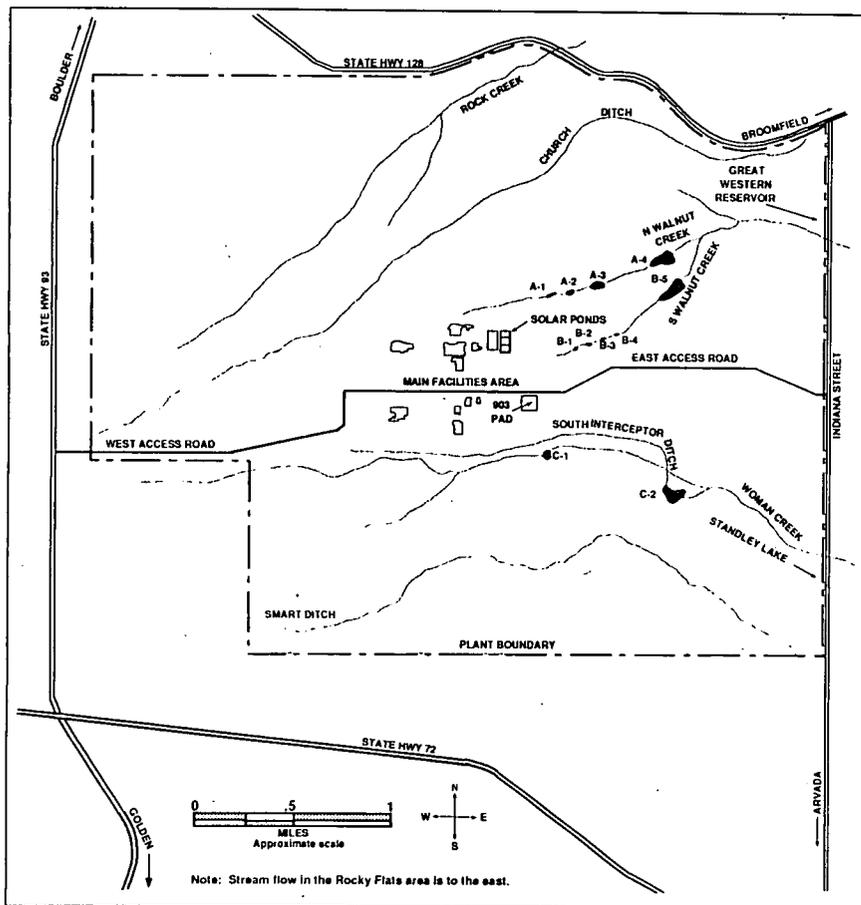


Figure 3.3-1. Holding Ponds and Liquid Effluent Water Courses

Woman Creek

Woman Creek flows across the south side of RFP through the south drainage basin (Figure 3.3-1). This creek flows through surface water monitoring Pond C-1 and then, after bypassing Pond C-2, discharges offsite. Surface run-off from the south side of the RFP manufacturing areas is collected in an interceptor ditch. The interceptor ditch also previously collected run-off from a spray irrigation field. Flow from this ditch is routed to surface water control Pond C-2, where the water is impounded and analyzed before discharge.

MONITORING PROGRAMS

Detention Ponds Monitoring

Before discharge from Ponds A-4, B-5, and C-2, samples are taken and split for analysis by CDH, EG&G Rocky Flats, Inc., and independent EPA-registered laboratories. Discharges are monitored for parameters listed in Appendix B in compliance with NPDES permit limitations. In addition, water quality is tested to ensure that it meets CWQCC standards for Segment 4 of Big Dry Creek before release. These standards are listed in Appendix B. Water is released with concurrence from CDH. Once concurrence is received, pond waters are passed through filter systems and carbon adsorption treatment facilities to reduce potential radionuclide and organic chemical contaminants. Carbon adsorption facilities exist at each of Ponds A-4, B-5, and C-2, and each has a treatment capacity of 750 gallons per minute (gpm).

Multiple samples of any discharges from Ponds A-4, B-5, and C-2 are collected by 24-hr compositing samplers for weekly analysis of plutonium, uranium, and americium. Daily analysis of tritium, pH, nitrate (as nitrogen), and non-volatile suspended solids are also performed. Discharges from Pond C-1 and flow from Walnut Creek near its intersection with Indiana Street are sampled in a similar manner. Daily samples from Pond C-1 and Walnut Creek are analyzed for tritium and then composited into weekly samples for plutonium, uranium, and americium analysis.

Discharges from Ponds A-4 and B-5 enter Walnut Creek and are diverted around Great Western Reservoir by the Broomfield diversion ditch. Discharges from Pond C-2 are pumped through an 8,000-ft pipeline into the Broomfield diversion ditch.

Sitewide Monitoring

In addition to monitoring discharges from detention ponds, RFP conducts sitewide surface water sampling programs to evaluate potential contaminant releases and to characterize baseline water quality. These programs assess trends and changing conditions in surface water quality, detect extreme values or excursions beyond a limit, assess the relationship between water quality and flow, identify new contaminant sources and releases, and address surface water sediment interactions.

Routine sitewide monitoring was begun in early 1989 to provide surface water quality and flow information for seeps and drainages in the main facilities area and buffer zone that may be affected by plant operations. The focus of this sampling program was to measure potential contaminants to surface water from suspected source areas such as designated CERCLA OUs. Results for 1989 are reported in the document titled *Draft 1989 Surface Water and Sediment Geochemical Characterization Report* (EG91d).

A separate background monitoring program began in 1989 to establish baseline water quality data for waters unaffected by plant operations. These data serve as a comparison to samples from affected areas of RFP to judge the impact of potential contamination from plant activities. Monitoring stations were selected upgradient and sidegradient of the main facilities where no impact from plant activities was presumed. Results are reported in the document titled *Background Geochemical Characterization Report for 1989* (EG90f).

MONITORING RESULTS**Nonradiological Monitoring**

Annual average concentrations of chemical and biological constituents measured in surface water effluent samples collected from Ponds A-3 (discharge point #002), A-4 (discharge point #005), B-3 (discharge point #001), B-5 (discharge point #006), and C-2 (discharge point #007) are presented in Table 3.3-1. These concentrations are indicative of the overall quality of effluent discharges. Certain discharges must meet NPDES permit monitoring and compliance limitations described in Appendix B.

Table 3.3-1
Chemical and Biological Constituents in Surface Water Effluents
at NPDES Permit Discharge Locations^{a, d}

Parameters	Number of Analyses	C minimum ^b	C maximum ^b	C mean ^{b,c}
Discharge 001 (Pond B-3)				
pH, standard units	125	6.5	8.6	N/A
Nitrate as N, mg/l	127	0.75	12.8	3.39
Total Suspended Solids, mg/l	127	0	78	11
Total Residual Chlorine, mg/l	238	0.0	0.35	0.06
Total Chromium, mg/l	127	<0.006	0.017	<0.008
Total Phosphorus, mg/l	127	<0.01	1.91	<0.31
Fecal Coliform, #/100 ml	120	<10	222,000	<41
Biochemical Oxygen Demand (BOD ₅), mg/l	125	<2.5	37.8	<7.8
Discharge 002 (Pond A-3)				
pH, standard units	57	7.2	8.6	N/A
Nitrate as N, mg/l	58	1.12	6.61	4.6
Discharge 003 (Reverse Osmosis Pilot Plant) During 1990 there were no discharges.				
Discharge 004 (Reverse Osmosis Plant) During 1990 there were no discharges.				
Discharge 005 (Pond A-4)				
pH, standard units	162	6.6	8.6	N/A
Nitrate as N, mg/l	163	0.22	6.96	2.89
Nonvolatile Suspended Solids, mg/l	163	0	73	3
Discharge 006 (Pond B-5)				
pH, standard units	93	7.1	8.5	N/A
Nitrate as N, mg/l	93	0.19	7.26	3.48
Nonvolatile Suspended Solids, mg/l	94	0	22	3
Discharge 007 (Pond C-2)				
pH, standard units	45	7.2	8.4	N/A
Nitrate as N, mg/l	45	<0.02	2.132	<0.85
Nonvolatile Suspended Solids, mg/l	46	0	16	3

- a. NPDES permit limitations are presented in Appendix B.
 b. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean measured concentration.
 c. For Fecal Coliform, #/100ml geometric mean used.
 d. Average annual concentration reported for each parameter is an estimate of central tendency (mean value) for all samples collected during the year. This provides an estimate of average effluent water quality for the entire year. The maximum values listed are the highest values observed and represent the worst-case scenario for the entire year. The NPDES Permit limits are specified as "Monthly Average" and "Weekly Average" and are measures of central tendency for the shorter time periods as required by the permit. The "Daily Maximum" is the largest value measured during the month. EPA has established limits for these required reporting intervals.

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Section 3.3 SURFACE WATER MONITORING

The frequency of discharges from Pond B-3 increased in 1990. Spray irrigation from Pond B-3 was discontinued in March 1990; consequently, point source discharges were used exclusively. Pond B-3 was discharged in two or three batches per week from early March through mid-May 1990. Samples were collected at the beginning of each batch discharge. Continuous discharge started in mid-May and continued for the remainder of the year. Discharges occurred only during daylight hours to ensure that flows could be inspected visually.

NPDES Exceedances. The NPDES permit limits for Biochemical Oxygen Demand-5 day (BOD₅) and fecal coliform were exceeded on occasions during April through September 1990.

In April 1990, the BOD₅ sample could not be analyzed because the sample was held longer than the amount of time allowed prior to analysis. Also, the fecal coliform sample was collected but subsequently lost. Data for those parameters could not be reported in the monthly Discharge Monitoring Report (DMR). Additional samples were collected and analyses showed that no effluent limits had been exceeded.

In May and June 1990, the 30-day average for BOD₅ (10 mg/l) was exceeded for Pond B-3. The calculated monthly averages for May (12.2 mg/l) and for June (22.1 mg/l) likely resulted from algal blooms in the pond. During July 1990, the fecal coliform 30-day geometric mean of 200 colonies/100 ml and the maximum 7-day geometric mean of 400 colonies/100 ml for Pond B-3 were exceeded. The calculated 30-day geometric mean was 333.3 colonies/100 ml, and the calculated maximum 7-day geometric mean was 4,806 colonies/100 ml. Both values were the result of a single sample result of 222,000 colonies/100 ml, approximately 1,000 times greater than other typical values found at Pond B-3. This single, abnormally high result is suspect; there were no other indications of unusual operating conditions at Pond B-3.

In August 1990, the fecal coliform 30-day geometric mean of 200 colonies/100 ml for Pond B-3 was again exceeded. The calculated 30-day geometric mean was 285 colonies/100 ml. There were no indications of unusual operating conditions that might have contributed to the observed exceedance.

Radiological Monitoring

In September 1990, the BOD₅ daily maximum (35 mg/l) and 30-day average (10 mg/l) for Pond B-3 was exceeded. The daily maximum was 37.8 mg/l and the calculated 30-day average was 11.14 mg/l. These exceedances resulted from continuing algal blooms.

All exceedances were communicated to DOE as soon as the individual data or calculated averages and geometric means became available. DOE notified the EPA by telephone, followed by written details in the DMR. No NOV's were issued by EPA in 1990 for exceeding NPDES limits.

Concentrations of plutonium, uranium, americium, and tritium in water samples from the outfalls of Ponds A-4, B-5, C-1, C-2, and from Walnut Creek at Indiana Street are presented in Tables 3.3-2 and 3.3-3. Mean plutonium, uranium, americium, and tritium concentrations at all sample locations were less than 0.4 percent of applicable DCGs (Appendix B).

The annual cumulative total amount of plutonium, uranium, and americium discharged to offsite waters during the year was calculated using each individual discharge concentration and flow measurement. During 1990, cumulative discharge amounts were:

	Pond A-4	Pond B-5	Pond C-2
Pu - Ci (Bq)	4.748 x 10 ⁻⁷ (1.76 x 10 ⁶)	4.477 x 10 ⁻⁷ (-1.66 x 10 ⁶)	8.554 x 10 ⁻⁷ (3.17 x 10 ⁶)
U-234 - Ci (Bq)	6.11 x 10 ⁻⁴ (2.25 x 10 ⁷)	2.44 x 10 ⁻⁴ (9.02 x 10 ⁶)	1.58 x 1 ⁻⁴ (5.85 x 10 ⁶)
U238 - Ci (Bq)	5.86 x 10 ⁻⁴ (2.17 x 10 ⁷)	2.12 x 10 ⁻⁴ (7.85 x 10 ⁶)	2.02 x 10 ⁻⁴ (7.46 x 10 ⁶)
Am - Ci (Bq)	2.590 x 10 ⁻⁶ (9.58 x 10 ⁴)	5.063 x 10 ⁻⁷ (1.87 x 10 ⁴)	6.604 x 10 ⁻⁶ (-2.44 x 10 ⁴)

Table 3.3-2
Plutonium, Uranium, and Americium Concentrations in Surface Water Effluents

Location	Number of Analyses	C minimum ^{a,b,c}	C maximum ^{a,b}	C mean ^{a,c}	Percent of DCG (C mean)
Plutonium-239, -240 Concentration (x 10 ⁻⁹ µCi/ml) ^d					
Pond A-4	46	-0.033 ± 0.022	0.033 ± 0.048	0.008 ± 0.009	0.03
Pond B-5	26	-0.036 ± 0.347	0.026 ± 0.045	-0.003 ± 0.008	0.00
Pond C-1	48	-0.023 ± 0.030	0.058 ± 0.025	0.011 ± 0.005	0.04
Pond C-2	12	-0.011 ± 0.031	0.035 ± 0.047	-0.001 ± 0.013	0.00
Walnut Creek at Indiana Street	48	-0.037 ± 0.028	0.078 ± 0.049	0.007 ± 0.004	0.02
Uranium-233, -234 Concentration (x 10 ⁻⁹ µCi/ml) ^e					
Pond A-4	46	0.01 ± 0.15	4.79 ± 0.68	1.45 ± 0.09	0.29
Pond B-5	26	0.02 ± 0.18	2.64 ± 0.46	1.46 ± 0.09	0.29
Pond C-1	49	0.10 ± 0.18	1.33 ± 0.47	0.55 ± 0.09	0.11
Pond C-2	12	0.79 ± 0.36	2.36 ± 0.44	1.89 ± 0.17	0.38
Walnut Creek at Indiana Street	50	0.38 ± 0.25	2.69 ± 0.45	1.51 ± 0.08	0.30
Uranium-238 Concentration (x 10 ⁻⁹ µCi/ml) ^e					
Pond A-4	46	0.07 ± 0.06	3.49 ± 0.53	1.63 ± 0.08	0.27
Pond B-5	26	0.05 ± 0.08	2.32 ± 0.34	1.27 ± 0.06	0.21
Pond C-1	49	0.05 ± 0.05	0.99 ± 0.22	0.41 ± 0.07	0.07
Pond C-2	12	1.16 ± 0.30	2.89 ± 0.41	2.40 ± 0.16	0.40
Walnut Creek at Indiana Street	50	0.25 ± 0.12	2.56 ± 0.12	1.45 ± 0.06	0.24
Americium Concentration (x 10 ⁻⁹ µCi/ml) ^f					
Pond A-4	46	-0.026 ± 0.014	0.068 ± 0.091	0.008 ± 0.009	0.03
Pond B-5	26	-0.017 ± 0.037	0.025 ± 0.048	0.003 ± 0.010	0.01
Pond C-1	48	-0.009 ± 0.010	0.040 ± 0.021	0.005 ± 0.003	0.02
Pond C-2	12	-0.029 ± 0.032	0.022 ± 0.044	-0.001 ± 0.013	0.00
Walnut Creek at Indiana Street	50	-0.016 ± 0.037	0.067 ± 0.063	0.006 ± 0.005	0.02

- a. C minimum = minimum measured concentration; C maximum = maximum measured concentration. For Pond C-1, C mean refers to calculated mean concentration. Due to intermittent flow meter operations at Pond C-1 during 1990, a volume weighted average was not possible to calculate. For Ponds A-4, B-5, C-2, and flow at Walnut Creek at Indiana Street, C mean refers to volume weighted averages.
- b. Calculated as 1.96 standard deviations of the individual measurement.
- c. Calculated as 1.96 standard deviations of the mean.
- d. Radiochemically determined as plutonium-239 and -240. The DOE Derived Concentration Guide (DCG) for plutonium in water available to members of the public is $30 \times 10^{-9} \mu\text{Ci/ml}$ (Appendix C).
- e. Radiochemically determined as uranium-233, -234, and -238. The DOE DCG for uranium-233, -234 in water available to members of the public is $500 \times 10^{-9} \mu\text{Ci/ml}$. The DCG for uranium-238 in water is $600 \times 10^{-9} \mu\text{Ci/ml}$ (Appendix C).
- f. Radiochemically determined as americium-241. The standard calculated DCG for americium in water available to members of the public is $30 \times 10^{-9} \mu\text{Ci/ml}$ (Appendix C).

Table 3.3-3
Tritium Concentrations in Surface Water Effluents

Location	Number of Analyses	C minimum ^{a,c}	C maximum ^{a,c}	C mean ^{a,d}	Percent of DCG (C mean)
Tritium Concentration (x 10 ⁻⁹ µCi/ml) ^b					
Pond A-4	163	-130 ± 120	250 ± 130	20 ± 10	0.00
Pond B-5	90	-110 ± 120	400 ± 130	30 ± 10	0.00
Pond C-1	48	-90 ± 160	110 ± 160	10 ± 20	0.00
Pond C-2	44	-120 ± 120	360 ± 130	30 ± 20	0.00
Walnut Creek at Indiana Street	180	-140 ± 120	360 ± 140	10 ± 10	0.00

- a. C minimum = minimum measured concentration; C maximum = maximum measured concentration. For Pond C-1, C mean refers to calculated mean concentration. Due to intermittent flow meter operations at Pond C-1 during 1990, a volume weighted average was not possible to calculate. For Ponds A-4, B-5, C-2, and flow at Walnut Creek at Indiana Street, C mean refers to volume weighted averages.
- b. The DOE DCG for tritium in water available to the members of the public is $2,000,000 \times 10^{-9} \mu\text{Ci/ml}$ (Appendix C).
- c. Calculated as 1.96 standard deviations of the individual measurement.
- d. Calculated as 1.96 standard deviations of the mean.

Tritium concentrations in water discharged from these ponds were within range of background concentrations; therefore, cumulative discharge amounts were not calculated. Average annual concentrations of plutonium, uranium, and americium from Ponds A-4, B-5, and C-2 for 1986 through 1990 are given in Figures 3.3-2, 3.3-3, and 3.3-4.

During 1990, RFP raw water supply was obtained from Ralston Reservoir and from the South Boulder Diversion Canal. Ralston Reservoir water usually contains more natural uranium radioactivity than the water flowing from the South Boulder Diversion Canal. During the year, uranium, plutonium, americium, and tritium analyses were performed monthly on samples of RFP raw water. Concentrations are presented in Table 3.3-4. These values can be used for comparison with the values measured in the RFP downstream discharge locations (Tables 3.3-2 and 3.3-3).

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Table 3.3-4
Plutonium, Uranium, Americium, and Tritium Concentrations in the Raw Water Supply

Location	Number of Analyses	C minimum ^a	C maximum ^a	C mean ^{a, g}	Percent of DCG (C mean)
Plutonium Concentration (x 10⁻⁹ µCi/ml)^b					
Rocky Flats Raw Water	12	-0.030 ± 0.027	0.046 ± 0.044	0.000 ± 0.014	0.00
Uranium-233, -234 Concentration (x 10⁻⁹ µCi/ml)^c					
Rocky Flats Raw Water	12	0.02 ± 0.16	1.90 ± 0.48	0.54 ± 0.29	0.11
Uranium-238 Concentration (x 10⁻⁹ µCi/ml)^c					
Rocky Flats Raw Water	12	0.12 ± 0.07	1.39 ± 0.30	0.45 ± 0.20	0.09
Americium Concentration (x 10⁻⁹ µCi/ml)^d					
Rocky Flats Raw Water	12	-0.011 ± 0.021	0.028 ± 0.051	0.004 ± 0.005	0.01
Tritium Concentration (x 10⁻⁹ µCi/ml)^e					
Rocky Flats Raw Water	12	-100 ± 100	50 ± 120	-10 ± 30	0.00

- a. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean calculated concentration.
- b. Radiochemically determined as plutonium-239 and -240. The DOE Derived Concentration Guide (DCG) for plutonium in water available to members of the public is 30 x 10⁻⁹ µCi/ml (Appendix B).
- c. Radiochemically determined as uranium-233, -234 and -238. The DOE DCG for uranium-233, -234 in water available to members of the public is 500 x 10⁻⁹ µCi/ml. The DCG for uranium-238 in water is 600 x 10⁻⁹ µCi/ml (Appendix B).
- d. Radiochemically determined as americium-241. The standard calculated DCG for americium in water available to members of the public is 30 x 10⁻⁹ µCi/ml (Appendix B).
- e. The DOE DCG for tritium in water available to members of the public is 2,000,000 x 10⁻⁹ µCi/ml (Appendix B).
- f. Calculated as 1.96 standard deviations of the individual measurement.
- g. Calculated as 1.96 standard deviations of the mean.

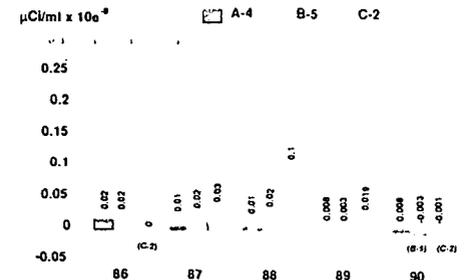


Figure 3.3-2 Plutonium-239, -240

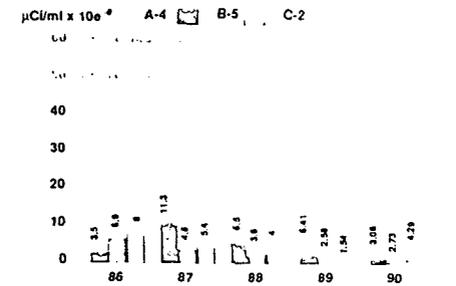


Figure 3.3-3 Uranium-233, -234, -238 Compositd

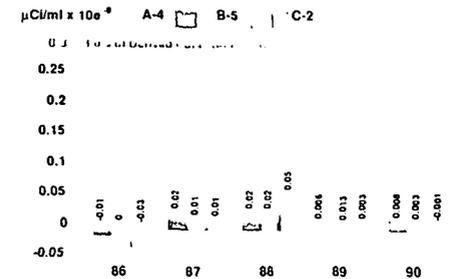


Figure 3.3-4 Americium

COMMUNITY WATER MONITORING

Community water monitoring includes sampling and analysis of public water supplies and tap water from several surrounding communities. Only Great Western Reservoir, one of the water supplies for the city of Broomfield, and Standley Lake Reservoir, a water supply for the cities of Westminster, Thornton, and Northglenn, receive run-off from RFP drainage systems. The city of Federal Heights purchases a portion of its water supply from the city of Westminster. Weekly samples were collected and composited into a monthly sample, and analyses were performed for plutonium, uranium, and americium concentrations. Tritium and nitrate (as N) analyses were conducted on weekly grab samples.

Annual background samples were also collected from Ralston, Dillon, and Boulder reservoirs, as well as from South Boulder Diversion Canal at distances ranging from 1 to 60 mi from RFP. Samples were collected to determine background levels for plutonium, uranium, americium, and tritium in water.

Drinking water from Boulder, Broomfield, and Westminster was collected weekly, composited monthly, and analyzed for plutonium, uranium, and americium. Analyses for tritium were performed weekly. Quarterly tap water samples were collected from the communities of Arvada, Denver, Golden, Lafayette, Louisville, and Thornton. These samples were analyzed for plutonium, uranium, americium, and tritium.

Results

Analyses of regional reservoir and drinking water samples are given in Tables 3.3-5 and 3.3-6. Plutonium, uranium, americium, and tritium concentrations for regional reservoirs represented 0.37 percent or less of the DCG. Average plutonium concentration in Great Western Reservoir was 0.004×10^{-9} $\mu\text{Ci/ml}$ (1.48×10^{-4} Bq/l [0.01 percent DCG]), which was within the range of concentrations predicted for Great Western Reservoir in the *Environmental Impact Statement, Rocky Flats Plant Site* (DOE80) based on known low-level plutonium concentrations in reservoir sediments.

Results of plutonium, uranium, americium, and tritium analyses for drinking water in nine communities were 0.13 percent or less of the applicable DCG. Drinking water standards have been adopted by the State of Colorado (CDH77, CDH81) and EPA (EPA76a) for alpha-emitting radionuclides (15×10^{-9} $\mu\text{Ci/ml}$ [5.55×10^{-1} Bq/l]) and for tritium ($20,000 \times 10^{-9}$ $\mu\text{Ci/ml}$ [7.4×10^2 Bq/l]). These standards exclude uranium and radon. During 1990, the largest mean concentration of plutonium and americium (alpha-emitting radionuclides) for community tap water was 0.008×10^{-9} $\mu\text{Ci/ml}$ (2.96×10^{-4} Bq/l). This value was 0.05 percent of the State of Colorado and EPA drinking water standards for alpha activity. Average tritium concentration in Great Western Reservoir, Standley Lake, and in all community tap water samples was 50×10^{-9} $\mu\text{Ci/ml}$ (1.85 Bq/l) or less. That value was typical of background tritium concentrations in Colorado and is less than 0.01 percent of the State of Colorado and EPA drinking water standards for tritium (CDH81, EPA76a).

Table 3.3-5
Plutonium and Uranium Concentrations in Public Water Supplies

Location	Number of Analyses	C minimum ^{a,c}	C maximum ^{a,c}	C mean ^{a,d}	Percent of DCG C mean
Reservoir					
Plutonium-239, -240 Concentration ($\times 10^{-9}$ $\mu\text{Ci/ml}$) ^b					
Boulder	1	0.009 \pm 0.042	0.009 \pm 0.042	0.009 \pm 0.042	0.03
Dillon	1	-0.002 \pm 0.033	-0.002 \pm 0.033	-0.002 \pm 0.033	0.00
Great Western	12	-0.004 \pm 0.007	0.015 \pm 0.016	0.004 \pm 0.004	0.01
Ralston	1	0.011 \pm 0.037	0.011 \pm 0.037	0.011 \pm 0.037	0.04
South Boulder Diversion Canal	1	-0.015 \pm 0.029	-0.015 \pm 0.029	-0.015 \pm 0.029	0.00
Standley	12	-0.007 \pm 0.007	0.048 \pm 0.029	0.004 \pm 0.008	0.01
Drinking Water					
Arvada	4	-0.018 \pm 0.039	0.028 \pm 0.041	0.000 \pm 0.021	0.00
Boulder	12	-0.008 \pm 0.011	0.020 \pm 0.017	0.002 \pm 0.004	0.00
Broomfield	12	-0.006 \pm 0.006	0.027 \pm 0.030	0.006 \pm 0.005	0.02
Denver	4	-0.020 \pm 0.028	0.003 \pm 0.023	-0.007 \pm 0.010	0.00
Golden	4	-0.004 \pm 0.029	0.026 \pm 0.039	0.006 \pm 0.013	0.02
Lafayette	4	-0.007 \pm 0.031	0.004 \pm 0.032	-0.004 \pm 0.005	0.01
Louisville	4	-0.014 \pm 0.030	0.002 \pm 0.030	-0.004 \pm 0.007	0.00
Thornton	4	-0.019 \pm 0.015	0.007 \pm 0.037	-0.002 \pm 0.012	0.00
Westminster	12	-0.010 \pm 0.019	0.010 \pm 0.012	-0.001 \pm 0.003	0.00

Table 3.3-5 (Continued)

Location	Number of Analyses	C _{minimum} ^a	C _{maximum} ^a	C _{mean} ^{a, d}	Percent of DCG (C _{mean})
Reservoir					
Uranium-233, -234 Concentration (x 10 ⁻⁹ µCi/ml) ^e					
Boulder	1	1.87 ± 0.52	1.87 ± 0.52	1.87 ± 0.52	0.37
Dillon	1	0.41 ± 0.34	0.41 ± 0.34	0.41 ± 0.34	0.08
Great Western	12	0.24 ± 0.21	0.88 ± 0.28	0.56 ± 0.12	0.11
Ralston	1	0.65 ± 0.30	0.65 ± 0.30	0.65 ± 0.30	0.13
South Boulder Diversion Canal	1	0.25 ± 0.23	0.25 ± 0.23	0.25 ± 0.23	0.05
Standley	12	0.22 ± 0.16	2.87 ± 0.51	0.90 ± 0.38	0.18
Drinking Water					
Arvada	4	0.00 ± 0.19	0.37 ± 0.21	0.17 ± 0.16	0.03
Boulder	12	0.01 ± 0.19	0.49 ± 0.22	0.23 ± 0.09	0.05
Broomfield	12	0.13 ± 0.21	0.48 ± 0.23	0.32 ± 0.08	0.06
Denver	4	0.05 ± 0.20	1.44 ± 0.38	0.67 ± 0.57	0.13
Golden	4	0.08 ± 0.20	1.01 ± 0.34	0.56 ± 0.37	0.11
Lafayette	4	-0.01 ± 0.23	0.10 ± 0.20	0.03 ± 0.05	0.01
Louisville	4	0.01 ± 0.19	0.46 ± 0.21	0.14 ± 0.21	0.03
Thornton	4	0.25 ± 0.19	0.95 ± 0.35	0.61 ± 0.32	0.12
Westminster	12	0.05 ± 0.15	0.46 ± 0.27	0.26 ± 0.08	0.05
Reservoir					
Uranium-238 Concentration (x 10 ⁻⁹ µCi/ml) ^f					
Boulder	1	0.50 ± 0.18	0.50 ± 0.18	0.50 ± 0.18	0.08
Dillon	1	0.31 ± 0.17	0.31 ± 0.17	0.31 ± 0.17	0.05
Great Western	12	0.33 ± 0.12	0.84 ± 0.17	0.55 ± 0.10	0.09
Ralston	1	0.53 ± 0.16	0.53 ± 0.16	0.53 ± 0.16	0.09
South Boulder Diversion Canal	1	0.30 ± 0.12	0.30 ± 0.12	0.30 ± 0.12	0.05
Standley	12	0.31 ± 0.09	0.99 ± 0.25	0.71 ± 0.12	0.12
Drinking Water					
Arvada	4	0.12 ± 0.09	0.37 ± 0.09	0.25 ± 0.14	0.04
Boulder	12	0.05 ± 0.08	0.48 ± 0.13	0.18 ± 0.08	0.03
Broomfield	12	0.10 ± 0.07	0.59 ± 0.13	0.31 ± 0.08	0.05
Denver	4	0.10 ± 0.09	0.10 ± 0.23	0.51 ± 0.42	0.09
Golden	4	0.25 ± 0.10	0.92 ± 0.22	0.52 ± 0.30	0.09
Lafayette	4	0.01 ± 0.08	0.14 ± 0.11	0.08 ± 0.07	0.01
Louisville	4	-0.02 ± 0.03	0.11 ± 0.06	0.04 ± 0.05	0.01
Thornton	4	0.17 ± 0.13	0.61 ± 0.18	0.41 ± 0.21	0.07
Westminster	12	0.07 ± 0.06	0.41 ± 0.10	0.24 ± 0.06	0.04

- C_{minimum} = minimum measured concentration; C_{maximum} = maximum measured concentration; C_{mean} = mean calculated concentration.
- Radiochemically determined as plutonium-239 and -240. The DOE DCG for plutonium in water available to members of the public is 30 x 10⁻⁹ µCi/ml (Appendix B).
- Calculated as 1.96 standard deviations of the individual measurements.
- Calculated as 1.96 standard deviations of the mean.
- Radiochemically determined as uranium-233, and -234. The DOE DCG for uranium in water available to members of the public is 500 x 10⁻⁹ µCi/ml (Appendix B).
- Radiochemically determined as uranium-238. The DOE DCG for uranium in water available to members of the public is 600 x 10⁻⁹ µCi/ml (Appendix B).

Table 3.3-6
Americium and Tritium Concentrations in Public Water Supplies

Location	Number of Analyses	C _{minimum} ^a	C _{maximum} ^a	C _{mean} ^{a, d}	Percent of DCG (C _{mean})
Reservoir					
Americium Concentration (x 10 ⁻⁹ µCi/ml) ^b					
Boulder	1	-0.018 ± 0.036	-0.018 ± 0.036	-0.018 ± 0.036	0.00
Dillon	1	0.031 ± 0.049	0.031 ± 0.049	0.031 ± 0.049	0.10
Great Western	12	-0.006 ± 0.009	0.001 ± 0.015	-0.001 ± 0.001	0.00
Ralston	1	-0.014 ± 0.039	-0.014 ± 0.039	-0.014 ± 0.039	0.00
South Boulder Diversion Canal	1	-0.010 ± 0.039	-0.010 ± 0.039	-0.010 ± 0.039	0.00
Standley	12	-0.005 ± 0.003	0.012 ± 0.012	0.002 ± 0.003	0.01
Drinking Water					
Arvada	3	0.001 ± 0.038	0.015 ± 0.042	0.008 ± 0.008	0.03
Boulder	12	-0.006 ± 0.009	0.013 ± 0.014	0.002 ± 0.003	0.01
Broomfield	12	-0.006 ± 0.012	0.005 ± 0.013	-0.001 ± 0.002	0.00
Denver	3	-0.018 ± 0.035	-0.014 ± 0.036	-0.016 ± 0.002	0.00
Golden	3	-0.021 ± 0.040	0.006 ± 0.038	-0.009 ± 0.016	0.00
Lafayette	3	-0.021 ± 0.033	-0.002 ± 0.037	-0.012 ± 0.011	0.00
Louisville	3	-0.034 ± 0.031	0.025 ± 0.046	-0.001 ± 0.034	0.00
Thornton	3	-0.014 ± 0.035	0.010 ± 0.043	-0.005 ± 0.015	0.00
Westminster	12	-0.006 ± 0.009	0.011 ± 0.011	-0.001 ± 0.003	0.00
Reservoir					
Tritium Concentration (x 10 ⁻⁹ µCi/ml) ^c					
Boulder	1	50 ± 120	50 ± 120	50 ± 120	0.00
Dillon	1	-10 ± 110	-10 ± 110	-10 ± 110	0.00
Great Western	46	-140 ± 100	260 ± 140	20 ± 20	0.00
Ralston	1	190 ± 120	190 ± 120	190 ± 120	0.01
South Boulder Diversion Canal	1	120 ± 120	120 ± 120	120 ± 120	0.01
Standley	52	-70 ± 80	150 ± 120	20 ± 10	0.00
Drinking Water					
Arvada	4	-100 ± 120	80 ± 160	-10 ± 70	0.00
Boulder	52	-130 ± 100	230 ± 130	20 ± 20	0.00
Broomfield	49	-110 ± 140	170 ± 110	10 ± 20	0.00
Denver	4	10 ± 100	130 ± 160	40 ± 60	0.00
Golden	4	-10 ± 130	110 ± 160	40 ± 60	0.00
Lafayette	4	-60 ± 100	100 ± 160	30 ± 60	0.00
Louisville	4	-20 ± 100	150 ± 170	50 ± 70	0.00
Thornton	4	-70 ± 120	90 ± 110	10 ± 70	0.00
Westminster	52	-190 ± 140	170 ± 160	20 ± 20	0.00

- C_{minimum} = minimum measured concentration; C_{maximum} = maximum measured concentration; C_{mean} = mean calculated concentration.
- Radiochemically determined as americium-241. The DOE DCG for americium in water available to members of the public is 30 x 10⁻⁹ µCi/ml (Appendix B).
- Calculated as 1.96 standard deviations of the individual measurements.
- Calculated as 1.96 standard deviations of the mean.
- The DOE DCG for tritium in water available to members of the public is 2,000,000 x 10⁻⁹ µCi/ml (Appendix B).

3. ENVIRONMENTAL MONITORING PROGRAMS

3.4 GROUNDWATER MONITORING

Bruce J. Bevir
Meredith L. Brogden
James W. Langman, Jr.

The RFP Groundwater Monitoring Program was initiated in 1960 to provide data on radionuclide and chemical contaminants present in groundwater. Changes have occurred in recent years as environmental regulations have evolved and expanded to improve groundwater monitoring and protection. These changes have resulted in the installation of additional monitoring wells, improved sample handling and data quality assurance, and enhanced analytical programs. This section defines the groundwater program.

bedrock sandstones of the Arapahoe formation that are isolated within intervals of claystone are confined and represent a lower flow system. Table 3.4-1 gives the relative hydraulic conductivities associated with the lithologic units present at RFP.

In the spring and early summer the Rocky Flats Alluvium and Arapahoe Formation, located in the central and eastern portion of RFP, are recharged by precipitation and groundwater lateral flow. In the late summer and early fall these formations are recharged mostly by groundwater lateral flow. As a result, the groundwater near the surface of the alluvium is discharged by evapotranspiration to such an extent that a hardened, impermeable soil layer (caliche layer) has developed over a large area where the water table is within 2 to 10 ft of the surface. In the stream drainages, groundwater discharges at seeps that are common at the base of the Rocky Flats Alluvium and where individual sandstones become exposed to the surface.

Table 3.4-1
Hydraulic Conductivities of Lithologic Units

Lithologic Unit	Hydraulic Conductivity
Rocky Flats Alluvium	10 ⁻⁵ cm/sec (10.4 ft/yr)
Subcropping Arapahoe sandstones	10 ⁻⁵ cm/sec (10.4 ft/yr)
Unweathered sandstones	10 ⁻⁶ cm/sec (1.04 ft/yr)
Weathered and unweathered claystone	10 ⁻⁷ to 10 ⁻⁶ cm/sec, (0.104 to 0.0104 ft/yr)

The present understanding of the hydrogeologic relationships indicates that there are no known bedrock pathways through which groundwater contamination may directly leave RFP and migrate into a confined aquifer system (EG90a).

Monitoring Procedures

A total of 364 monitoring wells (Figure 3.4-2) and piezometers were in place at RFP before 1990. An additional 18 wells and piezometers were installed in 1990 to provide for better characterization of the geology, hydrogeology, and geochemistry at RFP. Of these additional wells, four alluvial piezometers were completed on the 881 Hillside (OU1) to evaluate the volume and flow direction of groundwater. The remaining 14 wells were installed in northern and southern portions of the buffer zone to monitor

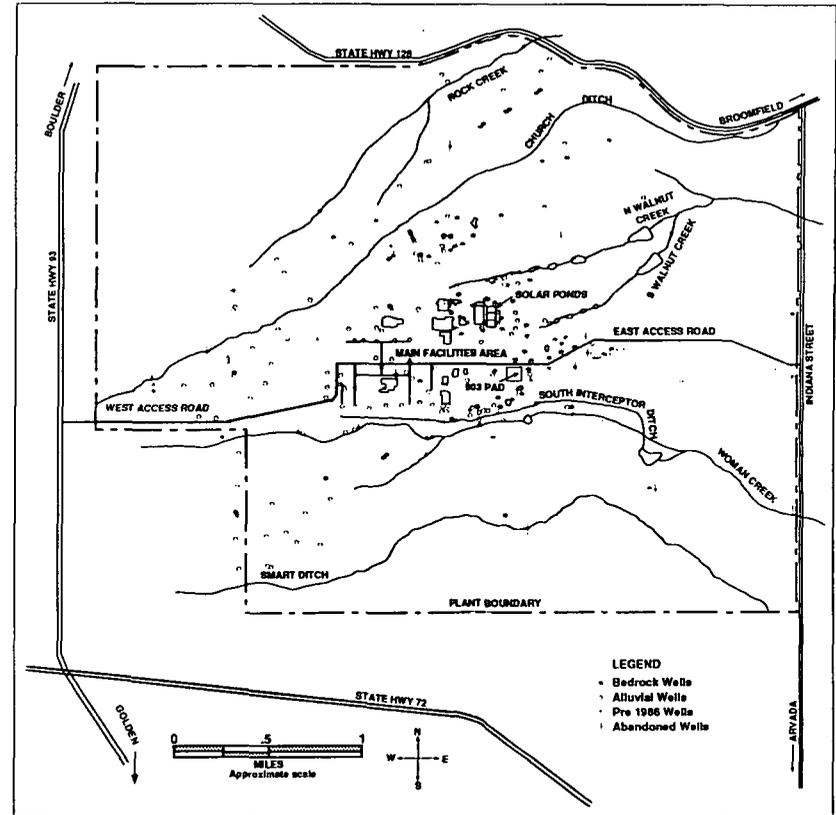


Figure 3.4-2. Location of Monitoring Wells

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groundwater quality as part of an investigation to locate a new landfill site. Table 3.4-2 shows groundwater wells installed by area at RFP.

Groundwater samples are collected quarterly from 258 alluvial and bedrock wells and analyzed for parameters shown in Table 3.4-3. These wells are spatially distributed throughout RFP to provide the necessary coverage to satisfy RCRA/CERCLA and CDH guidelines for monitoring groundwater at hazardous waste sites. Samples are not collected from the remaining wells at RFP either because they contain no water or because construction of the well was unknown or of questionable quality.

Monthly water-level measurements are taken from 116 wells to adequately categorize groundwater flow directions. These data are used to evaluate trends in groundwater quality and contaminant migration in the uppermost, unconfined aquifer.

Table 3.4-2
Groundwater Monitoring Wells

Location	Wells Installed in 1989	Wells Installed in 1988	Wells Installed before 1989	Total Number of Well Installations
Solar Ponds	-	32	33	65
Present Landfill	-	13	25	38
West Spray Field	-	8	18	26
Process Waste Lines	-	3	2	5
903 Pad	-	-	15	15
Mound	-	-	14	14
East Trenches	-	4	27	31
881 Hillside	4	3	37	44
Piezometers	-	40	-	40
Background	-	50	8	58
East Buffer	-	-	14	14
North Buffer	9	-	-	9
South Buffer	5	-	-	5
Totals	18	153	193	364

Table 3.4-3
Site Chemical Constituents Monitored in Groundwater

Metals	Organics ^d	Radionuclides ^e
Cesium (Cs)	Target Compound List - Volatiles:	Gross Alpha
Lithium (Li) ^b	Chloromethane (CH ₃ CL)	Gross Beta
Molybdenum (Mo)	Bromomethane (CH ₃ Br)	Uranium-233, -234, -235, and -238
Strontium (Sr)	Vinyl Chloride (C ₂ H ₃ CL)	(U-233, -234, -235; and -238)
Tin (Sn) ^a	Chloroethane (C ₂ H ₅ CL)	Americium-241 (Am-241)
	Methylene Chloride (CH ₂ CL ₂)	Plutonium-239, -240 (Pu-239, -240)
	Target Analyte List:	Strontium-89, -90 (Sr-89, -90) ^f
Aluminum (Al)	Acetone	Cesium-137 (Cs-137)
Antimony (Sb)	Carbon Disulfide	Tritium (H-3)
Arsenic (As)	1,1-Dichloroethane (1,1-DCA)	Radium-226, -228 (Ra-226, -228) ^g
Barium (Ba)	1,1-Dichloroethene (1,1-DCE)	
Beryllium (Be)	trans-1,2-Dichloroethene	
Cadmium (Cd)	1,2-Dichloroethene (total) (total 1,2-DCE)	
Calcium (Ca)	Chloroform (CHCl ₃)	Indicators
Chromium (Cr)	1,2-Dichloroethane (1,2-DCA)	Total Dissolved Solids (TDS)
Cobalt (Co)	2-Butanone (MEK)	pH ^a
Copper (Cu)	1,1,1-Trichloroethane (1,1,1-TCA)	
Iron (Fe)	Carbon Tetrachloride (CCl ₄)	
Lead (Pb)	Vinyl Acetate	Field Parameters
Magnesium (Mg)	Bromodichloromethane	pH
Manganese (Mn)	1,1,2,2-Tetrachloroethane	Specific Conductance
Mercury (Hg)	1,2-Dichloropropane (1,2-DCP)	Temperature
Nickel (Ni)	trans-1,3-Dichloropropene	Dissolved Oxygen
Potassium (K)	Trichloroethylene (TCE)	Alkalinity
Selenium (Se)	Dibromochloromethane	
Silver (Ag)	1,1,2-Trichloroethane	
Sodium (Na)	Benzene	Anions
Thallium (Tl)	cis-1,3-Dichloropropene	Carbonate (CO ₃)
Vanadium (V)	Bromoform (CBr ₃)	Bicarbonate (HCO ₃)
Zinc (Zn)	2-Hexanone	Chloride (Cl)
	4-Methyl-2-pentanone	Sulfate (SO ₄)
	Tetrachloroethene (PCE)	Nitrate/Nitrite (NO ₃ /NO ₂ as N)
	Toluene (C ₇ H ₈)	Cyanide (CN) ^f
	Chlorobenzene (C ₆ H ₅ CL)	
	Ethyl Benzene	
	Styrene	
	Total Xylenes	

- a. Not analyzed prior to 1989.
- b. Prior to 1989, lithium was only analyzed during fourth quarter 1987 and first quarter 1988.
- c. Cyanide was not analyzed during fourth quarter 1987.
- d. Not analyzed in background samples in 1989.
- e. Dissolved radionuclides replaces total radionuclides (except tritium) beginning with the third quarter 1987.
- f. Strontium-89, -90 was not analyzed during first quarter 1988.
- g. Not analyzed prior to 1989, and only analyzed if gross alpha exceeds 5 pCi/l.

NOTES:
 * Total suspended solids and phosphate were analyzed in 1986 only.
 * Chromium (VI) was analyzed during fourth quarter 1987 only.

RESULTS

The final IAG (Section 2, "Compliance Summary") divides RFP into 16 operable units for study and restoration. The following section discusses results of groundwater investigations on OUs 1, 2, 4, 7, and 11. OUs 4, 7, and 11 were identified collectively as OU 3 under the former draft IAG. Results of samples taken from background wells used to characterize the spatial and temporal variability of naturally occurring constituents are given in the documented titled *Background Geochemical Characterization Report for 1989* (EG90f).

Groundwater investigations and restoration activities at RFP follow a five-phase plan to identify contamination, design and implement treatment procedures, and monitor adequacy of restoration actions. This process includes establishment of groundwater quality standards that are specific to each OU and reflect state and federal requirements. No specific standards have been established for OUs at RFP, although possible limits have been identified pursuant to the CERCLA requirements that remedial actions comply with ARAR federal laws or more stringent, promulgated state laws. In addition, the CWQCC held a hearing on February 4, 1991, to discuss proposed groundwater quality classifications and standards for groundwater protection in the vicinity of RFP.

Operable Unit 1 (OU 1)

881 Hillside. The report titled *Phase III RFI/RI Work Plan, Rocky Flats Plant, 881 Hillside Area (Operable Unit No. 1)* (EG91i) contains information on groundwater quality at OU 1. Shallow groundwater under the 881 Hillside is contaminated with volatile organic compounds (VOCs), inorganics (including some metals), and elevated levels of uranium.

The contaminants of most concern are VOCs in the unconfined groundwater system within the boundaries of Solid Waste Management Units (SWMUs) 119.1 and 119.2 (Figure 3.4-3) in the eastern portion of this operable unit. These areas were used for barrel waste storage from 1967 to 1972. Figure 3.4-4 shows approximate outlines of the groundwater contaminant plumes on the plantsite and depicts the extent of contaminant movement under the 881 Hillside. Organic contaminants in the highest concentrations in 1990

were 1,1,1-trichloroethane (ranging up to 19,000 µg/l), 1,1-dichloroethene (ranging up to 16,000 µg/l), and trichloroethene (up to 13,000 µg/l). However, concentrations of this magnitude represent one-time sampling events and are very limited spatially.

Concentrations of VOCs diminish rapidly downgradient of SWMUs 119.1 and 119.2, becoming equal to or below detection limits (5 µg/l) within 200 ft of the original storage areas.

Highest concentrations of inorganic constituents also were found in the eastern portion of OU 1, where constituents above background concentrations included total dissolved solids (TDS), metals (nickel, strontium, selenium, zinc, and copper), and uranium.

Operable Unit 2 (OU 2)

903 Pad, Mound, and East Trenches Areas. The report titled *Phase II RFI/RI Work Plan, Rocky Flats Plant, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2* (EG91j) contains information on groundwater quality at OU 2. Groundwater in the alluvial materials and interconnected groundwater in the shallow subcropping sandstone bodies are contaminated with VOCs, inorganics (including metals), elevated TDS, and some radionuclides.

Inorganics commonly occurring above background levels include TDS, strontium, barium, copper, and nickel, and to a lesser extent, chromium, manganese, selenium, lead, zinc, and molybdenum. The majority of the radionuclide contamination is uranium-238. Americium and plutonium also are present in some samples.

Contaminants of most concern are VOCs. Concentrations of tetrachloroethene (ranging up to 20,000 µg/l), and trichloroethene (up to 96,000 µg/l) were detected in 1990. However, concentrations of this magnitude represent one-time sampling events and are limited spatially. Figure 3.4-4 depicts groundwater contaminant plumes on the plantsite and indicates the approximate extent of contamination at OU 2.

Section 3.4 GROUNDWATER MONITORING

Certain inorganic parameters and radionuclides were elevated above background values in OU 2, but did not appear to exist as a defined plume of contamination. Investigations are underway to further characterize these plumes and the magnitude and extent of contamination.

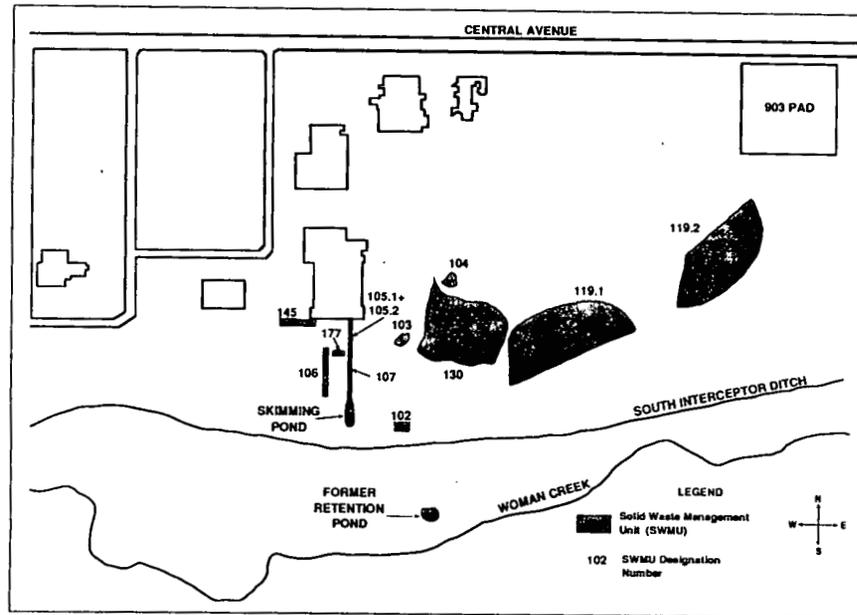


Figure 3.4-3. Solid Waste Management Units (SWMUs) Numbers 119.1 and 119.2

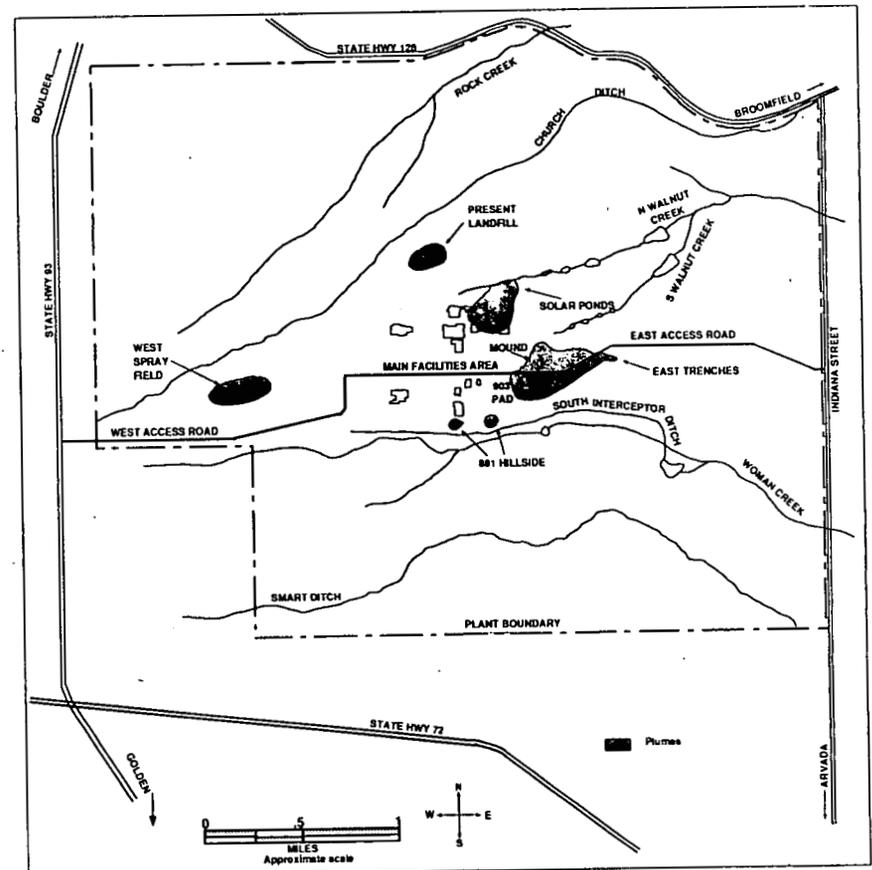


Figure 3.4-4. Location of Groundwater Contamination Areas

Section 3.4 GROUNDWATER MONITORING

Operable Units 4, 7, and 11
(OUs 4, 7, and 11)

Solar Ponds, Present Landfill, West Spray Field. OUs 4, 7, and 11 are RCRA-regulated units. The purpose of groundwater monitoring in these units is to determine impacts of waste management activities on groundwater quality in the uppermost aquifer beneath these units. The report titled *1990 Annual RCRA Groundwater Monitoring Report for Regulated Units at the Rocky Flats Plant* (EG91h), presents 1990 interim-status quarterly groundwater monitoring results. Results are given on groundwater elevations, migration rates, and quality analyses. A comparison is made between site concentrations and calculated statistical upper background concentrations to identify areas and types of exceedances. Concentrations are reported in mg/l for inorganics and dissolved metals, pCi/l for dissolved radionuclides, and µg/l for VOCs. The following sections highlight results of groundwater monitoring of OU 4, 7, and 11 in 1990.

Solar Ponds (OU 4). The Solar Evaporation Ponds area is undergoing groundwater assessment monitoring to further determine the level and extent of contamination migration in the uppermost aquifer beneath this unit. A total of 62 monitoring wells presently exist in the Solar Evaporation Ponds area (29 of these monitoring wells are alluvial [shallow] wells and 33 are bedrock [deep] wells). Water elevation data collected throughout 1990 reveals that groundwater flow from the solar ponds diverges along two major subsurface flowpaths: one northeast toward North Walnut Creek and the other southeast toward South Walnut Creek. Figure 3.4-5 displays 1990 flow contours for the shallow groundwater during the high flow season (February to March).

Data from 1990 indicate that groundwater in downgradient wells screened in surficial materials and weathered bedrock immediately north, east, and southwest of the ponds is impacted with nitrate/nitrite, sodium, TDS, sulfate, dissolved radionuclides, and VOCs. TDS concentrations ranged from 420 to 6,700 mg/l in wells north of the Solar Evaporation Ponds. Nitrate/nitrite ranged from 55 to 880 mg/l in wells north of the Solar Ponds. Radionuclides detected above background east of the Solar Ponds included uranium-233, -234 (900 pCi/l), uranium-235 (9 pCi/l), uranium-238 (190 pCi/l), tritium (940 pCi/l), and americium (0.02 pCi/l). VOCs were detected in shallow wells southeast of the Solar Ponds, including concentrations of vinyl chloride of up to 950 µg/l. Other inorganic parameters such as calcium, magnesium, bicarbonate, and fluoride were

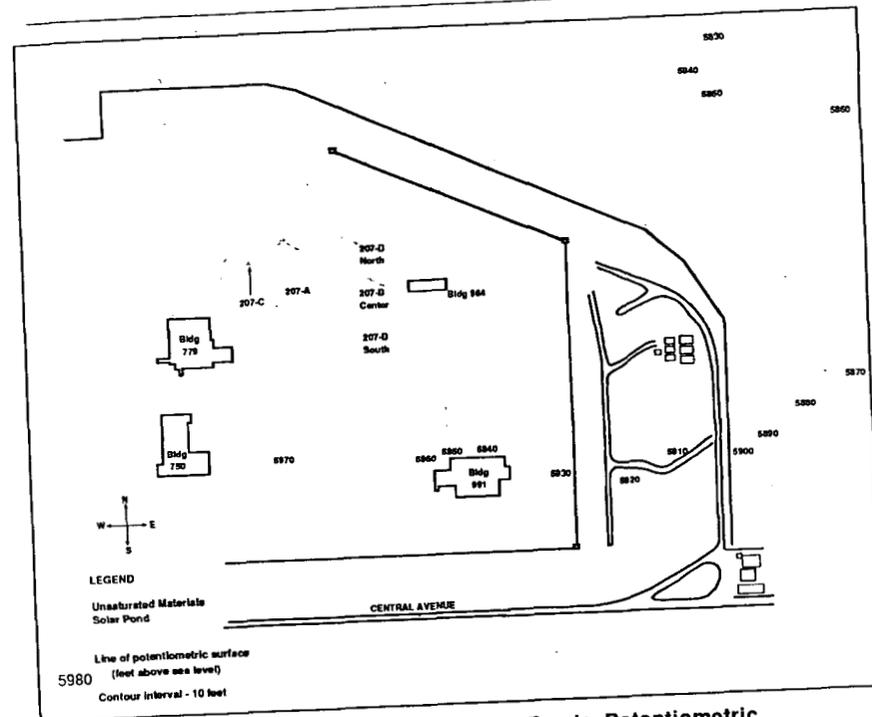


Figure 3.4-5. Solar Evaporation Ponds Potentiometric Surface in Surficial Materials

detected above background values in several wells north and east of the Solar Ponds. Background groundwater quality data for RFP calculated as upper statistical concentration limits for specific analytes is presented in Table 3.4-4.

Upgradient to the Solar Evaporation Ponds area, groundwater quality reflects elevated levels of TDS, nitrate/nitrite, calcium, magnesium, bicarbonate, and chloride. Uranium-233, -234, uranium-238, uranium-235, tritium, americium-241, and cesium-137 were detected within and adjacent to the Solar Evaporation Ponds. Concentrations and distributions of these radionuclides (reported in pCi/l) are presented in Figure 3.4-6.

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Table 3.4-4 (Continued)

Analyte	Background Groundwater Quality Value	Concentration
pH	8.20	pH unit
Cyanide	0.01*	mg/l
Gross Alpha	55.0	pCi/l
Gross Beta	59.60	pCi/l
Uranium-233, -234	0.1*	pCi/l
Uranium-235	2.090	pCi/l
Uranium-238	25.60	pCi/l
Strontium-89, -90	0.90*	pCi/l
Plutonium-239, -240	0.0150	pCi/l
Americium-241	0.01670	pCi/l
Cesium-137	0.3060	pCi/l
Radium-226	96.30	pCi/l
Radium-228	DL*	pCi/l
Tritium	359.00	pCi/l
Organics	DL*	µg/l
Fluoride	DL*	mg/l
Oil and Gas	DL*	mg/l
Phosphate	DL*	mg/l
Silica, dissolved	DL*	mg/l
Total Suspended Solids	DL*	mg/l
Sulfide	DL*	mg/l

a. Background Groundwater Quality Exceedance Value is equal to the upper limit of the tolerance interval reported in the Background Geochemical Characterization Report for 1989.

b. Background Groundwater Quality Exceedance Value is equal to the maximum concentration detected in background wells from the Background Geochemical Characterization Report for 1989.

c. Tolerance interval was calculated for Strontium-90 only.

d. Organic and inorganic compounds above detection limit are considered in exceedance of background groundwater levels if they were not included in the Background Geochemical Characterization Report for 1989.

NOTES:

- Chloride may have both a north and south value for the uppermost aquifer.
- Use north chloride values for the Present Landfill and Solar Evaporation Ponds only.
- Use south chloride values for the West Spray Field.
- All concentrations presented in this table have been rounded to three significant figures.

Table 3.4-4
Representative Background Groundwater Concentrations
in the Uppermost Aquifer

Analyte	Background Groundwater Quality Value	Concentration
Aluminum	0.327*	mg/l
Antimony	0.5*	mg/l
Arsenic	0.01*	mg/l
Barium	0.2	mg/l
Beryllium	0.005*	mg/l
Cadmium	0.011*	mg/l
Calcium	62.60	mg/l
Cesium	2.5*	mg/l
Chromium	0.02*	mg/l
Cobalt	0.05*	mg/l
Copper	0.0477*	mg/l
Iron	0.944*	mg/l
Lead	0.0396*	mg/l
Lithium	1.79*	mg/l
Magnesium	16.10	mg/l
Manganese	0.2130	mg/l
Mercury	0.0008*	mg/l
Molybdenum	0.5*	mg/l
Nickel	0.0432*	mg/l
Potassium	11.3*	mg/l
Selenium	0.221*	mg/l
Silver	0.004*	mg/l
Sodium	46.70	mg/l
Strontium	7.12*	mg/l
Thallium	1*	mg/l
Tin	1*	mg/l
Vanadium	0.05*	mg/l
Zinc	0.141*	mg/l
Total Dissolved Solids	389.0	mg/l
Chloride (north)	10.70	mg/l
Chloride (south)	22*	mg/l
Nitrate/Nitrite	3.40*	mg/l
Sulfate	67.10	mg/l
Bicarbonate	249.0	mg/l
Carbonate	5*	mg/l

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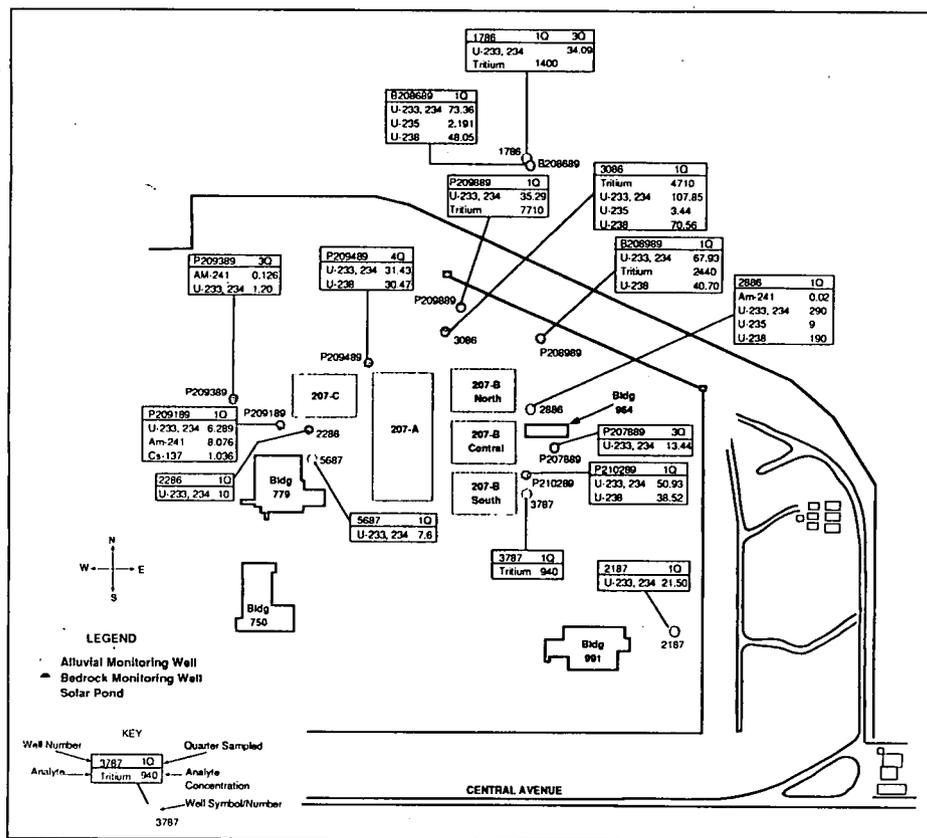


Figure 3.4-6. Solar Evaporation Ponds Dissolved Radionuclides Above Background in the Uppermost Aquifer

The Present Landfill (OU 7). The Present Landfill is undergoing groundwater monitoring to assess the level and extent of migration of contamination in the uppermost aquifer beneath the unit. Groundwater elevation data collected in 1990 indicates that groundwater beneath the landfill flows easterly through surficial geologic materials toward the landfill pond (Figure 3.4-7). The groundwater flow regime in the weathered bedrock is similar to that

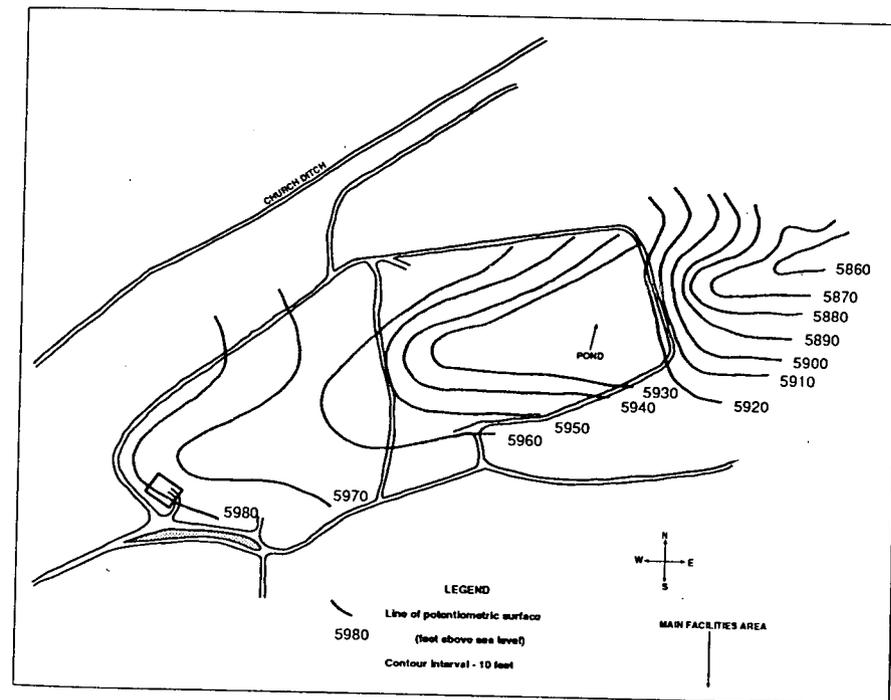


Figure 3.4-7. Present Landfill Potentiometric Surface in Surficial Materials

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observed in the surficial materials. Influencing the natural flow regime in the area are several engineering control systems installed to intentionally redirect surface and subsurface flow around the landfill. Engineering control systems include pond embankments, a leachate/groundwater interceptor system, a surface water interceptor ditch, and a buried slurry wall. Assessment of the 1990 data reveals that contaminants appear to migrate with the groundwater flow along the leachate detection system toward the landfill pond.

Thirty-one shallow and four deep groundwater wells are monitored quarterly at the Present Landfill. Groundwater quality data collected in and adjacent to the landfill in 1990 show major inorganic ions, dissolved metals, dissolved radionuclides, and VOCs in the shallow groundwater at concentrations above representative background concentrations. Specifically, the landfill is observed to impact groundwater quality through increased concentrations of bicarbonate, calcium, chloride, magnesium, sodium, and sulfate. Additionally, the landfill appears to contribute dissolved metals, primarily barium, calcium, copper, iron, magnesium, manganese, nickel, sodium, and to a lesser extent, aluminum, arsenic, cobalt, lead, mercury, selenium, and zinc. Nitrate/nitrite is also elevated in several wells; however, concentrations are similar to concentrations seen in wells upgradient to the landfill. Radionuclides detected in the first quarter of 1990 in and adjacent to the landfill include americium-241 up to 3.19 pCi/l, and uranium-233, -234 up to 20 pCi/l (Figure 3.4-8). Detections of VOCs were sporadic in occurrence with several different compounds occurring in just a single well or in a group of wells. The distribution and concentrations of these parameters are presented in Figure 3.4-9 where radionuclides are given in pCi/l; all other analytes are reported in mg/l.

The assessment of downgradient water quality is commonly used to determine impacts from landfill activities. Downgradient of the Present Landfill, concentrations of nitrate/nitrite were detected at 160 mg/l. Other inorganics detected in concentrations exceeding background include TDS (3,000 mg/l), chloride (550 mg/l), sulfate (520 mg/l), and bicarbonate (920 mg/l). Metals found to exceed background concentrations were manganese (0.38 mg/l), magnesium (88.9 mg/l), calcium (229 mg/l), mercury (1.4 mg/l), nickel (0.4 mg/l), and sodium (420 mg/l). No VOCs or radionuclides were detected downgradient of the landfill.

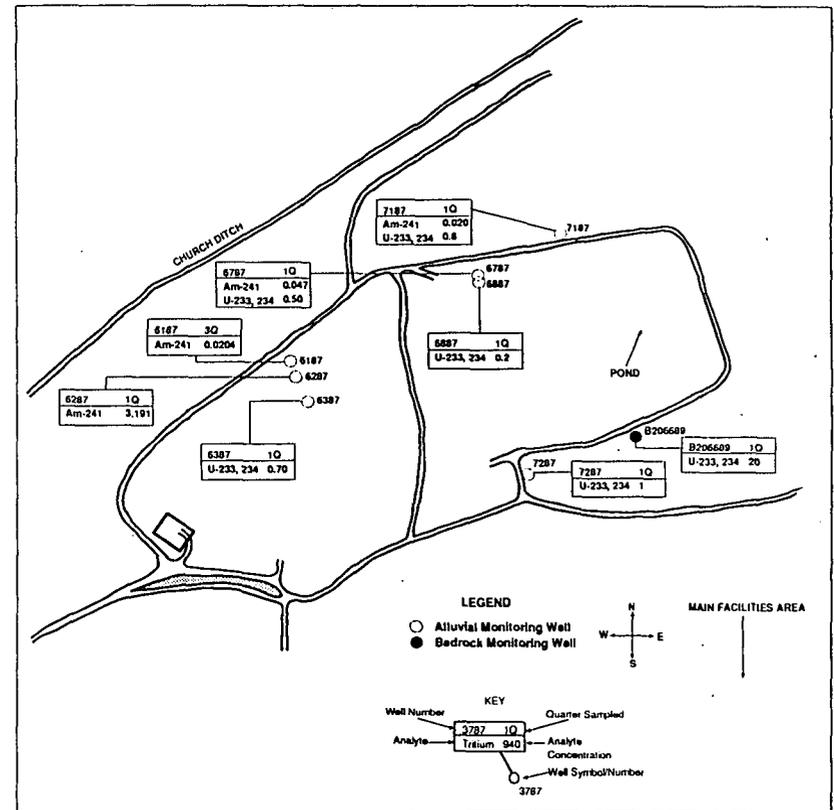


Figure 3.4-8. Present Landfill Dissolved Radionuclides Above Background in the Uppermost Aquifer

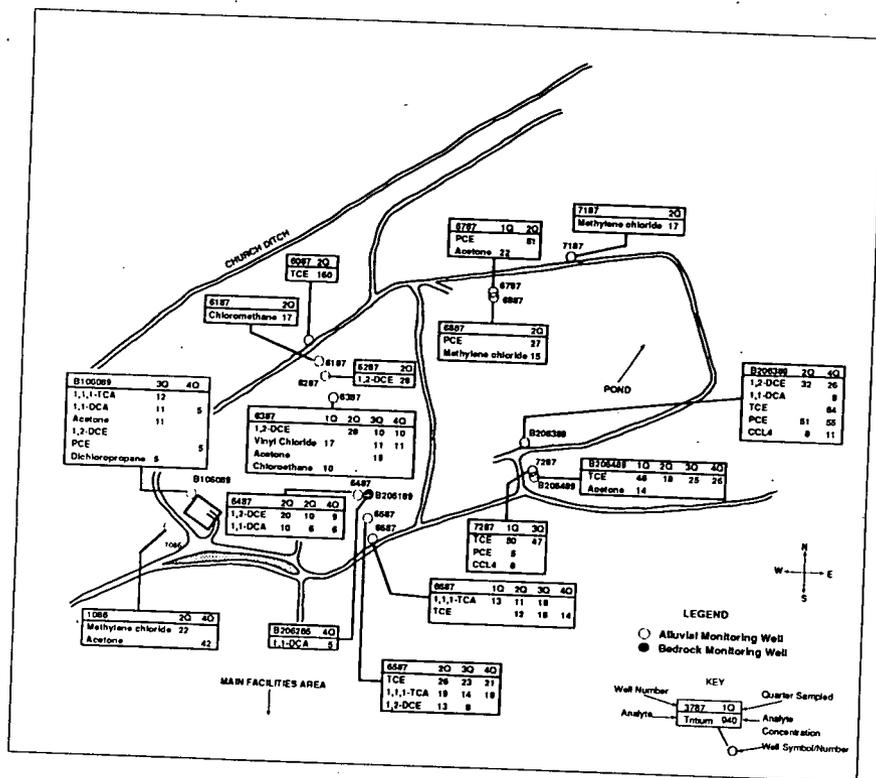


Figure 3.4-9. Present Landfill Volatile Organic Compounds Detected in the Uppermost Aquifer

West Spray Field (OU 11)

A groundwater monitoring program is underway at the West Spray Field to provide continuing monitoring and assessment of the level and extent of migration of contamination in the uppermost aquifer beneath this unit. Groundwater flow in the uppermost aquifer is relatively uniform in an east-northeasterly direction. Twenty alluvial wells and three bedrock wells are routinely sampled at the West Spray Field. A 1990 groundwater flow map for the high flow season, February to March, is presented in Figure 3.4-10.

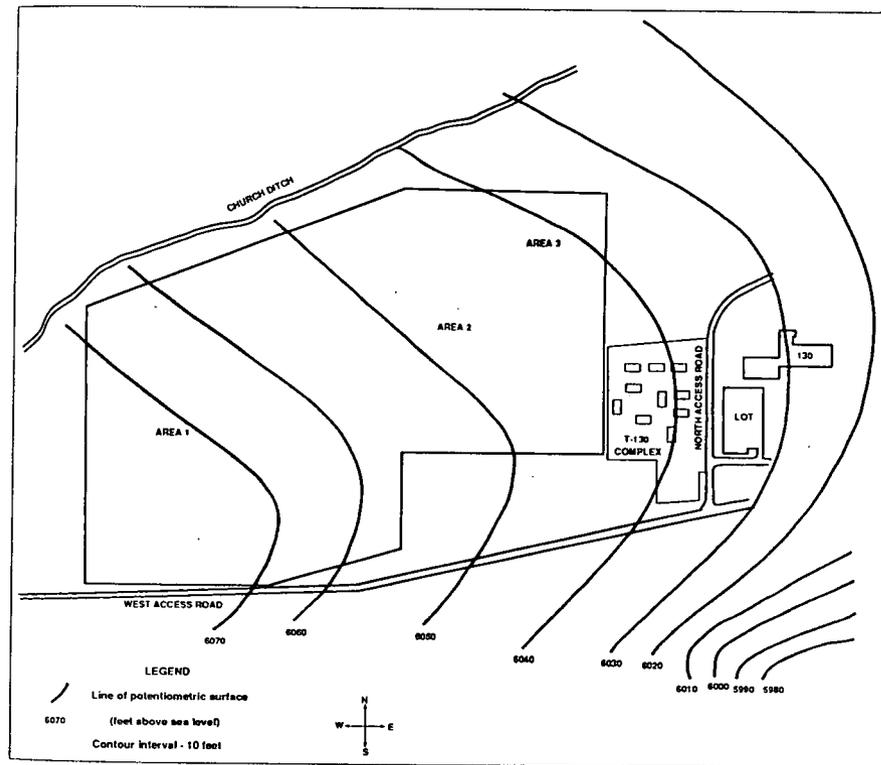


Figure 3.4-10. West Spray Field Potentiometric Surface in Surficial Materials

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In general, groundwater monitoring at the West Spray Field during 1990 detected several analytes at concentrations close to the background. These analytes included inorganics and some metals; however, some radionuclides and organic compounds were also detected. See Figure 3.4-11, where radionuclides are given in pCi/l; all other analytes are reported in mg/l. Water quality data from shallow wells within and adjacent to the West Spray Field indicate that groundwater is impacted with elevated levels of nitrate/nitrite, sodium, TDS, sulfate, dissolved radionuclides, and VOCs. Groundwater quality is unaffected beyond the site boundary in wells located approximately 1,100 ft to the north and 1,600 ft to the southeast. Concentrations of TDS ranged from 430 to 530 mg/l with the higher concentrations occurring in the central portion of the site. Nitrate/nitrite was detected in two wells in the western portion of the site at concentrations near background (4-6 mg/l) levels of concentration. Several metals including manganese, iron, lead, aluminum, and sodium were detected in 1990. These detections occurred sporadically at near background concentrations with the exception of iron and manganese, which were detected consistently.

Dissolved radionuclides and VOCs detected in the first quarter of 1990 in particular wells are also presented in Figure 3.4-11. Uranium-233, -234 concentrations ranged from 0.67 to 1.97 pCi/l. Radionuclides detected during 1989 (tritium, americium-241, plutonium-239, and cesium-137) were not detected during first quarter 1990. Benzene, toluene, methylene chloride, and acetone were detected at near laboratory detection limits as single occurrences. Benzene was detected once at 7 µg/l. Acetone was detected once at 11 µg/l. Methylene chloride and toluene were detected at the lab detection limit of 5 µg/l. Methylene chloride and acetone are common laboratory contaminants, and concentrations near the detection limit may not reflect impacts to groundwater quality.

Upgradient to the West Spray Field, groundwater quality was impacted by elevated levels of TDS and nitrate/nitrite. Nitrate/nitrite concentrations ranging from 4.6 to 5.6 mg/l exceeded the background concentration of 3.4 mg/l. TDS levels of 430 mg/l exceeded the statistical upper background concentration of 389 mg/l. Cadmium, sodium, and magnesium concentrations exceeded representative background concentrations also in wells downgradient of the West Spray Field.

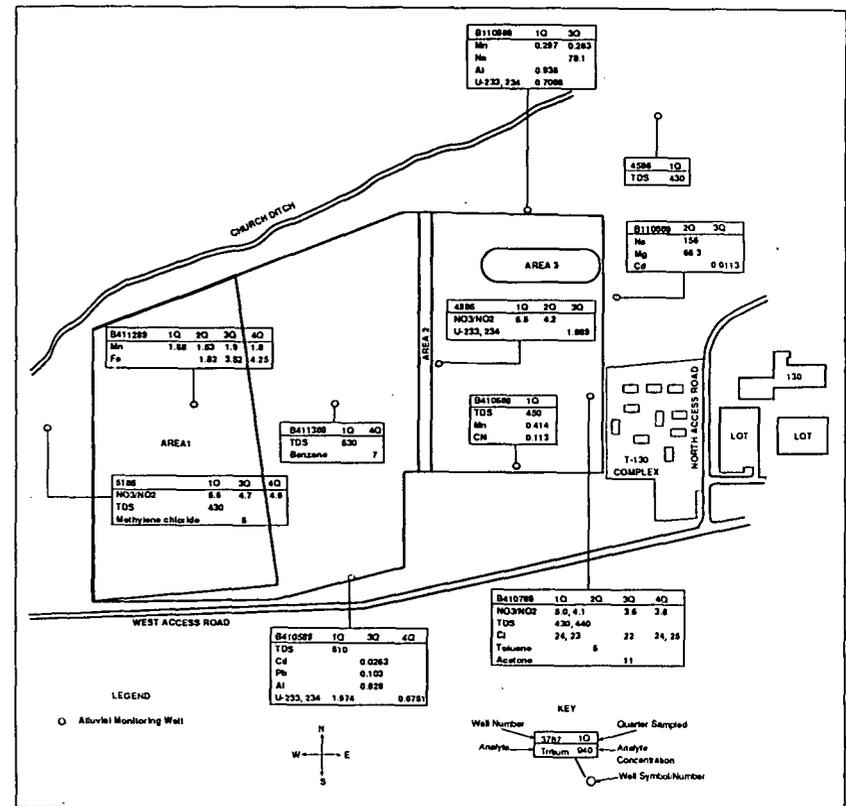


Figure 3.4-11. West Spray Field Analytes Above Background and Volatile Organic Compounds Detected in the Uppermost Aquifer

3. ENVIRONMENTAL MONITORING PROGRAMS

3.5 SOIL MONITORING

Michael Z. Litaor

The purpose of the RFP Soil Monitoring Program is to evaluate changes in plutonium concentrations that might occur through soil resuspension or other mechanisms. This section includes data on soil plutonium concentrations for 1984 through 1990.

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OVERVIEW

The soil monitoring program has been conducted since 1972 excepting the period between 1978 and 1983. Soils were sampled at RFP in September 1990 at 40 sites located within concentric circles, approximately 1.6 and 3.2 km (1 and 2 mi) radii from the center of RFP (Figure 3.5-1). Along each circle, sampling locations were spaced at 18° increments and designated accordingly (e.g., location 1-018 refers to the inner circle [#1] at 18° northeast). The soil samples were collected by driving a 10- by 10-centimeter (cm) (4- by 4-inch [in.]) cutting tool 5 cm (2 in.) deep into undisturbed soil. The soil sample within the tool cavity was collected and placed into a new 1-gallon stainless steel can. Ten subsamples were collected from the corners and the center of two 1-meter squares, which were spaced 1 meter apart. Each set of 10 subsamples was composited (5,000 cubic centimeters [cm³]) for soil radionuclides analysis. Laboratory analysis was performed to determine plutonium concentration, expressed as pCi/g.

RESULTS

Soil plutonium concentrations for 1984 through 1990 are presented on page 112 in Table 3.5-1. Figure 3.5-1 depicts the location of the soil sample sites, as well as the mean and standard deviation of soil plutonium concentrations from 1984 through 1990. Samples taken in 1990 from the inner concentric circle ranged from 0.03 pCi/g to 9.14 pCi/g. In previous years the highest soil plutonium concentration was found at sites 1-090 and 1-108 (Figure 3.5-2). During 1990, sample location 1-090 was relocated approximately 200 m to the north. The older site is located in an area currently under intensive study as part of the IAG.

Samples from the outer concentric circle ranged from 0.00 pCi/g to 3.94 pCi/g. The highest plutonium concentrations were found in soil samples from the eastern portion of the buffer zone (Figures 3.5-1 and 3.5-2). These sample locations are east and southeast of the major source of plutonium contamination in the soil environment at RFP. Plutonium contamination probably originated from an area known as the 903 Pad where steel drums were used to store plutonium-contaminated industrial oils from 1958 to 1968. Leakage from these drums contaminated surface soils and

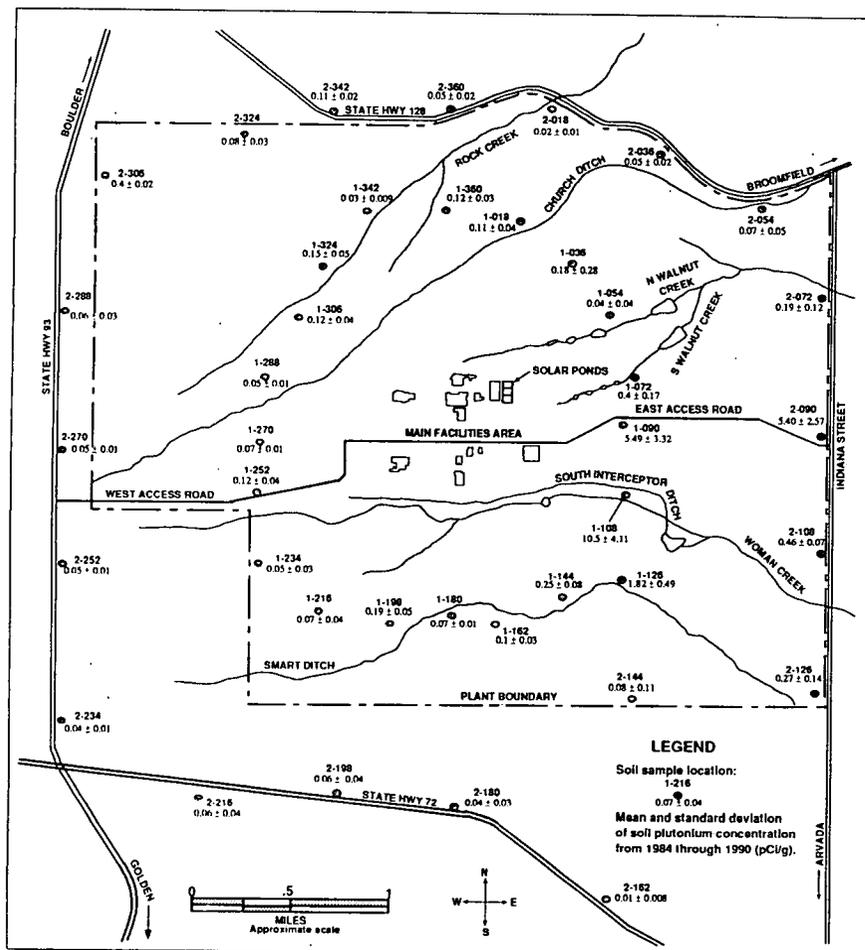


Figure 3.5-1. Soil Sampling Locations

plants. Plutonium particles entrapped in the fine fraction of top soil horizons were subsequently airlifted by winds and deposited on soils in an east and southeast-trending plume (KR70). Table 3.5-1 indicates that data from previous years have consistently shown elevated plutonium concentrations in soils from these sites.

The plutonium concentration in soils east and southeast of the 903 Pad varied somewhat between years (Table 3.5-1). Each monitoring site was adequately sized (30 by 30 m) to allow yearly selection of non-overlapping sample areas. Since the sampling location varied between years, small microtopographical variation was introduced, which affected wind deposition and resuspension rates of plutonium. In addition, natural variability in erosional and faunal activities,

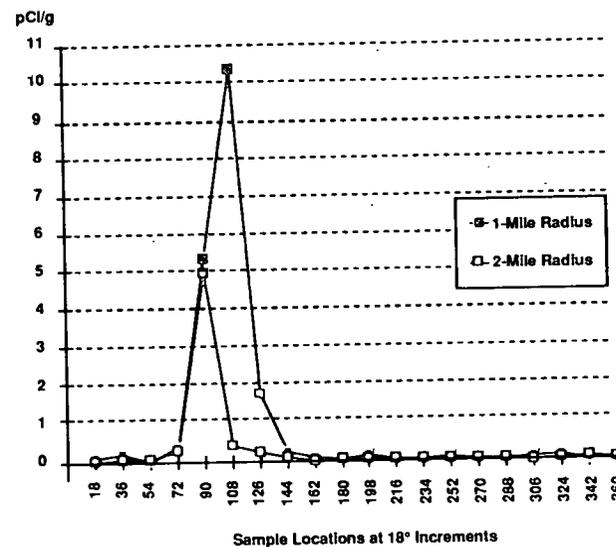


Figure 3.5-2. Mean Plutonium Concentration in Soils at 1- and 2-Mile Radii from the RFP, 1984 - 1990

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as well as sampling and analytical error, contribute to the observed high variability. Other investigators (P180) have observed high variability in soil plutonium concentrations in other contaminated sites, especially near the release source. Investigators ascribed these variations in plutonium-239, -240 to varying distances from the point of release (75 percent), microtopographical variations (21 percent), and analytical sampling error, which included subsampling and analytical error (5 percent). Variability in plutonium concentrations in soils taken from the two radial grids at 18° to 36° and 162° to 360° was extremely small.

Table 3.5-1
Plutonium Concentration in Soil Samples at 1 and 2 Miles from the Plant Center

Location	1984		1985		1986		1987		1988		1989		1990	
	Pu	Pu/g _{dry}												
Inner Circle:														
1-018	0.08	± 0.02	0.15	± 0.02 ^a	0.15	± 0.02	0.18	± 0.02	0.10	± 0.01	0.08	± 0.01	0.07	± 0.02
1-036	0.03	± 0.01	0.08	± 0.01	0.10	± 0.02	0.06	± 0.01	0.88	± 0.01	0.88	± 0.01	0.07	± 0.001
1-054	0.00	± 0.01	0.02	± 0.01	0.04	± 0.01	0.04	± 0.01	0.03	± 0.01	0.03	± 0.01	0.04	± 0.01
1-072	0.6	± 0.05	0.32	± 0.03	0.63	± 0.06	0.51	± 0.05	0.37	± 0.04	0.16	± 0.02	0.21	± 0.03
1-090	7.7	± 0.5	1.00	± 0.09	7.40	± 0.62	7.05	± 0.77	10.6	± 0.98	2.52	± 0.27	2.18	± 0.21
1-108	15.0	± 0.9	13.0	± 1.30	15.0	± 1.40	2.37	± 0.21	10.4	± 0.94	8.56	± 0.81	9.14	± 0.12
1-126	2.1	± 0.1	1.90	± 0.17	1.90	± 0.18	2.75	± 0.28	1.55	± 0.14	1.08	± 0.13	1.46	± 0.17
1-144	0.29	± 0.03	0.32	± 0.03	0.27	± 0.02	0.36	± 0.04	0.20	± 0.02	0.12	± 0.01	0.17	± 0.02
1-162	0.14	± 0.02	0.10	± 0.01	0.08	± 0.01	0.17	± 0.02	0.09	± 0.01	0.06	± 0.01	0.06	± 0.01
1-180	0.09	± 0.02	0.06	± 0.01	0.06	± 0.01	0.10	± 0.01	0.06	± 0.01	0.08	± 0.01	0.04	± 0.001
1-198	0.22	± 0.03	0.16	± 0.02	0.16	± 0.02	0.21	± 0.02	0.10	± 0.01	0.05	± 0.01	0.13	± 0.005
1-216	0.05	± 0.02	0.05	± 0.01	0.10	± 0.01	0.16	± 0.02	0.05	± 0.01	0.05	± 0.01	0.05	± 0.007
1-234	0.13	± 0.02	0.05	± 0.01	0.04	± 0.01	0.05	± 0.01	0.05	± 0.01	0.03	± 0.01	0.03	± 0.007
1-252	0.17	± 0.02	0.14	± 0.02	0.11	± 0.01	0.21	± 0.03	0.09	± 0.01	0.08	± 0.01	0.03	± 0.01
1-270	0.06	± 0.02	0.07	± 0.01	0.08	± 0.01	0.09	± 0.01	0.07	± 0.01	0.06	± 0.01	0.05	± 0.01
1-288	0.04	± 0.01	0.05	± 0.01	0.05	± 0.01	0.06	± 0.01	0.03	± 0.01	0.06	± 0.01	0.07	± 0.01
1-306	0.14	± 0.02	0.09	± 0.01	0.17	± 0.02	0.21	± 0.03	0.12	± 0.01	0.10	± 0.01	0.08	± 0.01
1-324	0.13	± 0.02	0.15	± 0.02	0.22	± 0.03	0.24	± 0.03	0.16	± 0.02	0.07	± 0.01	0.09	± 0.01
1-342	0.04	± 0.01	0.02	± 0.01	0.03	± 0.01	0.03	± 0.01	0.02	± 0.01	0.04	± 0.01	0.05	± 0.001
1-360	0.10	± 0.02	0.11	± 0.01	0.19	± 0.02	0.16	± 0.02	0.12	± 0.02	0.08	± 0.01	0.11	± 0.01
Outer Circle:														
2-018	0.00	± 0.01	0.04	± 0.01	0.03	± 0.01	0.04	± 0.01	0.02	± 0.00	0.02	± 0.01	0.00	± 0.003
2-036	0.02	± 0.01	0.02	± 0.01	0.03	± 0.01	0.10	± 0.01	0.07	± 0.01	0.04	± 0.01	0.05	± 0.01
2-154	0.03	± 0.01	0.03	± 0.01	0.03	± 0.01	0.03	± 0.01	0.03	± 0.01	0.06	± 0.01	0.18	± 0.03
2-172	0.4	± 0.04	0.33	± 0.03	0.23	± 0.02	0.36	± 0.04	0.11	± 0.01	0.46	± 0.06	0.14	± 0.02
2-090	10.0	± 0.6	2.50	± 0.25	5.30	± 0.48	4.48	± 0.52	7.12	± 0.87	1.94	± 0.23	3.94	± 0.5
2-108	0.46	± 0.02	0.41	± 0.04	0.44	± 0.05	0.47	± 0.05	0.53	± 0.01	0.28	± 0.04	0.20	± 0.02
2-126	0.14	± 0.02	0.42	± 0.04	0.46	± 0.05	0.40	± 0.04	0.03	± 0.01	0.28	± 0.04	0.20	± 0.02
2-144	0.02	± 0.01	0.04	± 0.01	0.02	± 0.01	0.08	± 0.01	0.03	± 0.01	0.03	± 0.01	0.02	± 0.005
2-162	0.00	± 0.01	0.01	± 0.00	0.02	± 0.01	0.03	± 0.01	0.02	± 0.01	0.02	± 0.01	0.01	± 0.004
2-180	0.02	± 0.01	0.11	± 0.01	0.08	± 0.01	0.03	± 0.01	0.03	± 0.01	0.08	± 0.01	0.03	± 0.007
2-198	0.05	± 0.02	0.02	± 0.01	0.08	± 0.01	0.14	± 0.02	0.10	± 0.01	0.01	± 0.01	0.05	± 0.01
2-216	0.04	± 0.01	0.04	± 0.01	0.06	± 0.01	0.07	± 0.01	0.07	± 0.01	0.05	± 0.01	0.04	± 0.007
2-234	0.04	± 0.01	0.05	± 0.01	0.05	± 0.01	0.07	± 0.01	0.03	± 0.01	0.05	± 0.01	0.04	± 0.002
2-270	0.09	± 0.01	0.04	± 0.01	0.06	± 0.01	0.06	± 0.01	0.04	± 0.01	0.04	± 0.01	0.04	± 0.007
2-288	0.01	± 0.01	0.04	± 0.01	0.05	± 0.01	0.13	± 0.02	0.07	± 0.01	0.08	± 0.01	0.03	± 0.006
2-306	0.00	± 0.01	0.06	± 0.01	0.02	± 0.01	0.08	± 0.01	0.02	± 0.01	0.06	± 0.01	0.09	± 0.01
2-324	0.08	± 0.02	0.04	± 0.01	0.09	± 0.01	0.08	± 0.01	0.14	± 0.02	0.06	± 0.01	0.09	± 0.01
2-342	0.13	± 0.02	0.13	± 0.01	0.12	± 0.01	0.14	± 0.02	0.10	± 0.01	0.06	± 0.01	0.10	± 0.01
2-360	0.02	± 0.01	0.09	± 0.01	0.05	± 0.01	0.08	± 0.01	0.05	± 0.01	0.04	± 0.01	0.06	± 0.01

a. Not blank corrected.
b. Samples to a depth of 5 cm.
c. Concentrations are for the fraction of soil measuring less than 2mm in diameter.
d. Error term represents two standard deviations.

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3. ENVIRONMENTAL MONITORING PROGRAMS

3.6 EXTERNAL GAMMA RADIATION DOSE MONITORING

Nancy M. Daugherty

Thermoluminescent dosimeters (TLDs) are used to measure external (i.e., the radiation source is outside the body) penetrating gamma radiation exposure on and off the RFP site. For a further discussion of these concepts, see Appendix A, "Perspective on Radiation," and Section 4, "Radiation Dose Assessment." This section includes results of onsite, perimeter, and community TLD measurements.

OVERVIEW

Thermoluminescent dosimeters (TLDs) contain a luminescent material that absorbs energy from exposures to ionizing radiation. When the TLD is heated later under controlled conditions, the energy is released as visible light. This light is measured and can be used to indicate the external gamma radiation dose that a person could receive under the same exposure conditions. The primary radioactive materials to which the public might be exposed as a result of RFP activities emit relatively little penetrating gamma radiation. The most important potential source of radiation dose to the public from RFP activities is the alpha radiation from inhalation or ingestion of plutonium, americium, or uranium. Gamma radiation measured with the RFP TLDs is primarily from naturally occurring cosmic and primordial sources.

RFP has 46 TLD monitoring locations with replicate TLDs at each location. All TLDs are replaced after an exposure of approximately 3 months. The TLDs are placed at 18 locations within the property enclosed by the security fence. Measurements are also made at 16 perimeter locations 2 to 4 mi from the center of RFP and in 12 communities located within 30 mi of RFP. The TLDs are placed at a height of about 3 ft above ground level.

During 1983, conversion from a Harshaw TLD system to a Panasonic system was initiated. For one complete calendar year, two TLDs of each type were used at each monitoring location. Beginning in 1984, only Panasonic TLDs have been used. It was determined that a statistically significant difference in response exists between the Harshaw environmental monitoring system and the Panasonic environmental monitoring system. To compare 1990 values with the Harshaw data reported prior to 1984, it is necessary to multiply the Panasonic results given in Table 3.6-1 by 1.046.

The Panasonic TLDs consist of two model 802 dosimeters, each of which has four elements. Only one of the elements of each dosimeter is used. This element consists of calcium sulfate, thulium doped ($\text{CaSO}_4:\text{Tm}$), deposited on a polyimide surface. The phosphor is covered with clear Teflon and backed with an opaque ABS plastic. The TLDs are packaged in a small plastic bag, a paper envelope, and

Table 3.6-1
Environmental Thermoluminescent Dosimeter Measurements

Location Category	Number of Locations	Number of Measurements	Mean Annual Measured Dose (mrem)	95% Confidence Interval on the Mean (mrem) ^a	95% Confidence Interval on an Individual Measurement (mrem) ^b
Onsite	18	143	154	5	59
Perimeter	16	126	157	6	71
Community	12	86	159	8	71

a. Calculated as 1.96 standard deviations of the mean
b. Calculated as 1.96 standard deviations of the individual measurements

another plastic bag to protect them from the weather. Total filtration over the phosphor is 178.5 milligrams per square centimeter (mg/cm²).

The TLDs have been individually calibrated (three times each) against an onsite cesium-137 gamma calibration source. Calibration linearity studies have confirmed that TLD response is linear for exposure levels ranging from 10 mrem to 1,000 mrem. The mean calibration factor for each dosimeter is applied to measurements taken with that dosimeter. An additional correction is applied to correct for day-to-day variations in reader calibration.

The annual dose equivalent for each location category was calculated by determining the average millirem per day (mrem/day) for each of the three categories, using data from the four quarters of 1990. These values then were multiplied by 365.25 to obtain yearly totals.

In previous annual reports, the annual measured dose was reported with a 95 percent confidence interval on the mean using the standard error of the mean, calculated from the variance of the individual measured values. Beginning in 1985, the 95 percent confidence interval on an individual observation within each location category, calculated as 1.96 standard deviations, was added to the report. This latter interval may be used for assessing the variability of the individual location measurements within a location category.

The 1990 environmental measurements using TLDs are summarized in Table 3.6-1. The average annual dose equivalents, as measured onsite, in the perimeter environs, and in local communities, were 154, 157, and 159 mrem (1.54, 1.57, and 1.59 millisieverts [mSv]), respectively. These values indicate background gamma radiation in the area; the annual background gamma radiation dose in the Denver area ranges from about 125 - 190 mrem (NA87b).

RESULTS

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4. RADIATION DOSE ASSESSMENT



Nancy M. Daugherty

This section is a detailed discussion of methodologies and results of an assessment of the radiation dose to the public that could result from activities at the RFP. Appendix A, "Perspective on Radiation," gives an overview of basic radiation concepts.

ROCKY FLATS PLANT RADIOACTIVE MATERIALS

Radioactive materials included in calculating radiation dose to the public from RFP activities are plutonium, uranium, americium, and tritium. Internal exposure to alpha radiation emissions from inhalation and water ingestion of plutonium, uranium, and americium is the primary contributor to the projected radiation dose. Previous pathways assessments in the *Rocky Flats Plant Site Environmental Impact Statement* indicate that swimming and consumption of foodstuffs are relatively insignificant contributors to public radiation dose (DOE80). Swimming and fishing are limited in the area, and most locally consumed food is produced at considerable distances from the plant. Current pathway analysis is being reviewed to ensure that appropriate pathways are included in the dose assessment methodology.

Radiation Protection Standards for the Public

Standards for protection of the public from radiation are based on radiation dose. Radiation dose is a means of quantifying the biological effect or risk of ionizing radiation. In the United States, the unit commonly used to express radiation dose is the rem or the millirem (1 rem = 1,000 mrem). The comparable International Standard (SI) unit of radiation dose is the sievert (1 sievert [Sv]=100 rem). Radiation protection standards for the public are annual standards, based on the projected radiation dose from a year's exposure to or intake of radioactive materials.

Radiation protection standards applicable to DOE facilities are based on recommendations of national and international radiation protection advisory groups and on radiation protection standards set by other federal agencies. On February 8, 1990, DOE adopted revised radiation protection standards for DOE environmental activities (DOE90a). These standards incorporate guidance from the National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiological Protection (ICRP), and the CAA NESHAP, as implemented in 40 CFR 61, Subpart H (EPA85). Effective December 15, 1989, EPA revised NESHAP standards for airborne emissions of radionuclides from DOE facilities (EPA89). These new NESHAP standards apply to air emissions from RFP in 1990 and are incorporated into the revised DOE standards.

organs receiving significant exposures, multiplying each organ dose equivalent by a health risk weighting factor, and summing those products. The health risk weighting factors used in the calculation of EDE normalize the risk against a whole body radiation dose. Therefore, the health risk (from cancer mortality and genetic damage) that is associated with 1 mrem of EDE is comparable to the risk associated with 1 mrem of whole body dose equivalent. Likewise, 1 mrem of EDE from natural background radiation would have the same health risk as 1 mrem of EDE from artificial produced sources of radiation, regardless of which organ(s) receive the dose.

Radiocactivity concentrations or source terms used in calculating dose can be determined from actual samples and measurements in the environment taken at the locations of interest. Alternatively, for airborne releases, these concentrations can be calculated by modeling the atmospheric dispersion of air emissions from buildings and contaminated land areas.

In the following dose assessment, actual environmental measurements are used to determine compliance with the DOE radiation standard for all pathways. These measurements are used to calculate annual average concentrations of radioactive materials in air and water at the RFP boundary.

As required in federal regulation 40 CFR 61, an EPA-approved computer code is used to determine compliance with CAA NESHAP radionuclide emissions standards for the air pathway only. The EPA-approved code, AIRDOS-PC, includes air dispersion modeling of measured air emissions from buildings and contaminated land areas, as well as dose conversion factors for calculating final radiation dose.

Intake rates of radioactive materials used to represent inhalation and ingestion for 1 yr are prescribed by the DOE (DOE888b, DOE90a). These rates are based on recommendations of the ICRP (IN75). The breathing and water ingestion rates for 1 yr are 8,400 cubic meters (m³) and 730 liters (l), respectively. Exposure times for external penetrating radiation are assumed to be 1 yr.

Radiocactivity Concentration

Intake Rate or Exposure Time

Appendix B, Table B-1, summarizes the revised DOE radiation protection standards for the public as established in 1990. The revised NESHAP standards of December 15, 1989, are included.

Radiation dose is calculated by multiplying radioactivity concentrations in air and water or on contaminated surfaces by assumed intake rates (for internal exposures) or exposure times (for external exposure to penetrating radiation). These products then are multiplied by the appropriate radiation dose conversion factors as follows:

$$\text{Radiation Dose} =$$

$$(\text{Radioactivity Concentration}) \times$$

$$(\text{Intake Rate or Exposure Time}) \times$$

$$(\text{Radiation Dose Conversion Factor})$$

In calculating radiation dose equivalent, differences in the biological effect of different types of ionizing radiation (e.g., alpha, beta, gamma rays, or X-rays) are accounted for in the dose conversion factor. Radiation energy absorbed in the tissue of interest is first calculated and then multiplied by a modification factor based on the type and energy of the ionizing radiation involved. One millirem of dose equivalent from alpha radiation would have the same biological effectiveness on a particular organ as one millirem of dose equivalent from gamma radiation. Dose equivalent can be calculated for the whole body when there is uniform irradiation of all tissues, or for individual organs as might be done when selected tissues are irradiated non-uniformly.

In 1985, DOE adopted radiation protection standards for the public based on the concept of EDE. The December 15, 1989, EPA NESHAP standards also incorporate EDE as the basis for radiation protection for the public from airborne emissions of radioactivity. Previously, whole body dose equivalent and individual organ dose equivalent, as described above, were used for this purpose. The following dose assessment for 1990 uses EDE as the basis for radiation protection of the public, but includes individual organ dose equivalents for comparison with previous RFP annual reports.

EDE is a means of calculating radiation dose that allows comparisons of the total health risk of cancer mortality and serious genetic effects from exposures of different types of ionizing radiation to different body organs. EDE is calculated by first determining the dose equivalent to those

Radiation Dose

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Radiation Dose Conversion Factors

Radiation dose conversion factors used for determining compliance with DOE standards for all pathways are prescribed by DOE (DOE88a, DOE88b, DOE90a). Dose conversion factors for internal exposures are based on recommendations of the ICRP (IN79). Dose conversion factors for external exposures to penetrating radiation are based on a methodology developed at Oak Ridge National Laboratory (ORNL) (KO81, KO83), with modifications by the original author (DOE88a).

Relative abundances of plutonium and americium isotopes in plutonium typically used at RFP (Table 4-1) were used to calculate composite dose conversion factors for plutonium and americium in air and for plutonium in water. The relative abundances used in developing the composite dose conversion factors were based on the isotopic activity fractions of plutonium-239 and -240, since these are the isotopes measured in environmental monitoring sample analyses. Fractions of ingested radionuclides absorbed from the gastrointestinal tract and lung clearance classes for inhaled radionuclides were chosen to maximize the

Table 4-1
Isotopic Composition of Plutonium Used at the RFP

Isotope	Relative Weight (Percent)	Specific Activity (Ci/g)	Relative Activity ^a (Ci/g)	Fraction of Pu Alpha Activity ^b	Fraction of Pu-239, -240 Activity ^c
Pu-238	0.01	17.1	0.00171	0.0233	0.0239
Pu-239	93.79	0.0622	0.05834	0.7962	0.8153
Pu-240	5.80	0.228	0.01322	0.1804	0.1847
Pu-241	0.36	103.5 ^d	0.37260 ^d	5.085 ^d	5.207
Pu-242	0.03	0.00393	1.18 x 10 ⁻⁶	1.61 x 10 ⁻⁵	1.65 x 10 ⁻⁵
Am-241				0.20 ^d	0.205

^d Beta Activity

- Obtained by multiplying the percent by weight by the specific activity.
- Obtained by dividing the relative activity by the sum of the relative activities for the plutonium alpha emitters.
- Obtained by dividing the relative activity by the sum of the relative activities of Pu-239 and Pu-240.
- The value for Am-241 is taken to be 20 percent of the plutonium alpha activity.

associated internal dose conversion factors and the resulting radiation dose. Each internal dose conversion factor is for a 50-yr dose commitment from 1 yr of chronic exposure. That is, the dose that an individual could receive for 50 yrs following 1-yr's chronic intake of radioactive material is calculated. The dose conversion factors used in this assessment are listed in Table 4-2. These dose conversion factors incorporate intake rates and exposure times discussed above.

The EPA-approved computer code AIRDOS-PC, used to determine compliance with the CAA NESHAP standard for the air pathway, incorporates EPA's own approved dose conversion factors. Plutonium emissions were modeled for the isotopes plutonium-238 and plutonium-239, -240. AIRDOS-PC includes no dose conversion factor for plutonium-241 or plutonium-242, but these would be relatively insignificant contributors to total dose. Plutonium-241 emits primarily beta radiation with a very small internal dose conversion factor; plutonium-242 emits primarily alpha radiation, but is a small component of the total plutonium activity mix (Table 4-1). The AIRDOS-PC default values for lung clearance class and gastrointestinal uptake fraction were used when running this code.

Maximum Plant Boundary Dose

Dose assessment for 1990 was conducted for several locations: RFP property boundary and sites to a distance of 80 km (50 mi). Following is a description of the radionuclide concentrations (source terms) used for calculating the maximum radiation dose to the public for all pathways and the results of that calculation.

Plutonium and americium in RFP environs are the combined result of residual fallout deposition from global atmospheric nuclear weapons testing and releases from the plant. Uranium, a naturally occurring element, is indigenous to many parts of Colorado and is used in RFP operations in various isotopic ratios. Tritium is both naturally occurring and produced artificially; tritium is sometimes used in RFP operations.

The ingestion source terms were based on measured concentrations of plutonium, americium, uranium, and tritium in surface water effluent. Ground-plane source terms of penetrating radiation exposure from contaminated soil areas were based on past measured values of plutonium in soil and an assumed ratio of 0.20 for the americium to

Table 4-2
Dose Conversion Factors Used In Dose Assessment Calculations
for the RFP in 1990

INHALATION

Rem * Milliliter
Microcurie

^{a,b}

Organ	Pu-239, -240
Effective Dose Equivalent	5.71 x 10 ¹²
Liver	2.22 x 10 ¹³
Bone Surfaces	1.04 x 10 ¹⁴
Lung	1.08 x 10 ¹³

WATER INGESTION

Rem * Milliliter
Microcurie

^{a,c}

Organ	Pu-239, -240	Am-241	U-233, -234	U-238
Effective Dose Equivalent	3.53 x 10 ⁶	3.29 x 10 ⁶	1.90 x 10 ⁵	1.70 x 10 ⁵
Liver	1.32 x 10 ⁷	1.24 x 10 ⁷	(f)	(e)
Bone Surfaces	6.42 x 10 ⁷	5.91 x 10 ⁷	2.99 x 10 ⁶	2.70 x 10 ⁶
Lung	(f)	(f)	(f)	(f)

GROUND-PLANE IRRADIATION

Rem * Square Meter
Microcurie

^d

Organ	Pu-239, -240	Am-241
Effective Dose Equivalent	4.80 x 10 ⁻⁵	2.99 x 10 ⁻³
Liver	4.53 x 10 ⁻⁶	1.78 x 10 ⁻³
Bone Surfaces	1.62 x 10 ⁻⁵	3.69 x 10 ⁻³
Lung	9.78 x 10 ⁻⁶	2.01 x 10 ⁻³

- a. Inhalation and water ingestion dose conversion factors were adapted from DOE/EH-0071 (US88b) and are for a 50-yr dose commitment period and a 1-micrometer (µm) activity median aerodynamic diameter (AMAD) particle size. Gastrointestinal (GI) absorption fractions and lung clearance classes were chosen to maximize the dose conversion factors.
- b. An inhalation rate of 2.66 x 10² milliliters per second (ml/s) for 1 yr was assumed and incorporated into the dose conversion factor.
- c. A water intake rate of 2 x 10³ ml (2.1 quarts) per day for 1 yr was assumed.
- d. Ground-plane irradiation dose conversion factors were adapted from DOE/EH-0070 (US88a). For Pu-239 and -240, the higher of the factors for the two isotopes was used. A 1-yr exposure period was assumed.
- e. The liver receives no significant dose from this pathway.
- f. The lung receives no significant dose from this pathway.

plutonium alpha activity in the soil. Inhalation source terms for the 1990 dose assessment were based on plutonium-239, -240 concentrations measured in ambient air samples. Although it is known that much of this plutonium in air is from residual fallout from past global atmospheric weapons testing, for the purposes of this dose assessment it was conservatively assumed that all plutonium originated from RFP.

The maximum site boundary dose assessment assumes that an individual is present continuously at the RFP perimeter. This assumption of an individual residing continuously at the plant boundary is used to provide a conservative upper bound on any radiation dose to the public that might originate from RFP.

The plutonium inhalation source term of 1.7 x 10⁻¹⁷ µCi/ml (6.7 x 10⁻⁷ Bq/m³) was the maximum annual average concentration of plutonium-239 and -240, as measured for a single location in the perimeter ambient air sampling network.

The water supply for a hypothetical individual at the RFP boundary was assumed to be Walnut Creek, which intermittently flows offsite and could potentially be a drinking water source at the site boundary. It should be noted that the assumption that someone may drink this water is extremely conservative, leading to an overestimate of dose to the individual. No individual uses the Walnut Creek water effluent at Indiana Street as a finished drinking water supply, and during 1990 no water effluent from RFP went directly to any drinking water supply. Plant surface water effluents were diverted around Great Western Reservoir and Standley Lake during 1990. Following diversion, these waters flowed from Walnut Creek to Big Dry Creek and subsequently to the South Platte River. The RFP contribution to total flow in the South Platte River would be less than approximately 0.2 percent based on South Platte River average flow from 1976 to 1989, as measured at the Henderson, Colorado, gaging station (UG90).

During 1990, plutonium concentration in Walnut Creek averaged 7.0 x 10⁻¹² µCi/ml (2.6 x 10⁻⁴ Bq/l). Average americium concentration was 6.0 x 10⁻¹² µCi/ml (2.2 x 10⁻⁴ Bq/l). These concentrations were used as the water ingestion source term for the maximum site boundary dose assessment. Uranium-233, -234 average concentration in

Walnut Creek at Indiana Street was 1.51×10^{-9} $\mu\text{Ci/ml}$ (5.59×10^{-2} Bq/l) and the average concentration of uranium-238 in Walnut Creek at Indiana Street was 1.45×10^{-9} $\mu\text{Ci/ml}$ (5.37×10^{-2} Bq/l). The average concentrations of uranium-233, -234 and uranium-238 in incoming raw water were 5.4×10^{-10} $\mu\text{Ci/ml}$ (2.0×10^{-2} Bq/l) and 4.5×10^{-10} $\mu\text{Ci/ml}$ (1.7×10^{-2} Bq/l), respectively. The source terms used for uranium ingestion were the difference between the Walnut Creek and raw water concentrations for each of the two uranium isotope categories: 9.7×10^{-10} $\mu\text{Ci/ml}$ (3.6×10^{-2} Bq/l) for uranium-233, -234 and 1.0×10^{-9} $\mu\text{Ci/ml}$ (3.7×10^{-2} Bq/l) for uranium-238. The average tritium concentration in Walnut Creek was 10 ± 10^{-9} $\mu\text{Ci/ml}$ (3.7×10^{-1} Bq/l) and within the background range typically measured in regional waters. Tritium is an insignificant contributor to dose.

Ground-plane irradiation by external penetrating radiation from contaminated soil areas also is an insignificant contributor to dose. External penetrating radiation associated with radioactive materials of importance at RFP is generally of low energy and intensity. The ground-plane irradiation source term used for this assessment is based on the maximum plutonium concentration in soil measured at the RFP perimeter, as reported by the Environmental Measurements Laboratory (EML) (KR70). This source term is 3×10^{-2} $\mu\text{Ci/m}^2$ (1×10^3 Bq/m²). Americium is assumed to be present at an alpha activity level of 20 percent of plutonium (DOE80). The americium source term is estimated at 6×10^{-3} $\mu\text{Ci/m}^2$ (2×10^2 Bq/m²).

Calculation of maximum radiation dose to an individual continuously present at the RFP boundary uses radionuclide concentrations in Table 4-3. From these concentrations and dose conversion factors given in Table 4-2, a 50-yr dose commitment of 5.2×10^{-1} mrem (5.2×10^{-3} mSv) is calculated as the EDE from all pathways. The bone surfaces receive the highest calculated individual organ dose (Table 4-4). The bone surfaces dose is 8.2 mrem (8.2×10^{-2} mSv). The DOE radiation protection standard for members of the public for all pathways and for prolonged periods of exposure is 100 mrem/yr (1 mSv/yr) EDE. The maximum site boundary dose in 1990 represents 0.52 percent of the standard for all pathways for EDE.

Table 4-3
Radioactivity Concentrations Used in Maximum Site Boundary Dose Calculations for All Pathways

Air (Ci/ml)	Water (Ci/ml)			Surface Deposition (Ci/m ²)		
	Pu-239, -240	Am-241	U-233, -234	U-238	Pu-239, -240	Am-241
1.7×10^{-17}	7.0×10^{-12}	6.0×10^{-12}	9.7×10^{-10}	1.0×10^{-9}	3×10^{-2}	6×10^{-3}

Table 4-4
50-Year Committed Dose Equivalent from 1 Year of Chronic Intake/Exposure from the RFP in 1990

Location	Effective Dose Equivalent (mrem)	Liver (mrem)	Bone Surfaces (mrem)	Lung (mrem)
Maximum Site Boundary	5.2×10^{-1}	5.6×10^{-1}	8.2	2.0×10^{-1}

Radiation Dose from Air Pathway Only

EPA-approved methodology (EPA89) is used to demonstrate compliance with CAA NESHAP standards for airborne radioactivity emissions. As of December 15, 1989, the EPA-approved standard is based on meteorological/dose modeling of air emissions using the AIRDOS-PC or CAP-88 computer codes. Table 4-5 lists the 1990 radioactivity air emissions used as input to the AIRDOS-PC computer code. These emissions include building air effluent release values for the year as discussed in Section 3.2 and an estimate of resuspension from soil as developed in the RFP EIS (DOE80). The estimated soil resuspension is included for comparison to the 1989 Rocky Flats Plant Site Environmental Report and for use in calculating collective population dose. Recent interpretation of the EPA NESHAP standard indicates that it may be applicable to point sources only.

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Table 4-5
Radionuclide Air Emissions for Input to AIRDOS-PC Computer Code

Radionuclide (a)	Air Emission Activity (Ci)
Measured Building Emissions:	
H-3	3.84×10^{-3}
Pu-238	2.80×10^{-6}
Pu-239, -240	1.04×10^{-6}
U-233, -234	1.63×10^{-7}
U-238	5.08×10^{-7}
Am-241	3.93×10^{-7}
Estimated Soil Resuspension:	
Pu-241	2.2×10^{-2}
Pu-239, -240	4.4×10^{-3}
Am-241	8.8×10^{-4}

Note: The discrepancy between measured building emissions activity totals used as input to AIRDOS-PC and the activity totals for effluent air reported in Section 3.2 results from the inability of AIRDOS-PC to accept negative release activities that were calculated for some of the AIRDOS-PC release locations. These negative values are generated from the statistical variability of analytical values close to zero and below the minimum detectable activity.

Meteorological input data for 1990, which was reformatted as required for input to the AIRDOS-PC calculations, is given in Tables C1 through C7, Appendix C. AIRDOS-PC default values for lung clearance class and gastrointestinal uptake fractions were used when running the code. The AIRDOS-PC default assumption of a 1- μ m activity median aerodynamic diameter (AMAD) particle size also was used.

The AIRDOS-PC computer code calculated an EDE from measured building air emissions of 4.3×10^{-5} mrem (4.3×10^{-7} mSv) to the maximally exposed individual residing approximately 2.4 miles from the plant emissions points. The EDE from estimated soil resuspension was calculated as 2.1×10^{-1} mrem (2.1×10^{-3} mSv).

Collective Population Dose

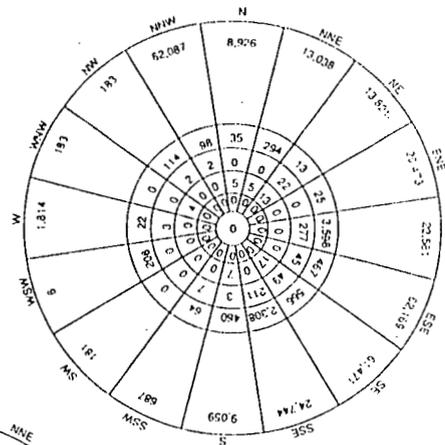
DOE Order 5400.5, promulgated February 8, 1990, requires the assessment of collective population radiation dose to a distance of 80 km (50 mi) from the center of a DOE facility (DOE90a). The assessment of maximum community dose (i.e., maximum dose to an individual in a neighboring community) that was presented in previous RFP annual site reports is no longer included in the DOE approach to radiation dose assessment.

Collective population dose is calculated as the average radiation dose to an individual in a specified area, multiplied by the number of individuals in that area. In assessing the 1990 collective population dose to the public within a radius of 50 mi of RFP, the assessment was limited to airborne emissions of radioactive materials from the plant as the major contributor to population dose. Only two raw water supplies, Great Western Reservoir and Standley Lake, can receive water directly from drainages crossing RFP, and all surface water effluent from RFP was diverted around these water supplies during 1990. Ground-plane irradiation from penetrating radiation found in contaminated soil is an insignificant contribution to dose at the RFP boundary; soil concentrations at more distant community locations would be much less.

Population estimates provided by the Denver Regional Council of Governments (DRCOG) and the State of Colorado were used to determine the 1990 population residing within 50 mi of RFP. An area defined by a circle of 50-mi radius around the center of RFP was further divided into 16 equal sectors, with segments formed by the intersection of the sectors and a total of 10 radial distances of 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 mi (See Figure 4-1). The population within each segment for 1989 was taken from a report prepared under contract to RFP and that used estimates of population patterns from DRCOG and the State of Colorado (DOE90d). The 1989 population estimates then were reduced by 2 percent, which is the overall estimate of population change from 1989 to 1990 that was developed by DRCOG for an eight-county area that includes the metropolitan Denver and Boulder communities. This estimated change from the 1989 estimates was based on preliminary 1990 United States census data for the area. It is expected that more accurate population estimates will be developed as final 1990 census data are available and can be evaluated for more localized areas. The estimates of 1990 segment

These population estimates were calculated from 1980 census tract data adjusted for yearly changes through 1990, assuming uniform population distribution throughout each section.

Concentric circles represent 1- to 2-, 2- to 3-, 3- to 4-, 4- to 5-, and 5- to 10-mile bands.



Concentric circles represent 10- to 20-, 20- to 30-, 30- to 40-, 40- to 50-mile bands.

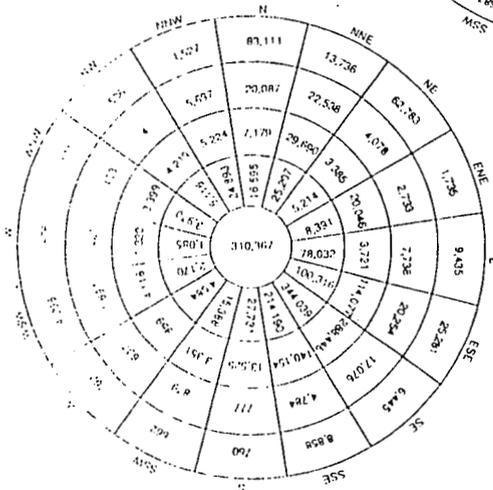


Figure 4-1. Demographic Estimates for Areas 0 - 10 and 10 - 50 Miles from the RFP

populations are given in Figure 4-1. Total population for the area within a radius of 50 mi for 1990 was estimated as 2.2 million people.

The EPA atmospheric dispersion/radiation dose calculation computer code, AIRDOS-PC, was used to calculate the average radiation dose to an individual within each population segment. AIRDOS-PC is the same computer code that is used by RFP to demonstrate compliance with CAA NESHAPs requirements, as promulgated at 40 CFR 61, Subpart H (EPA89). Meteorological data that was collected for RFP during 1990, as well as measured building air effluent radioactivity data and estimates of soil resuspension radioactivity, were input into the AIRDOS-PC code. EDEs were calculated by AIRDOS-PC to the midpoint of each segment's radial distance. These EDEs were used as estimates of the average radiation dose to an individual residing within the segment.

Multiplying the population (number of persons) within a segment by the average individual dose (in rem or sieverts, 1 Sv = 100 rem) within the segment, results in a calculated collective population dose for each segment in units of person-rem (or person-Sv). The total person-rem for all segments is the collective population dose for a distance of 50 mi around RFP, as presented in Table 4-6 for 1990. The collective population dose within 50 mi of RFP was calculated as 2×10^1 person-rem (0.2 person-Sv). By far the majority of this collective population dose results from estimated contaminated soil resuspension from the 903 Pad area of RFP. A very small contribution (7×10^{-3} person-rem [7×10^{-5} person-Sv]) is attributable to measured building air emissions for 1990. The estimated 903 Pad area soil resuspension rate is taken from the RFP EIS published in 1980 (DOE80). More recent unpublished field studies by RFP indicate that this estimated soil resuspension rate is likely to be considerably higher than is actually occurring, leading to a conservative overestimate of radiation dose to the public from this source. The soil resuspension source term may be modified in future RFP annual site reports to reflect the more realistic estimates of soil resuspension once peer review and publication are completed on the field study data.

Natural Background Radiation Dose

EDEs from RFP may be compared to an average annual EDE for the Denver area of about 350 mrem (3.5 mSv) from natural background radiation (NA87b) (Table 4-7). Natural

08

Section 4. RADIATION DOSE ASSESSMENT

Table 4-6

1990 Calculated Radiation Dose to the Public
from 1 Year of Chronic Intake/Exposure from the RFP

MAXIMUM INDIVIDUAL DOSE:

All Pathways ^a	5.2 x 10 ⁻¹ mrem (5.2 x 10 ⁻³ mSv) Effective Dose Equivalent (EDE)
Measured building air emissions ^b	4.3 x 10 ⁻⁵ mrem (4.3 x 10 ⁻⁷ mSv) EDE
Estimated soil resuspension ^c	2.1 x 10 ⁻¹ mrem (2.1 x 10 ⁻³ mSv) EDE

COLLECTIVE POPULATION DOSE
TO 80 km (50 mi):

Measured building air emissions ^b	7 x 10 ⁻³ person-rem (3 x 10 ⁻⁶ person-Sv) EDE
Estimated soil resuspension ^c	2 x 10 ¹ person-rem (2 x 10 ⁻¹ person-Sv) EDE
Total	2 x 10 ¹ person-rem (2 x 10 ⁻¹ person-Sv) EDE

ESTIMATED TOTAL POPULATION
WITHIN 80 km (50 mi):^d2.2 x 10⁶ personsDOE RADIATION PROTECTION
STANDARDS FOR THE PUBLIC:^e

All Pathways ^f	100 mrem (1 mSv) EDE
Air Pathway only ^g	10 mrem (1 x 10 ⁻¹ mSv) EDE

ESTIMATED ANNUAL NATURAL
BACKGROUND INDIVIDUAL
RADIATION DOSE FOR THE DENVER
METROPOLITAN AREA:

350 mrem (3.5 mSv) EDE

ESTIMATED ANNUAL NATURAL
BACKGROUND COLLECTIVE
POPULATION DOSE WITHIN
80 km (50 mi):8 x 10⁵ person-rem (8 x 10³ person-Sv) EDE

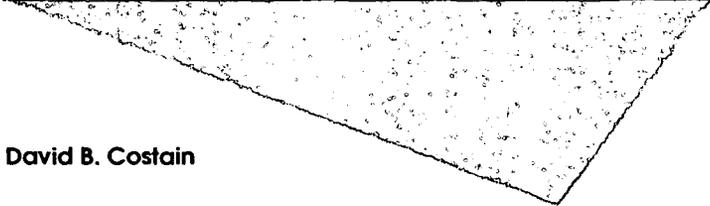
- Calculated using environmental monitoring input data.
- Calculated using AIRDOS-PC modeling of measured building air emissions.
- Calculated using AIRDOS-PC modeling of estimated soil resuspension from the 903 Pad area.
- Based on estimates from information provided by the State of Colorado and the Denver Regional Council of Governments.
- From DOE Order 5400.5. Excludes medical sources, consumer products, residual fallout from past nuclear accidents and weapons tests, and naturally-occurring radiation sources (DOE90a).
- Based on recommendations of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).
- Based on EPA Clean Air Act National Emission Standards for Hazardous Air Pollutants. This standard may be applicable to point sources only.

background radiation for Denver is higher than shown for the total body in RFP annual reports prior to 1985 and also higher than shown for EDE in the 1985 and 1986 annual reports. The level reflects the most recent assessment of natural background radiation exposure of the population of the United States by the NCRP. It includes the significant contribution to EDE from inhaled indoor radon, as well as the adoption of the ICRP 30 methodology of radiation dosimetry. Cosmic radiation and external primordial nuclides sources shown in Table 4-7 reflect the regional dose levels for the Denver area from Denver's higher elevation and greater concentration of naturally occurring radioactive materials in soil. The internal primordial nuclides source includes the average dose from indoor radon estimated by the NCRP for the entire United States. Investigations are now being conducted to determine whether any regional differences in indoor radon doses exist. Once these studies are completed, the estimates of natural background radiation dose for the Denver area may be modified to reflect indoor radon doses specific to this region.

Table 4-7
Estimated Annual Natural Background Radiation Dose for the
Denver Metropolitan Area

Source	Effective Dose Equivalent (mrem)
Cosmic Radiation	50
Cosmogenic Nuclides	1
Primordial Nuclides-External	63
Primordial Nuclides-Internal	239
Total for One Year (rounded)	353

5. QUALITY ASSURANCE AND QUALITY CONTROL



David B. Costain

Environmental monitoring and restoration programs are administered by the RFP Environmental Management (EM) Department, which is organized into six divisions. Each division manager is responsible for implementing management controls that achieve quality within his or her organization. This section describes the EM Quality Assurance Program in detail.

QUALITY ASSURANCE REQUIREMENTS

Quality Assurance Requirements (QAR) for Rocky Flats Management and Operations (February 12, 1990) establish the quality assurance (QA) requirements for the RFP environmental programs. The Rocky Flats QAR incorporates and supplements applicable QA requirements for the American National Standards Institute/American Society of Mechanical Engineers Nuclear Quality Assurance (ANSI/ASME NQA-1), Quality Assurance for Nuclear Facilities, which is endorsed by DOE Order 5700.6B, "Quality Assurance." The IAG, dated January 1991, requires DOE, RFO to develop a Quality Assurance Project Plan (QAPjP) that addresses EPA QA requirements established in EPA Quality Assurance Management Staff (QAMS) 005/80 for the RFP Environmental Restoration Program activities.

ENVIRONMENTAL MANAGEMENT (EM) QUALITY ASSURANCE PROGRAM

During 1990, the EM Department began to develop a comprehensive QA program for environmental management activities. This program establishes policies, requirements, and guidelines for the effective implementation of regulatory requirements and is designed to concurrently satisfy regulatory requirements established by EPA under provisions titled "QAMS-005/80" and DOE Orders 5400.1 and 5700.6B. The focus of the QA program (i.e., to ensure the quality of data) is accomplished through consistent monitoring of sampling procedures, sample analysis, and data reduction activities.

The QA program requirements that are adhered to during the implementation of environmental activities are described in the Quality Assurance Program Description (QAPD) (EG91g) and the RFP Site-Wide QAPjP for the Environmental Restoration Program (EG91e). The QAPD is applicable to all EM Department environmental program activities, while the QAPjP focuses on Environmental Restoration Program activities required by the IAG. In addition to the QAPD and the QAPjP, administrative and operating procedures have been, and will continue to be, developed to control the implementation of specific administrative and sampling, monitoring, and analytical activities.

**Quality Assurance Program
Description**

The QAPD is structured by the 18 criteria of ANSI/ASME NQA-1. Each criterion describes requirements for controlling those activities and functions that may affect the quality of information. The functional area governed by each criterion is briefly described below.

1. **Organization.** Overall coordination is provided by a Quality Assurance Program Manager. Implementation of the quality assurance program at the division level is through individual Quality Coordinators.
2. **Quality Assurance Program.** The QAPD defines required actions and responsibilities for ensuring that appropriate skills are available and effectively used. Education and experience requirements, indoctrination, training, and personnel proficiency are documented.
3. **Design Control.** Data from characterization of CERCLA OUs are used to design remediation programs and facilities. Quality assurance measures are employed during sampling and analysis to ensure that data quality objectives are met.
4. **Procurement Document Control.** Procurement documents contain criteria to ensure the quality of materials, equipment, and services. When appropriate, procurement documents require suppliers to have a quality assurance program. Technical and contract quality requirements and acceptance criteria are identified and documented, reviewed for adequacy, and revisions controlled to ensure that changes are correct and complete.
5. **Plans, Procedures, and Drawings.** Activities affecting quality are controlled and performed in accordance with documented plans, procedures, or drawings.
6. **Document Control.** Documents that include quality requirements or prescribe activities affecting quality are prepared, reviewed, and approved. Only the correct documents are available at work stations, and distribution is controlled.

7. **Control of Purchased Items and Service.** Purchasing and receiving of items and services (including subcontracts) are controlled by source evaluation, selection and inspection, evidence of quality, and examination of items or services upon delivery or completion.
8. **Identification and Control of Data, Samples, and Items.** Data are developed and used in a manner that provides traceability to determine correct use, samples are identified and controlled consistent with their intended use, and only correct and accepted items are used. Test methods are specified in the General Radiochemistry and Routine Analytical Services Protocol and by the standard methods controlled by the EPA's Contract Laboratory Program (CLP).
9. **Control of Processes.** Methods of controlling processes that affect the quality of items and services or the validity of data are part of implementing procedures and other sections of the QAPD; consequently, these methods are not identified separately.
10. **Inspection.** Engineered, manufactured, and constructed items, systems, or components are inspected.
11. **Test Control.** Conformance of engineered structures, systems, and components to specific requirements are verified by controlling tests.
12. **Control of Measuring and Test Equipment.** Tools, gauges, instruments, and other measuring and test equipment used for collecting environmental data, performing tests, or performing inspections, are controlled, adjusted, and calibrated at specified periods to maintain accuracy within designated limits.
13. **Handling, Storage, and Shipping.** Requirements are specified for personnel (including contractors and subcontractors) who handle, store, package, ship, or receive items that, if damaged, lost, or deteriorated, could affect quality.

14. **Status of Inspection, Test, and Operations.** Physical status indicators for items, products, structures, systems, or equipment are attached, maintained, and removed. When physical status indicators are not appropriate, inspection, test, and operations status are recorded in documents traceable to the specific items. Nonconforming items are identified with physical status indicators and documented and, when practical, segregated to ensure that those items are not inadvertently installed, used, or operated until properly dispositioned.
15. **Control of Nonconforming Items and Activities.** Nonconforming items and/or activities are identified, documented, evaluated, segregated, and disposed, and affected parties are notified. A non-conformance consists of a deficiency in the characteristics, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate.
16. **Corrective Action.** Corrective actions for adverse quality conditions are identified, documented, reported and verified. Conditions are adverse to quality when operating limits, specifications, standards, or administrative controls have not been implemented effectively and the results could have a significant adverse impact.
17. **Quality Assurance Records.** Quality assurance records that furnish documentary evidence of quality in design, construction, operation, decommissioning, and environmental restoration of RFP facilities are specified, prepared, maintained, and disposed.
18. **Audits and Surveillances.** Assurance audits and surveillances are conducted to determine the adequacy, effectiveness, and program compliance of an operation, task, process, or activity.

methods used in all phases of laboratory operations. This program includes the following elements:

- Development, evaluation, improvement, modification, and documentation of analytical procedures
- Scheduled instrument calibration, control charting, and preventive maintenance
- Participation in interlaboratory quality comparison programs
- Intralaboratory quality control programs

All sample batches analyzed by the H&S Laboratories Central Receiving Laboratory contain an average of 10 percent control samples. Controls consist of analytical blanks prepared in-house and standards prepared by the RFP Chemistry Standards Laboratory. An analysis or group of analyses may be rejected and the sample or samples scheduled for reanalysis for one or more of the following reasons:

- Overall chemical recovery of the spike is less than 10 percent or greater than 105 percent.
- Analytical blanks in the analysis batch are all out of acceptable range. A statistical test is used to reject blank outliers.
- Alpha energy spectrum is not acceptable because of extra and/or unidentified peaks, excess noise in background areas, or poor resolution of peaks.
- The chemist in charge of the laboratory believes there is reason to suspect the analysis.

Any unusual condition affecting the results, noted either during sample collection or analysis, is reported to the appropriate management officials. Table 5-1 is a summary of H&S Laboratories' participation in the RFP Interactive Measurement Evaluation and Control System for 1990. The H&S Laboratories participate in the EPA Environmental Monitoring Systems Laboratory and the DOE Environmental Measurements Laboratory (EML) Crosscheck Programs. Table 5-2 summarizes H&S Laboratories' participation in this program.

**HEALTH & SAFETY
 (H&S) LABORATORIES**

To ensure data reliability, the Health and Safety (H&S) quality assurance/quality control plan outlines quality control

Table 5-1
Health and Safety Laboratories' Interactive Measurement Evaluation and Control System (January - December 1990)

Attribute	Matrix	Method	Sample Range	Normal Sample Range	Annual Relative Error Percent ^a	Total Control Analyses
Pu-239, -240	Water Spectral	Alpha	1.2-35 d/mP	0-3 d/mf	-7.33	15
Am-241	Water Spectral	Alpha	0.7-21 d/mf	0-3 d/mf	±1.53	15
U-234	Water Spectral	Alpha	3-90 d/mf	0-30 d/mf	-16.7 ^{c,d}	41
H-3	Water Scintillation	Liquid	5,000-60,000 d/mf	0-9,990 d/mf	-5.7	46
Pu-239, -240	Effluent Filters	Alpha Spectral	4-120 d/mP	0-3 d/mf	-16.4	56
Am-241	Effluent Filters	Alpha Spectral	3-90 d/mf	0-4 d/mf	14.6	70
U-234	Effluent Filters	Alpha Spectral	10-300 d/mf	0-30 d/mf	-14.9 ^e	79
Be ^f	Effluent Filters	Atomic Absorption	0.3-10 µg/l ^b	0-5 µg/l	34.6 ^g	99
Be	Workplace Filters	Atomic Absorption	0.3-10 µg/l	0-20 µg/l	-1.9	1119
Pu-239, -240	Ambient Filters	Alpha Spectral	2-45 d/mf	0-50 d/mf	-10.4	40

- a. The mean of the ratio of the 12-month differences between observed and standard values to the standard values in percent. This term is inclusive of all random and systematic error in the standards, analytical chemistry, and measurement process for a given nuclide, matrix, and procedure.
- b. d/mf = disintegrations per minute per filter; d/mf = disintegrations per minute per liter; µg/l = micrograms per liter.
- c. Prior to June 1990, controls were not acidified. These results represent only their controls run since that time.
- d. The internal tracer used for uranium is U-236. The U-234 added to the control sample contains 2% U-235 by activity. The energies of U-235 and U-236 are so close they cannot be resolved by alpha spectroscopy. As a result, the U-234 added to the control sampled biases the recovery high and the sample result low. Efforts are underway to use U-232 as a tracer that will eliminate the source of bias discussed, as well as allow quantification of U-235.
- e. Analyzed by 881 General Laboratory.
- f. 881 Labs stopped blank subtraction.

Table 5-2
Health and Safety Laboratories' Participation in the EPA Environmental Monitoring Systems Laboratory Crosscheck Program During 1990

Isotope Reported	Matrix	Method	Number of Analyses	Number of Acceptable Analyses ^a	Annual Relative Error Percent ^b	Range of Relative Error Percent
Gross Alpha	Filter	Gas Proportional	2	2	5.2	1.3 to 9.2
Gross Beta	Filter	Gas Proportional	2	2	-5.9	-7.2 to 4.7
H-3	Water	Beta Liquid Scintillation	2	2	-6.4	-14.3 to 1.5
Cs-134	Water	Gamma Spectral	1	1	-3.0	Not applicable
Cs-137	Water	Gamma Spectral	1	1	1.3	Not applicable
Pu-239	Water	Alpha Spectral	2	2	-5.8	-6.9 to -4.8
U (nat.)	Water	Alpha Spectral	2	1	-20.6	-25.2 to -16.1

- a. "Acceptable analyses" are those analyses for which the observed value was within ± 3 standard deviations of the standard value.
- b. The mean of the ratio of the 12-month differences between observed and standard values to standard values in percent. This term is inclusive of all random and systematic error in the standards, analytical chemistry, and measurement process for a given nuclide, matrix, and procedure.

GENERAL LABORATORY

The Analytical Laboratories Quality Assurance Program provides comprehensive guidance to the General Laboratory to ensure data quality. The laboratory organization, functions, responsibilities, policies, and programs that comprise the overall quality assurance program are described. Highlights of the program include:

- Staff qualification and training
- Analytical procedure development, control, and compliance
- Laboratory records and sample handling protocols
- Analytical instrument calibration and maintenance
- Reagent purity and standardization
- Measurement control and data review
- Self-appraisals and corrective actions

Detailed quality control for the reliability of analytical data is provided in each General Laboratory analytical operating procedure. Typically, samples are analyzed in daily batches containing approximately 25 percent control samples. Control samples consist of various blanks, duplicates, standards, and spikes. This batching of samples and

reproducible, quality measurements. Traceable standards are prepared both within and independently of the laboratory. Reportability of data is judged by (1) the behavior of batch control samples, and (2) the responsible chemist and quality assurance officer.

The General Laboratory participates in a number of independent blind sample programs to control and assess analytical measurements. More than 125 blind samples are submitted monthly to the General Laboratory for the RFP Interactive Measurement Evaluation and Control System. This program provides immediate feedback on analyses as well as monthly reports and meetings to review analytical results. Performance samples from the EPA for the NPDES program are analyzed and evaluated annually. Environmental samples from the United States Geological Survey (USGS) are evaluated biannually. The laboratory participates in radiochemistry programs conducted by the EPA, Environmental Monitoring Systems Laboratory and the DOE EML. The General Laboratory also purchases (from an independent commercial laboratory) a suite of water samples for a quarterly program administered by the laboratory quality assurance officer.

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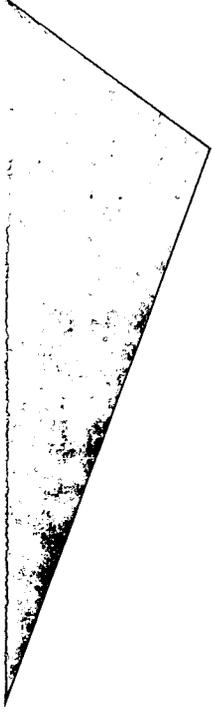
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7. USEFUL INFORMATION



ABBREVIATIONS

Units of Measure

Bq	Becquerel
Bq/l	Becquerel per liter
Bq/m ²	Becquerel per square meter
Bq/m ³	Becquerel per cubic meter
°C	Degree Celsius
Cl	Curie
Cl/g	Curie per gram
cm	Centimeter
cm ³	Cubic centimeter
d/m/y/μCi	Disintegration per minute per microcurie
d/m/pCi	Disintegration per minute per picocurie
d/m/f	Disintegration per minute per filter
d/m/l	Disintegration per minute per liter
dpm/g	Disintegration per minute per gram
dps	Disintegration per second
°F	Degree Fahrenheit
ft	Foot/feet
ft ²	Square Foot
ft ³ /min	Cubic foot per minute
fpm	Foot per minute
g	Gram
gal	Gallon
g/cm ²	Gram per square centimeter
g/day	Gram per day
gpm	Gallon per minute
ha	Hectare
hr	Hour
in.	Inch
kg	Kilogram
km	Kilometer
l	Liter
l/d	Liter per disintegration
l/s	Liter per second
lb	Pound
m	Meter
m ²	Square meter
m ³	Cubic meter
m ³ /s	Cubic meter per second
mg/cm ²	Milligram per square centimeter
mg/l	Milligram per liter

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USEFUL INFORMATION

mi	Mile
ml	Milliliter
ml/day	Milliliter per day
ml/s	Milliliter per second
mph	Mile per hour
mrem	Millirem
mrem/day	Millirem per day
mrem/yr	Millirem per year
m/s	Meter per second
m ³ /s	Cubic meter per second
mSv	Millisievert
mSv/yr	Millisievert per year
μCi	Microcurie
μCi/m ²	Microcurie per square meter
μCi/ml	Microcurie per milliliter
μg	Microgram
μg/f	Microgram per filter
μg/l	Microgram per liter
μg/m ³	Microgram per cubic meter
μg/ml	Microgram per milliliter
pCi	Picocurie
pCi/g	Picocurie per gram
pCi/l	Picocurie per liter
ppb	Part per billion
ppm	Part per million
pt	Pint
%	Percent
rem	Roentgen equivalent man
rem/yr	Roentgen equivalent man per year
s	second
SI	International Standard
Sv	Sievert
yd ³	Cubic yard
yr	year

Chemical Elements and Compounds

Am	Americium
Ba	Barium
Be	Beryllium
Ca	Calcium
CCl ₄	Carbon Tetrachloride
Cl	Chlorine
Cm	Curium
CO	Carbon Monoxide
Co	Cobalt
Cr	Chromium
Cs	Cesium
Fe	Iron
H-3	Hydrogen-3 (Also called "Tritium")
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Na	Sodium
NO ₂	Nitrogen Dioxide
NO ₃	Nitrate
O ₃	Ozone
Pb	Lead
PCB	Polychlorinated Biphenyls
PCE	Tetrachloroethene
Pu	Plutonium
Ru	Ruthenium
Se	Selenium
SO ₂	Sulfur Dioxide
SO ₄	Sulfate
Sr	Strontium
TCA	1,1,1 - Trichloroethane
TCE	Trichloroethene
Tm	Thulium
U	Uranium
Zn	Zinc

ACRONYMS AND INITIALISMS

AEC	Atomic Energy Commission
AIP	Agreement In Principle
AMAD	Activity Median Aerodynamic Diameter
ANSI	American National Standards Institute
APEN	Air Pollutant Emission Notice
AQCC	Air Quality Control Commission
ARAR	Applicable or Relevant and Appropriate Requirement
ASME	American Society of Mechanical Engineers
BAT	Best Available Technology
BOD ₅	Biochemical Oxygen Demand, 5-day incubation period
CAA	Clean Air Act
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS/FS	Corrective Measures Study/Feasibility Study
CWA	Clean Water Act
CWQCC	Colorado Water Quality Control Commission
DCG	Derived Concentration Guide
DMR	Discharge Monitoring Report
DOE	Department of Energy
DOE-HQ	Department of Energy Headquarters
DRCOG	Denver Regional Council of Governments
EA	Environmental Assessment
EDE	Effective Dose Equivalent
EIS	Environmental Impact Statement
EM	Environmental Management
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERDA	Energy Research and Development Administration
FD	Fire Department
FFCA	Federal Facilities Compliance Agreement
FONSI	Finding of No Significant Impact
FYP	Five-Year Plan
GI	Gastrointestinal
H&S	Health and Safety
HEPA	High Efficiency Particulate Air
HQ	Headquarters
IAG	Inter-Agency Agreement
ICP	Inductively Coupled Plasma
ICRP	International Commission on Radiological Protection
IM/IRA	Interim Measures/Interim Remedial Action

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LDR Land Disposal Restrictions
LEPC Local Emergency Planning Committee
LLW Low-level Waste
MAP Mitigation Action Plan
MDA Minimum Detectable Amount
MDL Minimum Detection Limit
MSDS Material Safety Data Sheet
NAAQS National Ambient Air Quality Standards
NCC NEPA Compliance Committee
NCRP National Council on Radiation Protection and Measurements
NEPA National Environmental Policy Act
NESHAP National Emission Standards for Hazardous Air Pollutants
NOI Notice of Intent
NOID Notice of Intent to Deny
NOV Notice of Violation
NPDES National Pollutant Discharge Elimination System
NQA1 Nuclear Quality Assurance
NRC Nuclear Regulatory Commission
ORNL Oak Ridge National Laboratory
OSHA Occupational Safety and Health Act
OU Operable Unit
PEIS Programmatic Environmental Impact Statement
PM-10 Particulate Matter less than 10 micrometers in diameter
PRMP EIS Plutonium Recovery Modification Project Environmental Impact Statement
QA Quality Assurance
QA/QC Quality Assurance/Quality Control
QAMS Quality Assurance Management Staff
QAPD Quality Assurance Program Description
QAPJP Quality Assurance Project Plan
QAR Quality Assurance Requirements
RCRA Resource Conservation and Recovery Act
RFI/RI RCRA Facility Investigations/Remedial Investigations
RFO Rocky Flats Office
RFP Rocky Flats Plant
RI/FS Remedial Investigation/Facilities Study
ROD Record of Decision
SAAM Selective Alpha Air Monitor
SARA Superfund Amendment and Reauthorization Act
SARF Supercompactor and Repackaging Facility
SERC State Emergency Response Commission
SI International Standard
SPCC/BMP Spill Prevention Control and Countermeasures/Best Management Practices
SSP Site-Specific Plan
STP Sewage Treatment Plant
SU Standard Units
SWMU Solid Waste Management Unit

TCLP Toxic Constituent Leaching Procedure
TDS Total Dissolved Solid
TLD Thermoluminescent Dosimeter
TRU Transuranic
TSCA Toxic Substances Control Act
TSP Total Suspended Particulates
USGS United States Geological Survey
VOC Volatile Organic Compound
WSRIC Waste Stream and Residue Identification and Characterization

GLOSSARY

activity. See radioactivity.

air pollutant. Any fume, smoke, particulate matter, vapor, gas, or combination thereof that is emitted into or otherwise enters the atmosphere, including, but not limited to, any physical, chemical, biological, radioactive (including source material, special nuclear material, and by-product materials) substance, or material, but does not include water vapor or steam condensate.

aliquot. Of, pertaining to, or designating an exact divisor or factor of a quantity, especially of an integer.

alpha particle. A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (2 protons, 2 neutrons).

atom. Smallest particle of an element capable of entering into a chemical reaction.

beta particle. A negatively charged particle emitted from the nucleus of an atom having a mass and charge equal to that of an electron.

concentration. The amount of a specified substance or amount of radioactivity in a given volume or mass.

contamination. The deposition of unwanted radioactive or hazardous material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation. Radiation of many types with very high energies, originating outside the earth's atmosphere. Cosmic radiation is one source contributing to natural background radiation.

curie (Ci). The traditional unit for measurement of radioactivity based on the rate of radioactive disintegration. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are in common usage:

millicurie (mCi). 10^{-3} Ci, one-thousandth of a curie; 3.7×10^7 disintegrations per second.

microcurie (μ Ci). 10^{-6} Ci, one-millionth of a curie; 3.7×10^4 disintegrations per second.

nanocurie (nCi). 10^{-9} Ci, one-billionth of a curie; 37 disintegrations per second.

picocurie (pCi). 10^{-12} Ci, one-trillionth of a curie; 3.7×10^{-2} disintegrations per second.

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femtocurie (fCi). 10^{-15} Ci, one-quadrillionth of a curie; 3.7×10^{-5} disintegrations per second.

attocurie (aCi). 10^{-18} Ci, one-quintillionth of a curie; 3.7×10^{-8} disintegrations per second.

decay, radioactive. The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

Derived Concentration Guide (DCG). Secondary radioactivity in air and water concentration guides used for comparison to measured radioactivity concentrations. Calculation of DCG assumes that the exposed individual inhales 8,400 cubic meters of air per year or ingests 730 liters of water per year at the specified radioactivity DCG with a resulting radiation dose of 0.1 rem (100 mrem) effective dose equivalent.

disintegration, nuclear. A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dose, absorbed. The amount of energy deposited by radiation in a given mass of material. The unit of absorbed dose is the rad or the gray (1 gray = 100 rad).

dose commitment. The total radiation dose projected to be received from an exposure to radiation or intake of radioactive material throughout the specified remaining lifetime of an individual. In theoretical calculations, this specified lifetime is usually assumed to be 50 yrs.

dose equivalent. A modification to absorbed dose that expresses the biological effects of all types of radiation (e.g., alpha, beta, gamma) on a common scale. The unit of dose equivalent is the rem or the sievert (1 sievert = 100 rem).

ephemeral. Lasting for a brief period of time; short-lived, transitory.

exposure. A measure of the ionization produced in air by X-ray or gamma + radiation. The special unit of exposure is the roentgen (R).

friable. Readily crumbled; brittle.

gamma ray. High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an atom. Gamma radiation frequently accompanies the emission of alpha or beta particles. Gamma rays are identical to X-rays except for the source of the emission.

half-life, radioactive. The time required for a given amount of a radionuclide to lose half of its activity by radioactive decay. Each radionuclide has a unique half-life.

isotopes. Forms of an element having the same number of protons in their nuclei and differing in the number of neutrons.

minimum detectable concentration (MDC). The smallest amount or concentration of a radioelement that can be distinguished in a sample by a given measurement system in a preselected counting time at a given confidence level.

natural radiation. Radiation arising from cosmic sources and from naturally occurring radionuclides (such as radon) present in the human environment.

outfall. The place where a storm sewer or effluent line discharges to the environment.

part per billion (ppb). Concentration unit approximately equivalent to micrograms per liter.

part per million (ppm). Concentration unit approximately equivalent to milligrams per liter.

pathway. Potential route for exposure to radioactive or hazardous materials.

person-rem. The traditional unit of collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

quality factor. The factor by which the absorbed dose (in rad or gray) is multiplied to obtain the dose equivalent (in rem or sievert). The dose equivalent is a unit that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. It is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad. A traditional unit of absorbed dose. The International System of Units (SI) unit of absorbed dose is the gray (1 gray = 100 rads).

radioactivity. The spontaneous emission of radiation, generally alpha or beta particles, often accompanied by gamma rays, from the unstable nucleus of an atom.

radionuclide. An atom having an unstable ratio of neutrons to protons so that it will tend toward stability by undergoing radioactive decay. A radioactive nuclide.

rem. The traditional unit of dose equivalent. Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem. The International System of Units (SI) unit of dose equivalent is the sievert (1 sievert = 100 rem).

roentgen (R). The traditional unit of exposure to X-ray or gamma radiation based on the ionization in air caused by the radiation. One roentgen is equal to 2.58×10^{-4} coulombs per kilogram of air. A common expression of radiation exposure is the milliRoentgen (1R = 1000 mR).

sievert (Sv). International System of Units (SI) unit for radiation dose (1 Sv = 100 rem).

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thermoluminescent dosimeter (TLD). A device used to measure external sources (i.e., outside the body) of penetrating radiation such as X-rays or gamma rays.

uncontrolled area. Any area to which access is not controlled for the purpose of protecting individuals from exposure to radiation and radioactive materials. The area beyond the boundary of the RFP is an uncontrolled area.

worldwide fallout. Radioactive debris from atmospheric weapons testing that is either airborne and cycling around the earth or has been deposited on the earth's surface.

APPENDIX A



PERSPECTIVE ON RADIATION

INTRODUCTION

Activities at the RFP involve handling radioactive materials and operating radiation-producing equipment. Environmental monitoring programs include monitoring for potential exposures to the public from RFP-related radiation sources. This section provides the basic concepts of radiation to assist in the understanding and interpretation of monitoring information and radiation dose assessment.

Further discussion on sources of ionizing radiation can be found in Report No. 93 of the National Council on Radiation Protection and Measurements, *Ionizing Radiation Exposure of the Population of the United States* (NAR7b), from which much of the information in this section was derived.

IONIZING RADIATION

Many kinds of radiation exist in our environment. Visible light and heat radiating from a warm object are examples. Radiation from radioactive materials and radiation-producing equipment is called ionizing radiation. Ionizing radiation has sufficient energy to separate electrons from atoms of material. This separation is called ionization. When ionizing radiation is absorbed in living tissues, it can cause damage from the ionization process. Consequently, protective measures may be required to minimize the amount of ionizing radiation to which a person might be exposed.

Types of Radiation

Common types of ionizing radiation include alpha, beta, gamma, X-ray, and neutron radiation. While all types can produce ionization, they have other, differing properties, including their ability to penetrate or pass through materials. Alpha radiation penetrates poorly; a piece of paper or outer skin tissue can stop it. Beta radiation has low to moderate penetrating ability. Gamma, X-ray, and neutron radiation usually have much greater penetrating ability. Radiation produced by medical X-ray machines, for example, is able to pass through a human body.

Production of Radiation

Ionizing radiation is produced by radioactive materials and radiation-producing equipment. Radiation-producing equipment includes X-ray machines and linear accelerators. Electrical power must be applied to this equipment to produce radiation. In contrast, radioactive materials will continue to emit ionizing radiation until they have undergone radioactive decay to nonradioactive, stable states. The time

required for a material to reach this stable state is dependent on a material's radioactive half-life. Half-life is the amount of time required for one-half of the atoms of a radioactive material to experience radioactive decay. Half-life is unique and unchanging for each specific radionuclide. Half-lives for different radionuclides may vary from seconds to billions of years.

Radiation Dose

The biological effect of ionizing radiation is called radiation dose. The radiation can be from a penetrating radiation source located outside of the body (external radiation) or from radioactive materials taken into the body (internal radiation). In the United States, radiation dose is measured in the unit called the rem or millirem (1 rem = 1,000 millirem). The comparable International Standard (SI) unit of radiation dose is the sievert (1 Sv = 100 rem). A rem is a unit of biological dose that expresses biological damage on a common scale. The effective dose equivalent (EDE) is a means of calculating radiation dose. EDE takes into account the total health risk estimated for cancer mortality and serious genetic defects from radiation exposure regardless of which body tissues receive the dose or the sources or types of ionizing radiation producing the dose.

SOURCES OF RADIATION

All living things are exposed to naturally occurring ionizing radiation. However, since the discovery of radiation and radioactive materials at the beginning of this century, we can significantly increase the amount of radiation we are exposed to through use of artificially produced or enhanced sources of radiation.

Natural Sources

Naturally occurring sources are the greatest contributor to radiation exposures for the people living in the United States. Sources of natural background radiation include cosmic radiation from space and secondary radioactive materials (cosmogenic nuclides) created when cosmic radiation enters our atmosphere. Another source is naturally occurring radioactive materials originating from the earth's crust, referred to as primordial nuclides. These materials may contribute to radiation exposure when located outside the body or when taken into the body through inhalation or ingestion. Radon, for example, a radioactive gas derived from uranium, is an important contributor to internal radiation exposure as a result of inhalation inside buildings.

Different living situations can result in more or less exposure to naturally occurring ionizing radiation. Cosmic radiation exposure can increase as altitude increases because less atmosphere exists to shield against the radiation. Some geographical areas have higher concentrations of primordial nuclides such as uranium and thorium. Because the Denver area is located at a relatively high altitude and also has higher concentrations of uranium and thorium in rocks and soil, naturally occurring radiation levels are higher than those in many other regions in the country.

Annual, naturally occurring EDE to a typical resident of the Denver metropolitan area is given in Section 4.0. The total for this area, based on current published reports, is about 350 mrem/yr. This estimate may increase as the Denver regional difference in indoor radon concentration is determined. By comparison, the estimated total average EDE for a member of the United States population from natural sources is about 300 mrem/yr.

Medical Sources

Ionizing radiation is used in medicine for diagnosis and treatment of many medical conditions. This radiation can be produced by equipment such as X-ray machines or linear accelerators, or it can originate from radioactive materials incorporated into pharmaceuticals. Medical diagnosis and treatment account for the largest radiation doses to the United States public from artificially produced sources of radiation. The average EDE to a member of the United States population from medical sources is about 50 mrem/yr. However, individual doses from this source vary widely, with some people receiving little or none and others receiving much more than the average in any particular year.

Consumer Products Sources

Some consumer products, including tobacco, smoke detectors, and television sets, have ionizing radiation associated with them. Consumer products are the second largest contributor to radiation dose to the United States population from artificially produced or enhanced sources. The radiation may or may not be intentional and necessary for the functioning of the product. Ionization smoke detectors and X-ray baggage inspection systems at airports require ionizing radiation to perform their functions. Tobacco products, fuels such as coal, and television receivers have radiation associated with them even though it is not necessary for their use.

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Other Sources

Naturally occurring, medical, and consumer product sources contribute over 99 percent of the average radiation dose that a person living in the United States receives each year (Figure A-1). Other sources include occupational exposures, residual fallout from past atmospheric weapons testing, the nuclear fuel cycle, and miscellaneous sources. Combined, these other sources contribute less than 1 percent of the average radiation dose to a person living in the United States.

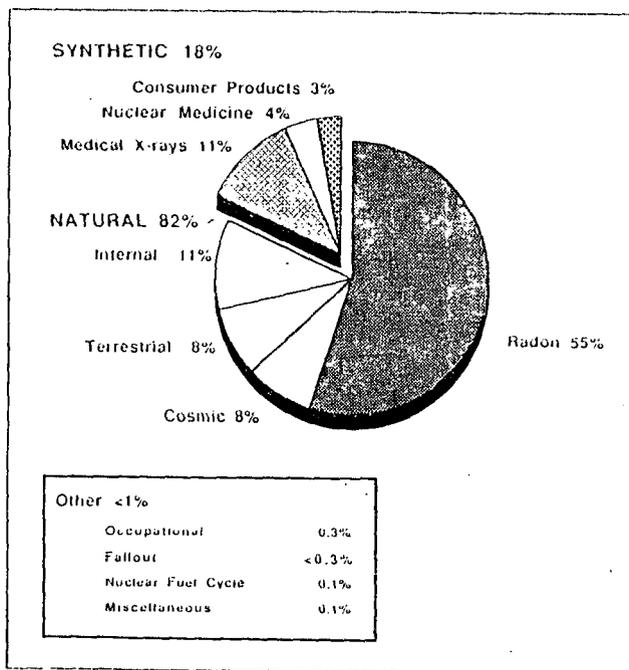


Figure A-1. Contribution of Various Sources to the Total Average Radiation Dose to the United States Population

APPENDIX B



APPLICABLE GUIDES AND STANDARDS

RFP environmental monitoring programs evaluate plant compliance with applicable guides, limits, and standards. Guide values and standards for radionuclides in ambient air and waterborne effluents have been adopted by the Department of Energy (DOE), the Colorado Department of Health (CDH), the Colorado Water Quality Control Commission (CWQCC) (water only), and by the Environmental Protection Agency (EPA) (for the air pathway only) (CDH78, EPA85). Many of these guides are based on recommendations published by the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).

AIR STANDARDS

Effluent Air

Air effluent limits are established under the Clean Air Act NESHAPs. Limits for radiation dose from radioactivity emissions are promulgated by EPA and are listed in Table B-1 (see "Air Pathway Only"). Nonradioactive (but otherwise hazardous) materials emissions are regulated by the State of Colorado under Colorado Air Quality Control Regulation #8. Regarding hazardous air pollutants at RFP, this regulation sets a limit for beryllium of 10 g per stationary source in a 24-hr period.

Ambient Air

Ambient air data for nonradioactive particulates have been collected historically at RFP for comparison to criteria pollutants listed under the EPA NAAQs established by the Clean Air Act (EPA81) (Table B-2). Instrumentation and methodology follow requirements established by the EPA in the *Quality Assurance Handbook for Air Pollution Measurement Systems* (EPA76b).

Ambient air data for radioactive particulates are compared with Derived Concentration Guides (DCGs) given in Table B-3. A further explanation of DCG is given in the Radiological Dose Standards section.

WATER STANDARDS

The DCGs for surface water effluents are given in Table B-3. A further explanation of DCG standards is given in the Radiological Dose Standards section.

Table B-1

DOE Radiation Protection Standards for the Public

ICRP-RECOMMENDED STANDARDS FOR ALL PATHWAYS:

Temporary Increase	500 mrem/year Effective Dose Equivalent (with prior approval of DOE EH-2)
Normal Operations	100 mrem/year Effective Dose Equivalent

EPA CLEAN AIR ACT NESHAP STANDARDS FOR THE AIR PATHWAY ONLY:

10 mrem/year Effective Dose Equivalent

Table B-2

National Ambient Air Quality Standards (NAAQS) for Particulates

NAAQS Averaging Time	Concentration
PM-10: Annual Arithmetic Mean 24-hr Average ^a	50 µg/m ³ 150 µg/m ³
TSP ^b : Annual Geometric Mean 24-hour Average	60 µg/m ³ 260 µg/m ³

- a. Not to be exceeded more than once per year.
b. TSP no longer used for determining compliance with NAAQS. Sampling and reporting continues for comparison purposes and general interest.

Table B-3

DOE Derived Concentration Guides for Radionuclides of Interest at RFP

Air Inhalation:

Radionuclide	DCG (µCi/ml)
Plutonium-239, -240	20 x 10 ⁻¹⁵

Water Ingestion:

Radionuclide	DCG (µCi/ml)
Plutonium-239, -240	30 x 10 ⁻⁹
Americium-241	30 x 10 ⁻⁹
Uranium-233, -234	500 x 10 ⁻⁹
Uranium-238	600 x 10 ⁻⁹
Hydrogen-3 (Tritium)	2,000,000 x 10 ⁻⁹

Surface Water Effluent

National Pollution Discharge Elimination System (NPDES). The NPDES permit sets limits for nonradioactive pollutants in effluent water from federal facilities (Table B-4). The RFP NPDES permit, which the EPA reissued to DOE in 1984 and administratively extended in 1989, establishes effluent limitations for seven discharge points from which Ponds A-3, A-4, B-5, and C-2 discharge into drainages leading off of RFP property.

Colorado Water Quality Control Commission Water Quality Standards. Resegmentation of Big Dry Creek and revised use classifications and water quality standards for Woman Creek and Walnut Creek tributaries to Standley Lake and Great Western Reservoir became effective on March 30, 1990. This action by the CWQCC established goal stream standards for Segment 5 of Big Dry Creek (tributaries from source to ponds A-4, B-5, and C-2) and final stream standards for Segment 4 of Big Dry Creek (from

Table B-4

NPDES Discharge Limitations for the RFP^a

Parameter	Monthly Average	Weekly Average	Daily Maximum
<i>Effluent Water Samples (Nonradioactive)</i>			
pH		6.0-9.0 SU	
Nitrates as N	10 mg/l	20 mg/l	NA
Total Phosphorus	8 mg/l	NA	12 mg/l
Biochemical Oxygen Demand, 5-Day	10 mg/l	NA	25 mg/l
Suspended Solids	30 mg/l	45 mg/l	NA
Total Chromium	0.05 mg/l	NA	0.1 mg/l
Residual Chlorine	NA	NA	0.5 mg/l
Oil and Grease	NA	NA	Visual
Fecal Coliform - No./100 ml	200	400	NA

- a. These limitations are presented as indicators of the types of parameters and associated concentration limits required by the NPDES permit. Details of these requirements specific to each discharge location are given in the referenced document (EPA84). The daily and monthly limitations indicated cannot be correlated with the annual water quality data summarized in the text.

pond outlets to Standley Lake and Great Western Reservoir). Limits were set for organic and inorganic chemicals, metals radionuclides, and certain physical and biological parameters (Tables B-5 through B-7).

Goal standards differ from final stream standards in that the term "goal" is a qualifier indicating that sufficient data did not exist at the time of the CWQCC hearing to establish Segment 5 standards. Therefore, a temporary modification based on existing ambient quality was established until data for Segment 5 can be collected. Goal is used to indicate that a temporary modification for one or more of the underlying numeric standards has been granted. The CWQCC allowed 3 years for the collection of data; this 3-year period will conclude in February 1993. On the basis of this data, the CWQCC will establish new standards for Segment 5, which may or may not be the same as Segment 4 standards. Goal standards will be reviewed against the classified stream use designated in 1990.

Drinking Water

In 1976, the EPA promulgated regulations for radionuclides in drinking water (EPA76a). These regulations were effective on June 24, 1977, along with primary drinking water regulations for microbiological, chemical, and physical contaminants. The intent of the Safe Drinking Water Act was to ensure that each state has primary responsibility for maintaining drinking water quality. To comply with these requirements, the CDH modified existing state drinking water standards to include radionuclides (CDH77, CDH81). Two of the community drinking water standards are of interest in this report. The state standard for gross alpha activity (including radium-226 but excluding radon and uranium) in community water systems is a maximum of 15 pCi/l or $15 \times 10^{-9} \mu\text{Ci/ml}$ ($5.6 \times 10^{-1} \text{ Bq/l}$). Americium and plutonium, which are alpha-emitting radionuclides, are included in this limit. The limit for tritium in drinking water is 20,000 pCi/l or $20,000 \times 10^{-9} \mu\text{Ci/ml}$ (740 Bq/l).

SOILS STANDARDS

The standard for plutonium adopted by CDH in 1973 is 2.0 disintegrations per minute per gram (dpm/g) (0.9 pCi/g) for a soil density of 1 gram per square centimeter (g/cm^2) for soils sampled to a depth of 0.318 cm (1/8 in.) (CDH73).

Table B-5
Colorado Water Quality Control Commission (CWQCC)
Water Quality Stream Standards
Effective Date - March 30, 1990

Goal Standards, Segment 5 of Big Dry Creek

Chemical Classification	Parameter	CWCC Standards (mg/l)
Physical and Biological	Dissolved Oxygen	5.0
	pH	6.5 - 9.0
	Fecal Coliforms	2000/100
	Ammonia (Acute) (Chronic)	0.62/F ₁ /FPH/2 0.06
Inorganic	Chlorine	.003
	Cyanide	.005
	Sulfate as Hydrogen Sulfide	.002
	Nitrite	1.0
	Nitrate	10.0
	Chloride	250.0
	Sulfate	250.0
Metals	Boron	.75
	Arsenic	.05
	Cadmium	TVS ^a
	Chromium III	.05
	Chromium VI	TVS
	Copper	TVS
	Iron (Dissolved)	.3
	Iron (Total Recovery)	1.0
	Lead	TVS
	Manganese (Dissolved)	.05
	Manganese (Total Recovery)	1.00
	Mercury	.01
	Nickel	TVS
	Selenium	.01
Silver	TVS	
Zinc	TVS	

a. Table Value Standard

Table B-6

CWQCC Water Quality Stream Standards - Organic Chemical Standards* (µg/l)

Parameter	EPA Method	Chronic Standard	Gas Chromatography (GC) Detection Levels
Acrylonitrile	625	0.058	15*
Aldrin	508	0.000074	0.1
Atrazine	608 (b)/507 (c)	3.0	1.0
Benzidine	625	0.00012	10*
Chlordane	508	0.00046	0.1
Chloroform	502.2	0.19	1.0
Chloroethyl Ether BIS	625	0.0000037	10*
DDT	508	0.000024	0.1
Dichlorobenzidine	625	0.01	10*
Dieldrin	508	0.000071	0.1
Dioxin (2, 3, 7, 8-TCDF)	613	0.00000013	0.01
Halomethanes	502.2	0.19	1.0
Heptachlor	508	0.00028	0.1
Hexachloroethane	525	1.9	1.0
Hexachlorobenzene	525	0.00072	1.0
Hexachlorobutadiene	525	0.45	1.0
Hexachlorocyclohexane, Alpha	505	0.0092	0.1
Hexachlorocyclohexane, Beta	505	0.0163	0.1
Hexachlorocyclohexane, Gamma (Lindane)	505	0.0186	0.1
Hexachlorocyclohexane, Technical	505/608	0.0123	0.5
Nitrosodibutylamine N	607	0.0064	5
Nitrosodiethylamine N	607	0.0008	5
Nitrosodimethylamine N	607	0.0014	5
Nitrosodiphenylamine N	607	4.9	10
Nitrosopyrrolidine N	625	0.016	10*
PCBs	508	0.000079	1.0
Polynuclear Aromatic Hydrocarbons	610	0.0028	1.0
Simazine	608 (b)/507 (c)	4.0	1.0
Tetrachloroethane 1, 1, 2, 2	502.2	0.17	1.0
Tetrachloroethane	502.2	0.8	1.0
Trichloroethane 1, 1, 2	502.2	0.6	1.0
Trichlorophenol 2, 4, 6	502.2	1.2	1.0

- a. In the absence of specific, numeric standards for non-naturally occurring organics, the narrative standard "no toxics in toxic amounts" (Section 3.2.22 [1] [d]) shall be interpreted as zero with enforcement based on the practical quantification levels (POLs) for those compounds as defined by the Water Quality Control Division or the U.S. Environmental Protection Agency.
- b. Extraction Method.
- c. Analytical Method.
- * Gas Chromatography/Mass Spectrometry Method.

Table B-7
CWQCC Water Quality Stream Standards - Radionuclides*

The radionuclides listed below shall be maintained at the lowest practical level and in no case shall they be increased by any cause attributable to municipal, industrial, or agricultural practices to exceed the site-specific numeric standards.

A. Ambient based site-specific standards:

	Segment 2 Standley Lake	Segment 3 Great Western Reservoir	Segment 4 Segment 5 Woman Creek	Segment 4 Segment 5 Walnut Creek
Gross Alpha	6	5	7	11
Gross Beta	9	12	5	19
Plutonium	.03	.03	.05	.05
Americium	.03	.03	.05	.05
Tritium	500	500	500	500
Uranium	3	4	5	10

B. Other site-specific standards applicable to segments 2, 3, 4 and 5:

Curium	244	60
Neptunium	237	30

a. Statewide standards also apply for radionuclides not listed above. Values listed are in pCi/l.

The EPA has not established a standard for plutonium concentration but has proposed a screening level of 44.4 dpm/g (19.98 pCi/g) for a soil density of 1 g/cm³ for soils sampled to a depth of 1 cm (0.394 in.) (EPA77).

RADIOLOGICAL DOSE
STANDARDS

On February 8, 1990, DOE adopted DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, a radiation protection standard for DOE environmental activities (DOE90a). This standard incorporates guidance from the ICRP, as well as from the EPA Clean Air Act (CAA) NESHAP standards (as implemented in 40 CFR 61, Subpart H). Included in DOE Order 5400.5 is a revision of the dose limits for members of the public. Tables of radiation dose conversion factors currently used for calculating dose from intakes of radioactive materials were issued in July 1988 (DOE88a, DOE88b). The dose factors are based

**DOE Derived
Concentration Guides**

on the ICRP Publications 30 and 48 methodology and biological models for radiation dosimetry. The DOE Order 5400.5 and the dose conversion factor tables are used for assessment of any potential RFP contribution to public radiation dose. On December 15, 1989, EPA published revised CAA NESHAP standards for DOE facilities (EPA89). DOE radiation standards for protection of the public are given in this Appendix and include the December 15, 1989, EPA CAA air pathway standards.

Secondary radioactivity concentration guides can be calculated from the primary radiation dose standards and used as comparison values for measured radioactivity concentrations. DOE provides tables of these DCGs in DOE Order 5400.5. DCGs are the concentrations that would result in an EDE of 100 mrem from 1 year's chronic exposure or intake. In calculating air inhalation DCGs, DOE assumes that the exposed individual inhales 8,400 cubic meters of air at the calculated DCG during the year. Ingestion DCGs assume a water intake of 730 liters at the calculated DCG for the year. Table B-3 on page 180 lists the most restrictive air and water DCGs for the principal radionuclides of interest at the RFP.

Plutonium Concentrations. Plutonium concentrations at RFP represent the alpha radioactivity from plutonium-239 and -240. These constitute over 97 percent of the alpha radioactivity in plutonium used at the plant.

Uranium Concentrations. Uranium concentrations are the cumulative alpha activity from uranium-233, -234, and -238. Components containing fully enriched uranium are used at the RFP. Depleted uranium metal is fabricated and also is used as a process waste material. Uranium-235 is the major isotope by weight (93 percent) in fully enriched uranium; however, uranium-234 accounts for approximately 97 percent of the alpha activity of fully enriched uranium. In depleted uranium, the combined alpha activity from uranium-234 and -238 accounts for approximately 99 percent of the total alpha activity. Uranium DCGs used in this report for air and water are those for uranium-233, -234, and -238, which are the most restrictive.

Environmental uranium concentrations can be measured by various laboratory techniques. Nonradiological techniques yield concentration units of mass per unit volume such as milligram per cubic meter and milligram per liter. Uranium

concentrations given in this report were derived by measuring radioactivity from alpha-emitting uranium isotopes and are expressed in terms of activity units per unit volume. RFP data include measurements of depleted uranium, fully enriched uranium, and natural uranium.

Conversion factors for specific types of uranium can be used to compare the data in this report to data from other facilities and agencies that are given in units of mass per unit volume; however, the resulting approximations will not have the same assurance of accuracy as that of the original measured values. Uranium in effluent air from plant buildings is primarily depleted uranium. The conversion factor for these data is 2.6×10^6 g/Ci. Natural uranium is the predominant species found in water. The conversion factor for water data is 1.5×10^6 g/Ci.

APPENDIX C



WIND STABILITY CLASSES

Table C-1
Wind Frequency Distribution by Percent in 1990, Stability Class A^{a,b,c,d}

Wind	Wind Speed Classes (Knots)						Class ^e	Total ^f
	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0		
N	5.2	2.1	.0	.0	.0	.0	7.34	.18
NNE	7.3	3.7	.0	.0	.0	.0	11.01	.27
NE	8.7	3.8	.0	.0	.0	.0	12.54	.31
ENE	7.0	3.8	.0	.0	.0	.0	10.86	.26
E	14.2	5.8	.0	.0	.0	.0	20.03	.49
ESE	7.6	3.3	.0	.0	.0	.0	11.01	.27
SE	7.4	2.1	.0	.0	.0	.0	9.48	.23
SSE	3.7	.6	.0	.0	.0	.0	4.28	.10
S	2.9	.6	.0	.0	.0	.0	3.52	.09
SSW	1.7	.0	.0	.0	.0	.0	1.68	.04
SW	.4	.4	.0	.0	.0	.0	.76	.02
WSW	.9	.0	.0	.0	.0	.0	.92	.02
W	.6	.1	.0	.0	.0	.0	.76	.02
WNW	.9	.1	.0	.0	.0	.0	1.07	.03
NW	1.6	.4	.0	.0	.0	.0	1.99	.05
NNW	2.3	.5	.0	.0	.0	.0	2.75	.07
All	72.5	27.5	.0	.0	.0	.0	100.00	2.44

- a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
- b. The percentage of calm occurrences from this stability class was = 24.1 percent. Calms are speeds ≤ 0.9 m/s (1.75 knots).
- c. Total number of invalid and valid observations in this stability class were 1 and 811, respectively.
- d. Calms are distributed as per NCDC Star Deck procedures.
- e. Total percent for this stability class.
- f. Total percent relative to all stability classes.

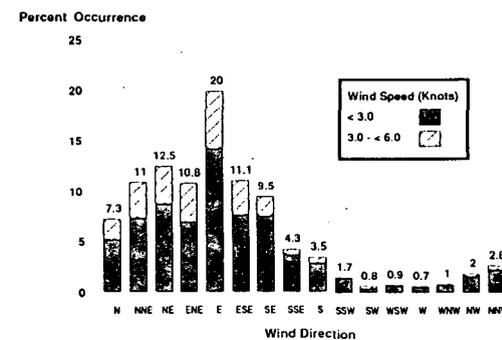


Figure C-1 Stability Class A

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Table C-2

Wind Frequency Distribution by Percent in 1990, Stability Class B^{a,b,c,d}

Wind	Wind Speed Classes (Knots)						Class ^a	Total ^f
	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0		
N	1.5	3.9	2	.0	.0	.0	5.62	.07
NNE	2.8	5.7	.5	.0	.0	.0	8.89	.12
NE	3.2	12.0	.0	.0	.0	.0	15.24	.20
ENE	3.8	9.3	.0	.0	.0	.0	13.13	.17
E	4.0	15.9	.0	.0	.0	.0	19.92	.26
ESE	4.3	10.9	2	.0	.0	.0	15.46	.20
SE	2.9	3.6	2	.0	.0	.0	6.79	.09
SSE	.5	2.3	.0	.0	.0	.0	2.71	.04
S	1.7	.7	2	.0	.0	.0	2.57	.03
SSW	1.0	1.1	.0	.0	.0	.0	2.11	.03
SW	.5	2	2	.0	.0	.0	.93	.01
WSW	.7	.0	.0	.0	.0	.0	.70	.01
W	.7	.0	2	.0	.0	.0	.93	.01
WNW	.7	2	.5	.0	.0	.0	1.39	.02
NW	.5	.7	.0	.0	.0	.0	1.17	.02
NNW	.7	1.1	.5	.0	.0	.0	2.33	.03
All	29.6	67.6	2.7	.0	.0	.0	100.00	1.32

- a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
- b. The percentage of calm occurrences from this stability class was = 3.2 percent. Calms are speeds ≤ 0.9 m/s (1.75 knots).
- c. Total number of invalid and valid observations in this stability class were 0 and 441, respectively.
- d. Calms are distributed as per NCDC Star Deck procedures.
- e. Total percent for this stability class.
- f. Total percent relative to all stability classes.

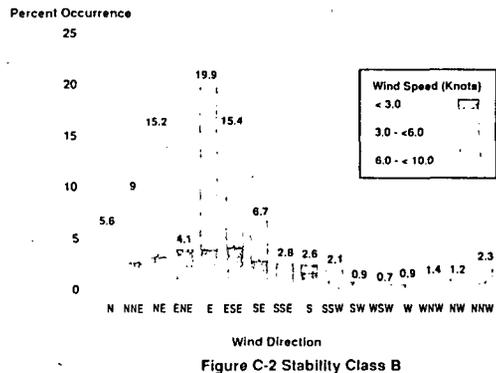


Figure C-2 Stability Class B

Table C-3

Wind Frequency Distribution by Percent in 1990, Stability Class C^{a,b,c,d}

Wind	Wind Speed Classes (Knots)						Class ^a	Total ^f
	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0		
N	.8	4.0	.6	.0	.0	.0	5.43	.19
NNE	1.6	9.0	.7	.0	.0	.0	11.32	.39
NE	1.4	10.4	.7	.0	.0	.0	12.48	.43
ENE	2.1	9.1	.3	.0	.0	.0	11.51	.40
E	2.1	13.3	.3	.0	.0	.0	15.70	.54
ESE	1.7	10.3	.4	.1	.0	.0	12.57	.43
SE	2.1	8.7	.4	.1	.0	.0	11.32	.39
SSE	1.2	3.0	.2	.0	.0	.0	4.28	.15
S	.6	2.1	.2	.0	.0	.0	2.85	.10
SSW	.6	.9	.3	.0	.0	.0	1.78	.06
SW	.1	.6	.3	.0	.0	.0	.97	.03
WSW	.4	.3	.3	.0	.0	.0	.89	.03
W	.2	.6	.3	.0	.0	.0	1.15	.04
WNW	.6	.5	.1	.1	.0	.0	1.25	.04
NW	.9	1.7	.7	.0	.0	.0	3.28	.11
NNW	.9	2.0	.3	.0	.0	.0	3.20	.11
All	17.2	76.4	6.1	.3	.0	.0	100.00	3.46

- a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
- b. The percentage of calm occurrences from this stability class was = 2.6 percent. Calms are speeds ≤ 0.9 m/s (1.75 knots).
- c. Total number of invalid and valid observations in this stability class were 0 and 1151, respectively.
- d. Calms are distributed as per NCDC Star Deck procedures.
- e. Total percent for this stability class.
- f. Total percent relative to all stability classes.

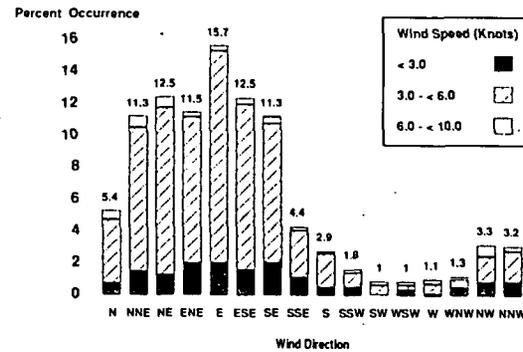


Figure C-3 Stability Class C

Table C-4

Wind Frequency Distribution by Percent in 1990, Stability Class D^{a,b,c,d}

Wind	Wind Speed Classes (Knots)						Class ^e	Total ^f
	<3.0	3.0-<6.0	6.0-<10.0	10.0-<16.0	16.0-<21.0	>21.0		
N	.7	2.1	3.1	2.7	.4	.3	9.32	4.65
NNE	.8	2.3	2.6	1.4	.1	.0	7.15	3.57
NE	.7	1.9	1.5	.4	.0	.0	4.54	2.27
ENE	.6	1.2	.8	.1	.0	.0	2.75	1.37
E	.6	1.6	.7	.0	.0	.0	2.94	1.47
ESE	.5	1.8	1.9	.1	.0	.0	4.28	2.14
SE	.5	2.5	3.6	.8	.0	.0	7.44	3.71
SSE	.6	2.0	2.5	.8	.1	.0	6.15	3.07
S	.5	1.3	1.1	1.0	.1	.0	4.08	2.04
SSW	.4	.9	.7	.8	.1	.0	2.85	1.42
SW	.4	.6	.7	1.1	.2	.0	2.94	1.47
WSW	.3	.6	.6	2.6	.7	.4	5.15	2.57
W	.6	.5	.8	3.2	1.9	2.7	9.72	4.86
WNW	.5	.7	1.2	5.9	3.5	3.6	15.27	7.63
NW	.6	1.0	1.6	4.3	1.2	.4	9.09	4.54
NNW	.5	1.2	2.1	2.2	.3	.0	6.33	3.16
All	8.9	22.2	25.3	27.6	8.5	7.5	100.00	49.94

- a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
- b. The percentage of calm occurrences from this stability class was = 3.0 percent. Calms are speeds ≤ 0.9 m/s (1.75 knots).
- c. Total number of invalid and valid observations in this stability class were 18 and 16,619, respectively.
- d. Calms are distributed as per NCDC Star Deck procedures.
- e. Total percent for this stability class.
- f. Total percent relative to all stability classes.

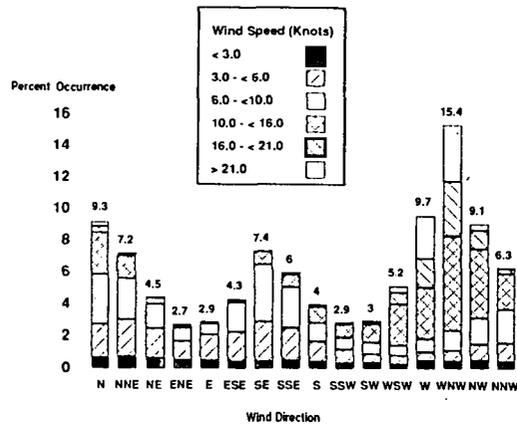


Figure C-4 Stability Class D

Table C-5
Wind Frequency Distribution by Percent In 1990, Stability Class E^{a,b,c,d}

Wind	Wind Speed Classes (Knots)						Class ^e	Total ^f
	<3.0	3.0-6.0	6.0-10.0	10.0-16.0	16.0-21.0	>21.0		
N	.8	2.2	3.2	.0	.0	.0	6.17	1.85
NNE	.8	2.2	2.4	.0	.0	.0	5.42	1.62
NE	.7	1.9	1.2	.0	.0	.0	3.74	1.12
ENE	.7	1.2	.4	.0	.0	.0	2.33	.70
E	.7	.8	.3	.0	.0	.0	1.79	.54
ESE	.3	1.0	.8	.0	.0	.0	2.10	.63
SE	.5	1.5	1.4	.0	.0	.0	3.49	1.05
SSE	.7	1.4	1.9	.0	.0	.0	3.90	1.17
S	.9	1.8	4.4	.0	.0	.0	7.04	2.11
SSW	.8	1.7	4.5	.0	.0	.0	7.02	2.11
SW	.7	1.6	7.1	.0	.0	.0	9.47	2.84
WSW	.9	1.7	8.4	.0	.0	.0	11.09	3.32
W	.9	2.4	5.2	.0	.0	.0	8.45	2.53
WNW	1.1	2.4	5.5	.0	.0	.0	8.93	2.68
NW	1.1	2.6	6.8	.0	.0	.0	10.45	3.13
NNW	1.1	2.4	5.1	.0	.0	.0	8.64	2.59
All	12.8	28.8	58.4	.0	.0	.0	100.00	29.99

- a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
- b. The percentage of calm occurrences from this stability class was = 2.6 percent. Calms are speeds ≤ 0.9 m/s (1.75 knots).
- c. Total number of invalid and valid observations in this stability class were 7 and 9,978, respectively.
- d. Calms are distributed as per NCDC Star Deck procedures.
- e. Total percent for this stability class.
- f. Total percent relative to all stability classes.

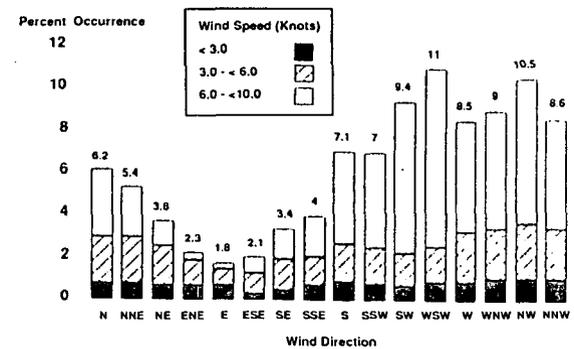


Figure C-5 Stability Class E

Table C-6
Wind Frequency Distribution by Percent in 1990, Stability Class F^{a,b,c,d}

Wind	Wind Speed Classes (Knots)						Class ^e	Total ^f
	<3.0	3.0-6.0	6.0-10.0	10.0-16.0	16.0-21.0	>21.0		
N	.7	3.6	.0	.0	.0	.0	4.33	.54
NNE	.4	1.8	.0	.0	.0	.0	2.25	.28
NE	.2	.8	.0	.0	.0	.0	1.06	.13
ENE	.2	.6	.0	.0	.0	.0	.79	.10
E	.2	.6	.0	.0	.0	.0	.82	.10
ESE	.1	.6	.0	.0	.0	.0	.77	.09
SE	.3	2.0	.0	.0	.0	.0	2.30	.29
SSE	1.1	4.3	.0	.0	.0	.0	5.36	.67
S	1.4	7.0	.0	.0	.0	.0	8.43	1.05
SSW	1.5	7.8	.0	.0	.0	.0	9.30	1.16
SW	1.6	7.9	.0	.0	.0	.0	9.49	1.19
WSW	1.9	10.3	.0	.0	.0	.0	12.16	1.52
W	2.0	13.1	.0	.0	.0	.0	15.08	1.89
WNW	1.8	11.3	.0	.0	.0	.0	13.08	1.63
NW	1.4	7.9	.0	.0	.0	.0	9.34	1.17
NNW	.7	4.8	.0	.0	.0	.0	5.44	.68
All	15.5	84.5	.0	.0	.0	.0	100.00	12.50

- a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
- b. The percentage of calm occurrences from this stability class was = 2.8 percent. Calms are speeds ≤ 0.9 m/s (1.75 knots).
- c. Total number of invalid and valid observations in this stability class were 2 and 4,160, respectively.
- d. Calms are distributed as per NCDC Star Deck procedures.
- e. Total percent for this stability class.
- f. Total percent relative to all stability classes.

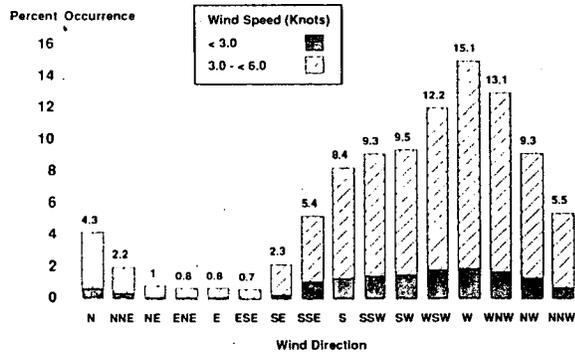


Figure C-6 Stability Class F

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1B

Table C-7
Wind Frequency Distribution by Percent in 1990, Stability Class All a,b,c,d

Wind	Wind Speed Classes (Knots)						Class*	Total ^f
	<3.0	3.0 - <6.0	6.0 - <10.0	10.0 - <16.0	16.0 - <21.0	>21.0		
N	.9	2.4	2.5	1.4	.2	.2	7.51	7.48
NNE	1.0	2.5	2.0	.7	.0	.0	6.28	6.25
NE	.9	2.3	1.1	.2	.0	.0	4.48	4.46
ENE	.9	1.6	.5	.0	.0	.0	3.02	3.01
E	1.0	1.9	.4	.0	.0	.0	3.42	3.40
ESE	.7	1.8	1.2	.1	.0	.0	3.79	3.77
SE	.7	2.4	2.2	.4	.0	.0	5.78	5.76
SSE	.8	2.1	1.8	.4	.1	.0	5.22	5.20
S	.8	2.2	1.9	.5	.0	.0	5.44	5.42
SSW	.7	2.0	1.7	.4	.0	.0	4.84	4.82
SW	.6	1.8	2.5	.5	.1	.0	5.58	5.56
WSW	.7	2.1	2.8	1.3	.3	.2	7.51	7.48
W	.8	2.6	2.0	1.6	.9	1.4	9.38	9.34
WNW	.8	2.5	2.2	3.0	1.8	1.8	12.07	12.03
NW	.9	2.4	2.8	2.1	.6	.2	9.05	9.02
NNW	.8	2.0	2.6	1.1	.1	.0	6.66	6.64
All	13.0	34.6	30.5	13.8	4.2	3.8	100.00	99.65

- a. Measurements taken at the 10-meter level from the 61-meter meteorological monitoring tower.
- b. Total number of invalid and valid observations were 28 and 33,159 respectively.
- c. Calms are distributed as per NCDC Star Deck Procedures
- d. Joint Data recovery rate = 99.9 percent
- e. Total Number of invalid observations in this stability class = 28
- f. Total number of valid observations in this stability class = 33159

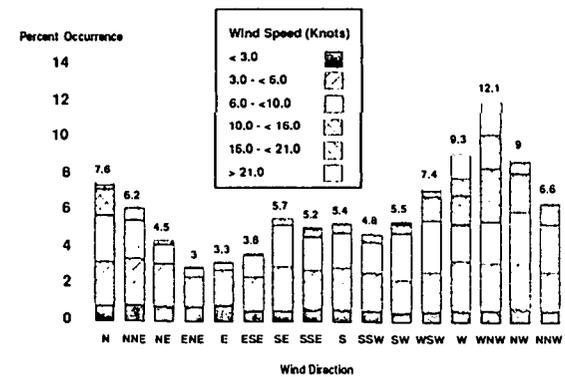
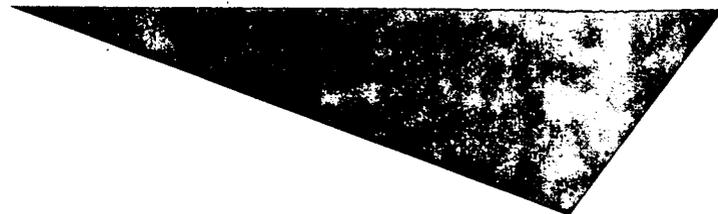


Figure C-7 Stability Class - All

APPENDIX D



ANALYTICAL PROCEDURES

HEALTH AND SAFETY (H&S) LABORATORIES

H&S Laboratories routinely perform the following analyses on environmental and effluent samples:

1. Total Air Filter Counting (Plutonium specific alpha)
2. Gas Proportional Counting (Gross alpha and gross beta)
3. Gamma Spectral Analysis
4. Alpha Spectral Analysis (Plutonium-239, -238; Americium-241; Uranium-238, -233, -234)
5. Beta Liquid Scintillation (Tritium)
6. N,N-Dimethyl-p-phenylenediamine (DPD) (Chlorine)
7. Atomic Absorption (Beryllium)
8. Millipore Filtration Method (Fecal and Total Coliform)

Procedures for these analyses are described in the *Health and Safety Laboratories Procedures and Practices Manual* (WI82). The procedures for bacteria and chlorine analyses were developed following EPA guidelines. Soil procedures were developed following specifications set forth in *Measurements of Radionuclides in the Environment, Sampling and Analysis of Plutonium in Soil*, Nuclear Regulatory Commission (NRC) Regulatory Guide 4.5. All new procedures and changes to existing procedures must be thoroughly tested, documented, and approved in writing by the manager of H&S Laboratories before being implemented. Environmental Management (EM) is notified of any major changes that could affect analytical results. All procedures are reviewed annually (or at any time an analytical problem is suspected) for consistency with state-of-the-art techniques. Copies of all procedures are kept on file in the office of the manager of H&S Laboratories.

Analytical Procedures

Samples received for air filter screening are counted at approximately 24 hrs and then 48 hrs after collection. Samples exceeding specified limits are recounted. If the total long-lived alpha concentration for a screened filter exceeds specified action limits, the filter is directed to individual specific isotope analysis and/or follow-up investigation to determine the cause and any needed corrective action.

All water samples, except those scheduled for tritium analysis, are poured into 1-liter Marinelli containers and sealed before delivery to the gamma counting area. Routine water samples are counted for approximately 12 hrs. Samples requiring a lower detection limit are counted from 16 to 72 hrs.

Soil samples scheduled for gamma spectral analysis are dried, sieved through a 10-mesh sieve, weighed, and the fine portion is ball-milled. The fine portion is then placed in a 500-milliliter (ml) Marinelli container and counted for at least 16 hrs.

All samples scheduled for alpha spectral analysis are analyzed in a similar manner regardless of matrix. Before dissolution, a known quantity of nonindigenous radioactive tracer is added to each sample. The tracer is used to determine the chemical recovery for the analysis. Tracers used include plutonium-236, plutonium-242, uranium-232, uranium-236, americium-243, and curium-244. The type and activity level of the tracer used depends on the type and projected activity level of the sample to be analyzed. All refractory or intractable actinides are dissolved by vigorous acid treatment using both oxidizing and complexing acids. After samples are dissolved, the radioisotopes of concern are separated from each other and from the matrix material by various solvent extraction and ion exchange techniques. The purified radioisotopes are electro-deposited onto stainless steel discs. These discs are alpha counted for 12 hrs. If a lower minimum detection limit is required, samples may be counted from 72 to 168 hrs, depending on the specific sensitivity requirement. Samples that exhibit a chemical recovery of less than 10 percent or greater than 110 percent are automatically scheduled for reanalysis.

Tritium analyses are routinely performed on specified environmental water samples, as well as on stack effluent samples. Ten ml of the samples are combined with 10 ml of liquid scintillation fluid. Environmental and airborne effluent samples are generally counted for 120 min.

GENERAL LABORATORY

The General Laboratory routinely performs the following analyses for environmental monitoring of plant effluent streams, process wastes, and soil residues:

1. Metallic elements including tests for 19 cations by inductively coupled plasma spectroscopic techniques and 17 elements by atomic absorption spectroscopy techniques (including beryllium in airborne effluent sample filters).

2. Oxygen demand tests on water including total organic carbon, dissolved oxygen, chemical oxygen demand, carbonaceous biological oxygen demand, and biological oxygen demand (5-day incubation).
3. Nutrient tests including free ammonia, ortho and total phosphate phosphorus, nitrite, and nitrate anions.
4. Physical tests, including pH, conductivity, color, total dissolved solids, suspended solids, total solids, non-volatile suspended solids, turbidity, and specific gravity.
5. Soap residues (as alkyl sulfonate).
6. Oil and grease residues, by extraction and infrared or gravimetric detection, and by visual observation.
7. Specific chemical property or element including total hardness (as calcium carbonate), alkalinity (as hydroxide, bicarbonate, or carbonate), chloride, fluoride, cyanide, sulfate, and hexavalent chromium.
8. Radioactive species including gross alpha and beta by gas proportional detection; tritium by liquid scintillation detection; total radiostrontium by gravimetric separation followed by gas proportional detection. Isotopes of plutonium, americium, and uranium are determined by ion exchange and liquid extraction techniques followed by alpha pulse height analysis.
9. Volatile and semivolatile compounds from the EPA Contract Laboratory Program (CLP) Target Analyte List are analyzed by gas chromatography/mass spectrometry. Phenols also are analyzed using spectrophotometry. Polychlorinated biphenyl compounds are analyzed by gas chromatography.
10. Toxic Constituent Leaching Procedure (TCLP) extractable metals and organics for compliance to land ban restrictions.

Procedures for these analyses, developed by the General Laboratory analytical technical staff, were adopted from EPA-approved sources or from other recognized authoritative publications where EPA-approved procedures were not available. Laboratory operations procedures are documented in a standard format, approved by the manager of the Rocky

Flats Analytical Laboratories, and distributed to a controlled distribution list to ensure that proper testing and approval is performed before changes are adopted. The Analytical Laboratories Quality Assurance Program requires annual review of procedures for consistency with state-of-the-art techniques and compliance of laboratory practice with written procedures. In addition, a review is performed whenever an analytical problem is indicated.

Analytical Procedures

Water samples to be tested for chemical and physical parameters are preserved and/or refrigerated, when required. The tests performed include gravimetric, titrametric, calorimetric, chromatographic, or electroanalytical methods, following procedures specified in the seventeenth edition of *Standard Methods for the Examination of Water and Waste Water*, *Methods for Chemical Analysis of Water and Wastes*, EPA-SW846, or other authoritative publications.

All water samples analyzed for radioactive materials, except those scheduled for tritium analysis, are acidified immediately upon collection.

Liquid samples received for gross alpha and beta screening are evaporated, and the residue is electroplated on planchets for gas proportional counting. When activities exceed action guidelines, notification is made, and reanalysis and/or investigation may be required.

Tritium is measured using liquid scintillation counting. Counting efficiency is determined using a separately prepared vial to which is added a known standard tritium activity.

Strontium is radiochemically separated from the sample matrix using precipitation techniques. Strontium is deposited on planchets with a carrier element, and the activity in the sample is quantified using beta gas proportional counting.

For some liquids such as machine oils, a specified volume is evaporated, ashed, and the salt residue is taken up in nitric acid for deposition onto the counting planchet. A correction factor is determined for each sample to account for self-absorption effects.

Water samples to be analyzed for metal ions are preserved with nitric acid and are digested before being analyzed by atomic absorption or inductively coupled plasma (ICP)

methods. Organic toxic species are determined by Gas Chromatograph/Mass Spectrometry/Data Systems following EPA protocol for volatile organics and semivolatile organics. Some organics, such as phenol, are determined by developing achromaphoric complex and measuring light absorption at a specific wavelength with a spectrophotometer. Measuring occurs after extraction into an appropriate solvent phase.

DETECTION LIMITS AND ERROR TERM PROPAGATION

Radioactivity Parameters

Health and Safety Laboratories have adopted the following definition for detection limit, as given by Harley (HA72):

"The smallest amount of sample activity using a given measurement process (i.e., chemical procedure and detector) that will yield a net count for which there is confidence at a pre-determined level that activity is present."

The minimum detectable amount (MDA) is the term used to describe the detection limit and is defined as the smallest amount of an analyzed material in a sample that will be detected with a "b" probability of non-detection (Type II error), while accepting an "a" probability of erroneously detecting that material in an appropriate blank sample (Type I error). In the formulation below, both α and β are equal to 0.05.

Based on the approach presented in draft ANSI Standard N13.30, *Performance Criteria for Radiobiassay* (HE85) the formulation of the MDA for radioactive analyses is:

$$\text{MDA} = \frac{4.65 S_B + 2.71/(T_s E_s Y)}{aV}$$

where S_B = standard deviation of the population of appropriate blank values (disintegrations per minute, d/m)

T_s = sample count time (minutes, m)

E_s = absolute detection efficiency of the sample detector

Y = chemical recovery for the sample

a = conversion factor (disintegrations per minute per unit activity)

(a = 2.22 disintegrations per minute per picocurie [d/m/pCi] when MDA is in units of pCi, and a = 2.22×10^6 disintegrations per minute per microcuries [d/m/ μ Ci] when MDA is in units of μ Ci)

V = sample volume or weight (V=1 if the MDA per sample is desired)

The major component of the MDA equation is the variability of the blanks.

Table D-1 shows the various formulas used for alpha data reduction during 1990. Table D-2 shows the typical MDA values for the various analyses performed by the H&S Laboratories. These values are based on the average sample volume, typical detector efficiency, detector background, count time, and chemical recovery. MDA values calculated for individual analyses may vary significantly depending on actual sample volume, chemical recovery, and analytical blank used.

Nonradioactivity Parameters

For nonradioactivity parameters, various means are used to estimate a minimum detection limit (MDL) depending on the parameter measured. MDL is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. The MDL for beryllium in effluent air, analyzed using flameless atomic absorption spectroscopy, is based on a sample blank absorbance reading. Total chromium in effluent water samples undergoes a fourfold concentration of the received sample prior to its analysis using flame atomic absorption spectroscopy. Its approximate MDL is based on a net sample absorbance reading of 0.010.

The parameters of nitrate as N, total phosphorous, suspended solids, oil and grease, and total organic carbon have MDLs determined by procedural methods found in EPA-600, *Environmental Monitoring and Support Laboratory, Methods for Chemical Analysis of Water and Wastes* (EPA87b). Biochemical oxygen demand and pH have MDLs determined by the minimal readout capability of the instrumentation that is used. The MDL for residual chlorine

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Table D-1
Formulas for Activity and Uncertainty Calculations for the
Alpha Spectral Analysis Systems

<u>Non-Blank Corrected Sample Activity</u>	<u>Blank Corrected Sample Activity</u>
$A_{si} = \frac{\frac{C_{si}}{T_s} - \frac{C_{Bi}}{T_B}}{\frac{C_{sj}}{T_s} - \frac{C_{Bj}}{T_B}} \cdot \frac{D_{sj}}{V \cdot 2.22}$	$B_{si} = A_{si} - A_{ri}$
<u>Non-Blank Corrected Sample Uncertainty*</u>	<u>Blank Corrected Sample Uncertainty</u>
$*a_{si} = A_{si} \left[\frac{\frac{C_{si}}{T_s^2} + \frac{C_{Bi}}{T_B^2}}{\left(\frac{C_{si}}{T_s} - \frac{C_{Bi}}{T_B}\right)^2} \right]^{1/2} + \left[\frac{\frac{C_{sj}}{T_s^2} + \frac{C_{Bj}}{T_B^2}}{\left(\frac{C_{sj}}{T_s} - \frac{C_{Bj}}{T_B}\right)^2} \right]^{1/2}$	$*b_{si} = (a_{sj}^2 + a_{ri}^2)^{1/2}$

*Sample uncertainty is the propagated standard deviation of sample activity using counting statistics.

- A_{ri} = Non-blank corrected activity of laboratory reagent blank for isotope i expressed as picocuries (pCi) per unit volume.
- a_{ri} = Non-blank corrected uncertainty of laboratory reagent blank expressed as pCi per unit volume.
- A_{si} = Sample activity for isotope i expressed as pCi per unit volume.
- *a_{si} = Sample activity uncertainty expressed as pCi per unit volume.
- B_{si} = Blank corrected sample activity for isotope i expressed as pCi per unit volume.
- b_{si} = Blank corrected sample uncertainty expressed as pCi per unit volume.
- D_{sj} = Activity (dpm) of internal standard isotope j added to sample.
- C_{si} = Sample gross counts for isotope i.
- C_{sj} = Sample gross counts for internal standard isotope j.
- C_{Bi} = Detector background gross counts for isotope i.
- C_{Bj} = Detector background gross counts for internal standard isotope j.
- T_s = Sample count time expressed in minutes.
- T_B = Detector background count time expressed in minutes.
- V = Sample unit volume or sample unit weight.

Table D-2
Detection Limits for Radioactive and Nonradioactive Materials

Parameter	Minimum Detectable Activity (per sample)	Approximate Sample Volume Analyzed ^a	Minimum Detectable Activity (per unit volume or mass)
Airborne Effluents			
Plutonium-239,240	$1.6 \times 10^{-7} \mu\text{Ci}$	7,340m ^{3b}	$.02 \times 10^{-15} \mu\text{Ci/ml}$
Uranium-234	$4.6 \times 10^{-7} \mu\text{Ci}$	7,340m ^{3b}	$.06 \times 10^{-15} \mu\text{Ci/ml}$
Uranium-238	$3.4 \times 10^{-7} \mu\text{Ci}$	7,340m ^{3b}	$.05 \times 10^{-15} \mu\text{Ci/ml}$
Americium-241	$1.0 \times 10^{-7} \mu\text{Ci}$	7,340m ^{3b}	$.01 \times 10^{-15} \mu\text{Ci/ml}$
Tritium (H-3)	$2.1 \times 10^{-6} \mu\text{Ci}$	1.4m ³	$1,530 \times 10^{-15} \mu\text{Ci/ml}$
Beryllium	$2.5 \times 10^{-1} \mu\text{Ci}$	7,340m ^{3b}	$3.0 \times 10^{-5} \mu\text{g/m}^3$
Ambient Air Samples			
Plutonium-239,240	$7.2 \times 10^{-8} \mu\text{Ci}$	29,000m ^{3c}	$.002 \times 10^{-15} \mu\text{Ci/ml}$
Effluent Water Samples (Radioactive)			
Plutonium-239,240	$8.2 \times 10^{-8} \mu\text{Ci}$	1,000 ml	$0.78 \times 10^{-9} \mu\text{Ci/ml}^c$
		5,000 ml	$.016 \times 10^{-9} \mu\text{Ci/ml}^c$
Uranium-234	$5.0 \times 10^{-7} \text{mCi}$	1,000 ml	$.50 \times 10^{-9} \mu\text{Ci/ml}^c$
Uranium-238	$1.5 \times 10^{-7} \mu\text{Ci}$	1,000 ml	$.15 \times 10^{-9} \mu\text{Ci/ml}^c$
Americium-241	$8.9 \times 10^{-8} \mu\text{Ci}$	1,000 ml	$0.82 \times 10^{-9} \mu\text{Ci/ml}^c$
		5,000 ml	$.017 \times 10^{-9} \mu\text{Ci/ml}^c$
Tritium (H-3)	$2.1 \times 10^{-6} \mu\text{Ci}$	10 ml	$2.14 \times 10^{-9} \mu\text{Ci/ml}^c$
Soil Samples (Radioactive)			
	0.03 pCi/gr	1-5 yr	
Effluent Water Samples (Nonradioactive)			
pH		100 ml	0-14 SU
Nitrates as N		4 ml	0.02 mg/l
Total Phosphorus		50 ml	0.2 mg/l
Biochemical Oxygen Demand, 5-Day		300 ml	5.0 mg/l
Suspended Solid		100 ml	1.0 mg/l
Total Chromium		100 ml	0.05 mg/l
Residual Chlorine		10 ml	0.1 mg/l
Oil and Grease		1,000 ml	0.5 mg/l
Fecal Coliform Count		100 ml	1.0 colony/100 ml
Total Organic Carbon		5 ml	5.0 mg/l

- a. Volume analyzed is usually an aliquoted fraction of the total sample volume collected.
 b. Monthly composite.
 c. Composite of two biweekly samples.

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is determined by the procedure found in a publication by Hach Company, *DPD Method for Chlorine* (HA83). For fecal coliform count, MDL is calculated as 4.65 times the standard deviation of the blank value from the millipore filter.

**REPORTING OF
MINIMUM
DETECTABLE
CONCENTRATION
AND ERROR TERMS**

Plutonium, uranium, americium, tritium, and beryllium measured concentrations are given in this report. Most of the measured concentrations are at or very near background levels, and often there is little or no amount of these materials in the media being analyzed. When this occurs, the results of the laboratory analyses can be expected to show a statistical distribution of positive and negative numbers near zero and numbers that are less than the calculated minimum detectable concentration for the analyses. The laboratory analytical blanks, used to correct for background contributions to the measurements, show a similar statistical distribution around their average values. Negative sample values result when the measured value for a laboratory analytical blank is subtracted from a sample analytical result that is smaller than the analytical blank value. Results that are less than calculated minimum detectable levels indicate that the results are below the level of statistical confidence in the actual numerical values. All reported results - including negative values and values that are less than minimum detectable levels - are included in any arithmetic calculations on the data set. Reporting all values allows all of the data to be evaluated using appropriate statistical treatment. This assists in identifying any bias in the analyses, allows better evaluation of distributions and trends in environmental data, and helps in estimating the true sensitivity of the measurement process.

The reader should use caution in interpreting individual values that are negative or less than minimum detectable levels. A negative value has no physical significance. Values less than minimum detectable levels lack statistical confidence as to what the actual number is, although it is known with high confidence that it is below the specified detection level. Such values should not be interpreted as

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being the actual amount of material in the sample, but should be seen as reflecting a range - from zero to the minimum detectable level - in which the actual amount would likely lie. These values are significant, however, when taken together with other analytical results that indicate that the distribution is near zero.

Error terms in the form of $a \pm b$ are included with some of the data. For a single sample, "a" is the analytical blank corrected value; for multiple samples, "a" represents the average value (arithmetic mean). The error term "b" accounts for the propagated statistical counting uncertainty for the sample and the associated analytical blanks at the 95 percent confidence level. These error terms represent a minimum estimate of error for the data.

EG&G ROCKY FLATS

EG&G ROCKY FLATS, INC.
ROCKY FLATS PLANT, P.O. BOX 464, GOLDEN, COLORADO 80402-0464 • (303) 966-7000

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Ms. Peg Hooper
U.S. Environmental Protection Agency
Superfund Records Center
999 18th Street, Suite 500
Denver, Colorado 80202-2405

Mr. Gary Baughman
Colorado Department of Health
Room 351
4210 East 11th Avenue
Denver, Colorado 80220

Ms. E.E. Dee Bordner
FOI and Privacy Branch
AD234.1, 1G-051/FORS
U.S. Department of Energy HQ
1000 Independence Ave, S.W.
Washington, DC 20585

Ms. Ginger Swartz
Rocky Flats Environmental Monitoring Council
1536 Cole Boulevard, Suite 325
Building 4, Denver West Office Park
Golden, Colorado 80401

Ms. Will-Ann Lamsens
Rocky Flats Public Reading Room
Front Range Community College
3645 W. 112th Ave.
Westminster, CO 80030

TRANSMITTAL OF DOCUMENTS FOR PLACEMENT IN READING ROOMS

E 90 - 089

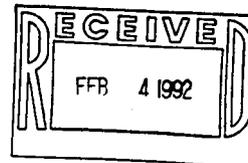
Enclosed are two documents for your reading room: 1) the *Rocky Flats Plant Site Environmental Report* for calendar year 1990, and 2) a brochure entitled *A Closer Look at Rocky Flats*. *E 92 - 007*

Please call me at 966-6159 if I can be of further assistance.

Very truly yours,

Patricia S. Lee

Patricia S. Lee
Community Relations



Enclosures:
two (2)

cc:
B. Brainard DOE, RFO w/o Enc.
T.A. Smith EG&G Rocky Flats w/o Enc.
J.M. Wilson EG&G Rocky Flats w/o Enc.

For additional information about this report, please contact:
EG&G Rocky Flats, Inc.
Rocky Flats Plant
Environmental Management Department
Resource Information Management Division
P.O. Box 464
Golden, CO 80402-9188
(303) 966-7000

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