January through December

1994

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

ENVIRONMENTAL REPORT

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Rocky Flats Environmental Technology Site

SITE ENVIRONMENTAL REPORT FOR 1994

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ABOUT THIS EDITION

Change has become a way of life at Rocky Flats Environmental Technology Site. In keeping with that spirit, this edition of the annual *Site Environmental Report* has a new look.

Radiation dose monitoring and assessment are combined into one section, there is a new section on waste management, and information formerly found in appendices is incorporated into the appropriate subject section. "Useful Information" now appears right after the table of contents and references cited in individual sections are found at the end of the sections.

The pictorial focus this year is on the varied ecological life of the Site, illustrated by photos of some of the many birds found within its boundaries. Reader comments on these efforts to communicate information about Rocky Flats Environmental Technology Site in a more user-friendly way are welcome and encouraged.

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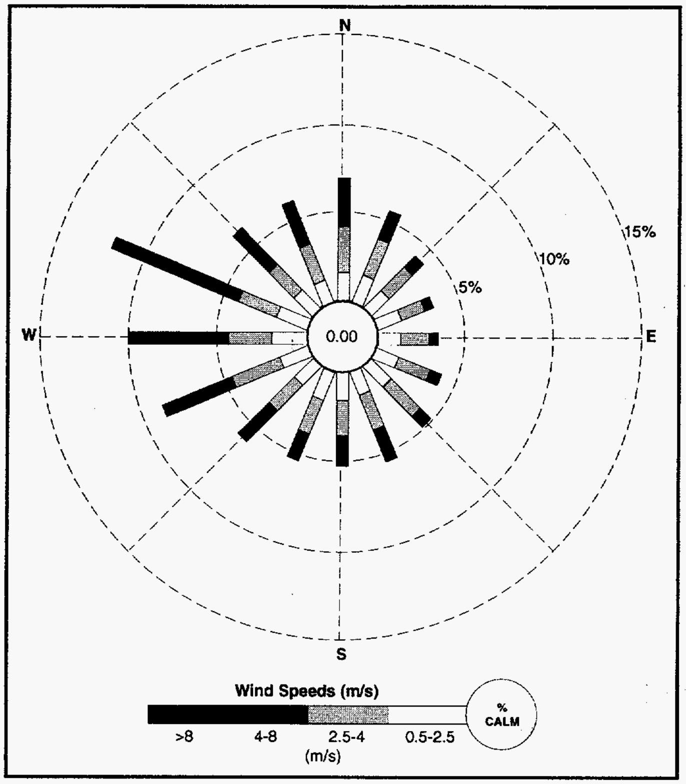


Figure 3.1-3. Rocky Flats 1994 Windrose - 24-Hour

The change in winds is illustrated in the day and night windroses (Figures 3.1-4 and 3.1-5). Day is defined as the period between one hour after sunrise to one hour before sunset. Night is defined as the remainder of the 24-hour period. Locally and regionally produced, thermally driven winds are apparent during the day, with northeasterly up-valley and southeasterly upslope winds. Locally produced winds usually have wind speeds of 11.0 mph (5.0 m/s) or less. Stronger, synoptically induced winds occur from the west and, to a lesser extent, from northerly and southerly directions.

The distribution of nighttime winds is nearly reversed, with Rocky Flats drainage winds causing a high frequency of westerly winds. The South Platte Valley drainage also contributes to the high frequency of southwesterly winds. The frequency of stronger, larger-scale winds is similar to that of the daytime distribution.

Pasquill-Gifford stability classes are used to estimate horizontal and vertical dispersion and are input into atmospheric dispersion models. Stability classes at the Site were estimated using the *sigma theta* technique, where stability is determined from the standard deviation of horizontal wind, mean horizontal wind speed, and time of occurrence as day or night. Another EPA-recommended technique, the *sigma phi* method, results in an unrealistically high number of neutral and stable cases, thereby underestimating Site dispersion and generally overestimating atmospheric concentrations resulting from potential releases.

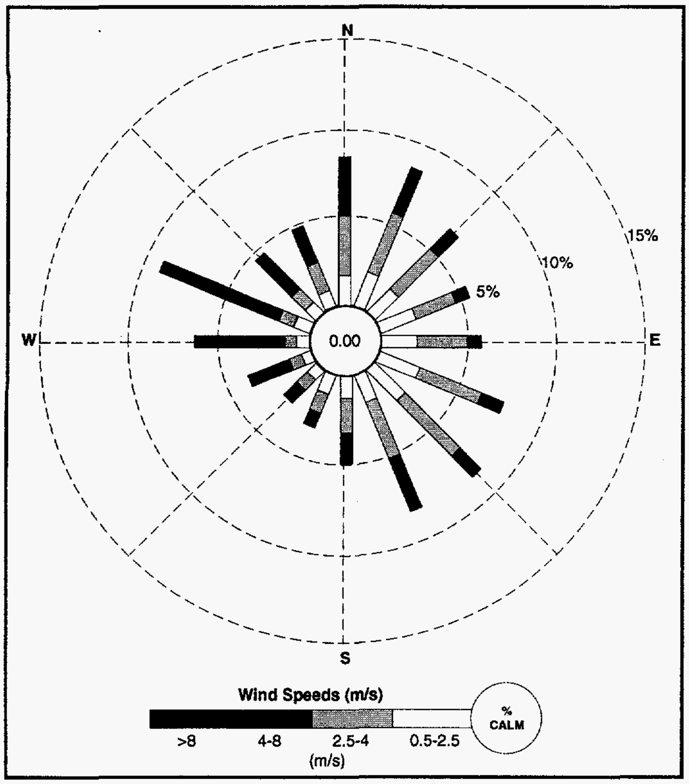


Figure 3.1-4. Rocky Flats 1994 Windrose - Day

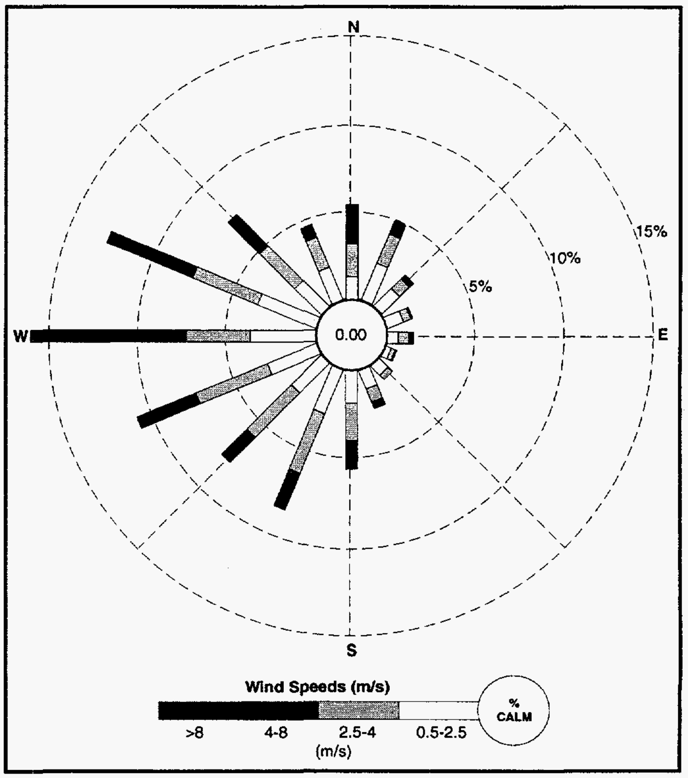


Figure 3.1-5. Rocky Flats 1994 Windrose - Night

U. S. DEPARTMENT OF ENERGY
1994 SITE ENVIRONMENTAL REPORT FOR ROCKY FLATS

Attached for your information is the 1994 Site Environmental Report for Rocky Flats Environmental Technology Site. The report describes our programs for compliance with existing permits, laws, and regulations; highlights the significant issues and events of 1994; and summarizes the radiological and nonradiological monitoring data. In addition, the methodology used for radiation dose assessment and the Environmental Restoration, Waste Management, and Quality Assurance programs in place at the Site are discussed.

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

Mark N. Silverman
Manager

USEFUL INFORMATION

Acronyms

ACO	Administrative Compliance Order
ADM	Action Description Memorandum
AEC	Atomic Energy Commission
AIP	Agreement in Principle
ALARA	As Low As Reasonably Achievable
AMAD	Activity Median Aerodynamic Diameter
AMRRR	Annual Mixed Residue Reduction Report
ANOVA	Analysis of Variance
ANSI	American National Standards Institute
APCD	Air Pollution Control Division
APEN	Air Pollutant Emission Notice
APR	Annual Progress Report
AQCC	Air Quality Control Commission
AQD	Air Quality Division
AR	Administrative Record
ARA	Accelerated Response Action
ARAR	Applicable or Relevant and Appropriate Requirement
ASME	American Society of Mechanical Engineers
BAT	Best Available Technology
BEAR	Biological Effects of Atomic Radiation
BEIR	Biological Effects of Ionizing Radiation
BMP	Best Management Practices
BMPP	Biocide Management Program Plan
BOD_5	Biochemical Oxygen Demand, 5-day incubation period
BRA	Baseline Risk Assessment Plan
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAD	Corrective Action Decision
CAQCC	Colorado Air Quality Control Commission
CBO	Colorado Bird Observatory
CCR	Colorado Code of Regulations
CDPHE	Colorado Department of Public Health and Environment
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
CLP	Contract Laboratory Program
CMS/FS	Corrective Measures Study/Feasibility Study
COC	Contaminant of Concern
ComRad	Community Radiation Monitoring Program
CPDWR	Colorado Primary Drinking Water Regulations
CPFM	Colloid Polishing Filter Method

CPIR	Contingency Plan Implementation Report
CRP	Community Relations Plan
CSU	Colorado State University
CT&CS	Chemical Tracking and Control System
CTMP	Comprehensive Treatment and Management Plan
CWA	Clean Water Act
CWP	Cleanup Work Plan
CWQCC	Colorado Water Quality Control Commission
CX	Categorical Exclusion
CY	Calendar Year
DAR	Duct Assessment Report
DCG	Derived Concentration Guide
D&D	Decontamination and Decommissioning
DDS	Dustless Decon System
DMR	Discharge Monitoring Report
DOE	Department of Energy
DOE, HQ	Department of Energy Headquarters
DOE, RFFO	Department of Energy, Rocky Flats Field Office
DRCOG	Denver Regional Council of Governments
EA	Environmental Assessment
EC	Environmental Checklist
ECF	Element Correction Factors
EcMP	Ecological Monitoring Program
ECPP	Environmental Compliance Pilot Program
EDCN	Environmental Data Collection Network
EDE	Effective Dose Equivalent
EE	Environmental Evaluation
EHS	Extremely Hazardous Substance
EIS	Environmental Impact Statement
EIS/ODIS	Effluent Information System/Onsite Discharge Information System
EM	Environmental Management
EML	Environmental Measurements Laboratory
EO	Executive Order
EOCNO	Emergency Operations Center Notification Officer
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPM	Environmental Protection Management
EPMP	Environmental Protection Management Plan
ER	Environmental Remediation
ERA	Ecological Risk Assessment
ERDA	Energy Research and Development Administration
ERM	Environmental Restoration Management
ERWM	Environmental Restoration and Waste Management
ESE	Environmental Science and Engineering

FBI	Fluidized-bed Incinerator
FFCA	Federal Facility Compliance Agreement
FFCA II	Federal Facility Compliance Agreement II
FFC Act	Federal Facility Compliance Act
FIDLER	Field Instrument for the Detection of Low-Energy Radiation
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FR	Federal Register
FS	Feasibility Study
FSP	Field Sampling Plan
FTU	Field Treatability Unit
FY	Fiscal Year
FYP	Five-Year Plan
GAC	Granular Activated Carbon
GAO	General Accounting Office
GI	Gastrointestinal
GPS	Global Positioning System
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
GSA	General Services Administration
GUI	Graphical User Interface
H&S	Health and Safety
HAP	Hazardous Air Pollutant
HAZCOM	Hazardous Communication Standard
HB	House Bill
HEPA	High Efficiency Particulate Air
HFFSS	Halon Fixed Fire Suppression Systems
HHRA	Human Health Risk Assessment
HPGe	High Purity Germanium
HQ	Headquarters
HRR	Historical Release Report
HS	Hazardous Substance
HSP	Health and Safety Plan
HSWA	Hazardous and Solid Waste Amendments
HWCPP	Hazardous Waste Compliance Program Plan
IA	Industrial Area
IAG	Interagency Agreement
ICP	Inductively Coupled Plasma
ICP-MS	Inductively Coupled Plasma Mass Spectrometer
ICRP	International Commission on Radiological Protection
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measures/Interim Remedial Action
IRA	Interim Remedial Action
IRAP	Interim Remedial Action Plan
ITS	Interceptor Trench Ditch
IWCP	Integrated Work Control Program

LATO	Los Alamos Technical Office
LCO	Limiting Condition for Operation
LDR	Land Disposal Restrictions
LEPC	Local Emergency Planning Committee
LHSU	Lower Hydrostatigraphic Units
LIMS	Laboratory Information Management System
LLW	Low-level Waste
M&O	Management & Operating
MAP	Mitigation Action Plan
MDA	Minimum Detectable Amount
MDL	Minimum Detection Limit
MOU	Memorandum of Understanding
MRRP	Mixed Residue Reduction Program
MRRR	Mixed Residue Reduction Report
MSDS	Material Safety Data Sheet
MVAC	Motor Vehicle Air Conditioner
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NCC	NEPA Compliance Committee
NCRP	National Council on Radiation Protection and Measurements
NDA	Non-Destructive Assay
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFAJ	No Futher Action Justification
NHPA	National Historic Preservation Act
NOD	Notice of Deficiency
NOI	Notice of Intent
NOID	Notice of Intent to Deny
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NQA	Nuclear Quality Assurance
NRC	Nuclear Regulatory Commission; National Response Center
NRCP	National Commission on Radiation Protection
NRDA	Natural Resource Damage Assessment
NRPCP	Natural Resource Protection and Compliance Program
NTS	Nevada Test Site
ODS	Ozone-Depleting Substances
OPA	Operating Permit Application
OPWL	Original Process Waste Lines
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Act
OSR	Operational Safety Requirements
OU	Operable Unit

PA	Protected Area
PAH	Polycyclic Aromatic Hydrocarbons
PATS	Plant Action Tracking System
PCB	Polychlorinated Biphenyl
PEIS	Programmatic Environmental Impact Statement
PM-10	Particulate Matter less than 10 micrometers in diameter
PP	Proposed Plan
PPCD	Plan for Prevention of Contaminant Dispersion
PRMP EIS	Plutonium Recovery Modification Project Environmental Impact Statement
QA	Quality Assurance
QAA	Quality Assurance Agenda
QA/QC	Quality Assurance/Quality Control
QAM	Quality Assurance Manual
QAMS	Quality Assurance Management Staff
QAPD	Quality Assurance Program Description
QAPjP	Quality Assurance Project Plan
QAPM	Quality Assurance Program Manager
QAPP	Quality Assurance Program Plan
QAR	Quality Assurance Requirements
QC	Quality Control
RA	Remedial Action
RAAMP	Radiological Ambient Air Monitoring Program
RACT	Reasonable Available Control Technology
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RDLWP	Radionuclides Discharge Limits Work Plan
RFCA	Rocky Flats Cleanup Agreement
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFAO	Rocky Flats Area Office
RFEDS	Rocky Flats Environmental Database System
RFETS	Rocky Flats Environmental Technology Site
RFFO	Rocky Flats Field Office
RFQAM	Rocky Flats Quality Assurance Manual
RHL	Radiological Health Laboratories
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
RPP	Resource Protection Program
RQ	Reportable Quantity
RS	Responsiveness Summary
RTGUI	Real-time Graphical User Interface
SAAM	Selective Alpha Air Monitor
SAR	Safety Analysis Report
SARA	Superfund Amendment and Reauthorization Act
SARF	Supercompactor and Repackaging Facility
SDWA	Safe Drinking Water Act

SER	Site Environmental Report
SERC	State Emergency Response Commission
SI	International Standard
SIP	State Implementation Plan
SITE	Superfund Innovative Technology Evaluation
SLPP	Standley Lake Protection Project
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC/BMP	Spill Prevention Control and Countermeasures/Best Management Practices
SSP	Site-Specific Plan
STAR	Stability Array
STP	Sewage Treatment Plant
SU	Standard Units
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compound
SWD	Surface Water Division
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution Prevention Plan
T&ESA	Threatened and Endangered Species Act
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TE	Technical Evaluation
TLD	Thermoluminescent Dosimeter
TM	Technical Memorandum
TMP	Tank Management Plan
TPQ	Threshold Planning Quantity
TRG	Technical Review Group
TRU	Transuranic
TRUPACT	Transuranic Package Transporter
TSCA	Toxic Substances Control Act
TSP	Total Suspended Particulates
TSR	Technical Safety Requirement
TSS	Total Suspended Solids
TSWP	Treatability Study Work Plan
TTP	Technical Task Plan
UBC	Under-Building Contaminant
UHSU	Upper Hydrostratigraphic Units
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTL	Upper Tolerance Limits
UV	Ultraviolet
VOC	Volatile Organic Compound

WAC	Waste Acceptance Criteria
WARP	Well Abandonment and Replacement Program
WET	Whole Effluent Toxicity
WIPP	Waste Isolation Pilot Project
WMP	Watershed Management Plan
WSRIC	Waste Stream and Residue Identification and Characterization
WWTP	Waste Water Treatment Plant (previously referred to as STP)

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

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
Ci	Curie
Ci/g	Curie per gram
cm	Centimeter
cm^3	Cubic centimeter
d/m/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^2	Square foot
ft^3/min	Cubic foot per minute
fpm	Foot per mile
g	Gram
gal	Gallon
g/cm^2	Gram per square centimeter
g/day	Gram per day
gpm	Gallon per minute
ha	Hectare
kg	Kilogram
km	Kilometer
l	Liter
l/d	Liter per disintegration
l/s	Liter per second
lb	Pound
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
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

EXECUTIVE SUMMARY

Annual Site Environmental Report

The annual Site Environmental Report provides summary information on the environmental monitoring programs conducted at the Rocky Flats Environmental Technology Site (hereafter referred to as Rocky Flats or Site) during 1994. The report contains a compliance summary, results of environmental monitoring and other related programs, a review of environmental remediation and waste management activities, information on external gamma radiation dose monitoring, and radiation dose estimates for the surrounding population.

The purpose of the annual Site Environmental Report is to present environmental data to help characterize site environmental management performance, confirm compliance with environmental standards and requirements, and highlight significant programs and efforts. The Site Environmental Report helps characterize both the radiological and nonradiological condition of the Site environment and helps identify trends in effluent releases and environmental conditions. This report represents a key component of the Department of Energy's (DOE's) effort to keep the public informed about the environmental condition at Rocky Flats.

Historical Site Background

Rocky Flats has been part of the nationwide DOE complex for the research, development, and production of nuclear weapons since the 1950s. The Site was responsible for fabricating nuclear weapons components from plutonium, uranium, beryllium, and stainless steel. Plutonium and americium in the Site environments are the combined result of residual fallout deposition from global atmospheric nuclear weapons testing, and releases from the Site. Uranium, which is indigenous to many parts of Colorado, was used in both highly enriched and depleted forms. Tritium, which occurs naturally in small quantities and is produced artificially, was sometimes present at the Site.

The primary production activities included metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions. Research and development in the fields of chemistry, physics, metallurgy, materials technology, nuclear safety, and mechanical engineering were conducted to advance the Site's mission.

In the process of fulfilling its earlier national security mission, the Site's use of these materials and processes contaminated facilities, soil, groundwater, and surface water with chemical and radioactive substances. As a consequence, Rocky Flats has numerous potential health and safety risks, high baseline operating costs, significant legal requirements, and other infrastructure burdens which stem from the presence of significant quantities of nuclear material; radioactive and hazardous waste; contaminated facilities, land, and water; and surplus equipment and materials.

In 1989, Rocky Flats was placed on the Superfund's National Priorities List. In 1991, the DOE entered into a cleanup agreement with the two principal regulatory agencies overseeing cleanup activities: the Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE). This Federal Facility Agreement and Consent Order, known as the Interagency Agreement (IAG), provides a legally enforceable framework for assessing the nature and extent of contamination; determining the risks posed by that contamination to workers, the public, and the environment; and implementing actions designed to remediate the contamination. The IAG specifies 268 milestones over a 12-year period for accomplishing cleanup of 177 contaminated areas known as Individual Hazardous Substance Sites (IHSSs) grouped together into 16 Operable Units (OUs). Assessment of the contamination in these OUs and implementation of cleanup activities in 1994 are described in Section 4 of this report, Environmental Remediation. DOE, CDPHE, and EPA entered into negotiations in 1994 to amend the IAG. No agreement had been reached by year's end and the parties continued to work toward modifying the milestones.

Change in Site Mission

The mission of Rocky Flats changed with the announcement in early 1992 that certain planned weapons systems had been canceled. Although production of nonnuclear components continued through September 1994, the termination of nuclear production changed the primary mission of the Site. Rocky Flats no long produces weapons components, and is now in a transition phase into cleanup and decontamination and decommissioning. Primary objectives of this new mission include achieving and maintaining compliance with environmental regulatory requirements, as well as effecting proper decontamination and decommissioning steps that are under development. Under the new mission, the name of the Site was changed in July 1994 from the Rocky Flats Plant to the Rocky Flats Environmental Technology Site.

The goal of the new mission is to "manage waste and materials, clean up, and convert the Site to beneficial use in a manner that is safe, environmentally and socially responsible, physically secure, and cost-effective." Key risk-reduction activities and strategies at the Site include: stabilizing plutonium liquids, solids, and residues to a safer, easier-to-store-and-handle form; providing ventilation for containers which have potential for hydrogen generation; shipping hazardous and excess materials offsite; consolidating plutonium in safer and easier-to-secure locations; removing sources of contamination in the ground to cease or inhibit further spreading; and handling, storing, and monitoring wastes.

Environmental Protection Program

The highest priorities at Rocky Flats continue to be the protection of workers, the public, and the environment from exposure to plutonium and other potential hazardous materials, and the safeguarding of plutonium from terrorism and sabotage. Another high priority is compliance with the federal and state statutes, legal agreements, DOE Orders, and other requirements that affect virtually all activities at the Site.

Large amounts of plutonium and uranium present the greatest risks. Plutonium is of special concern because it is toxic to humans and animals and is pyrophoric (i.e., can ignite spontaneously in air). A by-product of plutonium decay is americium, which has higher levels of gamma radiation that increase the potential for worker radiation exposure. Other potentially dangerous materials including beryllium, asbestos, and depleted uranium are also present.

The Site maintains an extensive environmental protection program because radioactive and chemically hazardous materials may be used or handled during the transition period. Regular monitoring for radioactive and hazardous constituents at onsite, boundary, and offsite locations is included in the environmental protection program.

An environmental surveillance program has been ongoing at Rocky Flats since the 1950s. Results from the effluent air, ambient air, surface-water, and groundwater monitoring programs are published in the Monthly Environmental Monitoring Report. This information, collected by CDPHE, the U.S. Geological Survey (USGS), the Rocky Flats Community Radiation (ComRad) Program, and the nearby cities of Broomfield and Westminster, Colorado, is presented the last Tuesday of each month at an Exchange of Information Meeting that is open to the public. The meeting, which was initiated in 1972, provides a routine forum for technical staff from the agencies and entities mentioned above to examine the data, discuss potential impacts on the environment, and share this information with other interested parties.

It is both Site policy and practice to operate facilities and conduct remedial activities so that radiation exposures to workers and the public are as low as reasonably achievable (ALARA). At a minimum, exposure from Rocky Flats is maintained within the limits of DOE Order 5400.1, *Radiation Protection of the Public and the Environment.* This DOE Order states that public exposure to radiation sources as a consequence of all routine Site activities may not result in an annual effective dose equivalent (EDE) greater than 100 millirem (mrem). It is Site policy to maintain capabilities necessary to monitor routine and nonroutine releases and to assess doses to the public.

For a human being to be at risk of plutonium contamination, the plutonium must enter a person's body through what is known as an "exposure pathway." The most common pathways are inhalation or ingestion. Plutonium oxide particles deposited on the ground by accidental spills or atmospheric fallout can be "resuspended" (i.e., carried into the air) by wind or other means and then inhaled. The amount of plutonium that will remain in the lungs depends on many factors, including the size of the particles inhaled and the form of the plutonium at the time of inhalation. Forms of plutonium that do not dissolve easily are not readily absorbed when swallowed and a large proportion of the substance leaves the body through normal elimination processes. Plutonium that remains in the body is most often found in the lungs, liver, and bones and potentially can be the cause of various forms of cancer. Depending on the exposure level, it can take as long as 30 years for the symptoms of such cancers to appear.

Public dose assessments, as reported annually in this publication, are based on the extremely conservative assumption that a hypothetical individual resides at the Site's boundary continuously throughout the year. Three individual pathways contribute to the composite dose calculated each year (air, water, and soil ingestion). Exposure of one individual to the reported dose would require being in different places at the same time in order to receive the highest dose of each separate pathway. Furthermore, the maximum concentrations measured near the Site boundary were taken in different locations and for different constituents. Section 6, Radiation Dose Assessment, discusses the methodology used to arrive at the EDE for the public in 1994, which has been calculated at 0.08 to 0.1 mrem.

Since the early 1980s, soil and air sampling has been conducted and procedures have been in place to minimize the dust level from construction activities. Monitoring data gathered from air sampling have shown that contamination levels have not exceeded existing standards.

Monitoring Programs

The current environmental monitoring program at Rocky Flats examines the potential radiological and nonradiological impacts to air, surface water, groundwater, and soils, and results are discussed in Sections 3.2, 3.3, 3.4, and 3.5 in this report. Meteorological monitoring, ecological studies, and environmental remediation and waste management programs are also described.

Air Monitoring - Continuous sampling of ambient (outdoor) air is conducted at 21 onsite locations, 14 locations around the Site boundary, and 10 monitoring locations in neighboring communities including 5 community radiation (ComRad) monitoring stations (Figures 3.2-2 and 3.2-3). In addition, CDPHE reports particulate (dust) and radioactivity results from 11 onsite air samplers, 4 monitoring stations inside the security fence, 3 stations in the Buffer Zone, 3 stations within the Site perimeter, and 3 monitoring stations set in surrounding communities. CDPHE also operates 3 monitoring stations offsite near the fence line, for dust particles, volatile organic compounds, nitrogen oxides, and beryllium.

Surface Water - Rocky Flats is located on a mesa that drains into Woman Creek on the south side of the facility and into Walnut Creek to the north. Woman Creek normally flows into Mower Reservoir, and Walnut Creek flows into Great Western Reservoir east of the Site or into the bypass. Both Standley Lake and Great Western Reservoir provide drinking water supplies for local communities. Due to concerns over the safety of these supplies, flows are routed to a diversion canal that bypasses both reservoirs.

Storm water runoff and groundwater discharges contribute to Woman Creek and Walnut Creek flows. In addition, treated wastewater from the sewage treatment facility flows into South Walnut Creek. This water is routinely collected and held in ponds located in the Buffer Zone. The process of holding water in ponds allows for settlement of suspended sediments, water sampling, analysis, and treatment (if necessary) before the water is released.

Water releases from the holding ponds into the creeks are monitored by the Site, CDPHE, and local communities. These groups exchange water monitoring information at monthly meetings and compare the concentration levels to the discharge limits established in the National Pollution Discharge Elimination System (NPDES) permit for the Site and to the more stringent standards set by the Colorado Water Quality Control Commission (CWQCC). Although the regulation of radionuclides is governed under the Atomic Energy Act, DOE complies with the stringent water quality standards set by CWQCC for radionuclides in the groundwater and surface water around Rocky Flats.

Groundwater Programs - Groundwater is monitored to determine whether underground water sources have become contaminated. Groundwater samples taken from monitoring wells onsite have been checked since 1960. At the end of 1994, there were approximately 700 wells in existence at Rocky Flats. Water samples are checked for the presence of radionuclides, chemical contaminants, heavy metals, volatile organic compounds, trace metals, inorganics, and numerous other substances. Environmental monitoring results to date indicate that no significantly contaminated groundwater has left the Site, nor is it expected to leave the property in the near future.

Waste Management

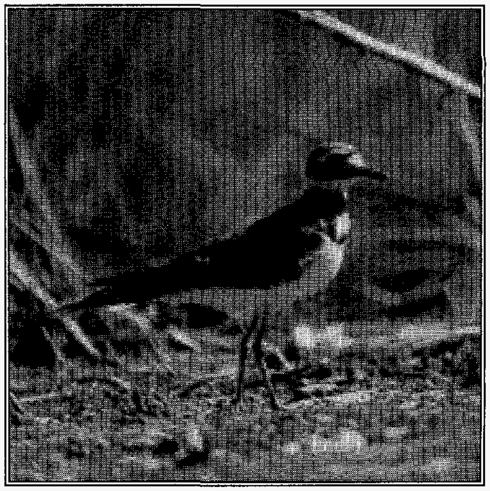
Two federal laws govern most of the cleanup activities at Rocky Flats: the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). RCRA regulates all activities at the Site associated with hazardous waste and mixed waste and includes provisions for corrective action. CERCLA requires cleanup at sites that have contamination and are recognized as high priority sites by EPA.

EPA has delegated some authority for implementation of RCRA requirements to CDPHE. This effort is accomplished through authority of the Colorado Hazardous Waste Act (CHWA) and other implementing regulations. The IAG defines how the overlapping cleanup authorities of RCRA, CERCLA, and CHWA are to be integrated and how oversight authorities by EPA and CDPHE will be conducted to achieve compliance with regulatory requirements.

The management of waste at Rocky Flats is complex, expensive, and subject to overlapping regulations. Waste management also involves characterization, treatment, storage, or disposal of several different types of waste material. Section 5, Waste Management, describes these activities at the Site, as well as technologies currently in use and under development.

The final section of this 1994 Site Environmental Report provides an overview of the Quality Assurance Program in place at Rocky Flats to help achieve the objective that work at the Site is performed in a manner that protects workers, public health, and the environment.

1.0 INTRODUCTION



The Rocky Flats Site Environmental Report (SER) is prepared annually in accordance with U.S. Department of Energy (DOE) Order 5400.1, *General Environmental Protection Program.*[1] This edition of the SER contains summaries of environmental monitoring data collected during 1994 and descriptions of environmental management programs implemented during the year. Section 2, Compliance Summary, summarizes compliance with applicable federal and state environmental protection statutes.

A major section of the report, Section 3, Environmental Monitoring Programs, describes the air, surface-water, groundwater, and soil monitoring programs and their results (Sections 3.2 through 3.5). These programs focus on the potential routes for exposure to radioactive or nonradioactive materials referred to as pathways (inhalation and ingestion) by which potentially harmful materials could enter the body. A description of climatic conditions at Rocky Flats is contained in Section 3.1, Meteorology and Climatology.

Environmental protection efforts are aimed at minimizing the release of radioactive materials to the environment. Ecological studies are performed to assess both the short- and long-term implications of impacts to ecological resources that may have occurred in the past or are occurring at present. A detailed description of the Site's ecological studies is provided in Section 3.6, Ecological Studies.

In 1994, activities at Rocky Flats continued in environmental cleanup and restoration, waste management, and consolidation of special nuclear materials. Sections 4 through 7 of this report describe those activities.

Transition to New Mission

Rocky Flats Environmental Technology Site is owned by the DOE and has been operated by EG&G Rocky Flats, Inc. since 1990. Rocky Flats is transitioning from its historical production mission to a new mission focusing on the decontamination and decommissioning of facilities, environmental restoration, and waste management. An environmental surveillance program has been ongoing at Rocky Flats since the 1950s. Early programs focused on radiological impacts to the environment. The current program examines the potential radiological and nonradiological impacts to air, surface water, groundwater, and soil. The program also includes meteorological monitoring, ecological studies, and environmental remediation and waste management sampling programs. The description of these programs and the results of environmental monitoring form the basis of this annual SER.

The move from the production of weapons to environmental cleanup will be facilitated by a "transition process." The process begins when a building no longer needed for production and ends when the building is ready for decontamination, removal from service, or alternative uses.

This transition, which was initiated in 1992, will take a number of years to complete. After the transition, the mission of Rocky Flats will focus on environmental cleanup, which includes decontamination of buildings, cleanup of the environment, continued environmental monitoring, removal of plutonium residues, management of various waste forms, and storage of special nuclear materials and waste.

Included in this transition was a change of name for the facility and in the contractor responsible for the operation of the Site. On July 11, 1994, Rocky Flats Plant was renamed Rocky Flats Environmental Technology Site. On April 4, 1995, DOE Secretary O'Leary announced the awarding of the integrating contract for Rocky Flats to Kaiser-Hill Company. The change to the new integrating contractor is scheduled for July 1, 1995.

In addition, much work has been accomplished in the areas of Site planning and integration to provide recommendations for strategies, plans, and resource allocations to optimize progress toward DOE objectives. The *Rocky Flats Strategic Plan*[2] communicates the vision, goals, strategic objectives, strategies, and success criteria established to complete the current mission of Rocky Flats.

Site Location

Rocky Flats is located on approximately 6,550 acres in northern Jefferson County, Colorado. The facility is approximately 16 miles northwest of downtown Denver (Figure 1-1). From its first construction in the early 1950s, the original 2,520-acre site developed into an industrial complex consisting of over 440 permanent and temporary structures used as manufacturing, chemical processing, laboratory, support, and administrative facilities.

Although production activities have now ceased, many buildings still store radioactive waste materials and weapons components and require extensive effort and manpower to maintain safe and secure building conditions. In 1972, the surrounding 3,930-acre parcel Buffer Zone was acquired to minimize problems arising from the proximity of an industrial facility to the residential community. Land adjacent to the Buffer Zone is still used primarily for agricultural and mining purposes.

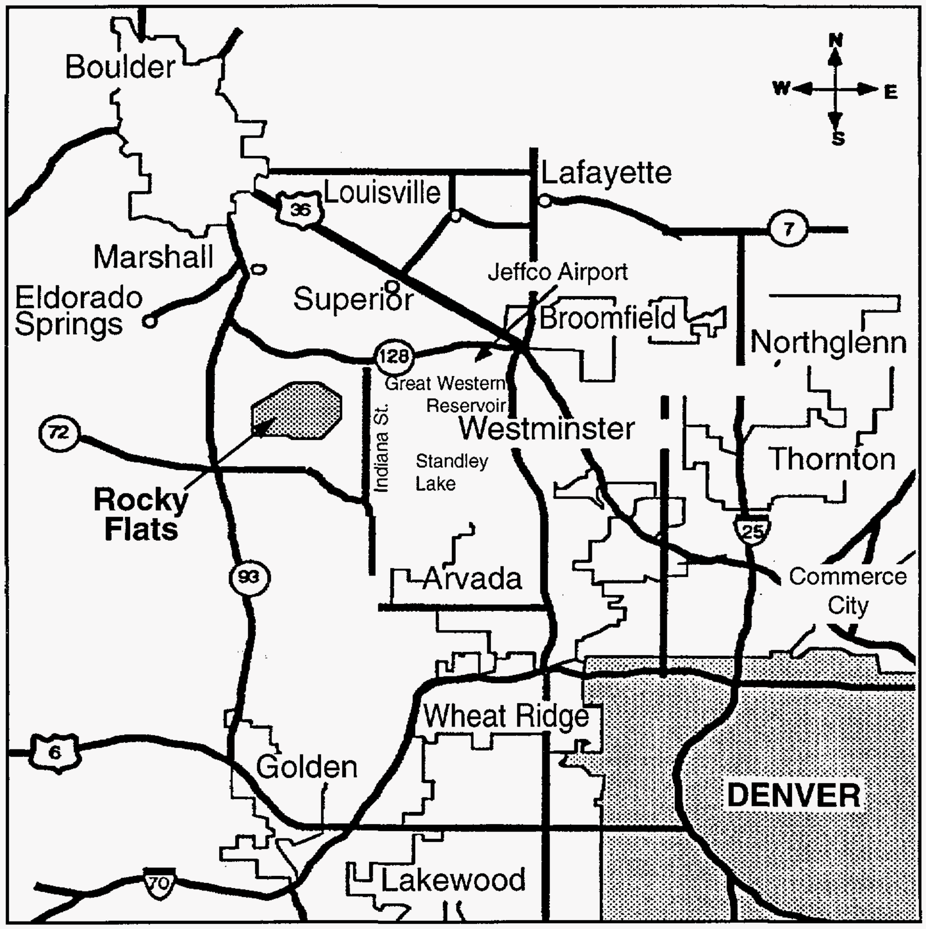


Figure 1-1. Area Map of Rocky Flats and Surrounding Communities

In the four decades since Rocky Flats was constructed, surrounding multi-use development has come closer, and the population of the Denver area has increased to the point where approximately 2.2 million people currently live within a 52-mile radius of the Site (see Figure 6-4 in Section 6, Radiation Dose Assessment). The growing public concern with the risks of radioactive contamination to the environment has been heightened by two highly publicized fires involving plutonium (Pu) in 1957 and 1969, by the windblown spread of small amounts of Pu-contaminated soil from a waste storage area in the early 1980s, and by the proximity of community reservoirs used as public water supplies.

Site Operations

The United States Atomic Energy Commission, the early predecessor to the DOE, originally announced plans to construct the Site in 1951. Construction of the facility began in 1952. The primary mission of the facility was to produce components for nuclear weapons from materials such as plutonium, uranium, beryllium, and various alloys of stainless steel. The first components were completed and shipped offsite in 1953. Additional plant missions included plutonium recovery and reprocessing, and waste management. Production activities included metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions.

The Dow Chemical Company was the first prime contractor for operations at Rocky Flats. Rockwell International replaced the Dow Chemical Company in 1975 and operated the facility through 1989. EG&G Rocky Flats, Inc., replaced Rockwell International in 1990. EG&G Rocky Flats employed 6,103 people in December 1994.

Environmental operations at Rocky Flats are under the jurisdiction of several local, state, and federal authorities, particularly the Colorado Department of Public Health and Environment (CDPHE), the Environmental Protection Agency (EPA), and DOE. A variety of reports are prepared at different intervals for these and other agencies in addition to this SER. A list of these reports is provided in Section 3 (Table 3-1).

Radiation at the Site

Radioactive materials and radiation-producing equipment are managed at Rocky Flats. Radiation-producing equipment includes X-ray machines and linear accelerators. Primary radioactive materials include plutonium, americium, and uranium. Small amounts of other radioactive materials, including tritium, have been or are also present. Many of these materials will continue to be handled at the Site as activities proceed with the decontamination of facilities and consolidation of materials for safe storage and eventual transfer to offsite locations. The potential exists for these materials to be handled in sufficient quantities during the transition process to pose an offsite hazard.

The most important potential contributor to radiation dose from these materials is alpha radiation emitted by plutonium, americium, and uranium. Because of the low penetrating ability of alpha radiation, these materials pose 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 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.

Section 6, Radiation Dose Assessment, describes the concepts of radiation and the assumptions used for determining the Rocky Flats radiation dose assessment for 1994. This section also includes discussion of radiation protection standards and natural background radiation dose. Section 7, Quality Assurance, provides information on the Quality Assurance (QA) measures in place at Rocky Flats which help ensure that work is performed in a manner that protects worker and public health and safety, provides quality of services, minimizes risk and supports compliance with all applicable regulatory requirements.

Environmental Reporting

Routine reports to local, state, and federal agencies and to the public provide information on the performance of Rocky Flats Environmental Monitoring Programs in maintaining and improving environmental quality and public health and safety. Table 1-1 provides a list of these reports. Of particular note is the *Monthly Environmental Monitoring Report,*[3] which provides results from the effluent air, ambient air, surface-water, and groundwater monitoring programs. These data are presented monthly at an Information Exchange meeting held in Broomfield, Colorado. Participants in this meeting include CDPHE, the U.S. Geological Survey (USGS), a ComRad representative, and the cities of Broomfield and Westminster. This exchange of information provides a forum for technical staff from the participating agencies and municipalities to examine the data and share the information with other interested parties. Table 1-2 contains the primary environmental compliance standards and applicable regulations for environmental monitoring programs at Rocky Flats.

Table 1-1
Environmental Reports

Regulatory Report[a]	Agency[b]	Frequency
Air Compliance Report (40 CFR 61.94)	EPA	Annual
Effluent Information System/Onsite Discharge Information System (EIS/ODIS)	DOE	Annual
Emergency and Hazardous Chemical Inventory Forms (Tier II)	[c]	Annual
Toxic Chemical Release Inventory (Form R)	EPA	Annual
National Pollutant Discharge Elimination System/Discharge Monitoring Report	EPA/CDPHE	Monthly/ Annual
Polychlorinated Biphenyls (PCB) Inventory	EPA	Annual
Resource Conservation and Recovery Act Groundwater Monitoring Report	EPA/CDPHE	Annual/ Quarterly
Monthly Environmental Monitoring Report	DOE/EPA/CDPHE/ County/City	Monthly
Site Environmental Report	DOE	Annual
Groundwater Protection and Monitoring Program Plan	DOE	Annual
Background Geochemical Characterization Report	EPA/CDPHE	Annual[d]

a. Reports on major environmental programs prepared on a periodic basis
b. EPA - Environmental Protection Agency; DOE - Department of Energy; CDPHE - Colorado Department of Public Health and Environment; County - Jefferson; Cities - Arvada, Broomfield, Westminster, Denver, Boulder, Northglenn, Fort Collins, Thornton
c. Colorado Emergency Planning Commission
Jefferson County Emergency Planning Committee
Boulder County Emergency Planning Committee
Rocky Flats Fire Department
d. Final Annual Report was submitted in September 1993; no additional reports are planned

Table 1-2
Primary Compliance Standards and Applicable Regulations for Environmental Monitoring Programs

Monitoring Program	Compliance Standards
AIR	
Effluent Air	• Standards for Performance for New Stationary Sources (40 CFR 60) • National Emission Standards for Hazardous Air Pollutants (40 CFR 61) • Colorado Air Quality Control Regulations #3, #6, #7, #8, and #15 (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	• National Ambient Air Quality Standards and State Implementation Plans (40 CFR 50), Requirements for Preparation, Adoption, and Submittal of Implementation Plans (40 CFR 51), and Approval and Promulgation of Implementation Plans (40 CFR 52) • Colorado Air Quality Control Commission Regulations #1, #2, #3, and #8 (5 CCR 1001) • Colorado Air Pollution Control and Prevention Act, 1992 (25 CRS, Article 7, Part 1) • 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	• General Environmental Protection Program (DOE Order 5400.1) • Environmental, Safety, and Health Program for Department of Energy Operations (DOE Order 5480.1B) • National Emission Standards for Hazardous Air Pollutants (40 CFR 61, Subpart H)
SURFACE WATER	
Surface Water	• Clean Water Act • National Pollutant Discharge Elimination System (40 CFR 122 and 125) • Discharge of Oil (40 CFR 110) • Oil Pollution Prevention (40 CFR 112) • Criteria and Standards for the National Pollutant Discharge Elimination System (40 CFR 125) • Oil Pollution Prevention Act • Federal Insecticide, Fungicide, and Rodenticide Act • Federal Facilities Compliance Agreement • Colorado Water Quality Control Commission Surface Water Standards (5 CCR 1000) • General Environmental Protection Program (DOE Order 5400.1 - Chapters II, IV) • Environmental Compliance Issue Coordination (DOE Order 5400.2) • Environmental, Safety, and Health Program for DOE Operations (DOE Order 5480.1B • Radiation Protection for Occupational Workers (DOE Order 5480.11) • Radiation Protection of the Public and the Environment (DOE Order 5400.5 - Chapters I, II) • General Design Requirements (DOE Order 6430.1A) • Interim Measure/Interim Remedial Action Monitoring and Control • Interagency Agreement
Community Water	• National Interim Primary Drinking Water Regulations (40 CFR 141) • Colorado Primary Drinking Water Regulations (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	• Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. 9601) • Resource Conservation and Recovery Act (42 U.S.C. 6901) • *Colorado Hazardous Waste Management Act* (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 • Agreement in Principle to Sample Boundary Wells.

Table 1-2 (Continued)
Primary Compliance Standards and Applicable Regulations for Environmental Monitoring Programs

SOILS	• United States Atomic Energy Commission, 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	• 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)
ALL PROGRAMS	• Quality Assurance Requirements (10 CFR 830.20)

References

1. United States Department of Energy, Order 5400.1, *General Environmental Protection Program,* Washington, D.C., November 9, 1988.

2. United States Department of Energy, Rocky Flats Field Office, *Rocky Flats Strategic Plan,* Golden, Colorado, September 19, 1994.

3. EG&G Rocky Flats, Inc., *Monthly Environmental Monitoring Report,* Golden, Colorado, January to December, 1994.

2.0 COMPLIANCE SUMMARY

2.1 REGULATORY OVERVIEW

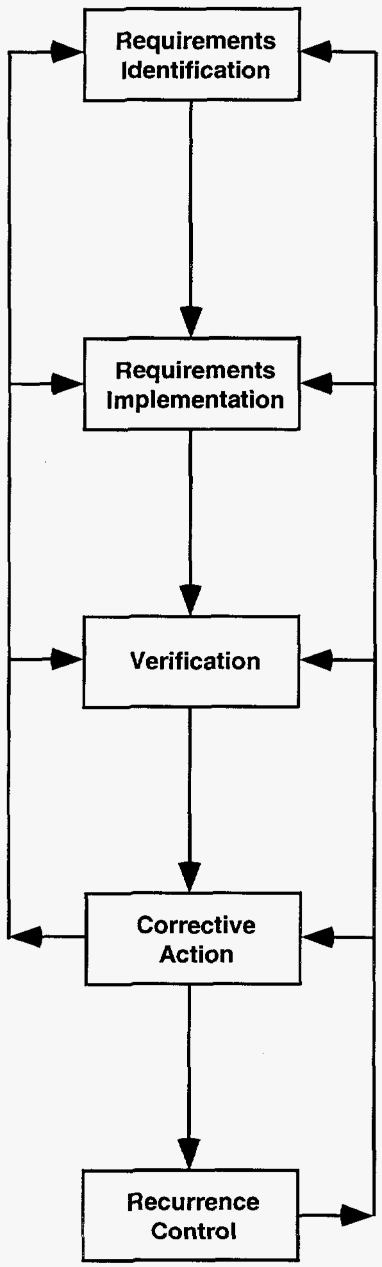
Historically, all Rocky Flats operations were governed by the Atomic Energy Act, the Department of Energy Organization Act, and the Energy Reorganization Act. These federal statutes still regulate defense- and nuclear-related activities at DOE facilities and are a source of authority for the promulgation of Secretary of Energy Notices, DOE Orders, and federal regulations drafted by DOE. However, since the suspension of plutonium operations at the Site in 1989 and the subsequent change in mission from nuclear weapons production to environmental cleanup and conversion to alternative beneficial uses, environmental laws have become a major driver for Site planning and operations.

The principal agencies responsible for enforcing and overseeing environmental requirements at Rocky Flats include Region VIII of EPA and CDPHE. These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect the facilities and operations, and oversee compliance with applicable regulations, orders, and agreements. DOE, through compliance audits and its directives to field offices, initiates and assesses actions to meet environmental requirements.

This section summarizes the activities conducted to verify that Rocky Flats is in compliance with federal and state environmental protection statutes and associated implementing regulations. The environmental compliance activities encompass several basic elements which are illustrated in Figure 2.1-1. Each of these elements, in various combinations and degrees of application, can be found in the individual environmental compliance systems in place at Rocky Flats and are evidence of the commitment to comply with all applicable environmental statutes, regulations, Executive Orders, DOE Orders, and compliance agreements with EPA and state agencies. More detailed information on the programs and activities conducted by the Site are found in later sections of this report.

2.2 CLEAN AIR ACT

The federal Clean Air Act (CAA), as amended by the Clean Air Act Amendments (CAAA) of 1990, sets standards of performance for sources that generate air pollutants and establishes ambient air quality standards to ensure protection of public health and the environment. The federal regulatory agency of authority is the EPA.



(Process Outputs and Activities)

- Standards
- Laws
- DOE Orders
- Best Management Practices
- Policies
- Level 1 Procedures Management Plans
- Program Descriptions
- Permits

- Plans (lower level)
- Procedures (Levels 2,3,4, Standard Operating Procedure)
- Training
- Actions
- Manuals
- Community Relations
- Shift & Operations Orders

- Self Evaluations
- Audits
- Assessments
- Inspections
- Surveillances
- External Oversight

- Revise procedures, policies, plans
- Plant ActionTracking System
- Occurrence Reporting and Processing System
- Issues Management
- Verification
- Sitewide Corrective Action Program

- Revise procedures policies, plans
- Revise training
- Tracking and trending
- New policies, plans, procedures

Figure 2.1-1. Environmental Compliance Process Flow

States may administer and enforce CAA provisions by obtaining EPA approval of a State Implementation Plan (SIP). Colorado was granted such CAA primacy by EPA for air pollutants other than radioactive materials. The 1992 Colorado Air Pollution Prevention and Control Act established Colorado's program of air pollution control, with implementing regulations promulgated by the Colorado Air Quality Control Commission (CAQCC).

National Emission Standards for Hazardous Air Pollutants (NESHAP) govern radioactive and other hazardous air pollutants. The Air Pollution Control Division (APCD) of CDPHE was granted authority by EPA to regulate CAA-identified hazardous pollutants including NESHAP for beryllium, mercury, vinyl chloride, and asbestos, as well as the 1990 CAAA Title III listed hazardous air pollutants. Authority to regulate radionuclides remains with EPA.

Since 1989, NESHAPS have limited the radiation dose to the public from airborne radionuclide emissions from DOE facilities to less than 10 millirem per year (mrem/yr) effective dose equivalent (EDE). A compliance report with dose calculations covering the previous calendar year is due to EPA by June 30 of each year for the previous calendar year. The 1994 report showed an EDE to the public of 0.08 to 0.1 mrem from radiologically contaminated soil and building emissions. Dose calculations for the 1994 calendar year are provided in Section 6, Radiation Dose Assessment.

During 1994, the EPA determined that Colorado must have authority to implement and enforce the provisions of the radionuclide NESHAP when issuing Federal CAA Title V Operating Permits to any major source subject to the radionuclide NESHAP. This will require the development of a Colorado radionuclide NESHAP program through adoption of new state regulations. The CAQCC must finalize all regulatory actions on this issue prior to November 1996.

CAQCC Regulation No. 3

Enforcement and implementation of air regulations concerning nonradionuclide air pollutant emissions have been delegated by the State to CDPHE, APCD. The CAQCC Regulation No. 3 establishes regulations that govern air emission inventory reporting and air permits. No Notices of Violations (NOV) were issued to the Site in 1994 for violations of state regulations for sources of nonradionuclide air pollutant emissions. Air Permit conditions were not exceeded by any permitted source.

Air Pollutant Emission Notices (APENs) - Under the provisions of Regulation No. 3, APENs must be submitted to CDPHE for any existing or new source of air pollutants from which regulated air pollutants are emitted above levels specified in Regulation No. 3. APENs provide source-specific data, the quantity and composition of the air emissions generated from source operations, and support information for air permit applications. When viewed as a related body of information, APENs make up the Site nonradionuclide air emission inventory.

As of January 1, 1994, 71 APENs were on file with the state for Site operations during 1993-94 and four new APEN submittals were provided to CDPHE for new or modified operations. The 75 APENs represent the criteria and nonradionuclide hazardous air pollutant inventory and reflect plantwide operations under the 1994 Site mission. During 1994 six additional APEN Reports were provided to CDPHE. A list of the buildings and operations for which new APENs and reports were submitted in 1994 is provided in Table 2.2-1.

Table 2.2-1
Air Pollutant Emission Notices and/or Reports Submitted or Resubmitted in 1994

Building Reference Number(s)	Building/Operation Description	Date Submitted To CDPHE
Building 374 (Revision 3)	Waste Treatment Process	10/07/94
Building 371 (Revision 4)	Actinide Solution Stabilization Project	11/22/94
Building 771 (Revision 4)	Actinide Solution Stabilization Project	11/22/94
New Sanitary Landfill	Construction Phase	04/19/94
Environmental Restoration Generator 1	Caterpillar Generator 320 kW	04/12/94
Environmental Restoration Generator 2	Caterpillar Generator 320 kW	07/12/94

Colorado Air Permits - The Colorado Air Permit Program is designed to control the release of air pollutant emissions from stationary sources in order to meet ambient air quality standards and hazardous air pollutant emissions standards. Under provisions of CAQCC Regulation No. 3, air emission permits must be obtained for each source of regulated air pollutants before the construction, modification, or operation of the source. Permits are obtained for source-specific operations and may require monitoring of point-source emissions and reporting of results. Table 2.2-2 lists the status of the current air emission permits for the Site.

As part of the 1993 changes to CAQCC Regulation No. 3, select source categories and sources emitting regulated pollutants below *de minimis* thresholds were deemed to have a negligible impact on air quality and were exempt from permit requirements. In response to this regulatory change and changes in Site operations, CDPHE was requested in 1994 to cancel nine air emission permits. This resulted in the cancellation of eight permits for exempt and discontinued sources and a delayed decision on the permit for Building 123 laboratory operations (pending review by the Colorado Attorney General of Regulation No. 3 language). In addition, the permit for Environmental Restoration fugitive dust sources expired.

Table 2.2-2
Air Emission Permits (Active)

BUILDING/EMISSION SOURCE	PERMIT #	PERMIT STATUS
Bldg. 123, urinalysis fume hood	86JE018	Categorical source exemption, requested permit cancellation 12/93, awaiting determination of lab exemption by Attorney General's Office
Bldg. 776, Supercompactor and Repackaging Facility (SARF) Transuranic Waste Shredder	91JE047	Initial permit issued 12/91, final review by CDPHE completed, awaiting issuance of final permit
Bldg. 910, three natural gas generators	91JE316-1	Initial permit issued 7/92, inactive source, removal of permit being considered by management
Bldg. 910, one natural gas water heater	91JE316-2	Final permit issued 2/93, inactive source, removal of permit being considered by management
Bldg. 374, salt crete operations	93JE542	Initial permit issued 11/93, CDPHE inspection complete, awaiting issuance of final permit
Bldg. 443, steam plant boilers (4 units)	92JE833(1-4)	Initial permits issued 2/94, CDPHE inspection completed, awaiting issuance of final permits
Emergency generators: Buildings 120, 566, 708(B), 708(C), 715A, 776, 881G (2 units), 920, 762A (PACS-1), 372A (PACS-2), 792A (PACS-3), Portables A and B, 124, 127, 371, 427, 443 (2 units), 559, 562, 708(A), 715, 727, 729, 779, 827, 989, Environmental Restoration (ER) 320 kW generators (2 units), and the ER generator trailer (2 units); Diesel-fired pumps, Buildings 373, 708, 711, and 928; Air compressors, Buildings 995 and 331	93JE1349	Initial permit issued 3/94, final approval of permit will occur after completion of opacity readings
Sanitary Landfill Construction	94JE282	Initial permit issued 8/17/94

The 1994 new or revised permit application activity included the following: (1) a new permit application was submitted for the New Sanitary Landfill - Construction Phase; (2) the diesel-fired internal combustion engine "bubble" permit was revised to include two new Environmental Restoration generators; and (3) the Building 374 permit was revised to include the planned changes to Building 374 equipment and operations.

Operating Permit Program - The 1992 Colorado Air Pollution Prevention and Control Act includes provisions to comply with the 1990 Federal CAAA. As a result, CAQCC passed revisions to Regulation No. 3 that implement a state-administered Operating Permit Program meeting the requirements of Title V of the CAAA. Under the guidelines of these new regulations, the Site has been identified by CDPHE as a major source of air pollutants and needs to develop a facility Operating Permit Application (OPA). A notification was received from CDPHE, APCD in

November 1994 indicating that the Site was obligated to submit a permit application prior to January 1, 1996. The OPA must be submitted to both CDPHE, APCD and EPA for regulatory review. During the review process the Site will operate under transitional status known as the Permit Application Shield. Once issued, the Operating Permit is valid for a term of five years.

During 1994, plans were developed and an extensive effort initiated to identify and resolve the issues associated with the preparation of the permit application. The OPA will be a comprehensive Site permit that will describe intended operating regimes and emission levels, applicable air pollution control requirements, applicable regulatory requirements, current compliance statuses, future compliance activities, and reporting requirements for each emission unit. Work on the OPA Development Project occupied the majority of 1994 and will extend through calendar year 1995.

A sitewide compliance program should be developed that will describe the actions required for each environmental unit to demonstrate regulatory compliance with OPA. This will include record-keeping requirements, emission monitoring conditions, control technology needs, and data quality control and assurance procedures. Documentation describing this compliance program must be submitted as part of the OPA.

CAQCC Regulation No. 8

CAQCC Regulation No. 8 implements NESHAP for nonradioactive hazardous air pollutants (HAPs) in Colorado. Work standards, emission limitations, and ambient air standards for HAPs are specified in this regulation. Potential HAPs at the Site include asbestos and beryllium. Asbestos was used as insulation in older facilities and is handled according to NESHAP regulations during demolition, renovation, or disposal. Beryllium was regularly machined at Rocky Flats prior to the suspension of manufacturing operations in 1989. The emissions standard is 10 grams (g) of beryllium over a 24-hour period. Beryllium emissions did not exceed this standard in 1994 (see Section 3.2, Air Monitoring).

Beryllium Effluent Monitoring and Analysis Program - Suspended plutonium and beryllium manufacturing operations have not resumed since the curtailment of production, and the existing Beryllium monitoring program should be realigned to match current Site needs. During 1994, successful discussions were held with CDPHE, APCD to identify needed changes to the effluent program which include discontinuing sampling where there is no potential for release and the continuation of sampling where the potential may exist. It is anticipated that CDPHE, APCD will provide final assessment and approval of changes in early 1995.

Air Toxics Program - CAQCC Regulation No. 8 was revised in December 1994 to incorporate the requirements of the 1990 Federal CAAA Title III Air Toxics Program. Under the new air toxics program, a list of 189 HAPs was established for regulation. This list includes all of the HAPs regulated under the NESHAP program. Control of HAP emissions will be through standards to be set for categories of sources that emit HAPs rather than for the pollutants themselves. Standards promulgated prior to 1990 under the NESHAP program will generally remain applicable until they are reviewed and revised.

CAQCC Regulation No. 15

Reportable Refrigerant Losses - CAQCC Regulation No. 15 requires the reporting of catastrophic losses of refrigerants. "Catastrophic loss" is any loss of refrigerant from registered equipment that is 50 percent or 200 pounds of the equipment's charge, whichever is less. Refrigerant losses from registered chillers were reported to CDPHE in April and July 1994. Leaks on chillers AQD 708-002 and AQD 708-003 were discovered and repaired in April 1994. In July and August 1994, 1,125 pounds of Freon-500 were added to chiller AQD 374-001 following maintenance to get the chiller running. The chiller was not in operation when it was registered with CDPHE in November 1993. Records indicate that these losses resulted from slow leaks over time and should not be categorized as "catastrophic losses."

Stratospheric Ozone Protection - CAQCC Regulation No. 15 incorporates requirements from 40 CFR 82, Subparts B and F. The other subparts apply to the Site but are implemented by EPA since they have not been included in CAQCC regulations. A summary of ozone depleting substances (ODS) used at Rocky Flats and the compliance activities related to stratospheric ozone protection regulations are provided in Table 2.2-3.

Ozone Depleting Substances Phaseout Activities - In August 1994, a CFC Retrofit/Conversion Team composed of representatives from several Site departments was formed. The team is tasked to develop, maintain, and implement an ozone-depleting substance retrofit/conversion plan to effectively and efficiently guide Rocky Flats through the retrofit/conversion process.

Table 2.2-3
Ozone Depleting Substances

SOURCES	COMPLIANCE INFORMATION
Stationary Refrigeration	In Buildings 708,776, 779, installation of high-efficiency purges and re-seating pressure relief valves for eight stationary refrigeration systems was completed in September 1994. Sixteen specialized maintenance technicians obtained EPA-approved certifications by November 1994 and are authorized to perform activities with the potential for freon contact.
Motor Vehicles	The Site Garage has established a tracking system to maintain accurate and complete records of air-conditioner servicing and refrigerant usage of the Site's vehicle fleet. Five Site technicians have completed EPA-approved certification programs and are authorized to operate the recovery equipment.
Halon Fire Suppression Systems	The Site Fire Department uses Halon 1211 in fire extinguishers and Halon 1301 in building fire-suppression systems. There are approximately 1,300 halon fire extinguishers and 14 Halon Fixed Fire Suppression Systems onsite. Replacements will consist of dry chemical, carbon dioxide (CO_2), and pressurized water units, as appropriate.
General Solvents	Historically, carbon tetrachloride (CCl_4), Freon-113, and trichloroethane (TCA) have been used in various laboratory and production processes at Rocky Flats as cleaning agents or solvents. Efforts to phase out chlorinated solvent usage have included investigations of alternative cleaning methods and alternative density determination methods.

2.3 CLEAN WATER ACT

The Clean Water Act (CWA), originally passed by Congress in 1972, established ambitious goals to control pollutants discharged to United States' surface waters. Among the main elements of the CWA were nationally applicable, technology-based effluent limitations set by EPA for specific industry categories and water quality standards set by states. The CWA also provided for the National Pollutant Discharge Elimination System (NPDES), a program requiring permits for discharges from a point source into surface waters of the United States. The first phase for expanding the NPDES to nonpoint sources is now underway with the issuance of storm water discharge permits to medium and large municipalities and facilities with industrial activity.

The EPA and the State of Colorado both have roles in determining the Site's compliance with the CWA. While Region VIII of the EPA issues and administers the NPDES permit for the Site, the state, through the Colorado Water Quality Control Commission (CWQCC), sets surface water quality standards for receiving streams and bodies of water, including standards for the stream segments immediately downstream of the Site. The state is also required to ratify federal permits issued within its borders and to ensure that they contain sufficient terms to protect water quality standards in the receiving stream.

National Pollutant Discharge Elimination System Permit Program

The NPDES permit program controls the release of pollutants into the waters of the United States and requires routine monitoring of point source discharges and reporting of results. The Site's first NPDES permit was issued by EPA in 1974. The permit was reissued by EPA in 1984, expired in 1989, and was extended administratively until renewed. An updated renewal application was submitted in March 1993.

The NPDES permit[1] for the Site (#CO-0001333) identifies seven monitoring points for control of discharges. Three of these discharge points, Ponds A-4, B-5, and C-2, are capable of discharging water offsite. The NPDES permit terms were modified in three major areas by the NPDES Federal Facility Compliance Agreement (FFCA), signed on March 25, 1991, by DOE and EPA: (1) the elimination of two inactive discharge points and the inclusion of new monitoring parameters at the other discharge locations; (2) the submittal of three compliance plans addressing administrative and physical changes to the plant; and (3) the submittal of quarterly progress reports to EPA updating the status and schedule of projects within each compliance plan. Other revisions to the NPDES monitoring requirements included changing one "point of compliance" location from Pond B-3 to the Wastewater Treatment Plant (WWTP) (also known as the Sewage Treatment Plant). Also added were monitoring requirements for total chromium and whole effluent toxicity (WET) at the terminal ponds and monitoring for metals, volatile organic compounds (VOCs), and WET at the WWTP discharge point.

EPA delivered a draft NPDES permit in February 1994. The discharge points identified were limited to the WWTP, Building 374 product water, and the storm water monitoring stations. The other previously NPDES-permitted discharge locations would be regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) if the Interim Measures/Interim Remediation Action (IM/IRA) were implemented. The first IM/IRA draft document was delivered to EPA and CDPHE on November 23, 1993 and a dispute resolution was signed on April 15, 1994 by the Senior Executive Committee as allowed by the Interagency Agreement (IAG). The draft IM/IRA was rewritten and submitted to EPA and CDPHE on October 14, 1994. No comments on the document had been returned by the Agencies by year's end.

No NOVs were issued to the Site in 1994 for violation of NPDES standards. There were no exceedances of NPDES permit limitations at any of the authorized outfalls during 1994.

The 1989 Agreement in Principle (AIP) between DOE and CDPHE established a procedure whereby the Site would provide CDPHE with split samples of water proposed for discharge from the terminal ponds to allow CDPHE to assess the "safety" of a discharge. When CDPHE makes its assessment and gives concurrence for discharge, pond waters are routed through the Broomfield Diversion Ditch to Walnut Creek downstream of Great Western Reservoir. Although the AIP expired September 30, 1994, and is being renegotiated, Rocky Flats continues to comply with its provisions.

The NPDES permit recommends, as a Best Management Practice (BMP), the maintenance of terminal pond water levels at a maximum of 10 percent of capacity to allow sufficient storage volume for spill containment and flood control. Because of inherent delays caused by concurrent sampling and analysis and continuing storage of inflows, Ponds A-4, B-5, and C-2 often hold more than 10 percent of pond capacity.

The discovery in 1989 of herbicides in Pond C-2 resulted in the termination of discharge through the outlet valves. Herbicides are not now found in Pond C-2. Rocky Flats submitted a valve test plan to CDPHE and the municipalities. On the recommendation of CDPHE and the surrounding municipalities, Rocky Flats prepared a "waiver request" to temporarily suspend the valve testing requirements. Response from the Office of the State Engineer had not yet been received by year's end.

During 1994, significant progress was made on the compliance plans required by the NPDES FFCA. Accomplishments and activities that occurred in 1994 on the compliance plans are provided below.

Groundwater Monitoring Plan for the WWTP Sludge Drying Beds - The *1994 Draft Final Groundwater Protection and Monitoring Program Plan*[2] implemented a method for characterizing groundwater beneath the sludge drying beds located east of the WWTP. The final phase of this four-year, $1.2 million project was completed in March 1994 and the EPA has been briefed on the results of this investigation.

Sewage Treatment Plant Compliance Plan - The *Federal Facilities Compliance Agreement Sewage Treatment Plant Compliance Plan*[3] of 1990 described planned improvements to the WWTP necessary to meet NPDES water quality standards and FFCA criteria. Completed work includes implementation of recommendations from diagnostic studies of treatment plant operations, installation of an autochlorination/ dechlorination system, and additional influent and effluent instrumentation.

Other planned improvements are included in a treatment plant upgrade project consisting of three phases: (1) construction of a mechanical sludge drying system, which was ready for routine operations in December 1993; (2) electrical improvements, construction of an addition to the existing laboratory building, upgrades to existing structures and equipment, and additional chemical storage which began in 1994 and are expected to be completed in 1996; and (3) construction of additional influent and effluent storage, modification of the existing plant to provide for nitrification, and construction of a new denitrification system. The final scope and schedule of the third phase will be addressed in the renewed NPDES permit.

Chromic Acid Incident Plan and Implementation Schedule - These documents were prepared following an unplanned release of chromic acid solution from Building 444 in 1989, and are intended to reduce the possibility and impact of future spill events. The Drain Identification Study will identify all connections to the WWTP and the Tank Management Program will provide a comprehensive inventory and inspection of all the above-ground storage tanks on the Site. Work initiated in 1992 was 70 percent complete by December 1994.

Spill Prevention Control and Countermeasures/Best Management Practices Plan - The Spill Prevention Control and Countermeasures/Best Management Practices Plan (SPCC/BMP) is a compilation of existing facility improvements, operational procedures, policies, and requirements for control of hazardous substance and oil spills. The current SPCC/BMP Plan was updated in September 1992 to meet the triennial review requirement. An Oil Pollution Prevention Plan was completed in 1994 to meet the requirements of the Oil Pollution Act of 1990. Storm Water Pollution Prevention Plan (SWPPP) provisions are expected in the renewed NPDES permit; a draft SWPPP was initiated in 1994.

Storm Water Permit Application - Rocky Flats submitted the required NPDES storm water permit application in 1992. Prior to the application, six storm water monitoring locations were established to provide storm water quality information for runoff that leaves the Industrial Area of the Site. Automated sampling equipment was installed to characterize the runoff, while data loggers collected the stored flow information at each monitoring location. Rocky Flats received the draft storm water requirements in February 1994.

Colorado Water Quality Control Commission Water Quality Standards

Surface Water - Effective March 1990, the CWQCC resegmented Big Dry Creek and revised use classifications and water quality standards for Woman Creek, Walnut Creek, Standley Lake, and Great Western Reservoir. Woman Creek and Walnut Creek are the Site's principal drainages. 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 stringent stream standards for Segment 4 of Big Dry Creek (from pond outlets to Standley Lake and Great Western Reservoir). "Goal" standards indicate that the waters at present are not fully suitable for classified use and that a temporary modification for one or more of the underlying numeric standards was granted. Stream standards were adopted for organic and inorganic chemicals, metals, radionuclides, and certain physical and biological parameters.

Subsequently, Rocky Flats requested an extension of the goal qualifiers and temporary modifications and asked the CWQCC to revise the site-specific organic standards to achieve consistency with the statewide numeric standards for organic chemicals. The CWQCC rejected the proposal to continue the narrative ambient modifiers for 3 additional years, and instead agreed to impose Segment 4 standards on Segment 5, but with temporary modifications for nine parameters. The CWQCC did accept several additional modifications to Segment 4 and 5 standards put forth by Rocky Flats to make the specific standards consistent with statewide standards for organic constituents. The Commission also adopted a standard for beryllium. These actions became final in March 1993.

In April 1994, CWQCC extended the temporary modification for radionuclide parameters on Segment 5 to allow the scheduled statewide and Rocky Flats site-specific radionuclide hearings to proceed before the temporary modification expires. The Commission also rescheduled the additional matter of standards and classification of Segments 4 and 5 for April 1995.

Groundwater - In March 1991, the CWQCC adopted site-specific standards and use classifications for the groundwater underlying Rocky Flats. This regulation (5 CCR 1002-8, Section 3.12.7) classifies the alluvial groundwater as (1) Domestic Use Quality, (2) Agricultural Use Quality, and (3) Surface Water Protection.

The designation of the alluvial groundwater as "Surface Water Protection" was intended to ensure that the groundwater capable of influencing surface water quality in Woman and Walnut Creek was designated with a protective use classification until the project for the permanent diversion of Site surface water around Standley Lake and the replacement of water from Great Western Reservoir is completed.

Classifications for groundwater occurring in the underlying Arapahoe and Laramie/Fox Hills bedrock aquifers are not specifically given in the regulation, although it is clear that the unconfined portions of these aquifers are considered to be part of the shallow groundwater, and would therefore, have the same classifications as the alluvial groundwater. The deeper, confined portions of these aquifers at Rocky Flats are not considered to be hydraulically connected to surface water, and are not mentioned in the regulation.

In 1994, a comprehensive programmatic evaluation of the groundwater program at the Site was completed. This report[4] was the result of a self-initiated, independent assessment of the program with respect to 34 specific criteria encompassing the requirements of RCRA, CERCLA, and DOE Orders. The report discusses each criterion and related findings and recommendations in detail. Additionally, the *1994 Draft Final Groundwater Protection and Monitoring Program Plan*[5] provides a detailed discussion of the groundwater program compliance status and a current progress report on the efforts to address the results of the assessment.

2.4 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT

The CERCLA and its major amendments (Superfund Amendments and Reauthorization Act - [SARA]) provide funding and enforcement authority for the restoration of hazardous substance sites (at primarily inactive facilities) and for responding to hazardous substance spills. Those sites contaminated by past activities must be investigated and remediation plans developed and implemented. The intent of these actions is to minimize the release of hazardous substances, pollutants, or contaminants, thereby protecting human health and the environment. The CERCLA requirements are addressed in phases designed to investigate, remediate, and complete the restoration of contaminated sites. These requirements generally rely on standards from a variety of federal and state environmental laws and guidance through the applicable or relevant and appropriate requirements (ARARs) process. Rocky Flats was added to CERCLA's National Priorities List (NPL) in 1989. CERCLA activities at Rocky Flats are generally implemented through the IAG described later in this section.

Any release of a hazardous substance in excess of the "reportable quantities" established under Section 102 of CERCLA must be reported immediately to the National Response Center (NRC). SARA also provided for the assessment of natural resource injury and for the recovery of natural resource damages under the Code of Federal Regulations (CFR) 43 CFR 11. The Natural Resource Damage Assessment (NRDA) is a key subject in the Memorandum of Understanding (MOU) signed by DOE and the Natural Resource Trustees in November 1994. With the approval of the MOU, trustee review of RCRA/CERCLA activities will take place as provided for under the IAG.

National Response Center Notifications

In 1994 the NRC was notified of one release at Rocky Flats in accordance with the requirements of 40 CFR 302.6. The notification was made on March 31, 1994, when approximately 35 gallons of decanted solar pond water was spilled from a tanker onto the roads between the 750 pad and Building 231. The release occurred because the cap on the transfer tanker had not been secured. The Area Operations Manager confirmed that there was no impact to the soil. The report to the NRC was made based on a conservative interpretation for calculating the reportable quantity of F-listed hazardous waste.

Emergency Planning And Community Right-To-Know Act

The Emergency Planning and Community Right-to-Know Act (EPCRA) was enacted as a freestanding provision of SARA in 1986. Also known as SARA Title III, EPCRA contains four major provisions, which are listed below.

- Chemical emergencies planning
- Emergency notification of chemical accidents and releases
- Hazardous chemical inventories reporting
- Toxic chemical release reporting

These provisions require Rocky Flats to notify state and local emergency planning entities of the presence of potentially hazardous substances on the Site and to report the inventories and environmental releases of those substances. The intent of these requirements is to provide the public with information on hazardous chemicals in their communities, enhance public awareness of chemical hazards, and facilitate development of state and local emergency response plans. Rocky Flats maintains an emergency preparedness document for the Site and conducts annual mock emergency response scenarios to determine the effectiveness of the plan and the ability of Site organizations to respond.

Executive Order 12856 (August 1993) required all federal agencies to comply with EPCRA and committed the federal government to participation in the SARA 313 Toxic Release Inventory Program by 1994. This Executive Order is aimed at full compliance with SARA Title III and reduction of the release of 17 priority chemicals by 50 percent before the end of 1999.

In 1994, there were no releases of extremely hazardous substances or CERCLA hazardous substances that posed a potential impact beyond the Site's boundaries and required notification to the State Emergency Response Commission (SERC). The Tier II report required by EPCRA has been submitted yearly by Rocky Flats since 1988. Chemical releases to the environment for the reporting years 1991, 1992, and 1993 as submitted on Form R of the Toxic Chemical Release Inventory are indicated in Table 2.4-1.

Table 2.4-1
Chemicals Released to the Environment as Reported on Form R*

Chemical	1991	1992	1993
Nitric acid	4,146 lbs.	2,960 lbs.	3,112 lbs.
Sulfuric Acid	-	12	19
Hydrochloric acid	-	625	332
Phosphoric Acid	-	-	50

*Form R is required to be filed by July 1 of each year and reports data for the previous year's operations.

Interagency Agreement

The 1991 Federal Facility Agreement and Consent Order, commonly referred to as the "IAG," delineates roles and responsibilities among DOE, CDPHE, and EPA, and establishes schedules for completing environmental restoration activities at the Site's 16 Operable Units (OUs). The IAG relies on a variety of other legal sources for specific guidance on how to undertake environmental restoration, including CERCLA and RCRA. It also provides mechanisms for resolving issues that may arise among the participants during cleanup activities. A complete listing of all the IAG milestones is found in the Interagency Agreement[6], and a series of monthly and quarterly Environmental Compliance Action reports document progress against IAG milestones.[7] Table 2.4-2 shows the current prioritization of the OUs, and Table 2.4-3 lists the IAG milestones completed in 1994. Section 4 of this report, Environmental Remediation, describes 1994 remediation activities at the Site.

The IAG requires that the DOE notify the public of any changes to the schedule set by the agreement and stipulates that various additional measures be taken for improved public involvement. DOE addresses these public involvement commitments in the Community Relations Plan described at the end of this section.

While many of the IAG milestones have been met, the established schedules for others have proven to be unworkable. In July 1994, the IAG signatories settled their differences over a series of 14 unmet administrative milestones. The settlement totaled $2.8 million, which DOE will provide to various environmental initiatives.[8] CDPHE and EPA agreed not to issue NOVs to DOE for any of the milestones covered in the agreement through January 1995. DOE, CDPHE, and EPA entered into negotiations in 1994 to amend the IAG. No agreement had been reached by year's end and the parties continue to work toward modifying the milestones.

Table 2.4-2
Prioritization of Operable Units by the IAG

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

*Final No Action Record of Decision approved October 1994.

Table 2.4-3
IAG Milestones Completed in 1994

IAG Milestone	Operable Unit
Final Treatability Study Report	Sitewide
Draft Decision Document Industrial Area (IA) IM/IRA	Sitewide
Draft Responsiveness Summary (IA IM/IRA)	Sitewide
Final Responsiveness Summary (IA IM/IRA)	Sitewide
Final Decision Document (IA IM/IRA)	Sitewide
Draft Corrective Measures Study/Feasibility Study Report	1
Submit Draft Proposed Plan	1
Submit Draft Phase I Proposed IM/IRA Decision Document	4
Submit Draft Phase II RFI/RI Work Plan	4
Submit Final Phase II RFI/RI Work Plan	4
Submit Draft Phase I RFI/RI Report	7
Draft Revised Phase I Work Plan Technical Memorandum	7
Submit Final Phase I RFI/RI Report	7
Final Phase II RFI/RI Work Plan	7
Final Revised Phase I Work Plan Technical Memorandum	7
Submit Preliminary Draft Leachate Collection IM/IRA	7
Release Final Draft Leachate Collection IM/IRA	7
Submit Final Leachate Collection Responsiveness Summary and IM/IRA	7
Submit Draft Phase I RFI/RI Report	15
Final Phase I RFI/RI Report	15

OU 16 Closure - The Record of Decision (ROD), effectively closing the first Rocky Flats OU under the terms of the IAG followed a two-month public comment period and was signed by DOE, EPA, and CDPHE in October 1994. OU 16 included five low-priority sites such as an antifreeze leak, a solvent spill, and steam condensate leak. Each was evaluated and determined to require no further action.

Remediation Goals

The CERCLA requires that remediation goals comply with ARARs of federal laws or more stringent promulgated state laws in relation to cleanup standards. ARARs evolve from general to very specific during the CERCLA Remedial Investigation/ Feasibility Study (RI/FS) process. Final remediation objectives are comprised of both ARARs and risk assessment information.

The IAG establishes the authority of CDPHE and EPA to request IM/IRA documents that identify, screen, and evaluate appropriate interim remedial action alternatives. "Interim Measures" is the RCRA term for corrective actions, generally of short term, taken to respond to immediate threats to public health, welfare, or the environment. "Interim Remedial Action" is the CERCLA term for an expedited response action taken in accordance with remedial action authorities to abate an actual or potential threat. The IM/IRA process considers ARARs for existing and proposed actions, comprehensively reviews existing management approaches, and evaluates a broad spectrum of alternatives to determine the best means of protecting human health and the environment.

2.5 FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) governs the manufacture, distribution, storage, application, and disposal of several different classes of biocides that are commonly called "pesticides." Federal and state regulation of pesticides imposes some requirements on Rocky Flats for management control of pesticides.

There are several management activities required of Rocky Flats to maintain compliance and to verify that pesticides are applied appropriately without endangering personnel or the environment. The Biocide Management Program Plan (BMPP) controls these activities.

The four fundamental objectives of the BMPP are to (1) verify compliance with both federal and state regulations; (2) verify that there are no restricted-use biocides onsite except those under the control of a licensed applicator; (3) verify that applied biocides do not impair the health of employees, contaminate the watershed, or enter the Site's surface waters; and (4) maintain records of these management activities.

2.6 NATIONAL ENVIRONMENTAL POLICY ACT

The National Environmental Policy Act (NEPA) applies to major federal actions that could affect the quality of the human environment significantly. Most actions taking place at the Site must have NEPA coverage under either existing or new NEPA documentation. An environmental checklist (EC) is prepared to determine whether each project is subject to NEPA review. This checklist is used to recommend to DOE the appropriate type of NEPA documentation for a project. NEPA coverage may come from an existing NEPA document, such as the Site's 1980 Final Environmental Impact Statement, or require new NEPA documentation. If the proposed action belongs to one of certain categories of actions described in DOE's NEPA implementing regulations at 10 CFR 1021 as having previously been defined as an action which does not individually or cumulatively have a significant effect on the human environment, the project may be categorically excluded (CX) from further NEPA documentation requirements. If DOE requires more information than is provided in an environmental checklist, it can direct that an action description memorandum be prepared.

If DOE determines that a project is not eligible for a CX, it will direct that an environmental assessment (EA) or an environmental impact statement (EIS) be prepared. An EA analyzes alternatives (including the "no action" alternative) to the proposed action, and the environmental effects of the proposed action and the alternatives. If the EA identifies no "significant" environmental impacts from the selected alternative, DOE may issue a "finding of no significant impact" (FONSI), ending the NEPA process for that project. If a FONSI is determined not to be appropriate, an environmental impact statement (EIS) must be prepared for the project. An EIS is a more detailed analysis of project alternatives and their environmental impacts, and results in a ROD.

In 1994, the Site's NEPA staff reviewed and provided recommendations on more than 70 projects. DOE approved 26 CXs during the year. Three projects (Actinide Solution Processing, Special Nuclear Materials Consolidation, and Comprehensive Treatment and Management Plan Projects) were recommended for EAs, and work was begun on those documents. In addition, three other EAs initiated in 1993 (New Sanitary Landfill, Drum Storage Facility for Interim Storage of Material Generated by Environmental Restoration Operations, and Resumption of Thermal Stabilization of Plutonium Oxide in Building 707) received FONSIs in 1994.

Finally, work continued during 1994 on a new Sitewide EIS. A revised notice of intent for the EIS was issued to reflect changes in the proposed action necessitated by changing national and international conditions. A ROD on the EIS is expected in late 1996.

Ecological Environmental Statutes and Regulations

Ecological Programs and evaluations for the CERCLA Ecological Risk process have been evolving since 1990. The Ecological Monitoring Program (EcMP) and the Natural Resource Protection and Compliance Program (formerly the Resource Protection Program) address the statutes and regulations listed below.

- Endangered Species Act
- Bald and Golden Eagle Protection Act
- Natural Resource Damages Assessment provisions of CERCLA
- Migratory Bird Treaty Act
- Clean Water Act
- DOE Order 5400.1 (General Environmental Protection Program)
- Fish and Wildlife Coordination Act
- 10 CFR 1022 (DOE compliance with Floodplain/Wetlands Environmental Review Requirements)
- Colorado Nongame, Threatened and Endangered Species Conservation Act
- 10 CFR 834 (DOE Environmental Radiological Protection Program)
- Floodplain Assessment, Executive Order No. 11988
- Protection of Wetlands, Executive Order No. 11990

These programs gather qualitative and quantitative ecological and biological data to monitor compliance with the statutes and regulations listed above. Support is also provided for strategies and methodologies related to the CERCLA risk assessment process and remediation activities.

In January 1994, Rocky Flats implemented protection procedures for threatened and endangered species and migratory birds. These procedures are intended to avoid, minimize, and mitigate impacts to protected animals and plants. A pair of Bald Eagles, a federally threatened species, continued nesting attempts at Standley Lake in OU 3. The Colorado Bird Observatory, under contract to Rocky Flats, continued to monitor the pair's activities. The 1994 spring nesting attempt was unsuccessful, but the eagles returned in October 1994 and resumed courtship. Data collected during 1994 indicated a continued increase in the number of over-wintering Bald Eagles. For the third consecutive year, surveys were conducted for the Ute ladies'-tresses orchid, a federally designated threatened species. Although Rocky Flats has suitable habitat for this plant, there were none found on the Site.

In August 1994, the U.S. Fish and Wildlife Service (USFWS) was petitioned by the Biodiversity Legal Foundation to list the Preble's Meadow Jumping Mouse as a threatened or endangered species. Rocky Flats is one of the few locations in the U.S. where the mouse is found and has one of the few known breeding areas. Site staff gathered information on the distribution and habitat requirements of this animal to verify that both populations and habitat were protected. DOE has since decided to treat the mouse as a threatened species until the USFWS makes a final determination on its legal status.

Rocky Flats continues to participate in the development of NRDA implementation guidelines for the Site. DOE signed a Memorandum of Understanding with the Natural Resource Trustees in November 1994.

National Historic Preservation Act

Preservation and management of prehistoric, historic, and cultural resources on lands administered by DOE are mandated under Sections 106 and 110 of the National Historic Preservation Act (NHPA). The NHPA requires a federal agency, before undertaking any project, to adopt measures to mitigate potential adverse effects of that project on sites, structures, or objects eligible for inclusion in the National Register of Historic Places.

A sitewide archaeological survey at Rocky Flats was originally conducted in 1991 for the Buffer Zone, and all cultural resources were evaluated against criteria for nomination to the National Register of Historic Places. The survey results were reported in *Cultural Resources Class III Survey of Department of Energy, Rocky Flats Plant, Northern Jefferson and Boulder Counties, Colorado.*[9] Although no new archaeological data were generated during 1994, information from the report continues to be used in planning remediation and other construction activities to prevent damage to, or destruction of, cultural resources at the Site.

2.7 RESOURCE CONSERVATION AND RECOVERY ACT

The RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA), 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 the Site. The Colorado Hazardous Waste Act (CHWA) establishes Colorado's program for hazardous waste management. Strictly radioactive wastes are regulated by the Atomic Energy Act of 1954, as administered through DOE Orders.

RCRA Part A and Part B Permits and Applications

RCRA regulations require existing facilities storing, treating, and/or disposing of hazardous waste to submit a Part A application identifying those hazardous waste operations. Following submittal of the Part A, a Part B permit application is submitted to the regulators including detailed information of the construction and operation of storage, treatment, and disposal facilities. Once issued, the permit contains conditions that must be adhered to in order to avoid fines and possible loss of the permit. In October 1991, Rocky Flats received its first Part B operating permit from CDPHE.

In 1994, one Part A permit revision and several Part B permit modifications were initiated and/or approved. Table 2.7-1 summarizes the changes made to these documents during 1994.

RCRA Closure Plans

The RCRA closure plans identify procedures for removing hazardous waste management units from service to prevent both short- and long-term threats to human health and the environment. These plans describe measures to eliminate or minimize future maintenance of hazardous waste management units, to control releases of hazardous constituents, and to close these units permanently. Post-closure monitoring is required if "clean-closure" of a unit cannot be achieved.

There are approximately 700 RCRA regulated individual units, grouped as "systems" under the Site's Part A permit, that will eventually undergo closure. Closure of these units will be accomplished as the units are no longer needed for treatment, storage, or disposal of hazardous waste.

RCRA Contingency Plan

The Rocky Flats RCRA Contingency Plan (Part VI of the Part B Permit) is designed to minimize the hazards to human health and the environment from fires and explosions, or any unplanned sudden or gradual release of a hazardous waste or hazardous waste constituent to the environment (i.e., air, soil, surface water, or groundwater). The Contingency Plan was revised twice in 1994 as a result of Permit Modification Numbers 10 and 21. The response actions outlined in the permit must be followed for all incidents involving a hazardous waste or material that becomes a hazardous waste if discharged. In addition, notifications and reports must be submitted to CDPHE and EPA Region VIII for the following situations.

- A release of a hazardous waste that results in an injury requiring more than first aid treatment.

- A spill or leak of hazardous waste to the environment (i.e., air, soil, or surface water outside of a building) greater than one pint or one pound.

Table 2.7-1
1994 RCRA Permitting Activity

	DESCRIPTION	DATE TO DOE	DATE TO CDPHE	PUBLIC COMMENT ENDS	APPROVAL DATE
Part A Permit Revision #21	Consolidated Part A to reflect previously approved requests for change to interim status				09/94
Permit Mod #5	Class III, requesting to train only those employees who are involved in hazardous waste management	01/24/92, 11/12/92, 09/17/93, 01/06/94	01/28/92, revised 11/19/92	04/04/92	TBD - most recent submittal to DOE 01/18/94
Permit Mod #7	Class I, reformatting all parts of the permit except for Part III, which was completed in Mod #6	06/12/92	06/20/94	N/A	
Permit Mod #10	Class I & II, revised unit numbers, additional waste codes, and contingency plan	10/05/92, 11/11/92, 2nd revision 01/13/93, 3rd revision 05/18/93	12/21/93	02/22/94	03/23/94
Permit Mod #14	Class I, incorporates Permit Mods 1, 2, 3, 4, 6, and 7	06/14/93	06/16/93	N/A	01/24/94
Permit Mod #17	Class II, requesting additional storage (due to excess chemicals) for Unit 1, container stacking in Units 1, 10, and 15A and 14 TC to Unit 1	03/11/94	05/06/94	07/11/94	08/10/94
Permit Mod #18	Class I, incorporates changes to the Environmental Restoration Interagency Agreement milestone schedules in the Corrective Action Section	12/03/93	12/10/93	N/A	01/24/94
Permit Mod #19	Class III, requesting to add the Centralized Waste Storage Facility to the permitted storage units	02/03/92	04/15/94	06/20/94	08/15/94
Permit Mod #20	Class II, requesting modifications to the RCRA Training section of the permit	08/16/94	10/03/94	10/08/94	01/06/95
Permit Mod #21	Class I, requesting changes to the Contingency Plan section of the permit	10/12/94	10/31/94	N/A	
Permit Mod #22	Class I, requesting changes to the Procedures to Prevent Hazards sections of the permit	11/04/94	11/07/94	N/A	
Permit Mod #23	Class II, requesting permitted storage for Unit 18.04 and construction of a metal building at Unit 18.04	11/03/94	12/07/94	03/26/95	

- A spill, leak, or other release of a hazardous waste inside a building that exceeds a reportable quantity (RQ) as defined in 40 CFR Part 302, or a release from a hazardous waste tank system that is not removed from secondary containment within 24 hours.

- A fire that involves a hazardous waste management unit or the release of hazardous waste.

- Situations other than those outlined above can result in the implementation of the RCRA Contingency Plan at the discretion of the Emergency Coordinator.

In 1994 the RCRA Contingency Plan was implemented on 13 occasions as compared with 10 occasions in 1993. The Contingency Plan Implementation Reports were forwarded to CDPHE and EPA Region VIII and described the nature and magnitude of the releases, the actual or potential threat to human health and the environment, and the corrective actions taken to remediate the affected areas and/or systems.

Table 2.7-2 summarizes incidents for which the Contingency Plan was implemented during 1994.

Table 2.7-2
1994 RCRA Contingency Plan Implementation

CPIR NUMBER	DATE	AMOUNT RELEASED	DESCRIPTION OF INCIDENT
94-001	01/12/94	2 gallons	A spill of approximately 2 gallons of hazardous waste was released into secondary containment in the NDT area of Building 460. Evaluation of the secondary containment revealed that a release to the environment could have occurred. A tank release report was also issued due to the possible release of hazardous waste to the environment.
94-002	01/27/94	100 pounds	A release of thorsaline (D001) was discovered in a paint locker in Building 551. The waste generator used Oil-Dri to absorb 5 gallons of the liquid without mixing the material. Due to the possibility of free liquid in the waste, the RCRA Contingency Plan was implemented as a precaution because the waste had been placed in the landfill. Any free liquids must be managed as hazardous waste due to the characteristic of ignitability.
94-003	02/25/94	50 gallons	During a transfer, approximately 50 gallons of process aqueous hazardous waste was released from a flange on the discharge side of pump 801A in Building 374.
94-004	03/10/94	6,200 gallons	A transfer pipeline coupling separated causing a release to the soil of approximately 200 gallons of surface water contaminated with hazardous waste in the area of OU2. An additional 6,200 gallons of surface water contaminated with hazardous waste was released back into the collection weir.

Table 2.7-2 (Continued)
1994 RCRA Contingency Plan Implementation

CPIR NUMBER	DATE	AMOUNT RELEASED	DESCRIPTION OF INCIDENT
94-005	03/31/94	35 gallons	Approximately 35 gallons of decanted solar pond water was spilled onto the roads from a tanker between the 750 Pad and Building 231. The release occurred due to the cap on the transfer tanker not being secured. The area Operations Manager confirmed that there was no impact to the soil.
94-006	05/17/94	1 quart	A spill of approximately one quart of cleaning detergent with a pH of 13 to 14 was released onto an asphalt surface from a trash dumpster.
94-007	05/17/94	2 gallons	A compressor unit on the roof of Building 444 leaked approximately 2 gallons of compressor oil. Based on analytical results of other compressor oils, the recovered material was managed as hazardous waste pending analytical results. Based on analytical results, the released used oil was determined not to be hazardous waste.
94-008	06/29/94	1,800 gallons	Approximately 1,800 gallons of process aqueous hazardous waste was released from primary containment into a secondary containment pit. A surveillance indicated that the Hypalon liner in the pit had leaked, allowing liquid to reach the concrete pit. Analysis indicated levels of cadmium above the RCRA regulatory limit.
94-009	07/20/94	1 pound	A spill of approximately one pound of hazardous waste was released from a tanker to the environment (soil) and onto workers. Approximately four gallons of hazardous waste was also released to the concrete spill basin located near Building 231. The release occurred during tanker truck transfer operations.
94-010	08/08/94	1 quart	The release occurred during sludge vacuuming operations at the 207B South Pond. Approximately one quart of hazardous waste leaked from the side door on the second stage separation chamber to the gravel surface under the tanker.
94-011	10/11/94	85 gallons	Medical treatment beyond first-aid was provided to an operator injured during the release of corrosive liquid. Injuries were localized acid burns on the back of one arm and one calf (second degree burns).
94-012	11/17/94	55 gallons (5 gallons to soil)	The release occurred during restart operations of the evaporator system when the level-indicating controller failed, allowing liquids to accumulate until the pressure disk ruptured as designed. Approximately 50 gallons were released to the containment berm and approximately 5 gallons sprayed to the dirt road north of the bermed area.
94-013	12/13/94	10 gallons	The release occurred during a tanker truck transfer of decanted water from tanks (5 gallons to soil) located on the 750 Pad to the Building 374 feed storage tanks. The release occurred during transportation because the vent/blow-down valve was left open.

Mixed Residue Settlement Agreement and Compliance Order On Consent

This administrative compliance order, issued by CDPHE on April 23, 1993, directs Rocky Flats to implement a Mixed Residue Reduction Program, which includes plans and schedules for achieving compliance with Colorado's hazardous waste regulations. Mixed residues are plutonium-bearing liquids and solids that were once held in reserve at Rocky Flats, pending plutonium recovery operations. Although mixed residues contain hazardous constituents, DOE and its operating contractors historically maintained that these materials were not subject to RCRA regulations because they were considered to be "product," rather than "waste." Legal challenges by the Sierra Club and CDPHE led DOE to reevaluate its stance. Since 1990, certain residues have been categorized as a waste form. Information on Waste Management programs can be found in Section 5. An inventory and analysis of potential/available waste storage space onsite was completed and delivered to CDPHE by October 1, 1994 in fulfillment of a Settlement Agreement requirement.

Judicial Orders

The U.S. District Court for the District of Colorado issued a judicial order on February 17, 1994, mandating a new permit schedule for mixed residues in 55-gallon drums and requiring DOE to submit several revised technical documents to CDPHE. These documents, which included room drawings, smoke and air test results, relabeling plans, unit-specific conditions, and closure plans, were submitted in June 1994.

To fully comply with the proposed permit for 55-gallon mixed residue drums, a Drum Consolidation Plan was developed in July 1994, and approved, implemented, and completed by January 1995. The smoke test, relabeling, and unit-specific condition requirements mandated in the February 1994 judicial order were also completed and forwarded to CDPHE. On January 6, 1995, CDPHE issued the RCRA permit for storage of 55-gallon mixed residues.

On August 25, 1994, U.S. District Court issued another judicial order that required the submission of information pertaining to the permitting of vaults and gloveboxes. These technical documents have been submitted to CDPHE. A vault/glovebox consolidation plan is being developed which will simplify inspections and ensure RCRA compliance for these areas. It is anticipated that mixed residues stored in vaults and gloveboxes will be permitted in late Fiscal Year (FY) 95.

Federal Facility Compliance Agreement for Land Disposal Restricted Waste

The Federal Facility Compliance Agreement (FFCA II) for Land Disposal Restricted (LDR) wastes superseded FFCA I and was signed by DOE and EPA on May 10, 1991. FFCA II was entered into by DOE and EPA to provide a two-year period for DOE to develop the physical and administrative controls necessary to demonstrate compliance with the LDR portions of the HSWA of 1984, regulations found in 40 CFR 268, and the applicable Colorado state law for Rocky Flats. The LDR rules identify hazardous wastes that are prohibited from land disposal and prescribe contaminant levels and treatment standards that must be met before restricted wastes may be land-disposed.

Although FFCA II expired on May 10, 1993, Rocky Flats is implementing programs initiated under FFCA II to achieve LDR compliance and to establish the baseline and framework required for compliance with the Federal Facility Compliance Act (FFC Act) of 1992. Rocky Flats is pursuing the requirements of FFCA II as if it were still in effect and is implementing programs initiated under FFCA II to achieve LDR compliance. Progress toward compliance achievement is reported annually in the Site's LDR Progress Report and the 1994 achievements are described in Section 5, Waste Management, of this 1994 Site Environmental Report.

Site Treatment Plans - The Draft Plan, submitted in August 1994, focused on identifying preferred options for treating the Site's mixed wastes, wherever possible, as well as proposed schedules for constructing capacity. The options presented represented the Site's best judgment of the available information and the preferences of the states involved. Each version of the plan has reflected discussions among states, as well as site-specific input from the regulatory agency and other interested parties. It is the intent of DOE that this iterative process, with ample opportunity for input and discussion, will facilitate approval of the Final Proposed Site Treatment Plan and issuance of the compliance order required by the FFC Act. The goal of DOE is to have all plans and orders in place by October 1995.

2.8 SAFE DRINKING WATER ACT

The Safe Drinking Water Act (SDWA) establishes primary drinking water standards for water delivered by a public water supply system, defined as a system that supplies drinking water to either 15 or more connections or 25 individuals for at least 60 days per year. The water supply system at Rocky Flats meets these criteria and is termed a noncommunity, nontransient system because persons who use the water do so on a daily basis but do not live on the premises. The SDWA is implemented in Colorado by the Colorado Primary Drinking Water Regulations. Rocky Flats is in compliance with all drinking water standards.

Drinking water for the Site is obtained either from Ralston or Gross Reservoir and once it passes the perimeter, is piped to the treatment plant. Drinking water is monitored periodically for various water quality parameters including primary and secondary water contaminants, inorganics, VOCs, and radionuclides. Results of these analyses are reported to CDPHE weekly, monthly, quarterly, and annually depending on the type of analyses performed. A complete description of the Drinking Water Monitoring Program at the Site is provided in the 1992 Environmental Monitoring Plan.[10]

2.9 TOXIC SUBSTANCES CONTROL ACT

The Toxic Substances Control Act (TSCA), administered by the EPA, addresses potential risks associated with the manufacture, use, and handling of toxic substances. TSCA supplements sections of the CAA, the CWA, and the Occupational Safety and Health Act (OSHA). Compliance with TSCA at Rocky Flats is directed at management of polychlorinated biphenyls (PCBs) and containerized waste asbestos from abatement projects.

In 1994, approximately 50 cubic yards of soil and concrete contaminated from past transformer leaks in a PCB remediation area on the south side of Building 443 were shipped offsite for disposal. PCB contamination at concentration levels of 230 ppm PCB were removed and remediated to levels of less than 4 ppm PCB. The area was released to plant services for installation of a new non-PCB transformer and substation.

The Site manages three PCB storage areas that contain radioactive PCB wastes which cannot be shipped offsite because there are no DOE or commercial facilities able to accept such waste for disposal. Rocky Flats and EPA Region VIII negotiated a Draft Compliance Agreement in 1993 for continued storage of these wastes until offsite disposal can be accommodated. The Draft Compliance Agreement was approved by DOE but approval by EPA Region VIII is still pending. In 1994, DOE and EPA also negotiated a National Draft Compliance Agreement for PCB/radioactive waste storage, which when ratified, will apply to all DOE sites and will supersede any regional agreement at Rocky Flats.

Two PCB transformers currently managed by the Site are in compliance with TSCA regulations and are in service and operational. One of them is being replaced by a non-PCB transformer and, after removal, will be shipped for disposal in 1995.

2.10 OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS

Agreement in Principle

The 1989 AIP between DOE and CDPHE commits DOE to an expanded environmental monitoring program at Rocky Flats, to accelerated cleanup activities at some contaminated areas, and to the implementation of several initiatives for achieving a more comprehensive environmental management system. Programs and projects put in place under this agreement include the air emissions inventory (see Section 2.2, Clean Air Act), concurrent sampling of pond discharges (see Section 2.3, Clean Water Act), and dose reconstruction studies conducted by CDPHE. Although the agreement expired in September 1994 and is being renegotiated, Rocky Flats continues to comply with its provisions.

Local Communities Water Diversion Agreement

DOE and the cities of Broomfield and Westminster signed the Local Communities Water Diversion Agreement on October 23, 1990. The purpose of the agreement is to isolate Rocky Flats effluent and runoff to ensure the water from the Site circumvents the drinking water supplies of Broomfield, Westminster, Northglenn, Federal Heights, and Thornton. Through a grant from DOE, Broomfield is replacing Great Western Reservoir as its drinking water supply, and Westminster is constructing a diversion system around Standley Lake.

Special Assignment Team

The original visit of a special assignment team (Tiger Team) in 1989 provided an independent audit of Rockwell operations and practices at Rocky Flats after an investigation by the Justice Department which led to a federal grand jury investigation. Results of the 1989 Tiger Team audit[11] were answered by the successor contractor, EG&G, in a document that outlined 93 separate actions to address the 1989 findings.[12] Progress of these action plans is described in reports submitted to DOE each quarter.[13]

Over 200 subtasks have been initiated to carry out the 93 action plans. Each subtask is monitored and tracked in the Plant Action Tracking System (PATS),which is managed by the Commitments Management Department. The status of these tasks, as of March 2, 1994, and still subject to DOE closure acceptance, is shown in Table 2.10-1.

In 1993, a second 17-member DOE Progress Assessment Team outlined nine concerns in management systems and two concerns in safety and health programs. All of the issues have corrective action plans in progress (also shown below). A Comprehensive Inspection Team visit is scheduled for March 1995.

Table 2.10-1
Corrective Action Plans

STATUS	1989 TIGER TEAM ACTION PLAN SUBTASKS	1993 TIGER TEAM ACTION PLANS
Verified Closed	61	0
Closed	141	0
Completed	42	8
On Hold	5	0
Delinquent	2	0
Referenced	2	0
Re-Opened	5	0
Open	12	3
Canceled	10	3
Total	280	14

Public Participation

Public interest in Site activities is expected to remain high during all phases of the cleanup efforts. DOE is committed to providing the surrounding communities and stakeholders with opportunities for input into the decisions that will be made regarding the ultimate cleanup and disposition of Rocky Flats facilities and land. Since the early 1970s, monthly public meetings have been held to exchange and compare environmental monitoring information independently gathered by the state, local municipalities, and Rocky Flats.[14]

A Community Relations Plan, updated in 1994, outlines several objectives to increase stakeholders' understanding of the environmental and waste management programs, and encourages and enhances their roles in the decision-making process. Major objectives of the plan include providing the community with accurate and timely information about environmental clean up and restoration; establishing communication and public involvement vehicles that allow stakeholders' concerns about planned actions to be heard and considered by decision-making authorities; and complying with federal and state environmental laws.

During 1994, many tools were employed to achieve these objectives. Quarterly public information meetings to discuss environmental and waste management activities were held, as agreed upon in the IAG of 1991. In addition, at least one public meeting was held monthly to provide stakeholders with information on a wide range of topics such as the Secretary's Openness Initiative, work force restructuring, Site economic development, and strategic planning, as well as current environmental and waste management activities. Various meeting formats were used: presentations with questions and answers; panel discussions; workshops; or combinations thereof.

Rocky Flats' stakeholders are a diverse combination of interested citizens including Site special interest groups, municipal governments, and state and federal regulators. Through representation on the Citizens Advisory Board, the Rocky Flats Local Impacts Initiative, and the Technical Review Group, stakeholders contribute their distinctive perspectives. Although each group may have a unique area of interest, each provides the interested public with opportunities to obtain timely information on the Site, ask questions of technical staff, and contribute comments. Public involvement during 1994 became a working partnership with the formation of the Public Participation Focus Group. Composed of representatives from existing citizen groups, regulatory agencies, Rocky Flats, and other public involvement practitioners, the group meets regularly to plan for upcoming public involvement opportunities.

Regularly scheduled tours offer the public and the media a first-hand look at some of the activities at Rocky Flats. In 1994, Rocky Flats offered an unprecedented look at plutonium storage vaults to dignitaries from Russia and Khazakhstan.

Information associated with the major programs and projects at the Site is available at the locations listed below:

Colo. Department of Public Health and Environment
4300 Cherry Creek Drive South, Bldg. A
Denver, Colorado 80222-1530

U.S. Environmental Protection Agency
999 18th Street, 5th Floor
Denver, Colorado 80202-2405

Standley Lake Library
8485 Kipling Street
Arvada, Colorado

Citizens Advisory Board
9035 Wadsworth Parkway, Suite 2250
Westminster, Colorado 80021

References

1. Authorization to Discharge Under the National Pollutant Discharge Elimination System, December 26, 1984.

2. EG&G Rocky Flats, Inc., *1994 Draft Final Groundwater Protection and Monitoring Program Plan,* Golden, Colorado, September 1994.

3. EG&G Rocky Flats, Inc., *Federal Facilities Compliance Agreement Sewage Treatment Plant Compliance Plan,* Golden, Colorado, July 1990.

4. *Evaluation of the Criteria Governing the Groundwater Protection and Monitoring Program at the Rocky Flats Plant* (Wright Water Engineers, 1994).

5. EG&G Rocky Flats, Inc., *1994 Draft Final Groundwater Protection and Monitoring Program Plan,* Chapters 5 and 9, September 1994.

6. U.S. Environmental Protection Agency Region VIII and the State of Colorado, *Rocky Flats Interagency Agreement,* January 22, 1991.

7. U.S. Department of Energy, *Monthly Environmental Compliance Action Report,* Golden, Colorado, January through December Report, 1992; U. S. Department of Energy, *Quarterly Environmental Compliance Action Report,* January - March 1992, April - June 1992, July - September 1992, October - December 1992.

8. Settlement funds will be distributed to CDPHE; EPA (via the Hazardous Substances Response Trust Fund); Colorado Foundation of Public Health; and special environmental projects relating to, at, or in the vicinity of Rocky Flats specified by CDPHE and EPA.

9. EG&G Rocky Flats, Inc., *Cultural Resources Class III Survey of Department of Energy, Rocky Flats Plant, Northern Jefferson and Boulder Counties, Colorado,* Version 1.0, Golden, Colorado, August 1, 1991.

10. EG&G Rocky Flats, Inc., *Rocky Flats Plant Environmental Monitoring Plan,* Golden, Colorado, November 1992.

11. U.S. Department of Energy, *Assessment of Environmental Conditions at the Rocky Flats Plant,* Golden, Colorado, August 1989.

12. EG&G Rocky Flats, Inc., *Corrective Action Plan in Response to the August 1989 Assessment of Environmental Conditions at the Rocky Flats Plant,* Golden, Colorado, September 1990.

13. U. S. Department of Energy, *Quarterly Environmental Compliance Action Report,* Golden, Colorado.

14. EG&G Rocky Flats, Inc., *Monthly Environmental Monitoring Report,* Golden, Colorado, January to December, 1994.

3.0 ENVIRONMENTAL MONITORING PROGRAMS

Specific operations at Rocky Flats involve or produce liquids, solids, and gases containing radioactive and nonradioactive potentially hazardous materials. Various environmental programs monitor penetrating ionizing radiation and pertinent radioactive, chemical, and biological pollutants. Site-specific data are used to evaluate risk to humans and to assist in the warning of unusual or unforeseen conditions. Sections 3.1 through 3.6 of this report summarize the results of the routine environmental monitoring programs at Rocky Flats during 1994.

3.1 METEOROLOGY AND CLIMATOLOGY

OVERVIEW

Typical of the Rocky Mountain Front Range, the climate at Rocky Flats is continental and semiarid. A climate is termed "continental" when the most profound influences on temperatures are determined by the air masses that form over the interior of continents and, in this case, over North America. Frigid air masses that form over the Northwest Territories and central Canada, Alaska, and Siberia in winter occasionally affect eastern Colorado. During the summer months, very warm air masses form over the deserts and high plateaus of the southwestern United States. These air masses account for the hottest days along the Front Range. Continentality accounts for the large seasonal temperature variations and, in part, for the occasionally large temperature changes over short periods of time experienced at Rocky Flats.

In addition to the continental climate, the Site's sloping geographical location and its proximity to a major mountain range permit dramatic changes in temperature and rapidly changing weather conditions. The location of Rocky Flats can also work to moderate the otherwise continental climate. Air masses approaching from the west and descending the eastern slope of the Continental Divide are warmed and dried out upon reaching the foothills and adjacent plains. These situations result from a strong pressure differential that develops across the Continental Divide, between low pressure over the plains and high pressure building over the Great Basin.

During the winter and early spring these downslope winds, known as chinooks, often produce strong westerly winds and large and rapid temperature increases. On occasion, chinooks can be damaging and dangerous but generally are just a temporary nuisance. Wind gusts will typically exceed 70.0 miles per hour (mph) (36.2 meter per second [m/]s) only a few times in a normal year. In the strongest wind events, gusts have exceeded 100.0 mph (44.6 m/s). Beneficial effects from chinooks are sublimation of snowcover (phase change of water from the frozen to the gas state), dispersion of pollutants from an inverted boundary layer in and near the foothills, and considerable warming. A well developed chinook will scour out a frigid Canadian air mass that is dammed up against the foothills. As strong chinook winds push an air mass with subzero readings away from the foothills, it is not uncommon to observe temperature rises of 60.0 degrees Fahrenheit (° F) (15.5 degrees Celsius [° C]) in a 12-hour period.

The lower elevations of the Front Range, including the Site, are considered semiarid because of the relatively small amount of precipitation they receive. A semiarid climate has a precipitation range of 10.00 to 20.00 inches (in.) (25.40 to 50.80 centimenter [cm]) a year and/or an amount exceeded by potential evaporation and transpiration. The Site receives approximately 15.00 in. (38.10 cm) of precipitation each year. Great distances from a major moisture source and shadowing and downsloping from the Rocky Mountains are the primary reasons for the semiarid climate of the Front Range.

Three oceanic air masses are responsible for moisture received as precipitation: the subtropical Pacific, the polar-maritime Pacific, and the subtropical Gulf of Mexico. Late spring and summer precipitation is mainly convective, that is, in the form of showers or thunderstorms. Most moisture during the spring and summer months reaches the Front Range from either the Gulf of Mexico or the Southeastern Pacific. Combined with strong diurnal heating and upslope flow, atmospheric instability frequently leads to afternoon or evening thunderstorms in spring and summer.

Although severe weather consisting of large hail, very heavy rain, strong wind, frequent lightning, and tornados is not uncommon over the plains just east of Rocky Flats, severe weather is infrequent at the Site. The foothills often initiate convection by providing an elevated heat source. Once initiated, thunderstorms usually intensify as they move eastward into the more humid and unstable air mass over the eastern plains of Colorado. Under certain conditions, the Site can experience large hail, very heavy rain, and strong, gusty winds. Tornado formation over Rocky Flats is very unlikely. The spring and early summer months see the most precipitation along the Front Range, with 42 percent of the annual precipitation falling from April through June. Summer precipitation generally increases east of the Site.

Most precipitation received at the Site from October through mid-April is in the form of snow. Snow falls primarily from migratory cyclonic storms that frequently redevelop in the lee of the Rocky Mountains: northeast New Mexico, the Texas panhandle, or southeast Colorado. These so-called "upslope" storms derive their name from the east or northeasterly winds, which are driven up the slope of the western plains toward the Front Range. Moisture-laden air, sometimes originating from the Gulf of Mexico, cools and becomes saturated as it is forced to ascend the eastern plains of Colorado and rise more abruptly as it approaches the Front Range.

In conjunction with the dynamic lift caused by cyclonic circulation, upslope winds can result in heavy precipitation, falling temperatures, and strong winds. Severe winter storms and even blizzards are not uncommon at Rocky Flats, especially in late winter and spring. An upslope snow event in December 1982, known as the "Christmas Eve blizzard," produced nearly 3.0 feet (ft) (0.9 meters [m]) of snow at the Site and was accompanied by 30.0-mph (13.4 m/s) sustained northeasterly winds with temperatures in the single digits. Records for seasonal snowfall totals have only been kept at the Site for four seasons but it is estimated that 90.0 in. (228.6 cm) is average.

Severe drought conditions will develop occasionally along the Front Range during unusually prolonged dry periods. These conditions often lead to wildfires in the prairies, which sometimes affect the Buffer Zone and surrounding areas.

The elevation of Rocky Flats at approximately 6,000 ft (1,860 m) and its location east of a major mountain range allow the continental climate to be somewhat temperate. During summer, the relatively high elevation allows for cooler and less-humid days in comparison to lower places at the same latitude. This coolness is enhanced by diurnal upslope breezes typical of the warm season. These breezes cool as they ascend the Rocky Flats slope from the east. In winter, air masses approaching from the west are warmed as they descend the east slope of the Continental Divide. Temperatures are relatively mild during the winter months, ranging from 40.0° to 45.0° F (4.4° to 7.2° C) during the day and 15.0° to 25.0° F (-9.4° to -3.9° C) at night.

The coldest air masses approach from the north, are relatively shallow, and often stay just east of the Front Range, thereby affecting the lower elevations and plains. These polar and Arctic air masses occasionally affect Rocky Flats, but usually for only short durations. In extreme cases, deep Arctic air masses may linger along the Front Range for several days with high temperatures failing to exceed 0.0° F (-17.8° C). During December 1990, the temperature at the Site remained below zero on the 20th and 21st, and below 20.0° F (-6.7° C) for four days from the 19th to the 24th, reaching the Site's coldest recorded low of -24.7° F (-31.5° C) on the 22nd. The thin atmosphere at the relatively high elevation of the Site allows large diurnal temperature variations, with strong daytime warming and nighttime cooling. This variation is generally larger in the Denver basin than at Rocky Flats because nighttime radiational cooling is stronger in and around the South Platte River Valley.

Large centers of high pressure build over the Great Basin and central Rockies and frequently dominate weather along the Front Range with dry and sunny periods, especially in autumn and mid-winter. On average, the number of days with fair and dry conditions at Rocky Flats greatly exceeds the number of days with inclement weather. It is not uncommon to see a month or more of dry and mostly clear days when large areas of high pressure build over the intermountain region.

The combination of clear skies, light winds, and sloping terrain causes locally produced winds to form and flow along sloping terrain. Daytime heating causes upslope breezes to form either southeasterly winds which flow up the Rocky Flats slope, or northeasterly winds which flow up the South Platte River Valley. Winds reverse at night with a shallow northwest wind draining down the Rocky Flats slope. These breezes are generally no deeper than 160 to 330 ft (50 to 100 m) above ground at the Site.

Meteorological Monitoring

The meteorological monitoring program supports various operations at Rocky Flats. Meteorological information is necessary for (1) assessing transport and diffusion characteristics of the atmosphere used in emergency response and environmental impact assessments, (2) designing other environmental monitoring networks, and (3) developing site-specific weather forecasts. Meteorological data are also used for climatological analyses, hydrological studies, and various design-based engineering studies.

The meteorological data provided in this report were taken from the 61-m tower located to the northwest of the Site (Figure 3.1-1). The tower site is approximately 6,140 ft (1,870 m) above sea level. Data recovery exceeded 99 percent for all variables during 1994, with the exceptions being outgoing radiative flux and relative humidity (dew point).

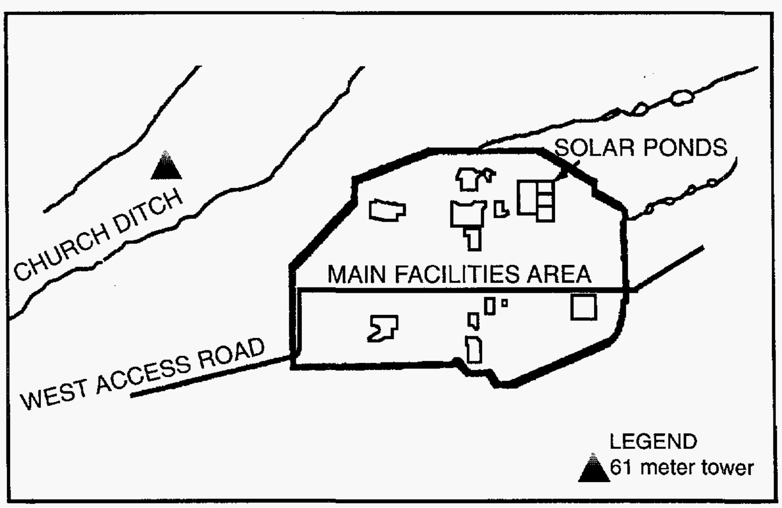


Figure 3.1-1. Location of the 61-M Meteorological Tower

Climate Summary

Annual climate summaries during 1994 are provided in Figure 3.1-2 and Table 3.1-1. The mean temperature of 49.4° F (9.7° C) was very close to the 34-year average. The annual temperature extremes ranged from a high of 101.0° F (38.3° C) on June 26 to a low of -5.4° F (-20.8° C) on January 31. The 1994 peak wind gust was 94.8 mph (42.3 m/s) on February 24, followed closely by a gust to 93.4 mph (41.7 m/s) on December 19. Although these gusts were the strongest on record since December 1975, meteorological data were not recorded from 1978 through 1983. Therefore, there may have been unrecorded gusts during these years as strong or stronger than those in 1994. Precipitation for the year was 2.50 in (6.35 cm) below the 30-year average, totalling 12.00 in. (30.48 cm). The largest daily precipitation event occurred during a strong thunderstorm on August 10, when 0.55 in. (1.39 cm) of rain was recorded. This thunderstorm was also responsible for the heaviest 15-minute (min.) rainfall of 0.23 in. (0.58 cm). Monthly precipitation ranged from a maximum of 2.46 in. (6.24 cm) in April to a minimum of 0.16 in. (0.41 cm) in December.

1994 Annual Climate Summary

The 1994 weather highlights included the hottest summer on record, which broke the previous summer record set in 1978. There were a total of 28 days in 1994 that exceeded 90.0° F (32.2° C), nine of which occurred in both June and July. The 33-year mean for the number of days exceeding 90.0° F was 13.4. November was the only month in 1994 with high temperatures that were colder than the 33-year average for the respective month. The average high for November is 48.1° F (8.9° C). November 1994 had an average high of 46.7° F (8.1° C). Every other month in 1994 saw high temperatures that were significantly above the 33-year-mean respective high temperatures. Had it not been for below-normal low temperatures, the annual mean temperature would have been considerably above normal. The 1994 average low temperatures are biased, however, due to measurement at the 1.5-m level, as opposed to the 10-m level of all past observations. So in reality, all past records of average low temperature at the Site are higher than they would have been had they been measured at the 1.5-m level. Consequently, 1994 was probably much warmer than the annual average at the Site.

Although measurable precipitation was recorded in all months, dry periods during the summer and fall months contributed most to the 1994 precipitation deficit. July, for example, averages 1.41 in. (3.58 cm) of water but only received 0.40 in. (1.01 cm) in 1994. September, October, and December were below to much-below normal as well.

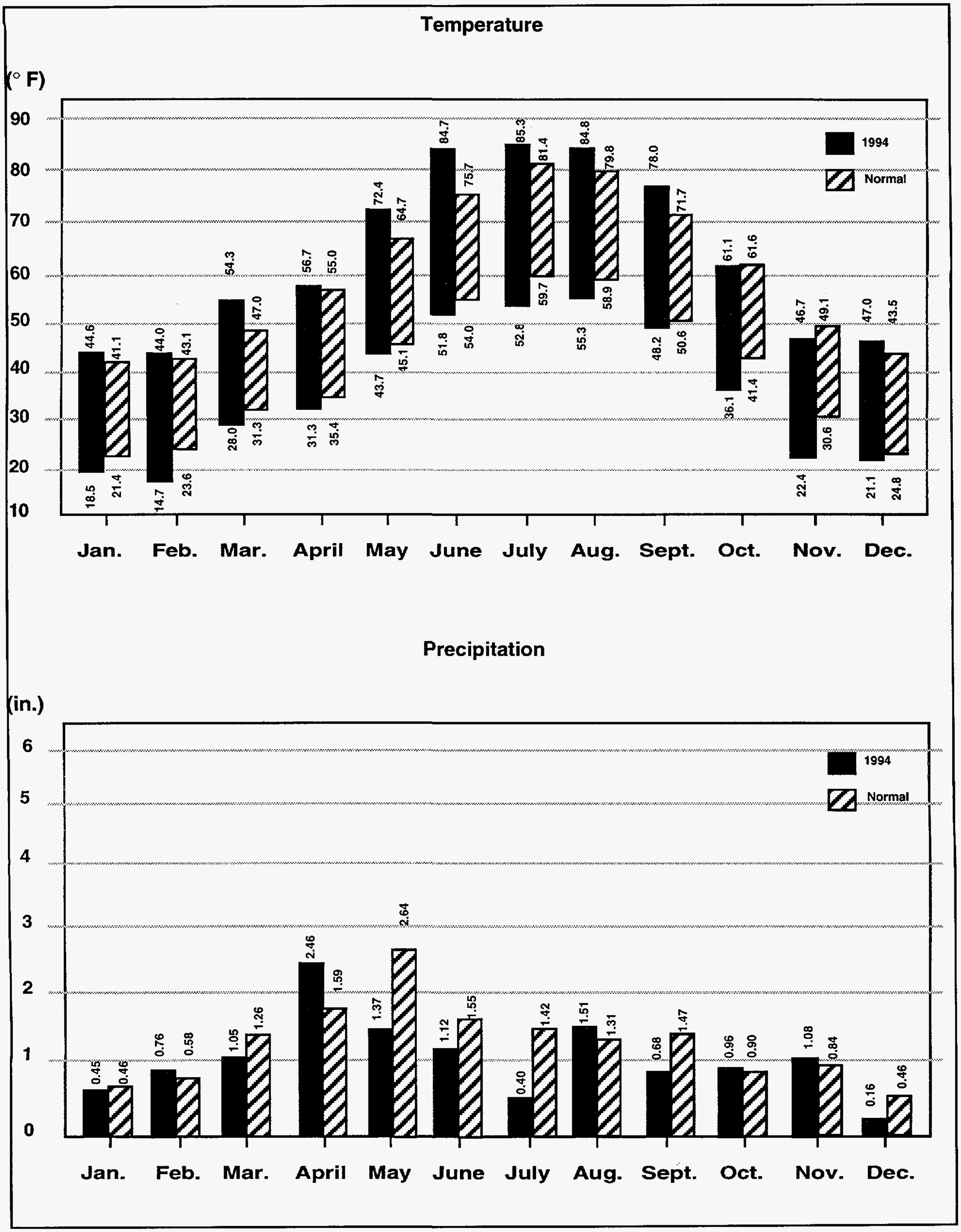


Figure 3.1-2. 1994 Rocky Flats Climate Summary

Table 3.1-1
1994 Annual Climatic Summary

Temperatures (°F)

Month	Means High	Means Low	Average	Extremes High	Date	Extremes Low	Date	Mean Dew Point (°F)	Mean. Rel. Humidity (%)
January	44.6	18.5	31.6	60.1	23	-5.4	31	10.4	45.2
February	44.0	14.7	29.4	61.0	16	-2.6	8	12.8	55.0
March	54.3	25.4	39.9	68.7	14	5.7	9	19.8	51.3
April	56.7	31.3	44.0	78.3	23	18.1	5	28.0	61.1
May	72.4	43.7	58.1	87.3	30	32.0	2	40.1	54.8
June	84.7	51.8	68.3	101.0	26	38.7	9	41.1	45.1
July	85.3	52.8	69.0	94.1	10	42.4	7,8	43.6	45.8
August	84.8	55.3	70.1	95.0	6	49.1	20	47.7	51.4
September	78.1	48.2	63.1	90.1	10	24.4	22	34.8	34.1
October	61.1	36.1	48.6	75.3	11	26.0	30	30.4	50.8
November	46.7	22.4	34.6	68.8	7	8.7	19	16.8	50.2
December	47.0	21.1	34.0	66.0	1	-4.0	31	11.7	39.7
Annual	63.3	35.1	49.2	101.0	6/26	-5.4	1/31	28.1	48.7

Month	Wind Speed (mph) Mean	Wind Speed (mph) Peak	Atmos. Pressure Mean (mb)	Solar Total kW h/m^2
January	12.8	85.4	810.9	81.1
February	10.7	94.8	807.8	101.3
March	8.9	72.0	811.4	145.2
April	9.1	67.3	810.8	137.8
May	8.9	57.0	812.9	201.2
June	8.4	42.7	814.4	224.9
July	8.6	76.9	816.8	201.5
August	8.6	62.2	817.7	171.9
September	8.7	56.4	816.7	152.7
October	9.4	61.4	811.7	118.6
November	10.0	75.5	808.1	93.0
December	9.5	93.4	811.2	71.0
Annual	9.5	94.8	812.5	141.7

Month	Precipitation (inches) Total	Daily Max.	Date	15-Min. Max.	Snowfall Inches	Precip. >0.10"	Number of Days Max. Temp. >90°F	Number of Days Min. Temp. <32 °F
January	0.45	0.2	26	0.0	7.5	0.0	0.0	30.0
February	0.76	0.4	28	0.0	9.4	3.0	0.0	27.0
March	1.05	0.4	28	0.0	11.5	4.0	0.0	24.0
April	2.46	0.5	25	0.1	24.5	7.0	0.0	18.0
May	1.37	0.4	13	0.2		5.0	0.0	1.0
June	1.12	0.4	22	0.1		4.0	9.0	0.0
July	0.4	0.1	31	0.0		1.0	9.0	0.0
August	1.51	0.6	10	0.3		5.0	8.0	0.0
September	0.68	0.5	21	0.1	5.0	2.0	2.0	2.0
October	0.96	0.4	17	0.1	3.0	2.0	0.0	7.0
November	1.08	0.4	8,13	0.2	18.0	4.0	0.0	27.0
December	0.16	0.0	6	0.0	11.5	0.0	0.0	29.0
Annual	12.0	0.6	8/10	0.3	90.4	37.0	28.0	165.0

Unusually warm weather continued into September 1994, when a snowstorm for the second September in a row ended this hot summer. Five in. (12.7 cm) of snow was measured on the 21st of September before temperatures rebounded to the mid-80s by September 28. The early snow event was the result of a vigorous Canadian cold front accompanied by an upslope condition. The annual snowfall total was near normal with about 90.4 in. (229.6 cm) for the year. April was the month of heaviest snowfall with 24.5 in. (62.2 cm), while November was the second with 18.0 in. (45.7 cm).

The annual summaries for wind direction and speed frequency measured at the 10-m height are provided in Table 3.1-2 and are shown graphically by a windrose in Figure 3.1-3.

Compass point designations indicate the direction from which the wind originated (wind along each vector blows towards the center). Wind directions at the Site are most frequently from west-southwest through west-northwest directions. Wind speeds above 18.0 mph (8.0 m/s) occurred primarily with directions from southwest to northwest and to a lesser extent with south-southeasterly winds.

Table 3.1-2
Site Wind Direction Frequency (Percent) by Four Wind-Speed Classes

(15 - Minute Averages - Annual 1994)

	Calm <0.5 m/s (≤1.1 mph)	0.5 - 2.5 m/s (1.1 - 5.6 mph)	2.5 - 4.0 m/s (5.6 - 9.0 mph)	4.0 - 8.0 m/s) (9.0 - 18 mph)	>8.0 m/s (≥18 mph)	Total %
	2.2					
N	-	1.55	2.60	2.57	0.15	6.87
NNE	-	1.63	2.21	1.55	0.14	5.53
NE	-	1.36	1.85	0.87	0.02	4.10
ENE	-	1.42	1.41	0.48	0.01	3.32
E	-	1.27	1.62	0.49	0.02	3.40
ESE	-	1.42	1.94	0.68	0.01	4.05
SE	-	1.66	2.32	0.82	0.02	4.82
SSE	-	1.40	2.11	1.70	0.22	5.43
S	-	1.59	2.03	1.54	0.13	5.29
SSW	-	1.67	2.08	1.52	0.10	5.37
SW	-	1.50	2.03	2.25	0.22	6.00
WSW	-	1.79	2.94	3.32	0.95	9.00
W	-	2.00	2.46	2.69	3.00	10.15
WNW	-	1.88	2.33	4.00	3.82	12.03
NW	-	1.49	2.00	2.35	0.53	6.37
NNW	-	1.35	2.21	2.51	0.10	6.17
TOTALS	2.20	24.98	34.14	29.34	9.44	100.00

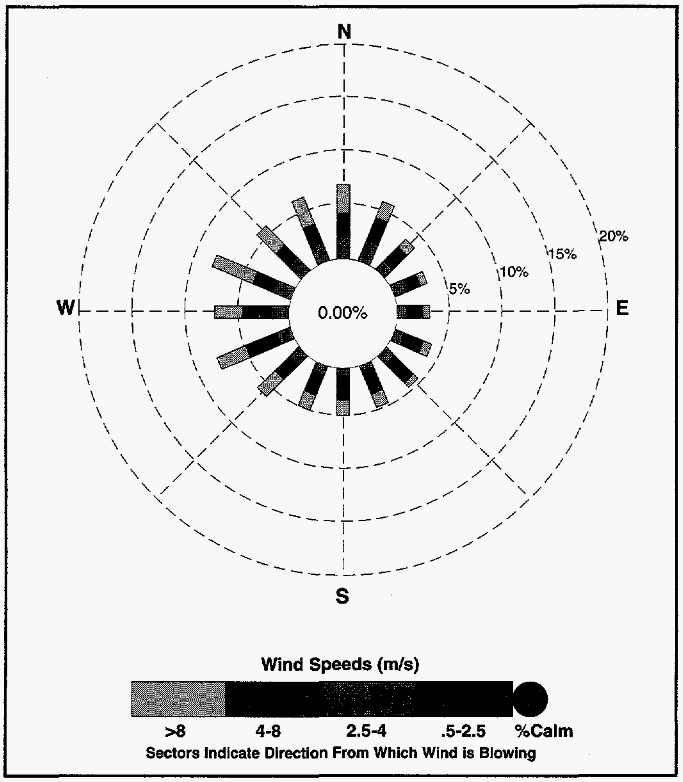


Figure 3.1-3. Rocky Flats 1994 Windrose - 24-Hour

The change in winds is illustrated in the day and night windroses (Figures 3.1-4 and 3.1-5). Day is defined as the period between one hour after sunrise to one hour before sunset. Night is defined as the remainder of the 24-hour period. Locally and regionally produced, thermally driven winds are apparent during the day, with northeasterly up-valley and southeasterly upslope winds. Locally produced winds usually have wind speeds of 11.0 mph (5.0 m/s) or less. Stronger, synoptically induced winds occur from the west and, to a lesser extent, from northerly and southerly directions.

The distribution of nighttime winds is nearly reversed, with Rocky Flats drainage winds causing a high frequency of westerly winds. The South Platte Valley drainage also contributes to the high frequency of southwesterly winds. The frequency of stronger, larger-scale winds is similar to that of the daytime distribution.

Pasquill-Gifford stability classes are used to estimate horizontal and vertical dispersion and are input into atmospheric dispersion models. Stability classes at the Site were estimated using the *sigma theta* technique, where stability is determined from the standard deviation of horizontal wind, mean horizontal wind speed, and time of occurrence as day or night. Another EPA-recommended technique, the *sigma phi* method, results in an unrealistically high number of neutral and stable cases, thereby underestimating Site dispersion and generally overestimating atmospheric concentrations resulting from potential releases.

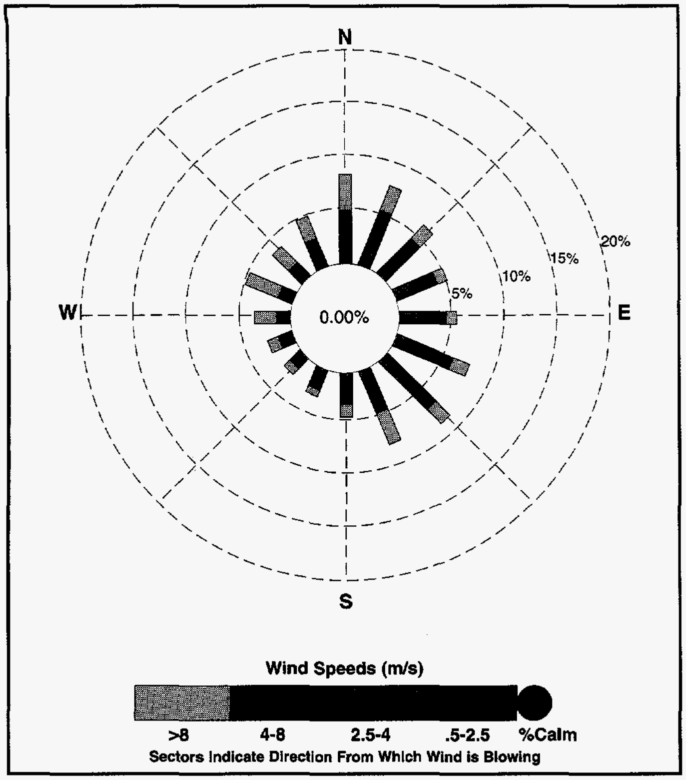


Figure 3.1-4. Rocky Flats 1994 Windrose - Day

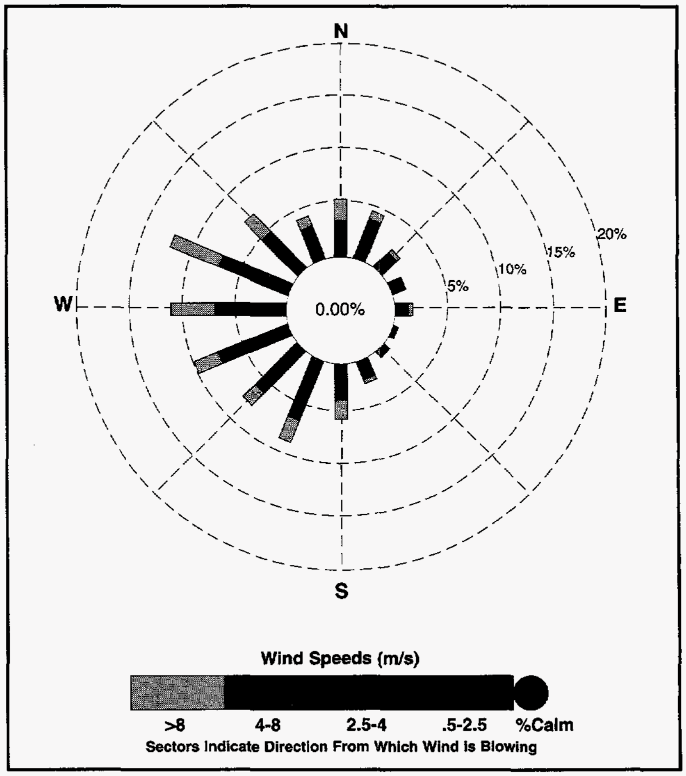


Figure 3.1-5. Rocky Flats 1994 Windrose - Night

The stability classes range from A to F, or extremely unstable to very stable, respectively. The D class represents neutral stability. By definition, daytime stability ranges from D to F. The stability category is defined as D class whenever the wind speed equals or exceeds 13.4 mph (6.0 m/s). The 1994 percent occurrence of winds by stability class is shown in Table 3.1-3.

Results show that unstable categories (A through C) occur 24.4 percent of the time and stable categories (E through F) occur 29.8 percent of the time. Neutral stability occurs most frequently, more than 45 percent of the time. The speed classes (knots) follow the guidelines for the Stability Array (STAR) deck used as input for various regulatory dispersion models. Calms were distributed according to STAR deck procedures.

Table 3.1-3
Percent Occurrence of Winds by Stability Class

Stability Class	Percent Occurrence
A	7.7
B	7.0
C	9.8
D	45.7
E	18.7
F	11.1

3.2 AIR MONITORING

An extensive monitoring program is in place at Rocky Flats to measure radiological and nonradiological air emissions from individual buildings and in the surrounding environment. The data generated by the monitoring are used to support compliance with applicable state and federal air quality regulations, and to help provide assurances that protection of the health of plant workers and the general public is being maintained. This section provides the results of monitoring of effluent air, and of radioactive and nonradioactive ambient air.

EFFLUENT AIR MONITORING

Overview

The term "effluent" refers to something that flows out into the environment. An effluent could be a stream flowing out of a lake or other body of water. It also can refer to the release of an air stream to the environment. At Rocky Flats, effluent refers to air emissions released to the environment from processing and laboratory facilities, and to the release of water (liquid effluents), particularly surface-water runoff and treated sanitary wastewater. (Liquid effluents are discussed further in Section 3.3, Surface-Water Monitoring.)

At Rocky Flats, several protective measures and controls are in place to minimize releases of radioactive or hazardous material to the environment. Ventilation and filtration systems constantly filter the air while monitoring equipment measures building emissions to the environment. Air pressure in the buildings is controlled to prevent unplanned releases. The system was designed so that if a leak were to develop in a glovebox, the radioactive material would be contained in the glovebox and filtered for radioactive particles.

Plutonium, uranium, and americium, the primary radioactive materials used and handled at Rocky Flats, are in a solid particle form. As a result, particle filtration of the airborne effluent streams is an important and effective means of preventing the release of these materials to the environment. Radioactive particles generated by Site activities enter exhaust air streams that are attached to the glovebox system where the particulate materials are removed by highly efficient filters. These high efficiency particulate air (HEPA) filters, referred to as absolute filters in the electronics industry, must meet strict construction and performance criteria before they are accepted for use at Rocky Flats.

Multiple banks of HEPA filters, combined with other protective measures, help ensure that airborne releases of radioactive material from Rocky Flats are minimal and do not pose any significant health risk to the public or the environment. Building air not associated with the glovebox system is controlled, filtered, and monitored before it is released to the environment.

Radionuclide air emissions are monitored continuously at 63 emission points in 17 buildings at Rocky Flats in order to satisfy regulatory requirements under 40 CFR 61 Subpart H (radionuclide NESHAP). The radiological particulate monitoring and sampling program uses a three-tier approach, comprising selective alpha air monitors (SAAMs), total long-lived alpha screening of routine air duct emission sample filters, and radiochemical analysis of isotopes collected for air duct emission samples. This approach balances both detectability and timeliness of results.

For immediate detection of abnormal conditions, building ventilation systems that service areas containing plutonium are equipped with 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 any out-of-tolerance conditions are detected. No such condition occurred during 1994.

At regular intervals, particulate material samples from the continuous sampling systems are removed from the exhaust systems 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 HEPA filtration system. If the total long-lived alpha concentration for an effluent sample exceeds the Site's action value of 0.020×10^{-12} microcuries per milliliter (μCi/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 Derived Concentration Guide (DCG) for plutonium activity in air.

At the end of each month, individual samples from each effluent duct are composited into larger samples by location. A portion 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, which 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 Rocky Flats. Processes that are ventilated from several exhaust systems potentially exhibit trace quantities of tritium contamination. Bubble-type samplers are used to collect samples generally three times each week from the monitored locations. Tritium concentrations in the samples are measured using a liquid scintillation photospectrometer. Tables 3-2 through 3-7 present these data.

Effluent Air Standards

Air effluent limits are established under the Clean Air Act (CAA) NESHAP. The limit for radiation dose to the public from radioactive emissions is promulgated by EPA and is listed in Table 3.2-1. Nonradioactive (but otherwise hazardous) material emissions such as beryllium are regulated by the State of Colorado under Colorado Air Quality Control Regulation #8. This regulation sets a limit for beryllium emissions of 10 grams(g) in a 24-hour period per stationary source.

Effluent Air Monitoring Results

Plutonium and Uranium - During 1994, total quantities of plutonium and uranium discharged to the atmosphere from Rocky Flats processing and support buildings were 0.2052 microcuries (μCi) (7.59×10^3 Bq) and 2.5609 μCi (9.48×10^4 Bq), respectively (Tables 3.2-2 and 3.2-3). These values were corrected for background radiation.

The overall decrease in radionuclide emissions since 1988 is a reflection of reduced production activities at Rocky Flats as a result of the curtailment of plutonium production operations in late 1989. Many of these operations have not resumed because of the subsequent cancellation of new weapons systems and the change in Site mission from production to decontamination and environmental restoration.

Table 3.2-1
DOE Radiation Protection Standards for the Public

ICRP-RECOMMENDED STANDARDS FOR ALL PATHWAYS:	
Temporary Increase	500 mrem/year EDE (with prior approval of DOE EH-2)
Normal Operations	100 mrem/year EDE
EPA CLEAN AIR ACT NESHAP STANDARDS FOR THE AIR PATHWAY ONLY:	
10 mrem/year EDE	

Note: In addition to the numerical dose standards listed above, it is the objective of DOE to maintain potential exposures to members of the public to ALARA levels.

Table 3.2-2
Plutonium in Effluent Air

		Plutonium-238		Plutonium-239/240	
Month	Number of Analyses	Total Discharge (μCi)	C maximum[a] (x 10^{-12} μCi/ml)	Total Discharge (μCi)	C maximum[a] (x 10^{-12} μCi/ml)
January	46	0.0013 ± 0.0008	0.0000 ± 0.0000	0.0076 ± 0.0016	0.0001 ± 0.0000
February	46	0.0014 ± 0.0008	0.0000 ± 0.0000	0.0225 ± 0.0019	0.0001 ± 0.0000
March	46	0.0007 ± 0.0009	0.0000 ± 0.0000	0.0103 ± 0.0015	0.0001 ± 0.0000
April	46	0.0007 ± 0.0014	0.0000 ± 0.0000	0.0194 ± 0.0019	0.0001 ± 0.0000
May	46	0.0004 ± 0.0006	0.0000 ± 0.0000	0.0152 ± 0.0015	0.0001 ± 0.0000
June	46	0.0006 ± 0.0008	0.0000 ± 0.0000	0.0204 ± 0.0019	0.0002 ± 0.0000
July	46	0.0015 ± 0.0014	0.0000 ± 0.0000	0.0240 ± 0.0030	0.0005 ± 0.0001
August	46	0.0010 ± 0.0013	0.0000 ± 0.0000	0.0203 ± 0.0033	0.0000 ± 0.0000
September	46	0.0081 ± 0.0017	0.0000 ± 0.0000	0.0127 ± 0.0019	0.0002 ± 0.0000
October	46	0.0036 ± 0.0013	0.0000 ± 0.0000	0.0099 ± 0.0016	0.0001 ± 0.0000
November	44	0.0015 ± 0.0015	0.0000 ± 0.0000	0.0084 ± 0.0016	0.0001 ± 0.0000
December	46	0.0030 ± 0.0008	0.0000 ± 0.0000	0.0169 ± 0.0018	0.0007 ± 0.0001
Overall	550	0.0178[b,c] ± 0.0132	0.0000 ± 0.0000	0.1874[b,c] ± 0.0234	0.0007 ± 0.0001

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 3.2-3
Uranium in Effluent Air

		Uranium-233/234		Uranium-238	
Month	Number of Analyses	Total Discharge (μCi)	C maximum[a] (x 10^{-12} μCi/ml)	Total Discharge (μCi)	C maximum[a] (x 10^{-12} μCi/ml)
January	54	-0.0118 ± 0.0074	0.0000 ± 0.0000	-0.0107 ± 0.0075	0.0001 ± 0.0000
February	54	0.1018 ± 0.0106	0.0001 ± 0.0000	0.1267 ± 0.0111	0.0002 ± 0.0000
March	54	0.0539 ± 0.0092	0.0001 ± 0.0000	0.0638 ± 0.0093	0.0001 ± 0.0001
April	54	0.1014 ± 0.0090	0.0001 ± 0.0000	0.1274 ± 0.0094	0.0003 ± 0.0001
May	53	0.1042 ± 0.0102	0.0001 ± 0.0000	0.1205 ± 0.0106	0.0002 ± 0.0000
June	54	0.0641 ± 0.0099	0.0001 ± 0.0000	0.1000 ± 0.0100	0.0003 ± 0.0001
July	54	0.0985 ± 0.0118	0.0002 ± 0.0001	0.1484 ± 0.0131	0.0003 ± 0.0001
August	54	0.1148 ± 0.0120	0.0002 ± 0.0001	0.1442 ± 0.0121	0.0004 ± 0.0001
September	54	0.1334 ± 0.0111	0.0003 ± 0.0001	0.1589 ± 0.0115	0.0003 ± 0.0001
October	54	0.1176 ± 0.0104	0.0004 ± 0.0001	0.1262 ± 0.0108	0.0005 ± 0.0001
November	52	0.1006 ± 0.0109	0.0006 ± 0.0001	0.1270 ± 0.0116	0.0012 ± 0.0002
December	54	0.1615 ± 0.0122	0.0003 ± 0.0001	0.1886 ± 0.0131	0.0005 ± 0.0001
Overall	646	1.1399[b,c] ± 0.1248	0.0006 ± 0.0001	1.4210[b,c] ± 0.1301	0.0012 ± 0.0002

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.

Values reported for total quantities of plutonium and uranium discharges for 1994 vary from the monthly environmental monitoring reports due to rounding in calculations and because this annual report includes plutonium-238, -239, and -240. Plutonium-238 represents 8.7 percent of the total plutonium discharged in 1994.

Americium - Total americium discharged in 1994 was 0.1093 µCi (4.04×10^3 Bq) (Table 3.2-4). The maximum concentration was 0.00022×10^{-12} µCi/ml, observed in samples taken in April. Americium values were corrected for background radiation.

Tritium - Total tritium discharged in 1994 from ventilation systems in which tritium is routinely measured was 0.0033 curies (Ci) (1.22×10^8 Bq) (Table 3.2-5). The maximum tritium concentration of 823×10^{-12} µCi/ml (30.45 Bq/m^3) was observed in January during a one-day repackaging project for some sources in preparation for shipment to another DOE facility. 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 sources not related to Rocky Flats.

Beryllium - The total quantity of beryllium discharged from ventilation exhaust systems was 4.536 g and the maximum concentration was 0.00112 µg/m^3 observed in July (Table 3.2-6). These values were not significantly above background levels associated with the analyses. The beryllium stationary-source emission standard is 10 g over a 24-hour period.

The total quantity of beryllium discharged from 1994 activities varies from the monthly environmental monitoring reports because this annual report includes values for all 49 exhaust systems whereas the monthly reports give discharges for six exhaust systems on buildings where beryllium is processed. Beryllium discharges are monitored monthly at the remaining 43 locations but the results are only given in monthly reports if they exceed a screening level of 0.1 g.

Rocky Flats ceased 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.

Table 3.2-4
Americium in Effluent Air

Americium-241

Month	Number of Analyses	Total Discharge (µCi)			C maximum[a] ($\times 10^{-12}$ µCi/ml)		
January	46	-0.0002	±	0.0017	0.0001	±	0.0000
February	46	0.0093	±	0.0029	0.0001	±	0.0000
March	46	0.0143	±	0.0039	0.0000	±	0.0000
April	46	0.0085	±	0.0025	0.0002	±	0.0001
May	46	0.0067	±	0.0023	0.0000	±	0.0000
June	46	0.0054	±	0.0020	0.0000	±	0.0000
July	46	0.0041	±	0.0031	0.0001	±	0.0000
August	46	0.0101	±	0.0043	0.0001	±	0.0000
September	46	0.0087	±	0.0025	0.0000	±	0.0000
October	46	0.0260	±	0.0029	0.0001	±	0.0000
November	44	0.0042	±	0.0028	0.0000	±	0.0000
December	46	0.0123	±	0.0033	0.0001	±	0.0001
Overall	550	0.1093[b,c]	±	0.0407	0.0002	±	0.0001

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 3.2-5
Tritium in Effluent Air

Tritium

Month	Number of Analyses	Total Discharge (Ci)	C maximum[a] ($\times 10^{-12}$ µCi/ml)		
January	66	0.00025	823	±	11
February	72	0.00024	15	±	5
March	78	0.00010	14	±	6
April	72	0.00022	39	±	6
May	78	0.00026	40	±	12
June	72	0.00006	18	±	12
July	72	0.00042	32	±	11
August	84	0.00051	22	±	11
September	72	0.00027	27	±	12
October	78	0.00038	24	±	11
November	66	0.00014	39	±	11
December	66	0.00041	62	±	20
Overall	876	0.00325[b]	823	±	11

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

Table 3.2-6
Beryllium in Effluent Air

Month	Number of Analyses	Beryllium[a,b] Total Discharge[c] (g)			Beryllium[a,b] C maximum[d] ($\mu g/m^3$)
January	54	0.1772	±	0.0053	0.00047
February	54	0.3360	±	0.0100	0.00030
March	54	0.2190	±	0.0065	0.00023
April	54	0.2688	±	0.0076	0.00023
May	54	0.2984	±	0.0092	0.00026
June	54	0.4357	±	0.0128	0.00058
July	54	0.5899	±	0.0203	0.00112
August	54	0.4532	±	0.0129	0.00058
September	54	0.5089	±	0.0141	0.00068
October	54	0.4450	±	0.0121	0.00067
November	52	0.3736	±	0.0137	0.00083
December	54	0.4303	±	0.0123	0.00069
Overall	646	4.5360[e]	±	0.1369	0.00112

a. The beryllium stationary source is no more than 10 grams of beryllium over a 24-hour period under the provisions of subpart 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.
e. One value only contributing to this total was based on best estimates of release activities because sample analytical results that met all quality assurance criteria were unavailable.

NONRADIOACTIVE AMBIENT AIR MONITORING

Overview

In addition to effluent sampling from individual buildings at Rocky Flats, ambient air in the surrounding environment is monitored. Ambient air monitoring includes sampling for nonradioactive particulates as well as radioactive materials. (Results of the radioactive ambient air monitoring program are provided in the following section.)

Nonradioactive ambient air monitoring was conducted in 1994 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 CDPHE under the CAA and its amendments, as defined by the National Ambient Air Quality Standards[1] (NAAQS), and CAQCC Ambient Air Standards. The regulations are based on regional rather than site-specific air quality parameters. The present EPA standards, referred to as Particulate Matter-10 (PM-10), are based on respirable particulates.

Final EPA respirable particulate standards were issued on July 1, 1987,[2] and reference methods were issued on October 6 and December 1, 1987. PM-10 samplers at Rocky Flats were procured to meet EPA design specifications. TSP, a former NAAQS pollutant, are collected to maintain the Site particulate baseline. TSP samplers collect a wider range of particle sizes (≥ 10 to 50 microns).

Nonradioactive Ambient Air Monitoring Results

Nonradioactive ambient air monitoring is performed in an area near the east entrance to Rocky Flats. Table 3.2-7 identifies sampling equipment used for measuring particulates. TSP and PM-10 samplers are collocated at the monitoring site. The location is unobscured by structures, is near a traffic zone, and is generally downwind from Site facilities. Samplers are operated on an EPA sampling schedule of one day per every sixth day. The EPA-style, high-volume air sampling method is used to measure TSP, which continue to be collected for reference purposes.

Particulate data are provided in Table 3.2-8. Current NAAQS standards for PM-10 are provided in Table 3.2-9. The highest TSP value recorded in 1994 (24-hour sample) was 92.0 $\mu g/m^3$. The annual geometric mean value was 45.2 $\mu g/m^3$. The observed 24-hour maximum for the PM-10 sampler was 48.5 $\mu g/m^3$ (32 percent of the 24-hour standard), and the annual arithmetic mean was 16.5 $\mu g/m^3$ (32 percent of the annual mean standard).

Nonradioactive Ambient Air Standards

Ambient air data for nonradioactive particulates historically have been collected at Rocky Flats for comparison to criteria pollutants listed under the EPA NAAQS established by the CAA[3] (Table 3.2-9). Instrumentation and methodology follow requirements established by the EPA in the Quality Assurance Handbook for Air Pollution Measurement Systems.[4]

The requirement for development of a VOC baseline for ambient air, and subsequent verification monitoring of releases from decontamination and decommissioning operations, was contained in the Industrial Area IM/IRA Decision Document of November, 1994.[5] This verification requirement documents potential chronic releases to the onsite and offsite air pathway as required by CERCLA and implemented by the 1991 Federal Facility Agreement and Consent Order, commonly referred to as the IAG. Baseline ambient VOC monitoring is scheduled to begin in June of 1995. Verification monitoring for releases of organics will be scheduled on an as-needed basis.

Table 3.2-7
Nonradioactive Ambient Air Monitoring Detection Methods

Parameter	Detection Methods
Particulate Matter less than or equal to 10 micrometers in diameter (PM-10)	Wedding PM-10 Sampler 24-Hour Sampling (6th-day scheduling)
Total Suspended Particulates (TSP)	Hi-Q High-Volume Sampler 24-Hour Sampling (6th-day scheduling)

Table 3.2-8
Ambient Air Quality Data for Nonradioactive Particulates

Respirable Particulates (PM-10)

	Total No. of Samples	Annual Arithmetic Mean (µg/m³)	Observed 24-hr Max. (µg/m³)	Second Highest Max. (µg/m³)
Primary Ambient Air PM-10 Sampler	54	16.5	48.5	28.3
Collocated Duplicate PM-10 Sampler	49	18.1	45.1	29.6

Total Suspended Particulates

	Total No. of Samples	Annual Geometric Mean (µg/m³)	Standard Deviation (µg/m³)	Observed 24-hr Max. (µg/m³)	Second Highest Max. (µg/m³)	Lowest Observed Value (µg/m³)
Primary Ambient Air TSP Particulate Sampler; Primary Unit	54	45.2	19.2	92.0	84.7	20.3
Collocated Duplicate TSP Sampler	56	52.2	17.2	86.6	86.1	21.5

Table 3.2-9
National Ambient Air Quality Standards (NAAQs) for Particulates

	NAAQS Averaging Time	Concentration
PM-10:	Annual Arithmetic Mean	50 µg/m³
	24-hr Average*	150 µg/m³

*Not to be exceeded more than once per year.

RADIOACTIVE AMBIENT AIR MONITORING PROGRAM

Overview

The Rocky Flats Radioactive Ambient Air Monitoring Program (RAAMP) is designed to monitor radioactive particles at near-background concentrations. This monitoring is performed in accordance with DOE Order 5400.1.[6] Samplers are positioned at 21 locations on the Site, at 14 locations around the Site boundary, and in 10 neighboring communities (Figures 3.2-1 and 3.2-2). The data are used to estimate the air-inhalation dose to the public resulting from routine Site operations and to compare that dose with the DOE standard of 100 mrem per-year EDE.

The high-volume air samplers operate continuously at a volumetric flow of approximately 20 liters per second (l/s) (40 cubic feet per minute [ft^3/min]), collecting air particulates on 20- by 25-cm fiberglass filters. Manufacturer's test specifications rate this filter medium to be 99.97 percent efficient for relevant particle sizes under conditions typically encountered in routine ambient air sampling.[7] RAAMP filters are collected monthly and composited for quarterly isotopic analysis. All RAAMP filters are analyzed for plutonium-239/240.

Radioactive Ambient Air Monitoring Results

Plutonium -239/240 concentrations for onsite samplers are provided in Table 3.2-10. Plutonium -239/240 concentrations for perimeter and community samplers are provided in Tables 3.2-11 and 3.2-12. The overall mean plutonium concentration for onsite samplers was 0.056×10^{-15} µCi/ml (2.07×10^{-6} Bq/m^3) or 0.28 percent of the offsite DCG for plutonium in air (20×10^{-15}). The overall mean plutonium concentration for perimeter samplers was 0.002×10^{-15} µCi/ml (5.5×10^{-8} Bq/m^3), or 0.012 percent of the offsite DCG for plutonium in air. Overall mean plutonium concentration for community samplers was 0.001×10^{-15} µCi/ml (3.7×10^{-8} Bq/m^3), or 0.006 percent of the offsite DCG for plutonium in air.

The mean annual concentrations of plutonium -239/240 for the 1989 to 1994 period are shown in Figure 3.2-3 (onsite samplers) and Figure 3.2-4 (perimeter and community samplers). The onsite data are based on the mean of the annual concentrations for five locations, S-5 through S-9, which represent the areas where the highest concentrations would most likely be observed. Isotope-specific analyses were not conducted for other onsite locations until 1990. The perimeter data points are the annual averages of 14 locations and the community data points are the annual average of 11 locations.

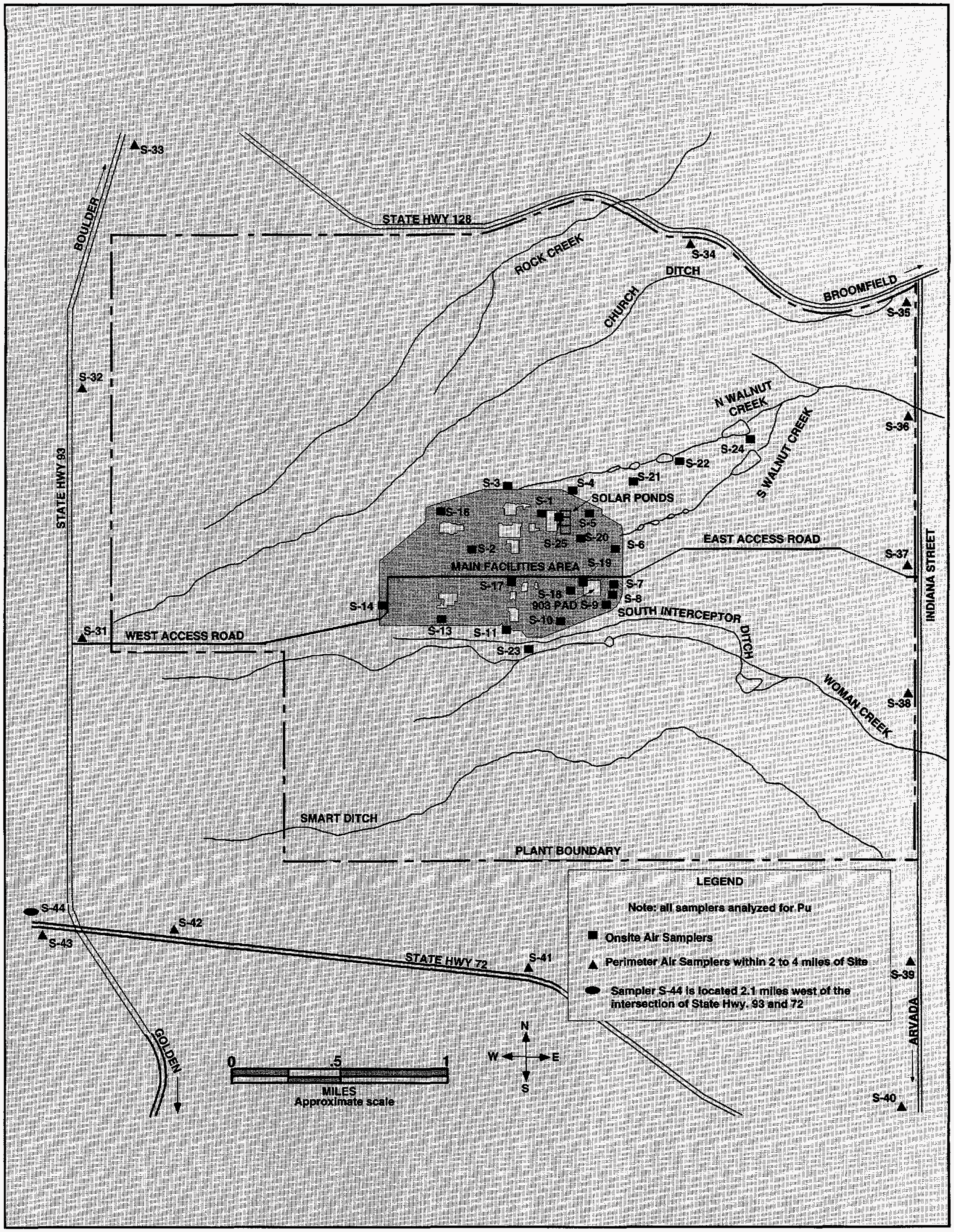


Figure 3.2-1. 1994 Onsite and Perimeter RAAMP Air Samplers

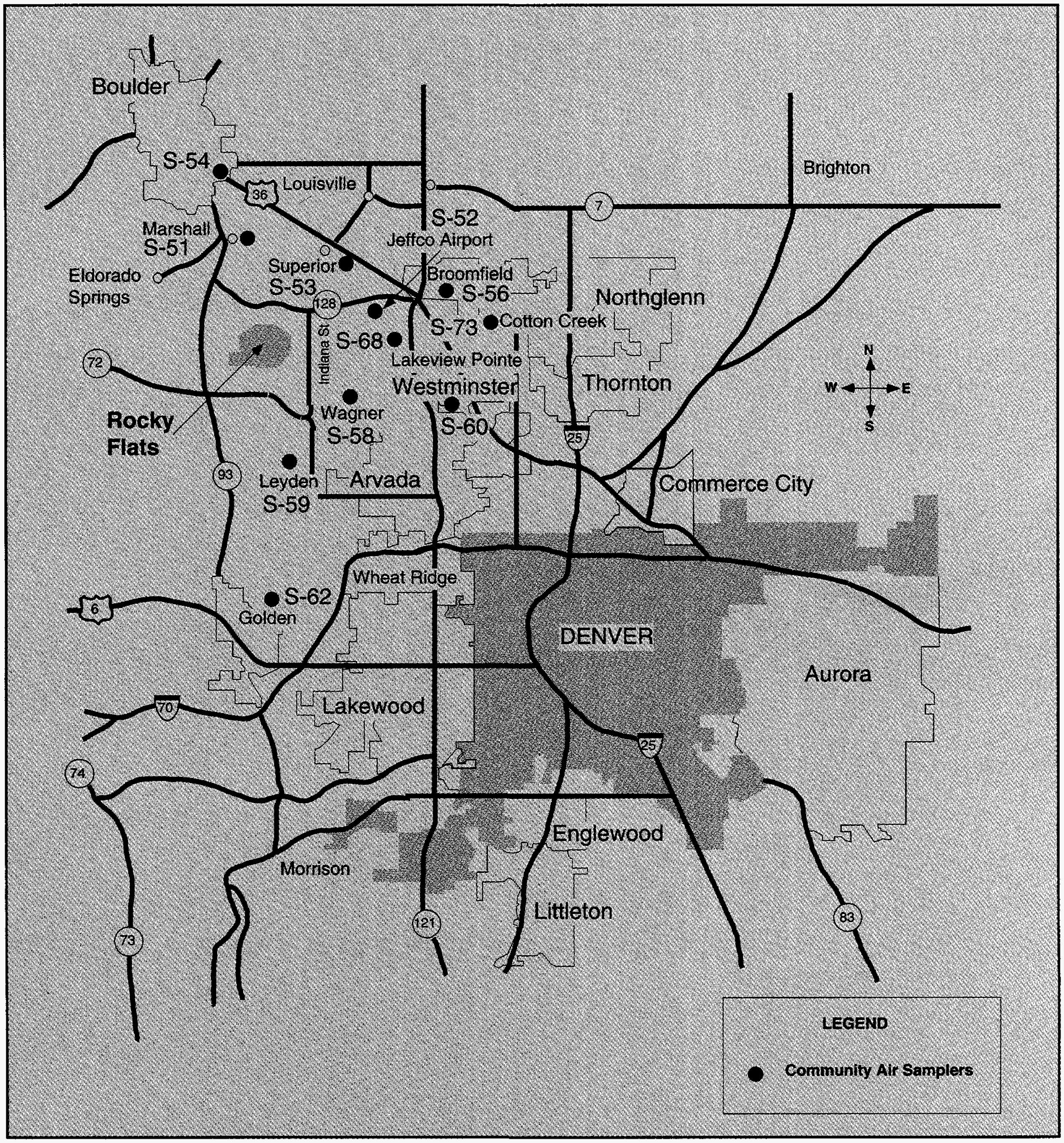


Figure 3.2-2. 1994 Community RAAMP Air Samplers

Table 3.2-10
Onsite RAAMP Air Sampler Plutonium Concentrations

Station	Number[a] of Samples	Concentration (x 10^{-15} µCi/ml)[b] C minimum	C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[c] (C mean)
S-3	11	0.00100	0.00300	0.00190	0.00089	0.00954
S-4	11	0.00300	0.02500	0.01640	0.00665	0.05818
S-5	12	0.01000	0.33000	0.06770	0.08777	0.33875
S-6	12	0.00200	0.12100	0.05320	0.03130	0.26583
S-7	9	0.04700	0.39800	0.19600	0.13219	0.98000
S-8	11	0.01700	1.08300	0.40209	0.32955	2.0104
S-9	11	0.00720	1.1010	0.30593	0.29966	1.52960
S-10	11	0.00100	0.48100	0.04645	0.13742	0.23227
S-11	10	0.00200	0.01600	0.00760	0.00429	0.03800
S-13	9	0.00100	0.01900	0.00366	0.00537	0.01018
S-14	9	0.00000	0.00400	0.00133	0.00133	0.00666
S-16	9	0.00000	0.00300	0.00167	0.00094	0.00833
S-17	9	0.00200	0.00700	0.00377	0.00154	0.01888
S-18	11	0.00600	0.02800	0.01498	0.00829	0.07490
S-19	10	0.00700	0.02000	0.01370	0.00498	0.06850
S-20	11	0.00300	0.01700	0.00780	0.00426	0.03900
S-21	8	0.00300	0.01500	0.00800	0.00409	0.04000
S-22	10	0.00140	0.01500	0.00750	0.00430	0.03770
S-23	9	0.00000	0.00400	0.00170	0.00125	0.00714
S-24	7	0.00100	0.00200	0.00142	0.00049	0.00714
S-25	7	0.01100	0.06400	0.03257	0.01758	0.16285
Overall	207	0.00000	1.10100	0.05692	0.05163	0.28511

a. Perimeter samplers operated from 7 to 12 months during 1994 due to the phasing in of the new RAAMP network.

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. Protection standards for members of the public are applicable for offsite locations. All locations in this table are on Site property. DCGs for the public are presented here for comparison purposes only.

Note: This table represents the 1994 ambient air network. The text and map reflect this 1994 network. Changes made in 1995 in sampler locations will be reflected in the 1995 SER.

Table 3.2-11
Perimeter RAAMP Air Sampler Plutonium Concentrations

Station	Number[a] of Samples	Concentration (x 10^{-15} µCi/ml)[b] C minimum	C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[c] (C mean)
S-31	9	.00000	.00100	.00044	.00049	.00222
S-32	9	-.00100	.00600	.00100	.00194	.00500
S-33	11	.00000	.00300	.00090	.00009	.00454
S-34	10	.00000	.00200	.00050	.00067	.00250
S-35	11	.00000	.00300	.00063	.00088	.00318
S-36	9	.00000	.00200	.00078	.00062	.00388
S-37	8	.00180	.00500	.00225	.00147	.01125
S-38	10	.00100	.00200	.00200	.00232	.01020
S-39	11	.00000	.00200	.00100	.00042	.03800
S-40	9	.00000	.00200	.00100	.00047	.00500
S-41	9	.00000	.00100	.00089	.00031	.00444
S-42	8	.00000	.00100	.00037	.03360	.06100
S-43	10	.00000	.11300	.01220	.00154	.01888
S-44	6	.00600	.02800	.00008	.00068	.00416
Overall	130	-.00100	.11300	.00245	.00945	.01243

a. Perimeter samplers operated from 6 to 11 months during 1994 due to the phasing in of the new RAAMP network.
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. Protection standards for members of the public are applicable for offsite locations. All locations in this table are on Site property. DCGs for the public are presented here for comparison purposes only.

Table 3.2-12
Community RAAMP Air Sampler Plutonium Concentrations

Station	Community Name	Number[a] of Samples	C minimum	Concentration (x 10^{-15} µCi/ml)[b] C maximum	C mean	Standard Deviation (C standard)	Percent of DCG[c] (C mean)
S-51	Marshall	10	.00000	.00200	.00030	.00064	.00181
S-52	Jeffco Airport	10	.00000	.00400	.00190	.00116	.00545
S-53	Superior	10	.00000	.02700	.00463	.00795	.02318
S-54	Boulder	9	.00000	.00100	.00033	.00047	.00167
S-56	Broomfield	11	.00000	.00200	.00082	.00093	.00409
S-58	Wagner	9	.00000	.00400	.00100	.00115	.00500
S-59	Leyden	11	.00000	.00100	.00060	.00049	.00300
S-62	Golden	11	.00000	.00100	.00054	.00049	.00272
S-68	Lakeview Pointe	9	.00000	.00300	.00111	.00087	.00555
S-73	Cotton Creek	9	.00000	.00400	.00167	.00011	.00833
Overall		99	.00000	.02700	.00129	.00138	.00605

a. Community samplers operated from 9 to 11 months during 1994 due to the phasing in of the new RAAMP network.
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. Protection standards for members of the public are applicable for offsite locations.

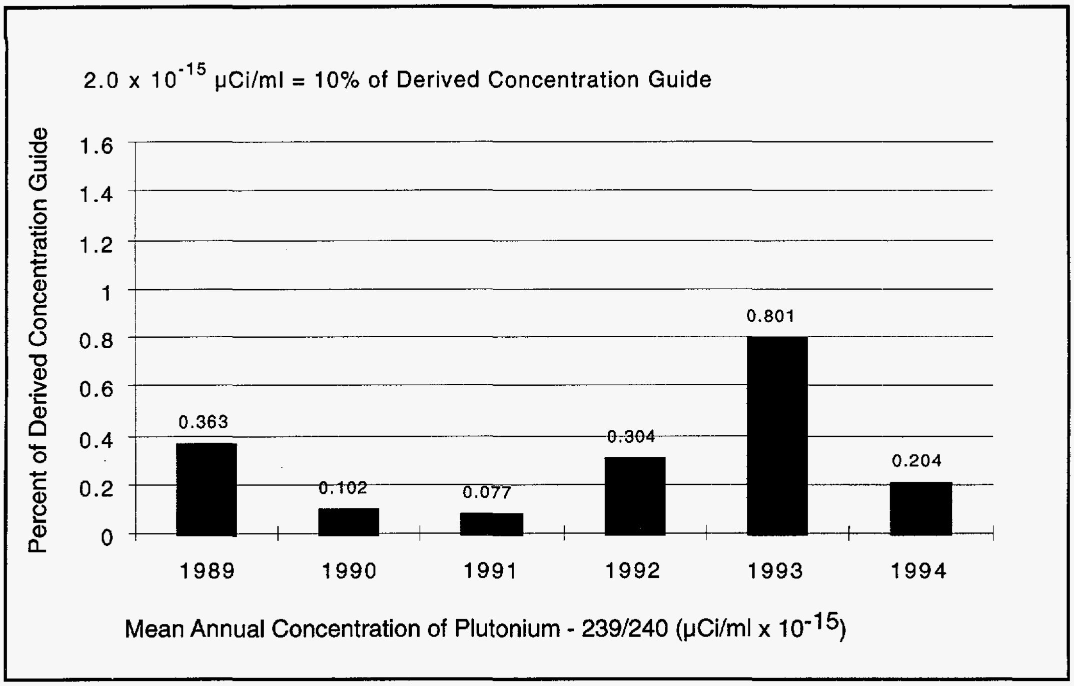


Figure 3.2-3. Mean Annual Concentration of Plutonium - 239/240 (Onsite Samplers)

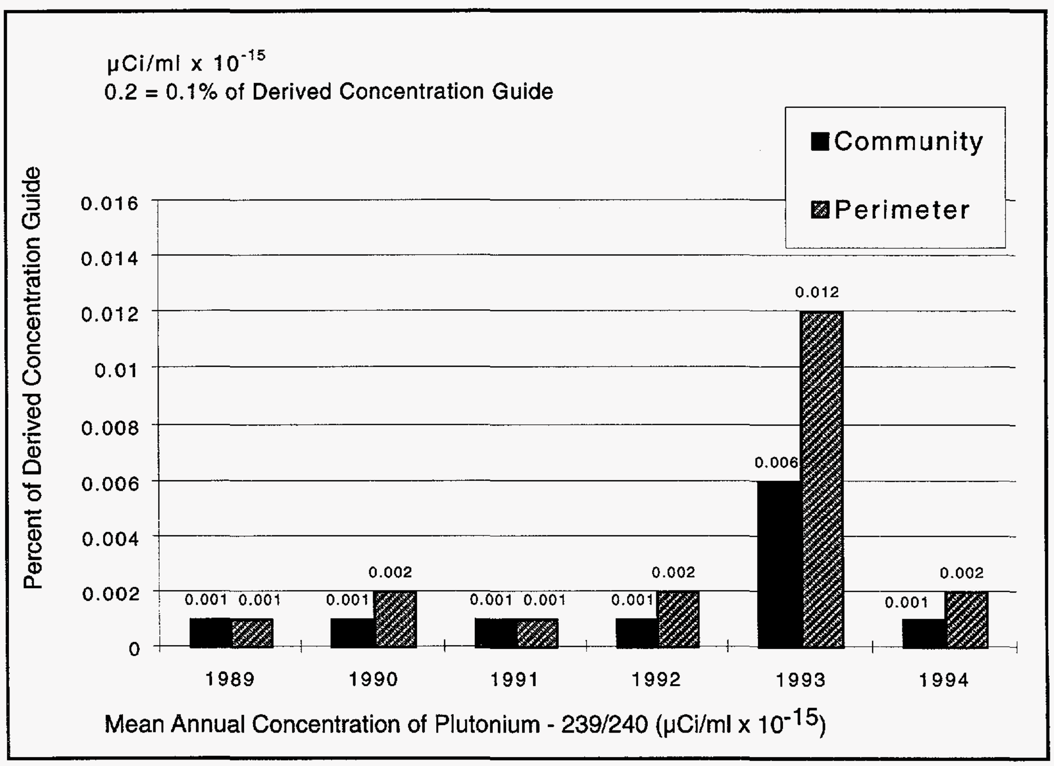


Figure 3.2-4. Mean Annual Concentration of Plutonium (Perimeter and Community Samplers)

In 1994, 41 new RAAMP samplers were installed to replace the aging network. Rocky Flats developed a new sampler that provides the ability to separate radioactive particles into two size ranges (one coarse, the other fine and respirable) and to retain them for analysis. The larger, coarse fraction is collected on an oiled impaction pad. The fine fraction is collected on a 20- by 25-centimeter fiberglass filter. Data will be reported quarterly starting in April, 1995.

COMMUNITY RADIATION MONITORING PROGRAM

The Rocky Flats Community Radiation Monitoring (ComRad) Program is a cooperative effort of DOE, Rocky Flats, and the communities surrounding the Site. ComRad involves citizen-operated environmental air surveillance stations.

The purpose of ComRad is to provide a mechanism for individuals living in the surrounding area to participate actively in the Site environmental surveillance program, increase public awareness of the program, and improve communication with local communities. Each ComRad station is assigned a manager and an alternate. The ten ComRad managers, the program coordinator, and an assistant all complete 160 hours of training on radiation concepts, dose assessment, instrumentation, community and media relations, meteorology, atmospheric dispersion, and the air monitoring history of Rocky Flats. The managers generally are local science teachers who are responsible for operating the equipment, collecting samples, and providing a detailed summary of the results to the public.

Each ComRad station consists of equipment to sample the air and to measure environmental radiation exposure. The stations are designed to sample for the following radioactive materials: airborne, beta-emitting particulates; airborne, alpha-emitting particulates; and ambient, external penetrating gamma radiation. The equipment also measures air temperature, barometric pressure, humidity, wind speed and direction, and rainfall. Samples are analyzed at the EPA Laboratory in Las Vegas, Nevada, and pertinent data are recorded by the station manager at defined intervals.

References

1. United States Environmental Protection Agency, "National Primary and Secondary Ambient Air Quality Standards," *United States Code of Federal Regulations, Title 40, Part 50, Subchapter C, Air Programs,* Washington, D.C., 1981.

2. United States Environmental Protection Agency, "Revisions to the National Ambient Air Quality Standards for Particulate Matter," *Federal Register 60, No. 126,* Washington, D.C., July 1, 1987.

3. United States Congress, *Clean Air Act,* Sections 112 and 301(a), as amended in 1983 (42 USC 7412, 7601a), Washington, D.C., 1983.

4. United States Environmental Protection Agency; "Principles," Volume I, EPA-600/9-76-005, March 1976; "Ambient Air Specific Methods," Volume II, EPA-600/4-77-027a; *The Quality Assurance Handbook for Air Pollution Measurements Systems,* Research Triangle Park, North Carolina, May 1977.

5. EG&G Rocky Flats, Inc., *Industrial Area Interim Measures/Interim Remedial Actions (IM/IRA) Decision Document,* Golden, Colorado, November 1994.

6. United States Department of Energy, Order 5400.1, *General Environmental Protection Program,* Washington, D.C., November 9, 1988.

7. Schleicher & Schuell, Publication No. 500, *Innovative Products for Separation Science,* March 1982.

3.3 SURFACE-WATER MONITORING

OVERVIEW

Surface waters at Rocky Flats are extensively analyzed to ensure that water quality standards are met, to characterize background water quality, and to evaluate potential contaminant releases from specific locations. Surface-water management at Rocky Flats focuses on Walnut Creek and Woman Creek drainages. Samples are routinely collected and analyzed from these drainages, seeps, and surface impoundments within the Site. This section provides results of the surface-water monitoring program.

Liquid effluents originating from Rocky Flats are carefully controlled and monitored as part of the Site's environmental protection program. Sources of liquid effluents include treated domestic sanitary water and surface-water runoff which are collected, controlled, and monitored in a series of ponds before being discharged offsite. Surface runoff at Rocky Flats moves from west to east and is carried from the Site by three major drainage basins: North Walnut Creek, South Walnut Creek, and Woman Creek.

DRAINAGE SYSTEMS

North Walnut Creek

North Walnut Creek receives surface-water runoff and some seepage water from the northern portion of the Industrial Area and from adjacent slopes within the drainage basin area. The drainage area associated with North Walnut Creek includes the north portion of the Site from First Street at Sage Avenue to Pond A-4 and encompasses approximately 378 acres (Figure 3.3-1). North Walnut Creek begins at the West Division Ditch and extends approximately 10,500 feet to the outfall of Pond A-4. Ponds A-1 and A-2 are isolated from Walnut Creek at the A-1 bypass. The gate valves at the A-1 bypass have the capability to divert the North Walnut Creek stream flow by way of an underground pipeline to Ponds A-3 or A-4. Ponds A-1 and A-2 are maintained for emergency spill control for the northern portion of the Industrial Area. Under normal operations, Pond A-2 receives water from several sources: (1) direct precipitation, (2) surface-water runoff from North Walnut Creek drainage, and (3) transfers from Ponds A-1, B-1, and B-2.

Pond A-3 on North Walnut Creek is used to impound the surface runoff for water quality analysis prior to discharge to Pond A-4 and subsequent release offsite to the Broomfield Diversion Ditch. Pond A-4 is located downstream of Pond A-3 on North Walnut Creek and provides the capability for additional water quality monitoring, additional detention capacity during storm or flood conditions, and

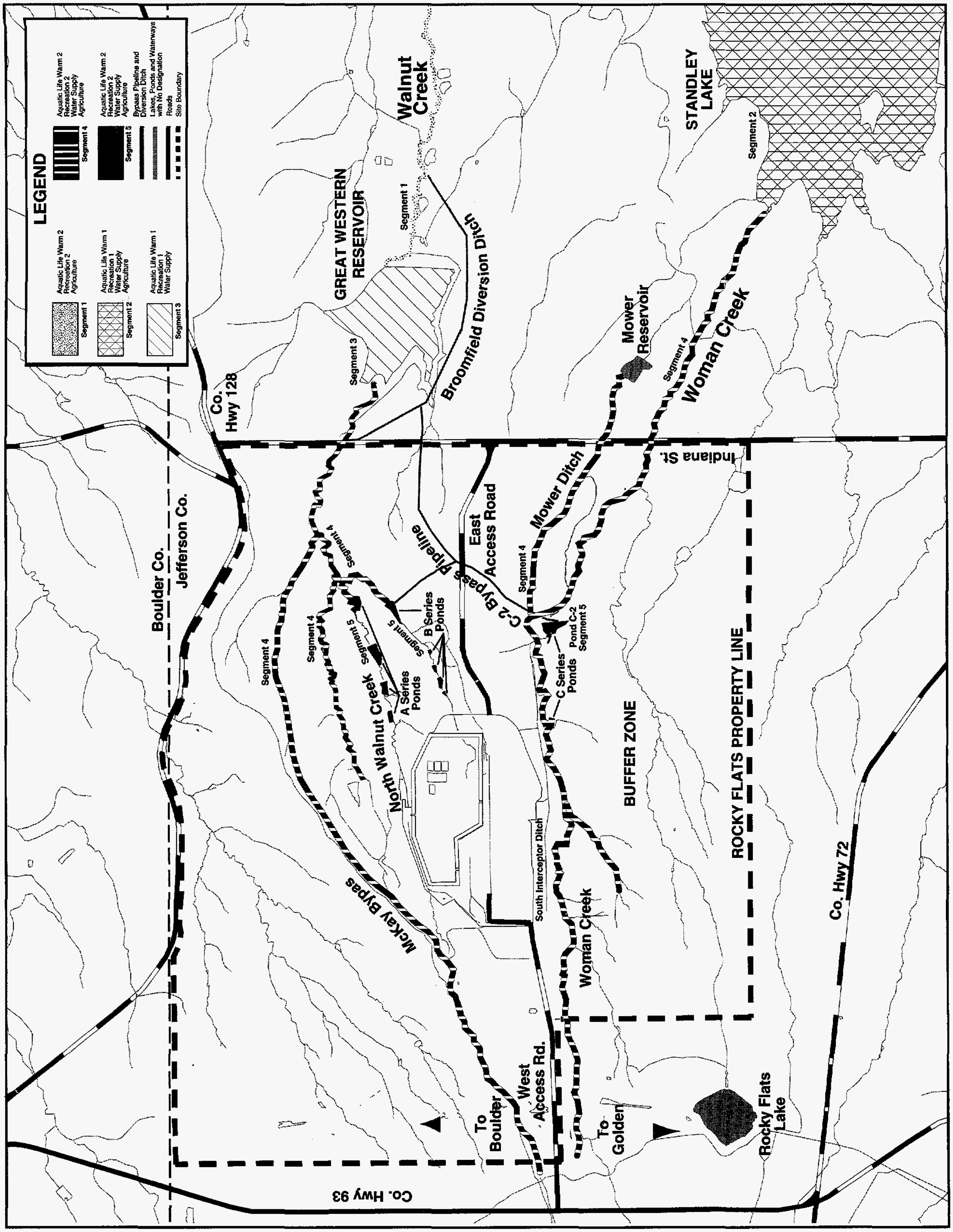


Figure 3.3-1. Holding Ponds and Liquid Effluent Water Courses

water treatment, if required. Pond A-4 is the terminal pond of the A series on North Walnut Creek. The volumetric capacity of Pond A-1 is 1.40 million gallons; Pond A-2, 6.00 million gallons; Pond A-3, 12.37 million gallons; and Pond A-4, 32.50 million gallons. NPDES permitted discharge sampling locations are Pond B-3 (discharge 001), Pond A-3 (discharge 002), Pond A-4 (discharge 005), Pond B-5 (discharge 006), Pond C-2 (discharge 007), and waste water treatment plant effluent (discharge STP). These locations and the parameters for which they are monitored are listed in Table 3.3-1.

South Walnut Creek

South Walnut Creek receives surface-water runoff, treated domestic sanitary water, and some seepage water from the central portion of the industrial area and from the adjacent grounds associated with the drainage. The drainage area associated with this portion of South Walnut Creek extends from the Site's First Street to Pond B-5 and is approximately 338 acres (Figure 3.3-1). The length of South Walnut Creek from Building 131 at First Street to Pond B-5 is approximately 9,625 feet. Ponds B-1 and B-2 are isolated from South Walnut Creek at the B-1 bypass. Ponds B-1 and B-2 are maintained for emergency spill control for the central portion of the main facility. In the event of a spill emergency, the gate valves at the B-1 bypass have the capability of diverting South Walnut Creek flows to Pond B-1, which can be subsequently pumped to Pond B-2 in case of impending overflow.

The WWTP has bypass capabilities to Ponds B-1 and B-2 in the event of an upset condition or emergency. Ponds B-1 and B-2 will be replaced as emergency containment by off-channel tankage with at least 500,000 gallons of effluent storage capacity. Operational requirements for the off-channel tankage project have been documented and installation is scheduled for 1998. During normal operations, the B-1 bypass conveys surface-water runoff by an underground pipeline from the bypass to Pond B-4 and subsequently to Pond B-5. During major precipitation events, storm water may be diverted prior to the B-1 bypass at the Central Avenue splitter box. These high flows are diverted directly to Pond B-5.

Treated sanitary effluent is discharged from the WWTP to Pond B-3. Pond B-3 water is impounded during evening hours and is released to Pond B-4 during daylight hours on a daily basis. Pond B-4 is a controlled flow-through pond and all flow is conveyed to Pond B-5. Pond B-5 is the terminal pond of the B series on South Walnut Creek. Under normal operations, water from Pond B-5 is transferred to Pond A-4, where sampling and water quality analyses are performed on the isolated water prior to final discharge offsite. During periods of excessive runoff (e.g., spring snowmelt, severe storms), water from Pond B-5 is sampled and analyzed, and may be discharged directly to South Walnut Creek which flows offsite. The volumetric capacity of Pond B-1 is 1.14 million gallons; Pond B-2, 1.50 million gallons; Pond B-3, 0.57 million gallons; Pond B-4, 0.18 million gallons; and Pond B-5, 24.00 million gallons.

Table 3.3-1
NPDES Permit Limits and Reporting Requirements as Modified by the FFCA Effective April 1991[a]

Location/Parameter	Daily Maximum	7-Day Max. Average	30-Day Max. Average
Discharge 001 (Pond B-3)			
Total Suspended Solids (mg/l)	Report[b]	N/A	Report[b]
Biological Oxygen Demand 5-Day (mg/l)	Report[b]	N/A	Report[b]
Carbonaceous Biological Oxygen Demand 5-Day (mg/l)	Report[b]	N/A	Report[b]
Nitrates as N (mg/l)	N/A	20	10
Total Residual Chlorine (mg/l)	0.5	N/A	N/A
Discharge 002 (Pond A-3)			
pH (SU)	9.0[c]	N/A	N/A
Nitrates as N (mg/l)	20	N/A	10
Discharge 005 (Pond A-4)			
Total Chromium (µg/l)	50	N/A	N/A
Nonvolatile Suspended Solids (mg/l)	Report[b,f]	N/A	N/A
Flow - million gallons per day (mgd)	Report[b]	N/A	N/A
Whole Effluent Toxicity (LC_{50})[d]	Report[b]	N/A	N/A
Discharge 006 (Pond B-5)			
Total Chromium (µg/l)	50	N/A	N/A
Nonvolatile Suspended Solids (mg/l)	Report[b,f]	N/A	N/A
Flow (mgd)	Report[b]	N/A	N/A
Whole Effluent Toxicity (LC_{50})[d]	Report[b]	N/A	N/A
Discharge 007 (Pond C-2)			
Total Chromium (µg/l)	50	N/A	N/A
Nonvolatile Suspended Solids (mg/l)	Report[b,f]	N/A	N/A
Flow (mgd)	Report[b]	N/A	N/A
Whole Effluent Toxicity (LC_{50})[d]	Report[b]	N/A	N/A
Discharge STP (995 Effluent)			
pH (SU)	9.0[c]	N/A	N/A
Total Suspended Solids (mg/l)	N/A	45	30
Oil & Grease (mg/l)	No Visual	N/A	N/A
Total Phosphorus (mg/l)	12	N/A	8
Total Chromium (µg/l)	100	N/A	50
Carbonaceous Biological Oxygen Demand 5-Day (mg/l)	25	N/A	10
Total Residual Chlorine (mg/l)	N/A	Report[b]	Report[b]
Fecal Coliform (#/100 ml)	N/A	400[e]	200[e]

a. The FFCA also requires reporting but does not specify discharge limitations for the following VOCs and metals: antimony, arsenic, beryllium, cadmium, copper, iron, lead, manganese, mercury, nickel, silver, zinc, benzene, bromoform, carbon tetrachloride, chlorobenzene, chlorodibromomethane, chloroethane, chloroform, dichlorobromomethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethylene, 1,2-dichloropropane, 1,3-dichloropropylene, ethylbenzene, methyl bromide, methyl chloride, methylene chloride, 1,1,2,2-tetrachloroethane, tetrachloroethylene, toluene, 1,2-trans-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, vinyl chloride.
b. Report only, no limitation placed on this analyte by permit.
c. pH daily minimum value = 6.0.

Woman Creek

The Woman Creek drainage is located south of the Industrial Area. The drainage associated with Woman Creek includes an area from the Boulder Diversion Canal just west of the Site to Indiana Street just east of the Site, encompassing approximately 1,400 acres (Figure 3.3-1). The length of Woman Creek from the Rocky Flats West Gate to Indiana Street is approximately 22,000 feet. The three sources of flow to Woman Creek are precipitation and surface runoff, seepage from Antelope Springs and lesser seeps, and conveyance flows as a result of water rights agreements. These flows are from Kinnear Ditch, Smart Ditch #1, and/or Smart Ditch #2 into Woman Creek. The Woman Creek stream flows through Pond C-1 and is then diverted around Pond C-2 by way of the Woman Creek Bypass Canal. Woman Creek flows are either diverted into the Mower Diversion Ditch or proceed in Woman Creek to Indiana Street and offsite.

Surface-water runoff from the southern slope of the Industrial Area is collected by the South Interceptor Ditch and conveyed to Pond C-2. The drainage area associated with the South Interceptor Ditch and Pond C-2 is approximately 193 acres. The South Interceptor Ditch is approximately 7,700 feet in length. Water is impounded in Pond C-2 and held for quality analysis. Upon completion of analysis, water may be discharged from Pond C-2 by pipeline to the Broomfield Diversion Ditch. The volumetric capacity of Pond C-1 is 1.70 million gallons. The capacity of Pond C-2 is 22.60 million gallons.

MONITORING PROGRAMS

Detention Ponds Monitoring

Prior to discharging Ponds A-4, B-5, and C-2, samples are taken and split for analysis between CDPHE and Rocky Flats. All predischarge split samples collected for analysis by Rocky Flats are analyzed by the onsite General Laboratories (located in Building 881) with the exception of pesticide and herbicide analysis. In accordance with the NPDES permit,[1] discharges are monitored for compliance with permit limitations listed in Table 3.3-1. In addition, water quality is tested before release to compare with CWQCC stream standards (listed in Table 3.3-2) for segment 4 of Big Dry Creek (Figure 3.3-1). Water is released with concurrence from CDPHE.

During discharge, Ponds A-4, B-5, and C-2 are monitored for plutonium, americium, uranium, and tritium. Tritium, pH, gross alpha/beta, and total suspended solids (TSS) are also collected and analyzed daily for Ponds A-4, B-5, and C-2 discharge. Pond C-2 is sampled once each week for four to six weeks for radionuclides prior to discharge and the sample is analyzed by the onsite Radiological Health Laboratory (located in Building 123) for isotopic analyses. Weekly radiological monitoring is conducted at Pond B-5 to ensure water quality before transfer to Pond A-4. Daily

Table 3.3-2
Colorado Water Quality Control Commission Standards (Site-specific)

Parameter Organics	CURRENT Segment 5 Standard µg/l	CURRENT Segment 4 Standard µg/l	footnotes
4-Chloro-3-methylphenol	30	30	a
Acenaphthene	520	520	a
Acenaphthylene	0.0028	0.0028	b
Acrolein	21	21	a
Acrylonitrile	0.058	0.058	b
Aldicarb	10	10	c
Aldrin	0.00013	0.00013	b,d
Anthracene	0.0028	0.0028	b
Atrazine	3	3	b
Benzene	1	1	c
Benzidine	0.00012	0.00012	c
Benzo(a)anthracene	0.0028	0.0028	b
Benzo(a)pyrene	0.0028	0.0028	b
Benzo(b)fluoranthene	0.0028	0.0028	b
Benzo(ghi)perylene	0.0028	0.0028	b
Benzo(k)fluoranthene	0.0028	0.0028	b
Bromodichloromethane	0.3	0.3	b
Bromoform	4	4	b
Butyl benzyl phthalate	3000	3000	a
Carbofuran	36	36	c
Carbon tetrachloride	18	0.25	c,e
Chlordane	0.00058	0.00058	b,d
Chlorobenzene	100	100	c
Chloroethyl ether (bis-2)	0.03	0.03	b,c
Chloroform	6.0	6.0	b
Chloromethyl ether (bis)	0.0000037	0.0000037	b
Chlorophenol	2000	2000	a
Chloropyrifos	0.041	0.041	a
Chrysene	0.0028	0.0028	b
DDD 4'4	0.00083	0.00083	a
DDE 4'4	0.001	0.001	c
DDT 4'4	0.00059	0.00059	b,d
Demeton	0.1	0.1	b
Di-n-butyl phthalate	2700	2700	a
Dibenzo(a,h)anthracene	0.0028	0.0028	b
Dibromochloromethane	6	6	b
Dichlorobenzene 1,2	620	620	c
Dichlorobenzene 1,3	400	400	c
Dichlorobenzene 1,4	75	75	c
Dichlorobenzidine	0.039	0.039	b
Dichloroethane 1,2	0.4	0.4	c
Dichloroethylene 1,1	0.057	0.057	c
Dichloroethylene 1,2-cis	70	70	c
Dichloroethylene 1,2-trans	100	100	c
Dichlorophenol 2,4	21	21	a
Dichlorophenoxyacetic acid (2,4-D)	70	70	b,d

Table 3.3-2 (Continued)
Colorado Water Quality Control Commission Standards (Site-specific)

Parameter	CURRENT Segment 5 Standard µg/l	CURRENT Segment 4 Standard µg/l	footnotes
Organics			
Dichloropropane 1,2	0.56	0.56	c
Dieldrin	0.00014	0.00014	b,d
Diethyl phthalate	23000	23000	a
Pentachlorobenzene	6	6	c
Pentachlorophenol	5.7	5.7	c
Phenanthrene	0.0028	0.0028	b
Pyrene	0.0028	0.0028	b
Simazine	4	4	b
Tetrachlorobenzene 1,2,4,5	2	2	c
Tetrachloroethane 1,1,2,2	0.17	0.17	a
Tetrachloroethylene	76	0.8	b,d,e
Toluene	1000	1000	c
Toxaphene	0.0002	0.0002	c
Trichloroethane 1,1,1	200	200	c
Trichloroethane 1,1,2	0.6	0.6	c
Trichloroethylene	66	2.7	c,e
Trichlorophenol 2,4,5	700	700	c
Trichlorophenol 2,4,6	2.0	2.0	c
Trichlorophenoxypropionic (2,4,5-tp)	50.0	50.0	b
Vinyl Chloride	2	2	c
Metals When not indicated, Total Recoverable metals are method required.			
Aluminum (*)	87	87	a
Arsenic	50	50	c
Barium	1000	1000	c
Beryllium (30 day avg)	4	4	f
Cadmium (*)	TVS = 1.50**	TVS=1.50	f,c
Chromium III	50	50	c
Chromium VI (*)	11	11	c
Copper	23	TVS=16	f,d
Iron (*)	300	300	c
Iron	13200	1000	a,e
Lead	28	50	c
Manganese (*)	560	50	c
Manganese (30 day avg)	200	200	f
Mercury	0.01	0.01	c
Nickel (*)	TVS=125	TVS=125	f
Selenium	10	10	c
Silver (*)	TVS=0.59	TVS=0.59	c
Thallium	0.012	0.012	c
Zinc	350	2,000 (30 day avg)	d,f
Cadmium	10	10	c
Silver	50	50	c

(*) = DISSOLVED METAL
**TVS = TABLE VALUE STANDARD - TVSs, promulgated by the Colorado Water Quality Control Commission, are variable standards subject to the measured values for other parameters, such as total hardness.

Table 3.3-2 (Continued)
Colorado Water Quality Control Commission Standards (Site-specific)

Parameter Organics	CURRENT Segment 5 Standard µg/l	CURRENT Segment 4 Standard µg/l	footnotes
Dimethylphenol 2,4	2120	2120	a
Dinitro-o-cresole	13	13	a
Dinitrophenol 2,4	14	14	c
Dinitrotoluene 2,4	0.11	0.11	a
Dinitrotoluene 2,6	230	230	a
Dioxin (2,3,7,8-TCDD)	0.000000013	0.000000013	b,d
Diphenylhydrazine 1,2	0.04	0.04	c
Endosulfan	0.056	0.056	b
Endrin	0.0023	0.0023	b,d
Endrin aldehyde	0.2	0.2	a
Ethylbenzene	680	680	c
Ethylhexyl phthalate (bis-2)	1.8	1.8	a
Fluoranthene	42	42	b
Fluorene	0.0028	0.0028	b
Guthion	0.01	0.01	b
Heptachlor	0.00021	0.00021	b,d
Heptachlor epoxide	0.0001	0.0001	c
Hexachlorobenzene	0.00072	0.00072	b,d
Hexachlorobutadiene	0.45	0.45	b,d
Hexachlorocyclohexane, alpha (BHC)	0.0039	0.0039	b
Hexachlorocyclohexane, beta (BHC)	0.014	0.014	b
Hexachlorocyclohexane, gamma (BHC)	0.019	0.019	b,d
Hexachlorocyclohexane, technical (BHC)	0.012	0.012	b
Hexachloroethane	1.9	1.9	b
Hexachlororocyclopentadiene	5	5	c
Indeno(1,2,3-cd)pyrene	0.0028	0.0028	b
Isophorone	8.4	8.4	c
Malathion	0.1	0.1	b
Methoxychlor	0.03	0.03	b,d
Methyl bromide	48	48	b
Methyl chloride	5.7	5.7	b
Methylene chloride	4.7	4.7	b
Mirex	0.001	0.001	b
Naphthalene	0.0028	0.0028	b
Nitrobenzene	3.5	3.5	c
Nitroso-di-n-propylamine-n	0.005	0.005	a
Nitrosodi-n-butylamine-n	0.0064	0.0064	b
Nitrosodiethylamine-n	0.0008	0.0008	b
Nitrosodimethylamine-n	0.00069	0.00069	b
Nitrosodiphenylamine-n	4.9	4.9	b
Nitrosopyrrolidine-n	0.016	0.016	b

Table 3.3-2 (Continued)
Colorado Water Quality Control Commission Standards (Site-specific)

Parameter **Physical & Biological**	CURRENT Segment 5 Standard µg/l	CURRENT Segment 4 Standard µg/l	footnotes
Minimum Dissolved Oxygen (mg/l)	5.0	5.0	c,f
pH (s.u.)	6.5-9.0	6.5-9.0	c
Fecal Coliforms per 100 ml	2000	2000	c
Inorganics			
Unionized Ammonia - March Through June	1800	calculated	c,f,g
Unionized Ammonia - July Through February	700	calculated	c,g
Ammonia	100	100	
Boron	750	750	f
Chloride	250000	250000	c
Chlorine (Acute)	19	19	a
Chlorine (Chronic)	11	11	a
Cyanide (Free)	5	5	c,f
Fluoride	2000		c
Nitrate	10000	10000	c
Nitrite	500	500	c
Sulfate	250000	250000	c
Sulfide (as H_2S)	2	2	c

Parameter **Radionuclides**	CURRENT Segment 5 Standard Woman Creek pCi/l	CURRENT Segment 4 Standard Walnut Creek pCi/l
Gross alpha	7	11
Gross beta	5	19
Americium-241	0.05	0.05
Curium-244	60	60
Neptunium-237	30	30
Plutonium-239, -240	0.05	0.05
Uranium	5	10
Uranium-233/-234		
Uranium-238		
Cesium-134	80	80
Radium-226, -228	5	5
Strontium-90	8	8
Thorium-230, -232	60	60
Tritium	500	500

a. Statewide aquatic standard.
b. Site specific standard.
c. Statewide water supply standard.
d. This standard is more restrictive than the sitewide water supply standard.
e. Segment 5 standard is a temporary modification, established 3/93.
f. Statewide agricultural standard.
g. Statewide water supply unionized ammonia standard of 0.5 µg/l applied at water supply intake.

samples are collected in a similar manner at a sampling station on Walnut Creek near its intersection with Indiana Street.

Total chromium samples are analyzed monthly while WET samples are analyzed quarterly when discharge occurs at Ponds A-4, B-5, and C-2. Pond B-5 is sampled monthly for total chromium during transfer to Pond A-4.

Discharges in 1994 from Pond A-4, which may include transfers from Pond B-5, entered Walnut Creek and were diverted around Great Western Reservoir by means of the Broomfield Diversion Ditch. Discharges from Pond C-2 may be pumped through an 8,000-foot pipeline which flows into the Broomfield Diversion Ditch. Table 3.3-3 indicates the 1994 monthly flow volumes and summaries of data from discharges at Ponds A-4, B-5, C-2, C-1, Walnut Creek at Indiana, and Pond B-5 transfers.

If the need should ever arise, carbon adsorption and filtration facilities are available for additional treatment of waters before release. Treatment capacity at Ponds A-4 and C-2 are 1,200 gallons per minute (gpm) and 750 gpm, respectively.

Remote Monitoring and Control Network

The remote monitoring program employs radio control and data acquisition systems and displays monitoring results on a computer-based system using graphical user interface (GUI) technology. Twenty-five surface-water remote monitoring stations have been installed since the summer of 1992. The remote surface-water monitoring

Table 3.3-3
Monthly Flow and Discharges for 1994

Month	Walnut Creek at Indiana	Pond A-4	Pond B-5	Pond C-2	Pond C-1
January	15,349,000	19,547,000	No Discharge	No Discharge	2,923,000
February	No Flow	No Discharge	No Discharge	No Discharge	2,986,000
March	9,958,000	11,999,000	1,374,000	No Discharge	9,010,000
April	15,459,000a	15,815,000	No Discharge	No Discharge	15,367,000
May	11,011,000a	7,464,000	No Discharge	No Discharge	5,548,000
June	11,076,000	12,268,000	No Discharge	No Discharge	1,378,000 a
July	8,944,000	9,737,000	No Discharge	No Discharge	No Flow
August	No Flow	No Discharge	No Discharge	No Discharge	No Flow
September	10,235,000	8,745,000	No Discharge	No Discharge	No Flow
October	9,138,000	10,497,000	No Discharge	No Discharge	376,000
November	No Flow	No Discharge	No Discharge	No Discharge	4,619,000
December	9,912,000	12,587,000	No Discharge	No Discharge	4,761,000
Total	101,082,000	108,650,000	1,374,000	No Discharge	46,968,000

a. Total volume is an estimate; flow was too low to quantify for part of the month.

system consists of the following major components.

- Field sensors, including flow equipment and water quality probes
- Remote bidirectional radio telemetry hardware
- Computer-based, Real-time Graphical User Interface (RTGUI) using networking capabilities

Field sensors are located throughout the Site at detention pond outlets, along creeks, and at monitoring locations identified in the Industrial Area IM/IRA. Field sensors measure flow and water-quality parameters (i.e., pH, dissolved oxygen, salinity, conductivity, temperature, and turbidity). Real-time water-quality data are used as indicators of pond water quality, and as such, data are archived but not summarized. Flow sensors are located at existing NPDES permit outfalls to record required information. At present, the 25 field sensors transmit data by means of 25 self-contained solar-powered network nodes. Three of these nodes are based on industrial-compliant programmable logic controllers and distributed process controllers.

Field sensors are linked by a remote radio-controlled network using radio telemetry to the RTGUI. The remote bidirectional radio network employs the Internet standard protocol, Transmission Control Protocol/Internet Protocol. The RTGUI system employs standard personal computer and work station-based software systems from Iconics, Geomation, and Silicon Graphics. Real-time data are animated by the RTGUI to support mission-based decisions on water management.

Hydrological Characterization and Storm Water Monitoring

Hydrological and storm water quality characterizations of the Site are generated from 21 stream gaging stations dispersed sitewide. The stream gages are equipped with continuously recording flow meters and automatic water samplers that are programmed to sample storm event and pond discharge event flows. The stream gages are part of the fixed-station monitoring network for evaluating contaminant fate and transport across the Site.

Data collected at the stream gaging stations in water years 1991, 1992, and 1993 are published in the *Event-Related Surface Water Monitoring Report, Rocky Flats Plant, Water Years 1991 and 1992 and Event-Related Surface Water Monitoring Report, Rocky Flats Environmental Technology Site,Water Year 1993.* Electronic copies of these data are available to support future hydrological investigations.

In May 1993, DOE entered into an IAG with the USGS to upgrade, operate, and maintain the Site's stream gaging station network and to provide expertise in hydrologic data collection. The USGS will publish Site hydrologic data in *USGS Open File* reports, and data analysis and interpretation will be published in *USGS Water Resources Investigation* reports. The USGS provides administrative reports on surface-water discharge from the Site at the monthly DOE-State Exchange of Information Meeting.[2] The USGS is scheduled to install satellite telemetry systems on the stream gages in Water Year 1995 to provide a real-time data collection platform that is accessible by modem to external data users such as DOE, EPA, or CDPHE.

MONITORING RESULTS

Nonradiological Monitoring

The release of pollutants into United States waters is controlled by the NPDES permit, which requires routine monitoring of point source discharges and reporting of results. An updated renewal application has been submitted for the Rocky Flats NPDES permit, which expired in 1989 and was extended administratively until renewed. In addition, the NPDES permit terms were modified by the NPDES FFCA that was signed by DOE and EPA in 1991. That FFCA established an additional monitoring point at the WWTP and added certain monitoring requirements. In 1994 there were no violations of NPDES limitations at Rocky Flats.

Annual average concentrations of chemical and biological constituents measured in surface-water effluent samples as part of the NPDES FFCA are provided in Table 3.3-4. Concentrations are indicative of the overall quality of effluent discharges. Certain discharges must meet the NPDES permit monitoring and compliance limitations described in Table 3.3-1.

Radiological Monitoring

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 3.3-5 and 3.3-6. The mean concentrations at all sample locations were less than 0.28 percent of applicable DCGs (Table 3.3-7), which is the applicable standard as prescribed by DOE orders under authority of the Atomic Energy Act.

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

Table 3.3-4
Chemical and Biological Constituents in Surface-Water Effluents at NPDES Permit Discharge Locations, 1994[a,b]

Parameters	Number of Analyses	C minimum[c]	C maximum[c]	C mean[c, d]
Discharge 001 (Pond B-3)				
Nitrate as N, mg/l	65	0.3	7.3	3.1
Total Residual Chlorine, mg/l	365	0	0.28	0.05
Discharge 002 (Pond A-3)				
pH, standard units	30	6.7	8.2	N/A
Nitrate as N, mg/l	30	<0.05	3.5	<1.0
Discharge 003 (Reverse Osmosis Pilot Plant)	During 1994 there were no discharges.			
Discharge 004 (Reverse Osmosis Plant)	During 1994 there were no discharges.			
Discharge 005 (Pond A-4)				
Total Chromium, µg/l	9	<4.0	<5.0	<4.6
Discharge 006 (Pond B-5)				
TotalChromium, µg/l	1	<4.0	<4.0	<4.0
Discharge 007 (Pond C-2)	During 1994 there were no discharges.			
Discharge 995 (Wastewater Treatment Plant)				
pH, standard units	365	6.4	7.6	N/A
Total Suspended Solids, mg/l	116	<4.0	52.0	6.0
Oil and Grease, mg/l	0	N/A	N/A	N/A
Total Phosphorus, mg/l	116	0.4	10.7	3.4
Total Chromium, µg/l	52	<4.0	8.5	<4.7
Fecal Coliform, #/100ml	119	<1.0	530.0	<2.0
Carbonaceous Biochemical Oxygen Demand, mg/l	116	0.3	13.2	3.2

a. NPDES permit limitations are presented in Table 3.3-1.
b. 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.
c. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean measured concentration.
d. For Fecal Coliform, #/100 ml geometric mean used.

Table 3.3-5
Plutonium, Americium, and Uranium 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 pCi/l[d]			
Pond A-4	18	-0.008 ± 0.007	0.009 ± 0.007	0.002 ± 0.001	0.01
Pond C-1	37	-0.001 ± 0.004	0.022 ± 0.008	0.006 ± 0.002	0.02
Pond C-2	No Discharge During 1994				
Walnut Creek at Indiana Street	23	-0.004 ± 0.007	0.024 ± 0.010	0.005 ± 0.002	0.02
		Americium-241 Concentration pCi/l[e]			
Pond A-4	18	-0.004 ± 0.016	0.015 ± 0.007	0.003 ± 0.002	0.01
Pond C-1	37	-0.003 ± 0.012	0.021 ± 0.016	0.007 ± 0.002	0.02
Pond C-2	No Discharge During 1994				
Walnut Creek at Indiana Street	23	-0.008 ± 0.008	0.023 ± 0.021	0.006 ± 0.003	0.02
		Uranium-233, -234 Concentration pCi/l[f]			
Pond A-4	18	0.56 ± 0.12	1.20 ± 0.16	0.48 ± 0.03	0.10
Pond C-1	37	0.63 ± 0.08	2.35 ± 0.26	1.39 ± 0.45	0.28
Pond C-2	No Discharge During 1994				
Walnut Creek at Indiana Street	23	0.42 ± 0.09	1.52 ± 0.20	0.84 ± 0.03	0.17
		Uranium-238 Concentration pCi/l[f]			
Pond A-4	18	0.64 ± 0.09	1.40 ± 0.18	0.51 ± 0.03	0.08
Pond C-1	37	0.08 ± 0.09	1.63 ± 0.15	1.01 ± 0.33	0.17
Pond C-2	No Discharge During 1994				
Walnut Creek at Indiana Street	23	0.27 ± 0.07	1.31 ± 0.18	0.85 ± 0.03	0.14

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration. For Pond C-1, C mean refers to calculated mean concentration. Because of intermittent flow meter operations at Pond C-1 during 1993, a volume weighted average was not possible to calculate. For Ponds A-4, 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 (95% Confidence Interval).
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 pCi/l (Table 3.3-8).
e. Radiochemically determined as americium-241. The standard calculated DCG for americium in water available to members of the public is 30 pCi/l (Table 3.3-8).
f. 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 pCi/l. The DCG for uranium-238 in water is 600 pCi/l (Table 3.3-8).

Table 3.3-6
Tritium Concentrations in Surface-Water Effluents

Location	Number of Analyses	C minimum[a, b]	C maximum[a, b]	C mean[a, c]	Percent of DCG (C mean)
		Tritium Concentration pCi/l[d]			
Pond A-4	88	-207 ± 148	297 ± 155	34 ± 18	0.00
Pond C-1	36	-128 ± 162	340 ± 180	46 ± 15	0.00
Pond C-2	No Discharge During 1994				
Walnut Creek at Indiana Street	102	-415 ± 189	375 ± 174	28 ± 18	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 1993, a volume weighted average was not possible to calculate. For Ponds A-4, 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 (95% Confidence Interval).
d. The DOE DCG for tritium in water available to the members of the public is 2,000,000 pCi/l (Table 3.3-8).

Table 3.3-7
DOE-Derived Concentrations Guides for Radionuclides of Interest*

Water Ingestion:	Radionuclide	DCG (μCi/ml)
	Plutonium -239/240	30×10^{-9}
	Americium -241	30×10^{-9}
	Uranium -233/234	500×10^{-9}
	Uranium -238	600×10^{-9}
	Hydrogen -3 (Tritium)	$2{,}000{,}000 \times 10^{-9}$

*Based on most restrictive assumptions for gastrointestinal uptake fraction.

The cumulative discharge amounts for 1994 are as follows.

	Pond A-4	Pond C-2
Pu - Ci (Bq*)	9.47×10^{-7} (3.50×10^{4})	No Discharge During 1994
Am - Ci (Bq)	1.35×10^{-6} (4.98×10^{4})	
U-234 - Ci (Bq)	2.02×10^{-4} (7.47×10^{6})	
U-238 - Ci (Bq)	2.11×10^{-4} (7.82×10^{8})	

* Becquerel

Volume-weighted average tritium concentrations in water discharged from Pond A-4 were at background levels (34 ± 18 μCi/ml). Pond C-2 water was not discharged during 1994. Average annual concentrations of plutonium, uranium, and americium from Ponds A-4 and C-2 for 1989 through 1994 are presented in Figures 3.3-2, 3.3-3, and 3.3-4. These graphs provide a comparison of 1994 results with five-year historical data for Pond A-4 and Pond C-2. Zero values are presented in the graphs for plutonium, uranium, and americium. This indicates an average value of zero for these radioisotopes with the exception of Pond C-2, where the zero value indicates that there was no discharge during 1994.

During 1994, the Site's 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, and americium analyses were performed monthly on samples of Rocky Flats raw water. Concentrations are presented in Table 3.3-8. These values can be used for comparison with the values measured in discharge locations downstream from Rocky Flats (Table 3.3-5).

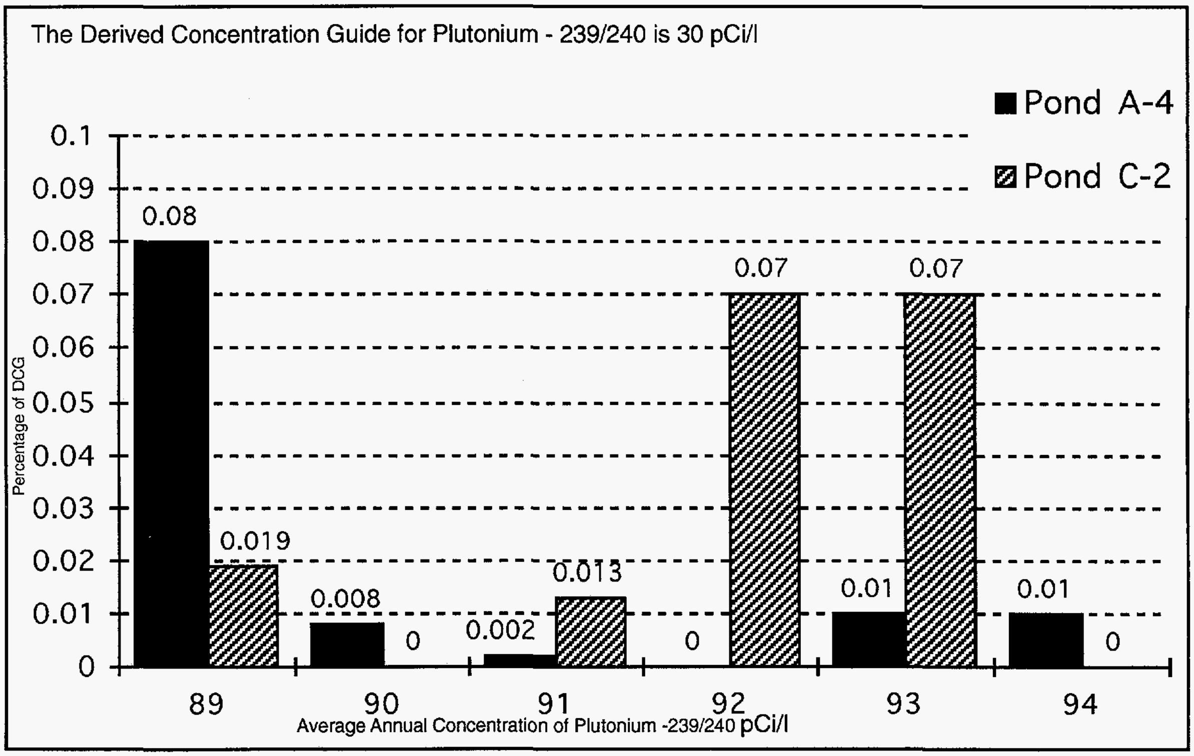


Figure 3.3-2. Average Annual Concentration of Plutonium - 239/240

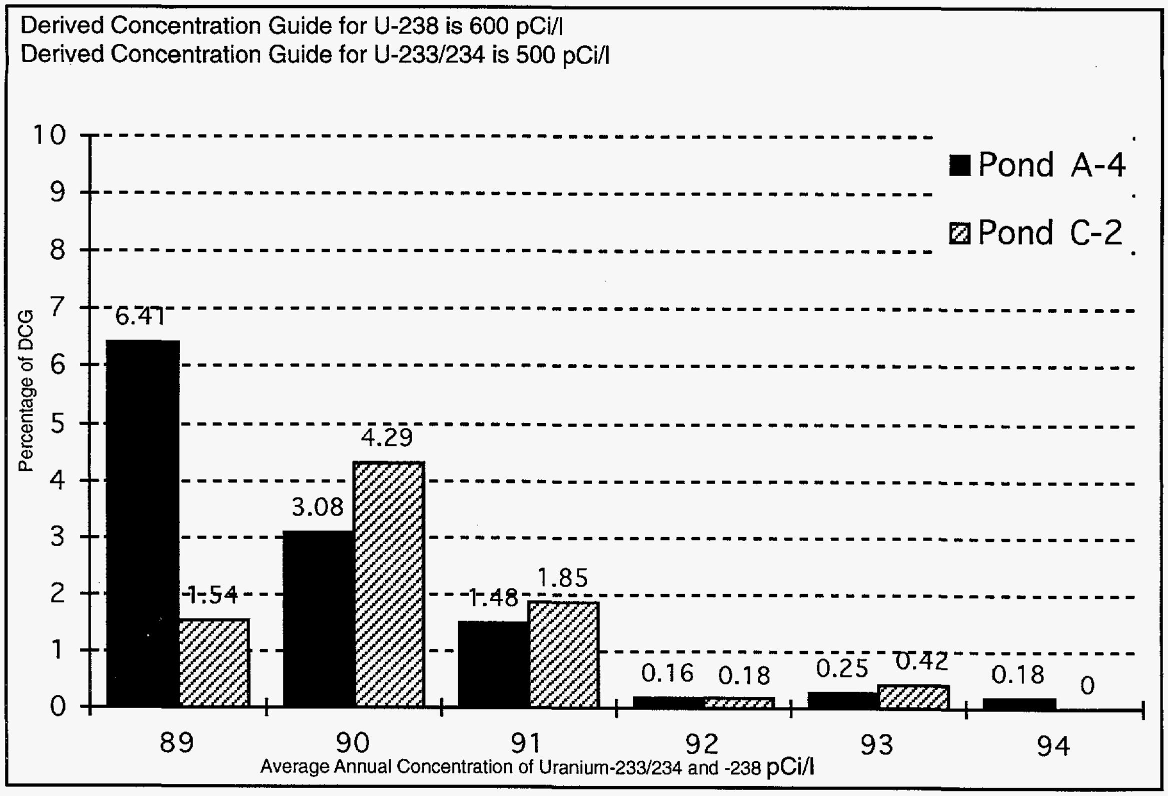


Figure 3.3-3. Average Annual Concentration of Uranium -233/234, -238 Total

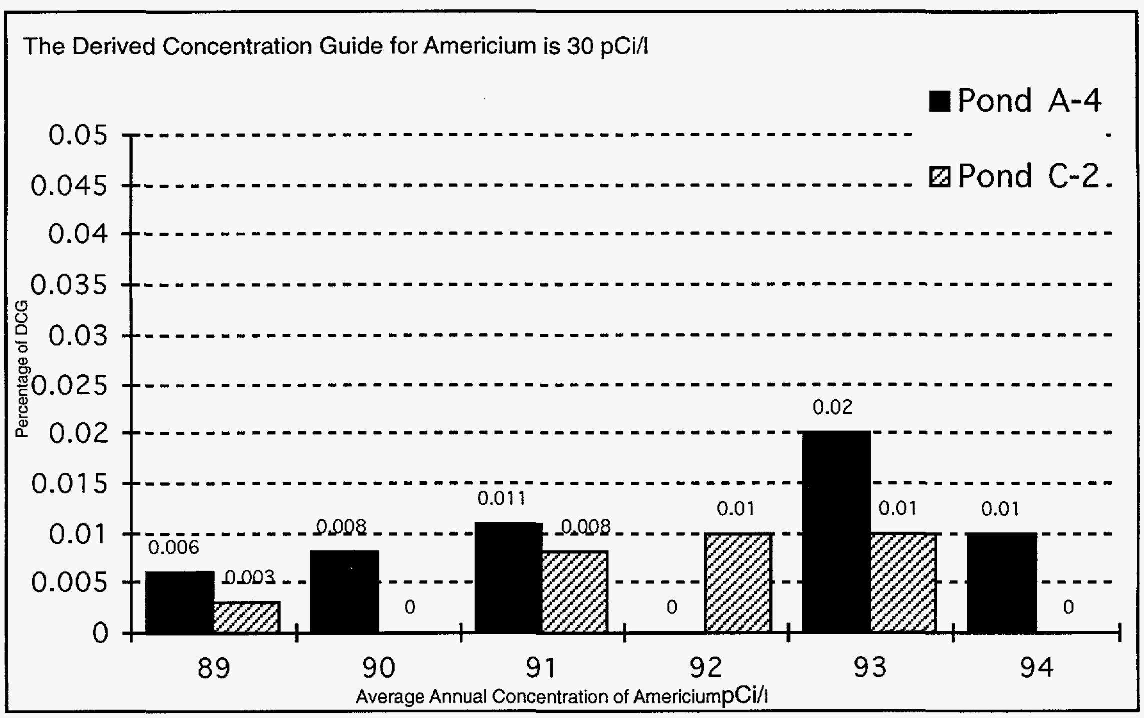


Figure 3.3-4. Average Annual Concentration of Americium

Table 3.3-8
Plutonium, Americium, and Uranium Concentrations in the Raw Water Supply

Location	Number of Analyses	C minimum[a, b]	C maximum[a, b]	C mean[a, c]	Percent of DCG (C mean)
		Plutonium Concentration pCi/l[d]			
Rocky Flats Raw Water	12	-0.003 ± 0.002	0.005 ± 0.005	0.000 ± 0.001	0.00
		Americium Concentration pCi/l[e]			
Rocky Flats Raw Water	12	-0.004 ± 0.005	0.005 ± 0.005	0.001 ± 0.002	0.00
		Uranium -233, -234 Concentration pCi/l[f]			
Rocky Flats Raw Water	12	-0.010 ± 0.010	1.300 ± 0.140	0.570 ± 0.260	0.11
		Uranium -238 Concentration pCi/l[f]			
Rocky Flats Raw Water	12	0.000 ± 0.010	1.160 ± 0.130	0.500 ± 0.220	0.08

a. C minimum = minimum measured concentration; C maximum = maximum measured concentration; C mean = mean calculated concentration.
b. Calculated as 1.96 standard deviations of the individual measurement.
c. Calculated as 1.96 standard deviations of the mean (95% Confidence Interval).
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 pCi/l (Table 3.3-8).
e. Radiochemically determined as americium -241. The standard calculated DCG for americium in water available to members of the public is 30 pCi/ll (Table 3.3-8).
f. 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 pCi/l. The DCG for uranium -238 in water is 600 pCi/l Table 3.3-8.

WATERSHED MANAGEMENT PLAN

The Watershed Management Plan (WMP) documents the programs that complement and support each other for maintenance and protection of the watershed. The major programs detailed in the plan are weed control, vegetation stabilization, erosion control, monitoring, biocide control, and ecology and NEPA field work.

Weed Control Program

The Weed Control Program instituted the application of approved herbicides at selected areas onsite to manage undesirable vegetation under federal, state, and county weed control regulations. In addition, biological and mechanical weed control methods were utilized to integrate the program fully and to reduce chemical usage.

Biocide Management Program

The Biocide Management Program is designed to ensure that Rocky Flats is in compliance with FIFRA, the Colorado Pesticide Act, and the Colorado Pesticide Applicator's Act. The program includes record-keeping responsibilities and oversight of the central FIFRA documentation file and of the use of all pesticides on the Site (whether applied by subcontractor or Site personnel). Pesticide procurement actions are reviewed and FIFRA training/qualification of building Environmental Coordinators and Facilities Operations Managers is implemented.

Dam Management and Upgrades

The twelve earthen dams at Rocky Flats are subject to federal and state regulations pertaining to the Federal Guidelines for Dam Safety[3] and the Colorado State Dam Safety Regulations.[4]

The Site Dam Rehabilitation work package has been expanded to provide for recommendations in the Federal Guidelines for Dam Safety pursuant to federal and state regulations. Surface water and civil engineering personnel received and evaluated the Draft Final Stability Analysis for Dam A-4, B-5, and C-2 at Rocky Flats, prepared by the U.S. Army Corps of Engineers; the 1994 Federal Energy Regulatory Commission Inspection Report; and the 1994 Office of the State Engineer Inspection Report concerning dams at the Site. A Rocky Flats Dam Inspection Program was proposed that satisfies recommendations in the federal guidelines for dam safety by establishing internal dam inspections, increased dam monitoring, identification of deficiencies or maintenance items, and dam improvement recommendations.

References

1. United States Environmental Protection Agency, Region VIII, NPDES Permit CO-0001333, *Authorization to Discharge Under the National Pollutant Discharge Elimination System,* Denver, Colorado, December 26, 1984.

2. The Exchange of Information Meeting is open to the public and is held on the last Tuesday of every month in the Broomfield City Council Chambers. Rocky Flats' monitoring information is published in *The Monthly Environmental Monitoring Report,* Golden, Colorado.

3. Interagency Committee on Dam Safety, Subcommittee on Emergency Action Planning, *Emergency Action Planning Guidelines for Dams,* FEMA 64, February 1985.

4. Code of Colorado Regulations, *Rules and Regulations for Dam Safety and Dam Construction,* 2 CCR 402-1, effective September 30, 1988.

3.4 GROUNDWATER MONITORING

OVERVIEW

The groundwater monitoring program at Rocky Flats maintains and operates a network of wells to background values and the concentration of hazardous constituents, measure hydrologic parameters of the aquifers, and estimate the rate of movement and extent of contaminant plumes in the uppermost aquifer within the Site boundaries. The analyses derived from the groundwater monitoring program are used to evaluate the impacts of past and present facility operations on groundwater and ensure appropriate protective measures for activities that may affect the quality of groundwater adversely.

Monitoring objectives include providing information on the presence, nature, areal extent, fate, and transport of contaminated groundwater, and providing data for trend evaluation, site characterization, and treatability studies. Groundwater data is provided to government agencies and surrounding communities and is maintained in the Rocky Flats Environmental Database System (RFEDS).

Characterization objectives include identifying hydrostratigraphic units, evaluating groundwater pathways and migration characteristics, qualifying and quantifying the interrelationships between groundwater and surface water at Rocky Flats, and the relationship among precipitation, infiltration, and groundwater recharge. Additional objectives include establishing background analyte concentrations and characterizing background groundwater geochemical interactions.

SITE CHARACTERIZATION

The following sections provide information related to the groundwater monitoring program, including information on the geology, hydrogeology, geochemistry monitoring procedures, and results recorded during 1994.

Geology

Underlying the Site is a series of stratigraphic units at increasing depths from surface deposits (composed of recent valley fill and loose rock debris) through the Rocky Flats Alluvium, Arapahoe Formation, Laramie Formation, and Fox Hills Sandstone to the Pierre Shale (Figure 3.4-1). The Rocky Flats Alluvium, Colluvium, Valley Fill Alluvium, and weathered bedrock comprise the uppermost hydrostratigraphic unit where potential groundwater contamination might occur at Rocky Flats. A description of the geology of Rocky Flats is provided in the Geologic Characterization of the Rocky Flats Plant.[1] An updated version of the sitewide Geologic Characterization Report, incorporating the results of additional studies since 1991, will be completed and released in 1995.

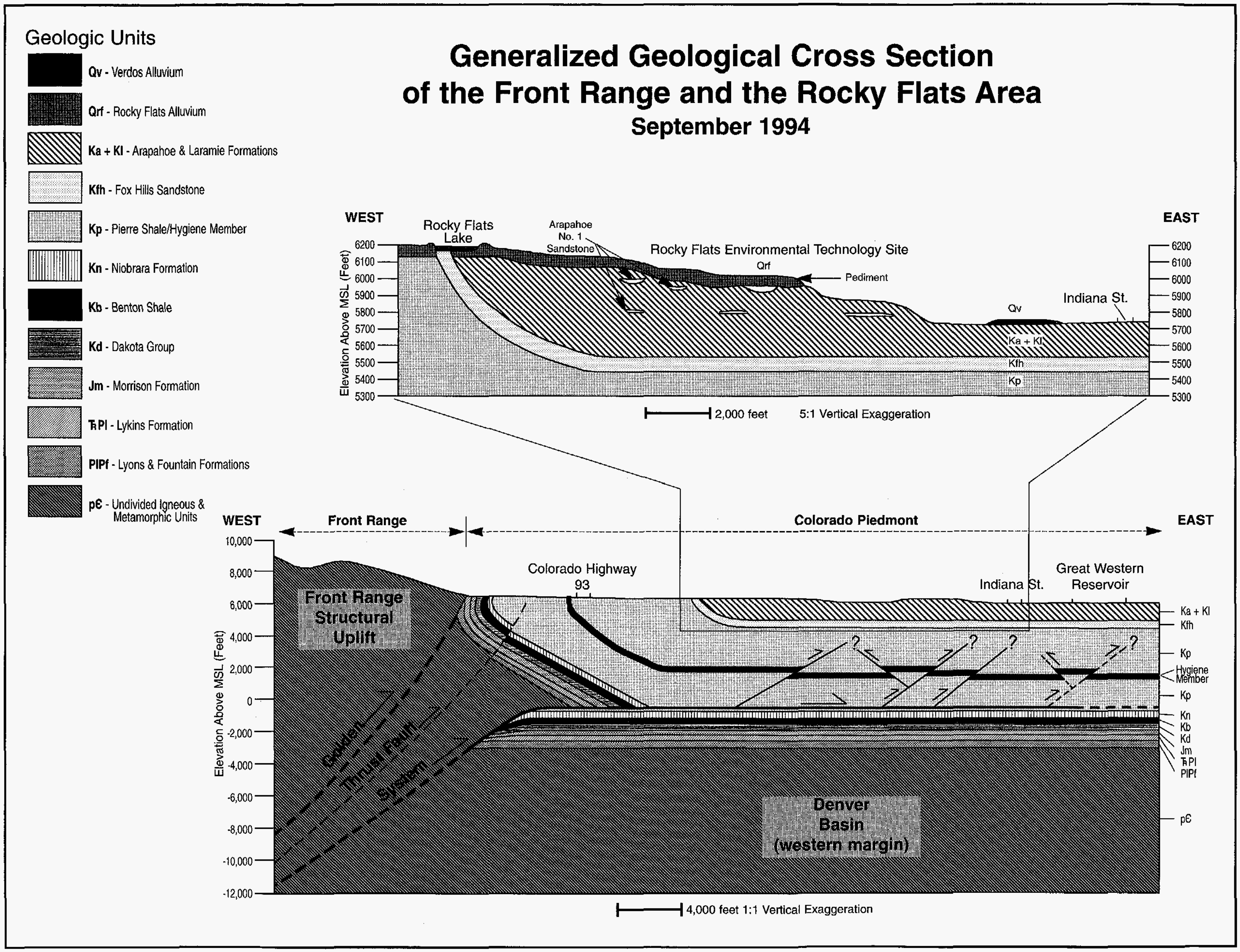


Figure 3.4-1. Generalized Geological Cross Section of the Front Range and the Rocky Flats Area

The Rocky Flats Alluvium is composed of cobbles, coarse gravel, sand, and clay, varying in thickness across Rocky Flats from approximately 103 feet on the west side, to less than 10 feet in the Industrial Area, and 45 feet on the east side.

The Upper Cretaceous Arapahoe Formation unconformably underlies the Rocky Flats Alluvium and has been partially to completely eroded in places, occupying topographic lows in the Laramie erosion surface. The Arapahoe is a medium-to-coarse grained sandstone with minor siltstone, claystone, and conglomerate. Thickness ranges from 0 to 50 feet. The #1 Sandstone in OU 4 and OU 2 is believed to be Arapahoe.

The Upper Cretaceous Laramie Formation unconformably underlies the Arapahoe Formation and is composed of claystone with minor discontinuous sandstone lenses. The Formation is 600 to 800 feet thick beneath Rocky Flats.

The Fox Hills Sandstone conformably underlies the Laramie and is 90 to 100 feet thick. The Fox Hills outcrops in the west part of the Site but occurs 900 feet below the Industrial Area. The Fox Hills is a significant aquifer east of the Site.

The Pierre shale underlies the Fox Hills Formation and consists of approximately 7500 feet of fine grained bentonitic shale, with a few thin silty sandstones. The Pierre functions as a significant aquatard to downward migration of groundwater.

A monoclinal fold limb exposed west of the Site is the most significant structural feature in the area. The west limb of the monoclinal fold dips to the east at approximately 50 degrees, while the east limb of the fold dips eastward at 1 to 2 degrees. This structure is the result of uplift of the Front Range during the Laramide Orogeny.

Hydrogeology

The Rocky Flats Alluvium and the valley fill alluvium, colluvium, landslide deposits, weathered Arapahoe and Laramie Formation bedrock, and sandstones within the Arapahoe and Upper Laramie Formations are in hydraulic communication. Together these represent the uppermost unconfined aquifer, or Upper Hydrostratigraphic Unit (UHSU). The bedrock sandstones of the Laramie Formation are isolated within intervals of claystone. Groundwater contained in those bedrock sandstones is confined and represents a lower flow system, or Lower Hydrostratigraphic Unit (LHSU). The lower Laramie and Fox Hills Formations comprise a stratigraphically lower and third distinct hydrostratigraphic unit at Rocky Flats. Table 3.4-1 provides the relative hydraulic conductivities associated with the lithologic units present at Rocky Flats. Hydraulic conductivity is a measure of the capacity of a porous medium to transmit water. It helps determine how fast groundwater and any accompanying contamination travel beneath the surface.

Table 3.4-1
Hydraulic Conductivities of Lithologic Units

Lithologic Unit	Hydraulic Conductivity (Geometric mean)*
Rocky Flats Alluvium	2.06×10^{-4} cm/sec (206 ft/yr)
Valley - Fill Alluvium	2.16×10^{-3} cm/sec (2068 ft/yr)
Valley - Fill Colluvium	1.14×10^{-4} cm/sec (103 ft/yr)
Weathered Bedrock Sandstone	3.89×10^{-5} cm/sec (41 ft/yr)
Weathered Bedrock Siltstone	2.88×10^{-5} cm/sec (31 ft/yr)
Weathered Bedrock Claystone	8.82×10^{-7} cm/sec (0.93 ft/yr)
Unweathered Bedrock Sandstone	5.77×10^{-7} cm/sec (0.62 ft/yr)
Unweathered Bedrock Siltstone	1.59×10^{-7} cm/sec (0.20 ft/yr)
Unweathered Bedrock Claystone	2.48×10^{-7} cm/sec (0.25 ft/yr)

* Draft Final Hydrogeologic Characterization Report, January 1995.

Before 1994, the hydraulic conductivity of the claystones between the UHSU and the LHSU was believed to be sufficiently low to ensure that contaminants could not have migrated vertically to lower formations under the Site. In 1994, borehole correlation work indicated the potential for near-surface faults to exist. Future assessment of the potential for the inferred faults to provide pathways of hydraulic communication to the lower aquifer or provide preferential pathways for lateral flow may be needed; however, the present understanding of the hydrogeologic relationships indicates that there are no known bedrock pathways through which groundwater contamination can migrate into a confined aquifer system offsite.

In the spring and early summer, the Rocky Flats Alluvium and Arapahoe Formation, located in the central and eastern portion of Rocky Flats, are recharged by precipitation and groundwater lateral flow. In the late summer and early fall, these formations are recharged primarily by groundwater lateral flow. In the stream drainages, groundwater discharges as seeps which typically occur at the base of the Rocky Flats Alluvium and where individual sandstone lenses become exposed to the surface.

A comprehensive evaluation of the hydrogeologic regime at the Site was conducted in 1994, and the resulting Hydrogeologic Characterization Report will be released in 1995.

Geochemistry

Understanding the geochemical setting of groundwater at the Site is important because many geochemical factors such as dissolution, complexation, adsorption, precipitation, and oxidation/reduction can influence the geochemical behavior (including speciation, migration, and decomposition) of constituents of concern in groundwater.

Another important aspect of the geochemical characterization program at Rocky Flats has been to determine the background water quality for groundwater unaffected by the facility. This information is used for comparison with average and point groundwater quality in areas that have been affected by Site operations.

The most recent geochemical characterization document is the *Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site.*[2] This report evaluates the spatial variation in groundwater geochemistry from upgradient to downgradient areas, along impacted and unimpacted flow paths. This work has shown that for total dissolved solids, major ions, and uranium, there is a trend of naturally increasing concentration in a downgradient direction along a given flow path.

Another relevant document, the *Background Geochemical Characterization Report,*[3] presents the results of a study to characterize and quantify the background levels for numerous constituents of concern at Rocky Flats. The results indicate that some naturally occurring metals, radionuclides, and other water quality constituents are present in background levels that exceed the current site-specific water quality standards.

Groundwater Modeling

Since 1990, Rocky Flats has invested significant resources to develop both area-specific groundwater models and a sitewide groundwater model in order to understand the extent and possible migration of contaminated groundwater. In 1994, additional effort was devoted to using modeling techniques to assess the effectiveness of the present monitoring-well network and the general interactions between groundwater and surface water. This work identified locations where additional groundwater monitoring may be useful. These locations are inside the Industrial Area and along the slopes leading into the Woman and Walnut Creek drainages.

Monitoring Program and Procedures

By the end of 1994, there were approximately 700 wells in existence at Rocky Flats, 352 of which are sampled for groundwater quality on a regular basis (Figure 3.4-2). Water level measurements are taken at approximately 500 locations each quarter.

Approximately 57 new wells were installed during 1994. These new wells support increased groundwater monitoring activities in the West Spray Field area (OU 11), the Indiana Street Boundary area, and the Present Landfill area (OU 7).

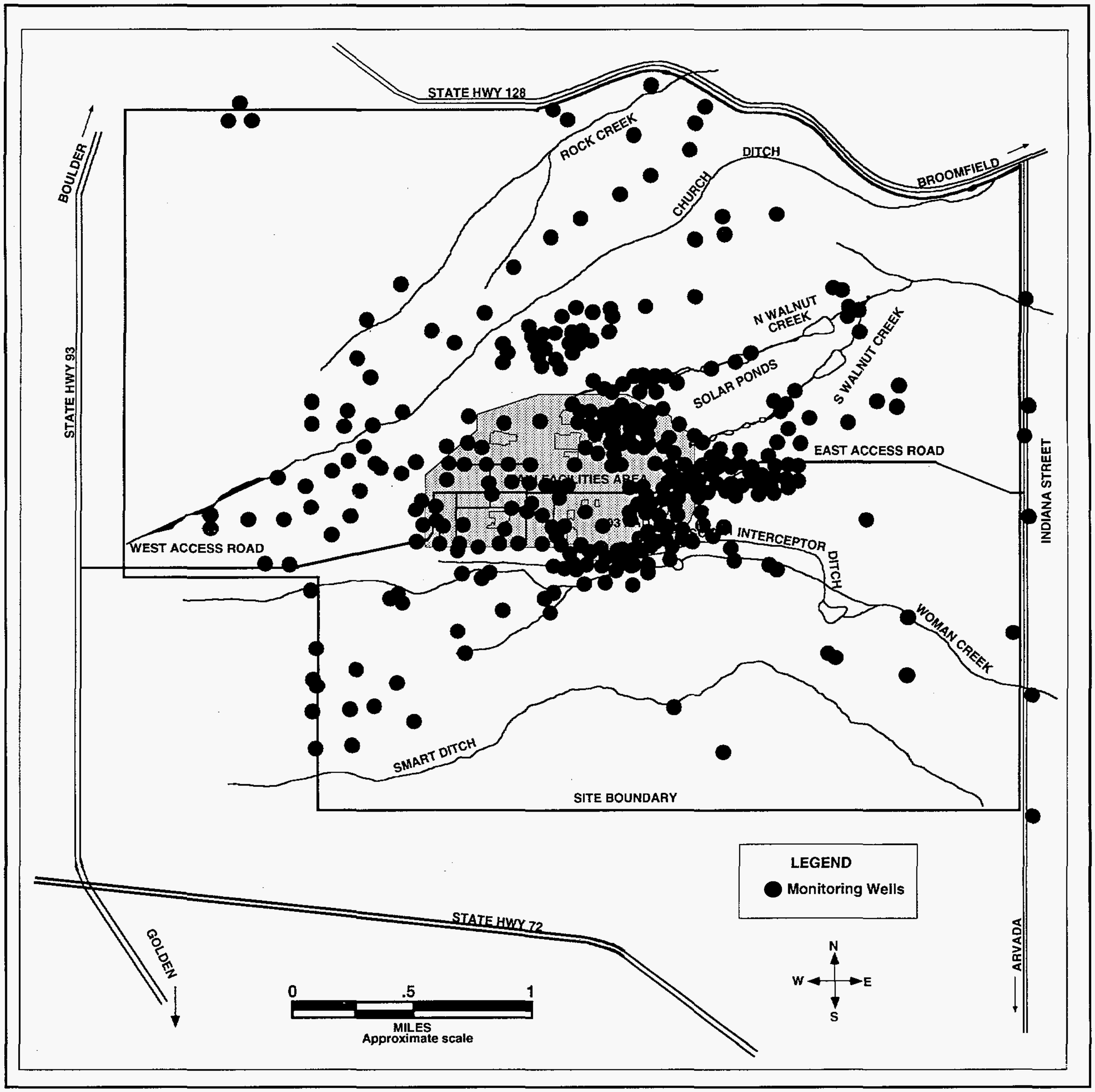


Figure 3.4-2. Location of Monitoring Wells

Groundwater quality samples are collected from both alluvial and bedrock wells. These samples are analyzed at several offsite laboratories for the parameters listed in Table 3.4-2. These wells are spatially distributed throughout the Site to provide the necessary coverage to satisfy RCRA guidelines for monitoring groundwater at hazardous waste sites, CERCLA characterization requirements, and detection of releases for operational environmental monitoring in accordance with the Site's environmental protection objectives under DOE Order 5400.1. Some additional wells are used to help characterize hydrogeologic conditions at Rocky Flats, while others are used to monitor background groundwater quality.

Table 3.4-2
Chemical Constituents Monitored in Groundwater

Dissolved Metals

Cesium
Lithium [a]
Molybdenum
Strontium
Tin [b]

Target Analyte List:

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

Organics [c]

Target Compound List - Volatiles:
Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethane
1,1,-Dichloroethene
trans-1,2-Dichloroethene
1,2-Dichloroethene (total)
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon Tetrachloride
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

Dissolved Radionuclides [d]

Gross Alpha
Gross Beta
Uranium-233/234, -235, and -238
Strontium-89/90 [e]
Cesium-137
Tritium
Radium-226/228 [f]

Total Radionuclides

Americium-241
Plutonium-239/240

Indicators

Total Dissolved Solids

Field Parameters

pH
Specific Conductance
Temperature
Alkalinity

Anions

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate/Nitrite
Cyanide [g]
Fluoride

a. Before 1989, lithium was only analyzed during fourth quarter 1987 and first quarter 1988.
b. Not analyzed before 1989.
c. Not analyzed in background samples in 1989.
d. Dissolved radionuclides replaces total radionuclides (except tritium) beginning with the third quarter 1987; however, total Pu and Am were collected starting in third quarter 1990.
e. Strontium-89/90 was not analyzed during first quarter 1988.
f. Not analyzed before 1989, and only analyzed if gross alpha exceeds 5 pCi/l.
g. Cyanide was not analyzed during fourth quarter 1987.

NOTES:
* Total suspended solids and phosphate were analyzed in 1986 only; orthophosphates were analyzed in 1990 and 1991.
* Chromium (VI) was analyzed during fourth quarter 1987 only.

Wells in the groundwater monitoring program have been classified as one of the following:

- Background wells monitor the groundwater in areas upgradient or cogradient to Rocky Flats.
- RCRA regulatory wells characterize and/or monitor the uppermost aquifer for RCRA units in accordance with RCRA monitoring requirements for land disposal units.
- RCRA characterization wells characterize and/or monitor aquifers other than the uppermost aquifer at or near RCRA units.
- CERCLA wells characterize and/or monitor the groundwater for CERCLA environmental restoration planning and performance monitoring.
- Boundary wells monitor the movement and quality of groundwater at the downgradient boundaries of Rocky Flats.
- Special purpose wells include other wells installed at Rocky Flats that are used to characterize groundwater and hydrogeology for a variety of purposes.

Generally, the well categorization reflects the primary driver for the well, but all relevant data from various well classes are utilized as appropriate for each program. The Site's groundwater protection program is documented in detail in the *Groundwater Protection and Monitoring Program Plan.*[4]

Water-level measurements are taken to assess the magnitude and direction of groundwater flow. These data are used to evaluate trends in groundwater quality and contaminant migration in the uppermost, unconfined aquifer. Wells receive either quarterly or monthly water-level measurements depending on the needs of the groundwater program.

Beginning in 1993, the program initiated an Annual Well Evaluation Report.[5] This document assesses the results of the previous year's monitoring and sets the technical foundation for adaptation of the monitoring network to meet changing conditions.

During 1994, thirty-nine monitoring wells were abandoned under the Well Abandonment and Replacement Program (WARP). WARP was developed to mitigate the potential for contaminant migration through improperly constructed or damaged wells, and to provide a programmatic structure for the ongoing physical inspection and maintenance of the groundwater monitoring network.

In 1994, a support vehicle was purchased for use in groundwater field operations. This van is equipped with a downhole video camera well inspection system and a light duty "Geoprobe" drilling apparatus. Using borehole geophysical logging, soil gas surveys, and other techniques, this equipment assesses the condition of the wells, and also evaluates the subsurface rapidly.

Groundwater investigation and restoration activities at Rocky Flats follow a phased approach to identify contamination, design and implement treatment procedures, and monitor the adequacy of restoration actions. Currently, groundwater is assessed with respect to the upper tolerance limits (UTLs) established in the Background Geochemical Characterization Report.

Site-specific groundwater standards and classifications have been established by the CWQCC. The standards apply to all unconfined groundwater in the alluvial materials, the Arapahoe aquifer, and the Laramie-Fox Hills aquifer. The alluvial aquifers are classified Domestic and Agricultural Use-Quality and Surface Water Protection. The Arapahoe and Laramie-Fox Hills aquifers are classified Domestic and Agricultural Use-Quality.

RESULTS

The following sections discuss the 1994 groundwater investigations and monitoring activities in OUs 1, 2, 4, 5, 6, 7, and 11, as well as in the Industrial Area and at the downgradient facility boundary along Indiana Street (Section 4, Environmental Remediation contains individual OU maps).

OU 1 (881 Hillside)

Phase III RFI/RI Report, Rocky Flats Plant, 881 Hillside Area, Operable Unit No. 1[6] contains information on groundwater quality at OU 1. No new wells were drilled in OU 1 in 1994. Based on the most recently completed Phase III RFI/RI, it is apparent that groundwater contamination posing the most significant public health risk arises from VOCs (i.e., carbon tetrachloride, perchloroethylene, trichloroethylene). These VOCs are historically linked to storage of drums containing cleaning solvents at individual hazardous substance site (IHSS) 119.1 from 1967 to 1972 (Section 4, Figure 4-1). Figure 3.4-3 shows approximate outlines of VOCs groundwater contaminant plumes on the Site and depicts the extent of contaminant movement in the 881 Hillside.

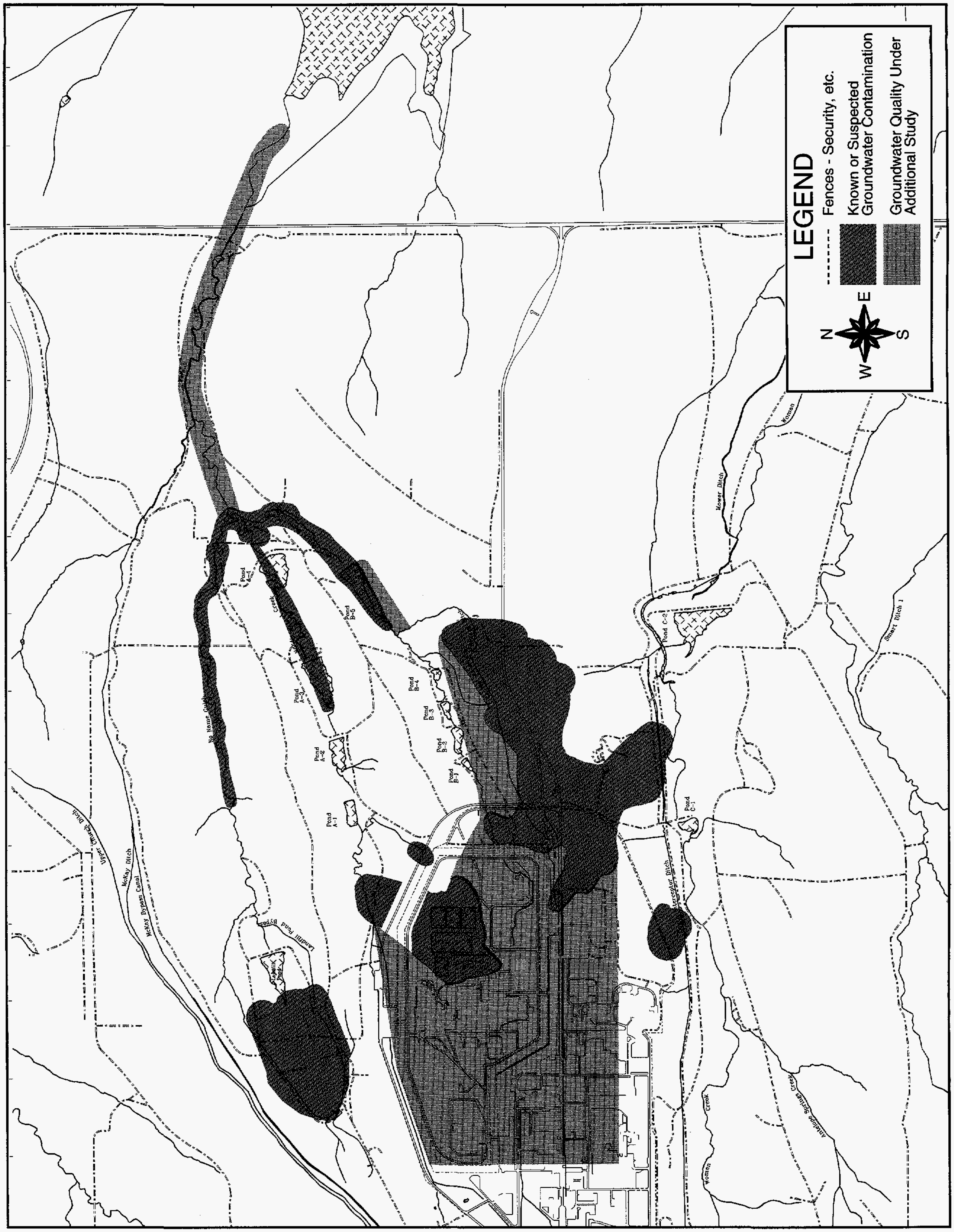


Figure 3.4-3. Location of Known or Suspected Groundwater Contamination

Concentrations of VOCs diminish downgradient of IHSS 119.1, becoming equal to or below detection limits (5 µg/l) within 200 feet of the original storage area. Slightly elevated concentrations of inorganic constituents also were found in the eastern portion of OU 1, where analytes detected above background levels included total dissolved solids (TDS), metals (nickel, strontium, selenium, zinc, and copper), and uranium.

OU 2 (903 Pad, Mound, and East Trenches Areas)

At OU 2, groundwater in the UHSU, which is composed of alluvial materials and shallow subcropping sandstones, is contaminated with VOCs, inorganics, dissolved metals, and some radionuclides. *Phase II RFI/RI Report, Rocky Flats Plant, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2*[7] contains information on groundwater quality at OU 2.

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

Contaminants of most concern are VOCs. Those detected include tetrachloroethene, trichloroethene, and carbon tetrachloride. Figure 3.4-3 depicts general groundwater contaminant plumes on the Site and indicates the approximate extent of contamination at OU 2. Certain inorganic parameters and radionuclides are elevated above background levels in OU 2, but they do not appear to exist as a well-defined plume of contamination. Investigations are continuing to further characterize these plumes and the magnitude and extent of contamination.

RCRA-Regulated OUs 4, 7, and 11 (Solar Evaporation Ponds, Present Landfill, and West Spray Field)

The purpose of groundwater monitoring in these RCRA-regulated units is to assess impacts of waste management activities on groundwater quality in the uppermost aquifer beneath these units. Results of the 1994 interim-status quarterly groundwater monitoring are reported in the *1994 Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Environmental Technology Site.*[8] Data are presented for groundwater elevations, flow rates, and quality analyses. A comparison is made between analyte concentrations upgradient of the unit and those downgradient of the unit to evaluate the impact of waste management activities on groundwater quality. The following sections highlight results of groundwater monitoring in each respective RCRA unit.

OU 4 (Solar Evaporation Ponds) - Groundwater assessment monitoring continues to be performed at the Solar Evaporation Ponds area to further assess the levels, extent, and migration characteristics of contamination in the uppermost aquifer beneath this unit.

There are 72 groundwater monitoring wells (71 active and 1 inactive) located at or near the Solar Evaporation Ponds. Of the 71 active wells, 61 are screened in the UHSU and 10 wells are in the LHSU. Fifty-eight of these wells are RCRA regulatory wells being sampled on a quarterly basis. No new monitoring wells were installed at the Solar Evaporation Ponds Area during 1994.

Groundwater flow in the area of the Solar Evaporation Ponds unit appears principally controlled by the topography of the underlying bedrock surface. Potentiometric-surface maps for UHSU surficial materials in the Solar Evaporation Ponds area indicate that groundwater flows to the north and southeast from the ponds. Surficial deposits are unsaturated across a large area immediately beneath the Interceptor Trench System and along the axis of a bedrock ridge trending east-northeast from the ponds area. The thickness of saturated surficial materials is highly variable; the maximum thicknesses of saturated material typically occurs at topographic depressions in the bedrock surface and in the immediate vicinity of the Solar Evaporation Ponds. The potentiometric surface in UHSU bedrock also indicates flow to both the north and east-southeast, but differs slightly from the surficial materials in that it has a relatively flat slope beneath the solar ponds and a steep slope immediately north of the solar ponds.

Statistical comparisons of groundwater quality upgradient of the Solar Evaporation Ponds to groundwater quality downgradient and at the compliance boundary indicates that the uppermost "aquifer," the UHSU, has been adversely impacted by leakage from the ponds. For analytes with greater than 50 percent quantifiable results, Analysis-of-Variance (ANOVA) testing indicated statistically significant increases (at the 5 percent significance level) in downgradient groundwater in surficial material wells for radionuclides (gross alpha, gross beta, uranium-233/234, uranium-235, uranium-238, and tritium), dissolved metals (calcium, lithium, magnesium, potassium, selenium, sodium, and strontium), and inorganic analytes (bicarbonate, chloride, fluoride, nitrate/nitrite, sulfate, TDS, and total suspended solids). All VOCs had less than 50 percent quantifiable results.

In the bedrock of the UHSU, ANOVA testing demonstrated statistically significant differences (at the 5 percent significance level) in upgradient versus downgradient radionuclide activities (gross alpha, gross beta, uranium-233/234, and uranium-238), and concentrations of dissolved metals (calcium, lithium, magnesium, potassium, selenium, sodium, and strontium), inorganic analytes (chloride, fluoride, nitrate/nitrite, sulfate, TDS, and total suspended solids). All VOCs had less than 50 percent quantifiable results.

Organic compounds, principally VOCs, were infrequently detected in Solar Evaporation Pond area wells. Detected organic compounds typically present in downgradient groundwater include 1,1,l-trichloroethane; 1,1-dichloroethane; bis-2-ethylhexyl phthalate; carbon tetrachloride; chloroform; cis-1,2-dichloroethene; methylene chloride; tetrachloroethane; and trichloroethene. Higher concentrations of VOCs were typically found in groundwater from wells immediately adjacent to Pond 207C.

Contaminant distributions shown on concentration-isopleth maps are distinct in surficial-material groundwater and UHSU-bedrock groundwater. Highest concentrations of contaminants in surficial material groundwater occur principally along the eastern unit compliance boundary. In UHSU-bedrock groundwater, the highest concentrations are generally recorded in wells located just north of the compliance boundary. This pattern of distribution is applicable to both dissolved and total constituents. The apparent distinction may be the result of different groundwater-flow directions in the two units or it may be an artifact of the spatial distribution of wells within these two units. No wells screened in surficial materials are present immediately north of the Solar Evaporation Ponds.

OU 7 (Present Landfill) - This section presents conclusions derived from data collected during the 1994 groundwater monitoring program at the Present Landfill. The discussion which follows addresses groundwater flow and contaminant distribution in the area.

Groundwater flow direction is generally to the east with the flow components converging toward the East Landfill Pond east of the landfill. Potentiometric-surface maps of the Present Landfill vicinity show that the elevation of the water table was lower inside the groundwater-intercept/diversion system than outside during 1994. Within the landfill in 1994, as in 1993, groundwater elevations were higher on the north side than on the south side of the landfill, suggesting that the groundwater-diversion system performs more effectively on the southwest side of the landfill than on the northwest side. Vertical flow is upwards within the landfill materials compared to downward in the surrounding USHU aquifer.

Statistical comparisons of upgradient versus downgradient UHSU groundwater at the Present Landfill indicate statistically significant increases in downgradient activities of uranium-233/234 and -238 and concentrations of calcium, lithium, magnesium, sodium, strontium, bicarbonate, chloride, fluoride, sulfate, and TDS. There is no statistically significant difference in upgradient versus downgradient concentrations of VOCs.

Generally, radionuclide activities and concentrations of VOCs, and inorganic parameters were notably highest within the landfill and in the area adjacent to IHSSs located southeast of the landfill relative to other areas in the vicinity of the Present Landfill. VOCs were detected infrequently in groundwater from UHSU bedrock beneath and downgradient of the landfill, but radionuclides were present at activities higher than background in UHSU-bedrock groundwater.

Conditions at the Present Landfill in 1994 appear generally consistent with those of 1993. However, in 1994, more inorganic parameters and radionuclides displayed statistically significant increases in concentration downgradient of the RCRA-regulated unit. The groundwater-intercept system did not appear as effective in 1994 as in 1993 in limiting the downgradient transport of contaminants. The increase in transport may be due to the increase in the potentiometric surface north of the landfill which may be increasing the flow, if any, into the landfill from the north. Contaminants detected in monitoring wells southeast of the Present Landfill may be due to an inadequately functioning groundwater-intercept system in this area, emplacement of wastes beyond the limit of the intercept system, or impacts associated with other IHSSs adjacent to the landfill.

OU 11 (West Spray Field) - This section presents conclusions derived from data collected during the 1994 groundwater monitoring program at the West Spray Field. The discussion which follows addresses groundwater flow and contaminant distribution in the area.

The direction of groundwater flow at the West Spray Field is generally to the east, and evidently is controlled by the topographic surface of the underlying bedrock. An east-trending bedrock ridge underlies the area and apparently acts as a groundwater divide. Groundwater flow in the UHSU north of the divide is directed primarily toward the northeast into the Walnut Creek drainage, while flow in the UHSU south of the divide is directed to the southeast toward Woman Creek.

For analytes with sufficient detectable results, ANOVA testing indicated a statistically significant difference at the 5 percent significance level in upgradient versus downgradient groundwater quality for specific constituents in the UHSU. Downgradient concentrations were greater than upgradient concentrations in the UHSU surficial materials for some metals (calcium, magnesium, sodium, and strontium) and inorganic parameters (bicarbonate, chloride, and total dissolved solids). Groundwater-quality data from UHSU-bedrock wells were insufficient in number to conduct statistical comparisons.

Other analytes detected at the West Spray Field are portrayed on analyte-distribution maps. Total radionuclides detected in UHSU-bedrock samples include gross alpha; gross beta; tritium; uranium-233/234; americium-241; plutonium-239/240;

strontium-89/90; and total radiocesium. In addition to these radionuclides, uranium-235, uranium-238, radium-226, radium-228, and cesium-137 were detected in groundwater from surficial materials.

The suite of dissolved radionuclides present in groundwater from UHSU-bedrock and surficial wells was similar to the suite of reported total radionuclides discussed above. With the exception of tritium which was not reported, each of the total radionuclides discussed above was also detected in dissolved concentrations.

The infrequently detected radionuclides typically present in downgradient groundwater include both dissolved radionuclides (total radiocesium and uranium-235) and total radionuclides (americium-241, plutonium-239/240, and tritium).

VOCs were detected in groundwater from monitoring wells upgradient, within, and downgradient of the RCRA unit (Figure 4-16 of the 1994 RCRA Groundwater Report). Most of the reported results occurred in wells completed in surficial materials, with the exception of well P416989 which showed three VOCS analytes detected at relatively low levels of less than 0.2 µg/l. Results of the third quarter sampling showed a significant suite of analytes in groundwater at UHSU surficial material well 4986 as reported previously. As in 1993, methylene chloride was the VOCS analyte most frequently detected in 1994 at the West Spray Field unit; however, the 1994 detections were approximately one order of magnitude less than corresponding levels in 1993. The highest concentration of methylene chloride detected in 1994 was 0.8 µg/l. Well locations can be found in Figure 4-1 of the 1994 RCRA Groundwater Report. Analytes chloroform, benzene, toluene, and tetrachloroethane were each reported twice in wells, not including well 4986. VOCs were rarely detected in groundwater from UHSU surficial materials downgradient of the West Spray Field. Detections in downgradient wells were limited to methylene chloride, tetrachloroethane, and trichloroethene.

Concentration-isopleth maps presented previously show the distribution of nitrate/nitrite, TDS, and chloride, respectively (Figures 4-17 through 4-19). Wells 4986 and B410789 and upgradient well 5186 show elevated concentrations of nitrate/nitrite (3.8 to 5.0 mg/l) relative to other West Spray Field area wells. Elevated TDS concentrations are shown in the eastern area of the unit continuing eastward to the West Access Road.

The RFI/RI field investigation for OU 11 was completed in August 1994 in accordance with the Revised Field Sampling Plan and Data Quality Objectives dated June 13, 1994. Thirteen boreholes were drilled in and around the West Spray Field, and monitoring wells were installed in each. Based upon the risk evaluations from analytical results, it is anticipated that no remedial actions will be required for

Operable Unit 11. Routine RCRA groundwater monitoring will continue until final closure has been approved. Following closure, post-closure monitoring will be performed as required.

OU 5 (Woman Creek)

Technical Memorandum (TM) #15, *Addendum to the Field Sampling Plan,*[9] was approved by the regulatory agencies in August 1994 and field work began in September 1994. TM#15 implements a program of additional sampling and analysis to the Phase I RCRA Facility Investigations/Remeidal Investigations (RFI/RI) Work Plan. The original landfill, IHSS 115, and the filter backwash pond, IHSS 196, require additional groundwater characterization and sampling. As part of the field work activities associated with TM#15, eight UHSU monitoring wells, six LHSU wells, and eight mini-wells were installed at IHSS 133 (Ash Pits). Groundwater sampling was conducted and water levels were collected in December 1994.

OU 6 (Walnut Creek)

In 1994, all groundwater activities in OU 6 were related to modelling. Preliminary groundwater modelling for OU 6 focused on the groundwater contaminant conditions, the potential sources of contaminants, and appropriate modelling methods. Additional wells were installed in North and South Walnut Creek drainages to investigate groundwater quality further.

Industrial Area

In 1994, approximately 51 previously installed wells in the Industrial Area were sampled to provide preliminary characterization information in conjunction with the Industrial Area IM/IRA program.

The Industrial Area IM/IRA is designed to provide additional environmental protection during decontamination and decommissioning activities. This program was developed in close cooperation with the regulatory agencies and resulted in a Decision Document being approved in December 1994. Actions outlined in this Decision Document will be implemented in 1995 and include the installation of supplemental groundwater, surface-water, and air monitoring capabilities.

Analysis of the 1994 sampling data identified elevated concentrations of a number of contaminants, but the data could not be spatially correlated without further technical analysis and additional wells. As a result, eleven additional wells are planned for installation in the Industrial Area in 1995. The technical analysis of the 1994 data will be performed as part of the 1995 Well Evaluation Report. Placement of additional wells for the monitoring network in the Industrial Area will be assessed.

Boundary Wells

Groundwater quality is monitored quarterly in a series of wells downgradient of Rocky Flats, along and adjacent to the Site's eastern boundary at Indiana Street. Eight boundary wells are sampled routinely to monitor water quality in the boundary area, and split samples are taken by CDPHE, in accordance with the AIP. Well locations can be found in Plate 1 of the 1994 RCRA Groundwater Report for Regulated Units at the Site.

In 1994 alluvial groundwater in the boundary area was monitored by four wells (0186, 41491, 41591, and 41691), while wells 0386 and B217289 monitored groundwater contained in the Arapahoe/Laramie Formation bedrock.

For 1995, the boundary wells include alluvial wells 0186, 41491, 41591, and 41691, together with bedrock wells 0386 and 06491. Additionally, offsite wells 11894 and 11994 will be monitored to investigate the anomalous total plutonium and americium measurements observed in the 1994 and earlier data for well 41691. Well 10394 may be phased in to replace well 0186 due to the frequently dry or turbid state of well 0186.

Wells 10294 (along Smart Ditch) 10394 (along Woman Creek) B217289 (along the intermittent drainage to the north of the east gate) and well 10894 (along the Walnut Creek drainage) are all additional protective monitoring wells which are sampled to monitor conditions in the vicinity of the boundary, but are not considered "boundary wells."

Dissolved metals of concern that were detected in the valley-fill alluvium, colluvium, and Arapahoe and Laramie Formations exhibited concentrations only slightly above detection limits. Radionuclides detected in boundary wells along Walnut Creek are associated with well 41691, which is discussed in a later section. There is no known direct hydraulic connection between this shallow alluvial aquifer and deeper aquifers in the Denver Basin which are used for domestic water supplies. Continued quarterly monitoring of boundary wells will be performed and the results will be used to assess potential changes in concentrations for analytes of interest.

Metals - Many metals are naturally present in boundary well groundwater as a result of dissolution of minerals in rock and soils. The groundwater program compares metal concentrations with background UTLs in order to identify areas of elevated concentration. Many of the locally elevated concentrations are, however, due to natural processes. Laboratory results from samples collected during 1994 were compared with the background upper tolerance limits.

Aluminum, arsenic, barium, beryllium, cobalt, copper, iron, lead, manganese, nickel, silicon, vanadium, and zinc were detected in concentrations above the background UTLs in wells 10294 and 41691. Sodium was detected in levels exceeding UTLs in wells 41591, 11894, 10294, and B217289. Strontium was present above background UTLs in wells 41591, 0386, and 10294. In addition, calcium and mercury were detected in above-background concentrations in well 10294.

Selenium is naturally occurring, and measurable levels in wells 0386, 41591, 11894, and 10294 may represent natural differences in concentrations at different locations. Lithium was detected in levels exceeding background UTLs in wells 10294 and 11894, with a recorded maximum of 250 mg/l. Potassium was detected at levels in excess of background UTLs in wells 41691, B217289, 10894, and 10294.

VOCs - VOCs were detected in several of the boundary wells at extremely low levels. Well 10294 showed two detections of bis-2-ethylhexyl-pthalate, with a high of 42 μg/l, as well as trace amounts of chloroform and methylene chloride at the detection limit.

Well 10894, upgradient of the boundary along Woman Creek, showed several unvalidated possible detects of bis-2-ethylhexyl pthalate, Di-n-butyl pthalate, and pyrene. Well 41491 showed a single detect of methylene chloride very near the detection limit, as did wells 41691 and B217289.

Well 41691 also showed a single possible below-detection-limit indication of tetrachloroethane. Well B217289 similarly showed a slight detect of trichloroethene in a single-sample result.

VOCs that were detected in the valley-fill alluvium, colluvium, and Arapahoe and Laramie Formations exhibited concentrations only slightly above detection limits.

Radionuclides - Significant attention was directed toward boundary well 41691, which is west of the point where Walnut Creek crosses under Indiana Street. Because of previously observed anomalies, as reported in the 1993 Site Environmental Report, well 41691 was sampled at a high frequency during the early part of 1994.

Total (dissolved plus suspended) plutonium-239/240 and total americium-241 were repeatedly measured at activities above background upper tolerance limits in well 41691. The highest reported activity for total plutonium-239/240 was 1.1 pCi/l in a sample taken on February 21, 1994. The highest total americium-241 result was 0.29 pCi/l in the same well from a sample taken on February 16, 1994.

In 1994, technical specialists in the groundwater program determined that one possible cause of the elevated plutonium in well 41691 might be the result of slightly contaminated surficial soils having entered the borehole during well construction. A new "aseptic" drilling method, which involves isolation of the surficial material near the collar of the well, is being evaluated. An alternate hypothesis is colloidal transport of plutonium and/or americium in the shallow groundwater within the Walnut Creek drainage.

Measurements of dissolved plutonium and americium from filtered samples from well 41691 did not show any significant elevation, pointing toward an association of elevated measurements with suspended solids.

During the second quarter of 1994, well 41691 was redeveloped in an effort to remove the suspended sediment in the well. Analysis of total plutonium and americium samples following redevelopment indicate infrequent detections above the background UTLs for plutonium.

Two new wells were installed offsite, downgradient of well 41691 (wells 11894 and 11994), and one additional well (10894) was installed upgradient of well 41691 in order to further evaluate the reasons for the elevated radionuclides observed in well 41691. As of the date of preparation of this report (March 1995), the laboratory analytical results were not yet available.

Dissolved radium-226 was detected in levels slightly above background UTLs in samples from wells 414901 and B21789. Total radium-226 was found in slightly elevated concentrations from samples from well 41691, which also showed slight elevations of total radiocesium in both total and dissolved samples.

Dissolved and total uranium-235 were detected at levels slightly above background in a single sample from well 10294 taken on August 25, 1994. The analytical package for this sample has not yet gone through quality assurance validation.

References

1. EG&G Rocky Flats, Inc., *Geologic Characterization Report for the Rocky Flats Environmental Technology Site,* Golden, Colorado, March 1995.

2. EG&G Rocky Flats, Inc., *Groundwater Geochemistry Report for the Rocky Flats Environmental Technology Site,* Golden, Colorado, 1995.

3. EG&G Rocky Flats, Inc., *Background Geochemical Characterization Report,* Golden, Colorado, September 1993.

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5. EG&G Rocky Flats, Inc., *Well Evaluation Report,* Golden, Colorado, April 1994.

6. EG&G Rocky Flats, Inc., *Phase III RFI/RI Report, Rocky Flats Plant, 881 Hillside Area, Operable Unit No. 1,* Golden, Colorado, March 1991.

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8. EG&G Rocky Flats, Inc., *1994 Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Environmental Technology Site,* Golden, Colorado, 1995.

9. EG&G Rocky Flats, Inc., Technical Memorandum #15, *Addendum to the Field Sampling Plan,* Golden, Colorado, 1994.

3.5 SOIL MONITORING

OVERVIEW

The soil monitoring program has been conducted since 1972 except for the period between 1978 to 1983. Soils were sampled at Rocky Flats in September 1994 at 40 sites located on concentric circles, approximately 1.6 and 3.2 kilometers (km) radii (1 and 2 miles) from the center of the Site (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 x 10 cm (4 x 4 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 one-gallon stainless steel can. Five 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 (5000 cubic centimeters [cm^3]) for soil radionuclides analysis. Laboratory analysis was performed to determine plutonium concentration, expressed as picocuries per gram (pCi/g).

RESULTS

Soil plutonium concentrations for 1984 through 1994 are presented 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 1994. Samples taken in 1994 from the inner concentric circle (1.6 km radius) ranged from 0.029 pCi/g to 9.2 pCi/g. In previous years the highest soil plutonium concentration was found at site 1-090 and 1-108 (Figure 3.5-1). Since the 1990 annual soil sampling, site 1-090 was relocated approximately 200 meters 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 (3.2 km) ranged from 0.011 pCi/g to 3.5 pCi/g. The highest plutonium concentrations were found in soil samples from the eastern portion of the Buffer Zone (Figure 3.5-1). 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 plants. Plutonium particles entrapped in the fine fraction of top soil horizons were subsequently airlifted by winds and deposited on soils in a east and southeast-trending plum. Table 3.5-1 indicates that data from previous years have consistently shown elevated plutonium concentrations in soils from these locations.

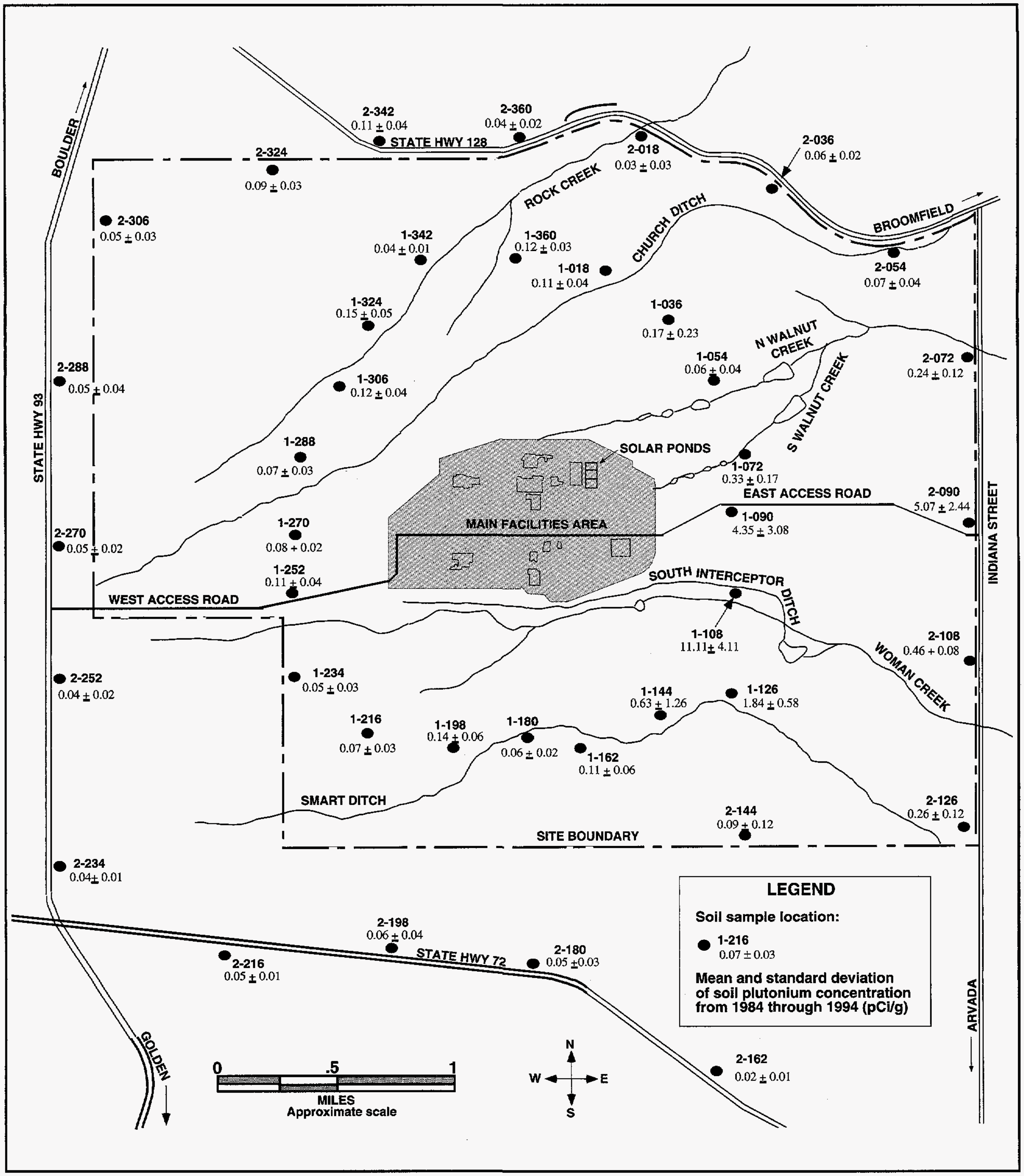


Figure 3.5-1. Soil Sampling Locations

Table 3.5-1
Plutonium Concentration in Soil Samples at a One- and Two-Mile Radius from Rocky Flats

Inner Circle:

Location	1984 Pu pCi/g[a,b,c,d]			1985 Pu pCi/g[a,b,c,d]			1986 Pu pCi/g[a,b,c,d]			1987 Pu pCi/g[a,b,c,d]			1988 Pu pCi/g[a,b,c,d]		
1-018	0.08	±	0.02	0.15	±	0.02d	0.15	±	0.02	0.18	±	0.02	0.10	±	0.01
1-036	0.03	±	0.01	0.08	±	0.01	0.10	±	0.02	0.06	±	0.01	0.88	±	0.01
1-054	0.00	±	0.01	0.02	±	0.01	0.04	±	0.01	0.04	±	0.01	0.03	±	0.01
1-072	0.6	±	0.05	0.32	±	0.03	0.63	±	0.06	0.51	±	0.05	0.37	±	0.04
1-090	7.7	±	0.5	1.00	±	0.09	7.40	±	0.62	7.05	±	0.77	10.6	±	0.98
1-108	15.0	±	0.9	13.0	±	1.30	15.0	±	1.40	2.37	±	0.21	10.4	±	0.94
1-126	2.1	±	0.1	1.90	±	0.17	1.90	±	0.18	2.75	±	0.28	1.55	±	0.14
1-144	0.29	±	0.03	0.32	±	0.03	0.27	±	0.02	0.36	±	0.04	0.20	±	0.02
1-162	0.14	±	0.02	0.10	±	0.01	0.08	±	0.01	0.17	±	0.02	0.09	±	0.01
1-180	0.09	±	0.02	0.06	±	0.01	0.06	±	0.01	0.10	±	0.01	0.06	±	0.01
1-198	0.22	±	0.03	0.16	±	0.02	0.16	±	0.02	0.21	±	0.02	0.10	±	0.01
1-216	0.05	±	0.02	0.05	±	0.01	0.10	±	0.01	0.16	±	0.02	0.05	±	0.01
1-234	0.13	±	0.02	0.05	±	0.01	0.04	±	0.01	0.05	±	0.01	0.05	±	0.01
1-252	0.17	±	0.02	0.14	±	0.02	0.11	±	0.01	0.21	±	0.03	0.09	±	0.01
1-270	0.06	±	0.02	0.07	±	0.01	0.08	±	0.01	0.09	±	0.01	0.07	±	0.01
1-288	0.04	±	0.01	0.05	±	0.01	0.05	±	0.01	0.06	±	0.01	0.03	±	0.01
1-306	0.14	±	0.02	0.09	±	0.01	0.17	±	0.02	0.21	±	0.03	0.12	±	0.01
1-324	0.13	±	0.02	0.15	±	0.02	0.21	±	0.02	0.24	±	0.03	0.16	±	0.02
1-342	0.04	±	0.01	0.02	±	0.01	0.03	±	0.01	0.03	±	0.01	0.02	±	0.01
1-360	0.10	±	0.02	0.11	±	0.01	0.19	±	0.02	0.16	±	0.02	0.12	±	0.02
Outer Circle:															
2-018	0.00	±	0.01	0.04	±	0.01	0.03	±	0.01	0.04	±	0.01	0.02	±	0.00
2-036	0.02	±	0.01	0.02	±	0.01	0.07	±	0.01	0.10	±	0.01	0.07	±	0.01
2-054	0.03	±	0.01	0.03	±	0.01	0.05	±	0.01	0.10	±	0.01	0.03	±	0.01
2-072	0.4	±	0.04	0.33	±	0.03	0.23	±	0.02	0.36	±	0.04	0.11	±	0.01
2-090	10.0	±	0.6	2.50	±	0.25	5.30	±	0.48	4.48	±	0.52	7.12	±	0.67
2-108	0.46	±	0.04	0.41	±	0.04	0.46	±	0.04	0.57	±	0.06	0.47	±	0.05
2-126	0.14	±	0.02	0.42	±	0.04	0.44	±	0.05	0.40	±	0.04	0.03	±	0.01
2-144	0.02	±	0.01	0.04	±	0.01	0.04	±	0.01	0.08	±	0.01	0.35	±	0.03
2-162	0.00	±	0.01	0.01	±	0.00	0.02	±	0.01	0.03	±	0.01	0.02	±	0.01
2-180	0.02	±	0.01	0.11	±	0.01	0.04	±	0.01	0.03	±	0.01	0.03	±	0.01
2-198	0.05	±	0.02	0.02	±	0.01	0.08	±	0.01	0.14	±	0.02	0.10	±	0.01
2-216	0.04	±	0.01	0.04	±	0.01	0.06	±	0.01	0.07	±	0.01	0.07	±	0.01
2-234	0.04	±	0.01	0.05	±	0.01	0.05	±	0.01	0.07	±	0.01	0.03	±	0.01
2-252	0.09	±	0.01	0.04	±	0.01	0.07	±	0.01	0.06	±	0.01	0.04	±	0.01
2-270	0.04	±	0.01	0.04	±	0.01	0.06	±	0.01	0.08	±	0.01	0.06	±	0.01
2-288	0.01	±	0.01	0.04	±	0.01	0.05	±	0.01	0.13	±	0.02	0.07	±	0.01
2-306	0.00	±	0.01	0.06	±	0.01	0.02	±	0.01	0.08	±	0.01	0.02	±	0.00
2-324	0.08	±	0.02	0.04	±	0.01	0.09	±	0.01	0.08	±	0.01	0.14	±	0.02
2-342	0.13	±	0.02	0.13	±	0.01	0.12	±	0.01	0.14	±	0.02	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

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

Table 3.5-1 (Continued)
Plutonium Concentration in Soil Samples at a One- and Two-Mile Radius from Rocky Flats

Inner Circle:

Location	1989 Pu pCi/g[a,b,c,d]	1990 Pu pCi/g[a,b,c,d]	1991 Pu pCi/g[a,b,c,d]	1992 Pu pCi/g[a,b,c,d]
1-018	0.08 ± 0.01	0.07 ± 0.02	0.13 ± 0.02	0.10 ± 0.048
1-036	0.08 ± 0.01	0.07 ± 0.001	0.25 ± 0.05	0.18 ± 0.076
1-054	0.13 ± 0.02	0.04 ± 0.01	0.06 ± 0.01	0.04 ± 0.030
1-072	0.16 ± 0.02	0.21 ± 0.03	0.18 ± 0.03	0.22 ± 0.09
1-090	2.52 ± 0.27	2.18 ± 0.21	1.49 ± 0.23	1.90 ± 0.39
1-108	8.56 ± 0.81	9.14 ± 0.12	9.76 ± 1.35	11.00 ± 2.0
1-126	1.08 ± 0.13	1.46 ± 0.17	2.13 ± 0.32	2.90 + 0.69
1-144	0.12 ± 0.01	0.17 ± 0.02	0.19 ± 0.03	4.60 ± 0.72
1-162	0.06 ± 0.01	0.06 ± 0.01	0.09 ± 0.02	0.13 ± 0.032
1-180	0.08 ± 0.01	0.04 ± 0.001	0.04 ± 0.01	0.09 ± 0.026
1-198	0.05 ± 0.01	0.13 ± 0.005	0.17 ± 0.04	0.03 ± 0.014
1-216	0.05 ± 0.01	0.05 ± 0.007	0.05 ± 0.02	0.06 ± 0.020
1-234	0.05 ± 0.01	0.03 ± 0.007	0.05 ± 0.01	0.03 ± 0.014
1-252	0.08 ± 0.01	0.07 ± 0.01	0.09 ± 0.02	0.08 ± 0.022
1-270	0.06 ± 0.01	0.05 ± 0.01	0.08 ± 0.02	0.06 ± 0.028
1-288	0.06 ± 0.01	0.07 ± 0.01	0.09 ± 0.02	0.13 ± 0.032
1-306	0.10 ± 0.01	0.08 ± 0.01	0.09 ± 0.02	0.14 ± 0.03
1-324	0.07 ± 0.01	0.09 ± 0.01	0.14 ± 0.03	0.11 ± 0.026
1-342	0.04 ± 0.01	0.05 ± 0.008	0.05 ± 0.02	0.05 ± 0.018
1-360	0.08 ± 0.01	0.11 ± 0.01	0.1 ± 0.02	0.12 ± 0.032

Outer Circle:

Location	1989 Pu pCi/g[a,b,c,d]	1990 Pu pCi/g[a,b,c,d]	1991 Pu pCi/g[a,b,c,d]	1992 Pu pCi/g[a,b,c,d]
2-018	0.02 ± 0.01	0.00 ± 0.003	0.01 ± 0.00	0.01 ± 0.014
2-036	0.04 ± 0.01	0.05 ± 0.01	0.06 ± 0.01	0.05 ± 0.036
2-054	0.06 ± 0.01	0.18 ± 0.03	0.07 ± 0.01	0.07 ± 0.014
2-072	0.46 ± 0.06	0.14 ± 0.02	0.14 ± 0.02	0.23 ± 0.058
2-090	1.94 ± 0.23	3.94 ± 0.5	3.61 ± 0.45	8.80 ± 1.1
2-108	0.53 ± 0.06	0.32 ± 0.04	0.06 ± 0.07	0.40 ± 0.10
2-126	0.28 ± 0.04	0.20 ± 0.02	0.25 ± 0.05	0.27 ± 0.096
2-144	0.03 ± 0.01	0.02 ± 0.005	0.04 ± 0.00	0.02 ± 0.018
2-162	0.02 ± 0.01	0.01 ± 0.004	0.03 ± 0.00	0.04 ± 0.036
2-180	0.08 ± 0.01	0.03 ± 0.007	0.05 ± 0.01	0.04 ± 0.032
2-198	0.01 ± 0.01	0.05 ± 0.01	0.07 ± 0.01	0.04 ± 0.020
2-216	0.07 ± 0.01	0.04 ± 0.007	0.05 ± 0.01	0.06 ± 0.044
2-234	0.05 ± 0.01	0.04 ± 0.002	0.04 ± 0.01	0.03 ± 0.030
2-252	0.04 ± 0.01	0.04 ± 0.007	0.04 ± 0.01	0.04 ± 0.030
2-270	0.06 ± 0.01	0.04 ± 0.007	0.03 ± 0.01	0.05 ± 0.042
2-288	0.08 ± 0.01	0.03 ± 0.006	0.03 ± 0.00	0.08 ± 0.044
2-306	0.04 ± 0.01	0.06 ± 0.01	0.08 ± 0.01	0.06 ± 0.022
2-324	0.06 ± 0.01	0.09 ± 0.01	0.08 ± 0.01	0.09 ± 0.037
2-342	0.06 ± 0.01	0.10 ± 0.01	0.1 ± 0.01	0.19 ± 0.058
2-360	0.04 ± 0.01	0.06 ± 0.01	0.02 ± 0.00	0.01 ± 0.012

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

Table 3.5-1 (Continued)
Plutonium Concentration in Soil Samples at a One- and Two-Mile Radius from Rocky Flats

Inner Circle:

Location	1993 Pu pCi/g[a,b,c,d]	1994 Pu pCi/g[a,b,c,d]
1-018	0.07 ± 0.02	0.06 ± 0.011
1-036	0.06 ± 0.02	0.11 ± 0.01
1-054	0.16 ± 0.03	0.072 ± 0.011
1-072	0.14 ± 0.03	0.32 ± 0.047
1-090	3.36 ± 0.39	2.7 ± 0.43
1-108	18.79 ± 1.93	9.2 ± 0.17
1-126	1.40 ± 0.16	1.1 ± 0.21
1-144	0.19 ± 0.04	0.18 ± 0.018
1-162	0.05 ± 0.02	0.25 ± 0.035
1-180	0.06 ± 0.02	0.032 ± 0.007
1-198	0.20 ± 0.04	0.12 ± 0.015
1-216	0.11 ± 0.03	0.063 ± 0.007
1-234	0.05 ± 0.02	0.029 ± 0.007
1-252	0.12 ± 0.03	0.072 ± 0.01
1-270	0.14 ± 0.03	0.077 ± 0.01
1-288	0.12 ± 0.03	0.011 ± 0.017
1-306	0.14 ± 0.03	0.082 ± 0.011
1-324	0.21 ± 0.04	0.13 ± 0.032
1-342	0.04 ± 0.01	0.045 ± 0.006
1-360	0.16 ± 0.03	0.11 ± 0.015

Outer Circle:

Location	1993 Pu pCi/g[a,b,c,d]	1994 Pu pCi/g[a,b,c,d]
2-018	0.11 ± 0.03	0.011 ± 0.003
2-036	0.07 ± 0.02	0.069 ± 0.011
2-054	0.11 ± 0.03	0.096 ± 0.013
2-072	0.13 ± 0.03	0.11 ± 0.012
2-090	4.55 ± 0.48	3.5 ± 0.45
2-108	0.40 ± 0.05	0.42 ± 0.029
2-126	0.18 ± 0.04	0.23 ± 0.029
2-144	0.02 ± 0.01	0.039 ± 0.007
2-162	0.02 ± 0.01	0.016 ± 0.004
2-180	0.09 ± 0.02	0.027 ± 0.005
2-198	0.05 ± 0.02	0.093 ± 0.01
2-216	0.06 ± 0.02	0.041 ± 0.011
2-234	0.03 ± 0.01	0.022 ± 0.006
2-252	0.02 ± 0.01	0.01 ± 0.003
2-270	0.02 ± 0.01	0.038 ± 0.005
2-288	0.00 ± 0.00	0.017 ± 0.004
2-306	0.10 ± 0.03	0.043 ± 0.006
2-324	0.12 ± 0.03	0.079 ± 0.009
2-342	0.02 ± 0.01	0.089 ± 0.01
2-360	0.04 ± 0.02	0.029 ± 0.006

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

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 x 30 m) to allow yearly selection of nonoverlapping 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, as well as sampling and analytical error, contribute to the observed variability. Other investigators 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 distance from point of release (75 percent), microtopographical variations (20 percent) and sampling error, which included subsampling and analytical error (5 percent). Variability in plutonium concentrations in soils taken from the two radial grids at 18, 36, and 162 to 360 degrees was extremely small (Table 3.5-1).

SOIL STANDARDS

There is no standard at the federal level for radionuclides in soil for transuranics. The EPA proposed a screening level for plutonium of 44.4 disintegrations per minute per gram (dpm/g) (19.98 pCi/g) for a soil density of 1 gram per square centimeter (g/cm^2) for soils sampled to a depth of 1 cm (0.39 in.).[1]

At the state level, CDPHE adopted a standard for plutonium in 1973 of 2.0 dpm/g (0.9 pCi/g) for a soil density of 1 g/cm^2 for soils sampled to a depth of 0.64 cm (0.25 inc.).[2]

References

1. United States Environmental Protection Agency, *Proposed Guidance on Date Limits for Persons Exposed to Transuranium Elements in General Environment,* Federal Register Notice, Washington, D.C., October 1977.

2. Colorado Department of Health, State of Colorado Division of Occupational and Radiological Health, Denver, Colorado, 1973.

3.6 ECOLOGICAL STUDIES

OVERVIEW

Ecological studies are performed at Rocky Flats to inventory natural resources, assess baseline or "natural" conditions of these resources, and determine ecological impacts from various agents of stress. Routine surveys are also conducted to gather information on wildlife and vegetation for compliance with applicable federal and state environmental statutes and regulations.

Ecological studies at the Site are designed to ensure compliance with DOE Order 5400.1 and with various federal and state regulations requiring the protection of ecological resources. Regular monitoring includes evaluation of the status of plants, wildlife, and birds; wildlife habitat use; characterization of plant communities; study of soil and aquatic invertebrates; and nutrient cycling in the ecosystem. Specialized monitoring of species of special concern (Bald Eagles and Preble's Meadow Jumping Mouse) was conducted in addition to the routine monitoring. The ecological programs also provided field support for Environmental Restoration programs such as rainfall/runoff studies in OU 2 and the polychlorinated biphenyls study in OU 6.

Ecological programs ensure that ecological concerns are increasingly considered and evaluated during planning of Site programs through interfaces with projects such as remediation actions, facilities upgrades, and revegetation efforts. This consideration of ecological impacts helps ensure compliance with the Endangered Species Act, the Migratory Bird Treaty Act, the Eagle Protection Act, and state wildlife protection laws, as well as providing data for Natural Resource Damage Assessment actions. As the Site moves into decommissioning and remediation phases, natural resources must be considered as a factor in determining Site uses.

ECOLOGICAL MONITORING PROGRAM

The Ecological Monitoring Program (EcMP) was established in compliance with DOE Order 5400.1 which requires an ecological monitoring program at federal facilities such as Rocky Flats. The EcMP complies with this order by quantitatively assessing Site ecological resources such as vegetation, small mammals, soil invertebrates, aquatic invertebrates, and nutrient cycling. These efforts include data collection at the population, community, and ecosystem levels. Data collection is performed at 12 permanent sample locations within the Buffer Zone of the Site. The EcMP annual report for 1994[1] summarized and analyzed the data collected by the EcMP during 1994.

Each year, the EcMP Annual Report includes the analyses and interpretation of the data collected in the prior year. In 1994, field programs began in April and continued through November. With the exception of laboratory analyses, all work in 1994 was performed by Site staff.

The technical modules in the EcMP are Ecosystem Functions, Terrestrial Vegetation, Small Mammals, Aquatic Ecology, Soil Invertebrates, Reclamation Monitoring, and Terrestrial Arthropods.

Ecosystem function measurements quantify carbon and nitrogen cycling by microbes. The production of soil CO_2 and the potential for soils to mineralize organic carbon and nitrogen to inorganic forms are being studied at 12 sites, three in each of four vegetation community types. The range and variation in baseline conditions are being determined and will be compared to conditions in the OUs.

Data collected in the Terrestrial Vegetation module include the composition of plant species from a site, and the amount of basal cover and production those species represent. The xeric grassland sites found on the alluvial piedmont at Rocky Flats have been found to be the most botanically diverse of the grassland plant communities at the Site, with remnants of tallgrass prairie which are rare for the region. This information has been used by DOE to assess the impacts of proposed mining activities in these areas.

Small mammal population studies continued in 1994 with the live-trapping of mice, voles, and ground squirrels from the 12 sites, and the subsequent characterization of their habitat. A special study examined the distribution and habitat requirements of the Preble's Meadow Jumping Mouse, a species that may become federally protected in the near future. This mouse primarily inhabits riparian areas and pond edges, and trapping efforts demonstrated that Rocky Flats has one of the few known breeding populations of this species in the world.

Aquatic ecology efforts in previous years demonstrated that almost all Site ponds, streams, and seeps have a unique biological character that is attributed to a variety of sources, including effects from past plant activities, anthropogenic manipulation of water flows, and other management practices.

Soil Invertebrate measurements are collected at the same times and locations as the Ecosystem Function measurements. Soil samples are analyzed for protozoans, nematodes, and arthropods, which are all classes of organisms that are sensitive to contaminants and disturbances.

Reclamation of soils and vegetation communities is becoming increasingly important at Rocky Flats during and following remediation efforts. Ecology staff members recommend appropriate seed mixtures, mulches, and reclamation procedures, and monitor the success of these activities. The primary work to date has been monitoring the reseeding of the 881 Hillside. Guidance has also been provided for several projects including the Systematic Evaluation Program, and the Geological Excavation and Seismic Investigation Project. These data are currently being analyzed to determine if groups of organisms can be indicative of adverse ecological effects.

The identification and enumeration of terrestrial arthropods (primarily insects and spiders) was a new EcMP module in 1994. Like soil invertebrates, insects are a group of organisms that are very sensitive to contaminants, and they inhabit a wide variety of ecological positions and physical habitats at the Site. Samples are sent to a local laboratory for analysis and data will be analyzed in 1995.

NATURAL RESOURCE PROTECTION AND COMPLIANCE PROGRAM

The Natural Resource Protection and Compliance Program (NRPCP), formerly known as the Resource Protection Program (RPP), provides technical analysis and performs surveys to identify and collect information needed to comply with federal and state natural resource protection statutes and regulations. The NRPCP concentrates on compliance-related species groups such as game species, raptors, threatened and endangered species, state protected species, migratory birds, higher-level indicator organisms such as predators, and other species with specific protection concerns. The EcMP concentrates on lower-level ecosystem organisms that are less visible, less charismatic, and easier to quantify. Programmatically, the EcMP is considered the research portion of the Ecology programs while the NRPCP is considered the compliance and protection portion. The NRPCP evaluates ecosystem quality by identifying trends in habitat use and numbers of the larger or more visible species. The NRPCP ensures compliance with wildlife protection regulations through protective procedures and monitoring of the status of these species.

Both sitewide and site-specific surveys are performed to provide information needed to comply with the Endangered Species Act; the Fish and Wildlife Coordination Act; the Clean Water Act; the Migratory Bird Treaty Act; the Bald and Golden Eagle Protection Act; the Colorado Nongame, Endangered, or Threatened Species Act; CERCLA, and Executive Orders 11988 and 11990.

Sitewide surveys were performed throughout the year by NRPCP biologists to monitor the presence, status, locations, and habitat use of protected species. Sitewide surveys also included relative abundance, featured species, migratory bird, breeding bird, waterfowl, raptor, big game, prairie dog, and carnivore surveys. Information from these surveys is entered into a biological database that is used to describe baseline conditions for categorical exclusions, environmental assessments, environmental impact statements, and other documents. These data may also provide background information to address natural resource damage concerns.

Independent sitewide surveys were conducted in 1994 for the Ute ladies'-tresses Orchid, a wild orchid that is listed as a federally threatened species, and for the Colorado Butterfly Plant, a Federal Category 1 species and a State Category 2 species. No Ute ladies'-tresses Orchid or Colorado Butterfly Plants were found during the surveys. A pair of bald eagles attempting to nest at Standley Lake were also monitored by the Colorado Bird Observatory under a subcontract administered by NRPCP.

NRPCP performed site-specific surveys throughout the year for proposed construction projects, remediation projects, and sampling activities to determine whether the proposed projects would impact protected natural resources.

Natural Resource Damage Assessment (NRDA) concerns were also addressed by NRPCP during 1994. A draft strategy for integrating NRDA concerns with CERCLA/RCRA activities was developed. Information on potential natural resource injuries is being gathered and analyzed to determine what natural resource liabilities may exist. NRPCP sitewide and site-specific surveys identify the natural resources that DOE is responsible for protecting, and allow DOE to carry out its responsibility as a Natural Resource Trustee to act in the public interest in managing those resources.

NRPCP biologists provided technical support for the Standley Lake Protection Project (SLPP) by monitoring Bald Eagles at Standley Lake, providing prairie dog census and mapping data, and overseeing a contract with the Colorado Bird Observatory (CBO) for Bald Eagle monitoring at Standley Lake. These efforts were in support of the SLPP Biological Assessment as required by the U. S. Fish and Wildlife Service (USFWS) under the Endangered Species Act. At issue was nesting activity near the inlet of Standley Lake, and other over-wintering activities by a mated pair of Bald Eagles, as well as foraging by several other visiting Bald Eagles near the SLPP construction areas.

As part of the Biological Opinion rendered on the Biological Assessment by the USFWS, the USFWS has required monitoring of the Bald Eagle pair, when they are present, at any time SLPP construction is under way. Due to some OU 3 construction activities in the vicinity of the Bald Eagle nest, NRPCP biologists also provided technical interfaces with the USFWS and compliance monitoring for OU 3 activities. NRPCP was responsible for oversight for and transmittal of the CBO monitoring report, *Final Report on the Behavioral Ecology and Habitat Use of the Standley Lake Bald Eagle Pair*[2] to DOE, Rocky Flats Field Office (RFFO). Bald Eagle monitoring will continue as required for Rocky Flats activities.

NRPCP developed and implemented procedures for migratory bird evaluation and protection, and for the identification and protection of threatened, endangered, and special concern species in 1994. A *Rocky Flats Plant Bald Eagle Protection Plan*[3] was also developed.

The sitewide wetland delineation project, started in the summer of 1993 by the U.S. Army Corps of Engineers and aided by NRPCP biologists, was completed in December 1994. The final report, *Rocky Flats Plant Wetlands Mapping and Resource Study,*[4] contains Site maps which will help project managers identify potential wetland impacts and avoid them whenever possible.

Efforts were initiated during 1994 to develop an offsite wetland mitigation bank to provide compensatory mitigation for unavoidable wetland impacts resulting from activities at Rocky Flats and allow projects to proceed without unnecessary delays.

ECOLOGICAL RISK ASSESSMENTS

Remedial Investigations under CERCLA provide an assessment of the nature and extent of contaminants and the human health and ecological effects of contaminant releases (Section 4.0, Environmental Remediation). Baseline Risk Assessments (BRA) required by CERCLA include two components: ecological and human health risk assessments.

The goal of an ecological risk assessment (ERA) is to provide risk managers with information on the likelihood that ecological values are at risk from past, present, and future sources of contamination or disturbance related to Site activities. To date, no demonstrable ecological effects associated with contaminant releases have been found at the Site. For this reason, ERAs focus on potential effects from sources of contamination.

In late 1994, IAG Agencies accepted proposed changes in the methodology and implementation of ERAs in accordance with recent EPA and DOE guidance and the review comments for the OU 1 BRA. The revised ERA methodology includes implementation of ERAs at ecologically sensible scales. Evaluation of OUs will be combined by source areas, offsite areas, and watershed, resulting in four ERAs instead of nine.

1. Source Areas: Industrial Area Integrated OUs
2. Woman Creek Watershed: OUs 1, part of 2, part of 11, and 5
3. Walnut Creek Watershed: OUs 4, 6, 7, part of 2 and 11
4. Offsite Areas: OU 3

The ERA methodology is being documented in three TM which will be submitted to the agencies for review in early 1995.

References

1. EG&G Rocky Flats, Inc., *Rocky Flats Environmental Technology Site Ecological Monitoring Program Annual Report,* Golden, Colorado, May 1995.

2. EG&G Rocky Flats, Inc., *Final Report on the Behavioral Ecology and Habitat Use of the Standley Lake Bald Eagle Pair,* prepared by the Colorado Bird Observatory, Golden, Colorado, May 1995.

3. EG&G Rocky Flats, Inc., *Rocky Flats Plant Bald Eagle Protection Plan,* Golden, Colorado, April 1994.

4. U. S. Army Corps of Engineers, *Rocky Flats Plant Wetlands Mapping and Resource Study,* December 1994.

4.0 ENVIRONMENTAL REMEDIATION

OVERVIEW

Operable Units (OUs)

The DOE, in consultation with EPA and CDPHE (the regulatory agencies) and in response to public comment, organized the original 177 inactive individual hazardous substance sites (IHSSs) at Rocky Flats into 16 OUs. Three factors were considered in assigning an IHSS to a particular OU: (1) geographic location, (2) type of contaminants involved, and (3) relative priority of the IHSS. Given these factors, there is considerable overlap of the OU boundaries. As provided for in the IAG, sites may be added to the IHSS list if previously unidentified potential contamination is discovered. Similarly, sites may be removed as technical analyses indicate that they no longer present a risk to public health or the environment.

The initial priorities for the OUs at Rocky Flats were established through the IAG by DOE and the regulatory agencies on the basis of available technical information. However, subsequent public comment on the IAG resulted in modification of the priorities. Assessment, characterization, and remedial activities for IHSSs are carried out for each OU, and the OUs form the basis for planning, scheduling, budgeting, and prioritizing environmental remediation activities. Contamination at the OUs is being assessed and cleanup activities are being undertaken, with higher-risk sites being addressed before lower-risk sites. However, remediation of one OU does not have to be complete before work can begin at the next OU. In addition, interim remedial actions may be started at any time in the event that a short-term solution is necessary to protect human health and the environment during the typically lengthy period required to conduct a full investigative study leading to selection of a final remedy. To date, OU 16 has been closed through the IAG process.

OU Assessment and Remediation

The RCRA and CERCLA statutes and supporting regulations govern the OU assessment and remediation process at Rocky Flats. RCRA establishes a "cradle-to-grave" regulatory program for present hazardous waste activities, while CERCLA establishes a comprehensive response program for past hazardous waste activities. Under RCRA, hazardous waste is defined as any material that is listed in state or federal regulations or exhibits hazardous characteristics such as reactivity, corrosivity, ignitability, and toxicity. Radionuclides are not covered under RCRA unless they are mixed with a hazardous waste. CERCLA covers radionuclides as well as hazardous substances. Hazardous substances are broadly defined as any material EPA has designated for special consideration under the CAA, CWA, TSCA, and any hazardous waste under RCRA.

The RCRA and CERCLA both establish a similar process for assessment and remediation of contaminated sites. In general, they require a work plan field investigation, a report to document the results of the field work, a study to determine the feasibility of remedial alternatives, and a final decision document leading to actual cleanup activity. This process is negotiated for each OU through the IAG and includes elements of RCRA, CERCLA, and other requirements. Technical memoranda and proposed plans are required to document progress and to keep the regulatory agencies apprised of strategic and technical information regarding the remedial efforts.

The RCRA process generally includes a Work Plan RCRA Facility Investigation (RFI), an RFI Report, a Corrective Measures Study (CMS), and a Remedy Selection leading to the actual cleanup activity of Corrective Measures. Any cleanup that starts before this process is completed is referred to as an Interim Measure (IM).

The CERCLA process generally includes a Work Plan Remedial Investigation (RI), an RI Report, a Feasibility Study (FS), and a ROD leading to the actual cleanup activity of Remedial Action (RA). Any cleanup that starts before this process is completed is referred to as an Interim Remedial Action (IRA). The terminology is often combined when describing the assessment and remedial process for OUs that are covered by both statutes. For example, RFI/RI, CMS/FS, and IM/IRA are referred to throughout this section, indicating the dual nature of these activities.

Stop Work Order Issued

A stop work order was issued by EPA Region VIII and CDPHE from August 1993 through April 1994. The reason for this action was to allow parties to the IAG time to reach an agreement on guidance for (1) methodology for the baseline risk assessment and (2) preparation of the RFI/RI Reports. In April 1994, the stop work order was lifted by the regulatory agencies and guidance was provided on the methodology for data aggregation for Human Health Risk Assessments (HHRAs) and the RFI/RI Reports. The stop work order affected OUs 2, 3, 4, 5, 6, and 7.

Industrial Area OUs

The Industrial Area OUs consist of OUs 8, 9, 10, 12, 13, and 14. Activities for these OUs were integrated to consolidate investigative efforts, initial field work, and nonintrusive sampling efforts, and to develop a combined action and approach for continuing investigation and remediation. Consolidation of the field work for these OUs has reduced costs by identifying and eliminating redundant sampling efforts. In addition, logistical problems and administrative support between the OUs have been reduced because field work efforts are consolidated for implementation. Schedules have been developed to combine the individual field sampling plans, thereby providing a common oversight of the tasks and resource allocations for not only initial field work but also for the entire project baseline.

Tolling Agreement

Due to insufficient resources and reprioritization of projects within the Environmental Restoration Program in previous years, IAG milestones were not met. In July 1994, DOE and the regulatory agencies signed the Settlement Agreement and State Compliance Order on Consent No. 94-07-01, also referred to as the "Tolling Agreement" for all missed milestones. This agreement provided for settlement of the stipulated fines and penalties under the IAG for OU milestones that were due through the end of January 1995. It allowed for more accurate milestone dates to be presented for these OUs.

The remainder of this section provides information specific to each OU and outlines other sitewide efforts required by the IAG to support environmental restoration activities at Rocky Flats.

OU 1 - 881 HILLSIDE

Description

OU 1 is composed of 11 IHSSs and is located at the 881 Hillside Area north of Woman Creek in the southeast section of Rocky Flats, approximately 1.5 miles from the eastern, outer edge of the Buffer Zone (Figure 4-1). Isolated areas of the shallow (alluvial) groundwater were contaminated in the 1960s and 1970s with solvents and radionuclides. OU 1 has been treated as a high-priority OU because of potentially elevated concentrations of organic compounds in the near-surface groundwater and the proximity of the contamination to the Woman Creek drainage system. (Woman Creek leads to Standley Lake which is an offsite drinking water supply.)

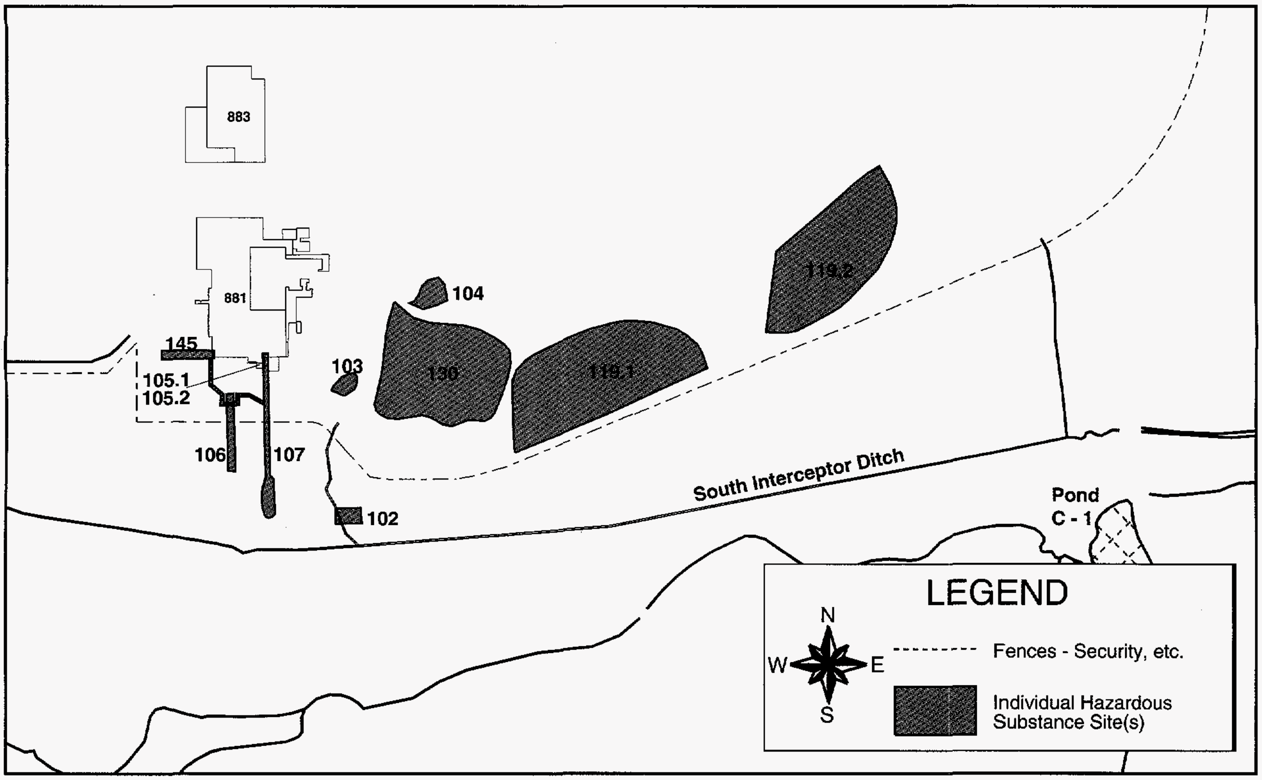


Figure 4-1. OU 1 - 881 Hillside

Major Contaminants

The major contaminants identified at OU 1 include VOCs (TCE and carbon tetrachloride) in groundwater. Plutonium, americium, and uranium were found in an isolated location and were removed via an Accelerated Response Action (ARA) that was completed in October 1994.

Individual Hazardous Substance Sites

IHSS	Site Name
102	Oil Sludge Pit
103	Chemical Burial Area
104	Liquid Dumping Pit
105.1	Out-of-Service Fuel Tank - West Tank
105.2	Out-of-Service Fuel Tank - East Tank
106	Outfall
107	Hillside Oil Leak
119.1	Multiple Solvent Spills - West Area
119.2	Multiple Solvent Spills - East Area
130	Radioactive Site - 800 Area Site #1
145	Sanitary Waste Line Leak

Assessment

Phase I and II Remedial Investigations (RIs) for OU 1, completed in 1987 and 1988 respectively, indicated the presence of VOCs in the alluvial groundwater system and the presence of volatile and semi-volatile compounds in the soils, specifically on IHSS 119.1. Phase III RI field work began in 1991 and the required laboratory sample analysis work and data validation were completed in 1992. The Final Revised Phase III RCRA Facilities Investigation Report was delivered to the regulatory agencies in June 1994. The Corrective Measures Study/Feasibility Study (CMS/FS) was begun in 1992 and will be completed in early 1995. The Draft CMS/FS was submitted to the regulatory agencies in August 1994. No formal approval of the document was obtained. The first Draft Proposed Plan was submitted to the regulatory agencies in November 1994. The Final CMS/FS and the Revised Draft Proposed Plan for OU 1 are scheduled for delivery to the regulatory agencies in early 1995 with the Final Proposed Plan scheduled for delivery in mid-1995.

Interim Remedial Action

DOE proposed an IM/IRA to minimize the release of hazardous substances from OU 1 while the assessment process and selection of the final remedial action are being conducted. The IM/IRA prevents potentially contaminated groundwater from reaching Woman Creek.

The IM/IRA selected by DOE, with input and review by the public, and approved by EPA and CDPHE, encompassed the construction of an underground drainage system called a French drain which was designed to intercept and contain contaminated near-surface groundwater from OU 1. In addition to the French drain, the IM/IRA also includes the collection of water from the Building 881 footing drain and a collection well. The collected water is transferred to an onsite treatment facility for removal of VOCs, radionuclides, and metals. After treatment and testing, the water is released onsite into the South Interceptor Ditch. Water collected from this ditch then undergoes a secondary analysis prior to release. An EA for the proposed IM/IRA was completed in 1990. Construction of the treatment building and excavation of the French drain are now complete, and the facility is in full operation.

Groundwater collected by the French drain and the collection well is treated using an ultraviolet (UV)/peroxide process to remove VOCs and an ion-exchange system to remove the metals and radionuclides. Through the end of 1994, the IM/IRA collected, treated, and released over 2.6 million gallons of groundwater from the 881 Hillside Area. The primary source of water is the footing drain for Building 881. It was determined that this water meets Safe Drinking Water Act (SDWA) standards. Collection was discontinued upon approval by the regulatory agencies.

An ARA was completed in October 1994 and removed radionuclide-contaminated soils (hot spots) at six specific locations within IHSS 119.1 and near IHSS 119.2. Contaminated soils approximately three feet in diameter and approximately two feet in depth at each of the six locations contained substantial indications of either plutonium, americium, or uranium and traces of several organic compounds. The ARA included excavating, containerizing, and storing until shipment of the contaminated soils from these hot spots was feasible. The action significantly reduced potential risks to workers and the public posed by the radionuclides present in the hot spots. The ARA was consistent with long-term cleanup plans for OU 1 which seek to permanently reduce health risks and potential migration of contamination. The regulatory agencies sanctioned the ARA with their approval of the Final Proposed Action Memorandum for OU 1 regarding the hot spot removal. Waste drum hot spot sample analytical results were obtained in January 1994, and validation of the data is expected to be complete by March 1995. It is anticipated that the waste drums will be shipped offsite at that time.

OU 2 - 903 PAD, MOUND, AND EAST TRENCHES

Description

OU 2 consists of 20 IHSSs located within 3 contaminated areas on the east side of the Industrial Area (the 903 Pad Area, the Mound Area, and the East Trenches Area) (Figure 4-2). Contamination at the 903 Pad Area is attributed largely to the storage of waste drums in the 1950s and 1960s. The drums, containing cutting oils and carbon tetrachloride contaminated with plutonium, were removed in 1967 and 1968. By that time, the drums had corroded and allowed hazardous and radioactive material to leak onto the surrounding soil. In 1969, the area was covered with an asphalt pad to provide containment. Some contamination may have resulted from wind dispersion during drum removal and soil movement activities at that time. Other barrels contaminated with uranium were stored at the Mound Area in the 1960s. Preliminary cleanup of the Mound Area was completed in 1970, and the barrels and material removed were packaged and shipped offsite as radioactive waste. The East Trenches Area was used for disposal of plutonium- and uranium-contaminated waste, and sanitary sewage sludge from 1954 to 1968. Two areas adjacent to the trenches were used for spray irrigation of sewage treatment plant effluent, some of which may have had contaminants that were not removed by the treatment system.

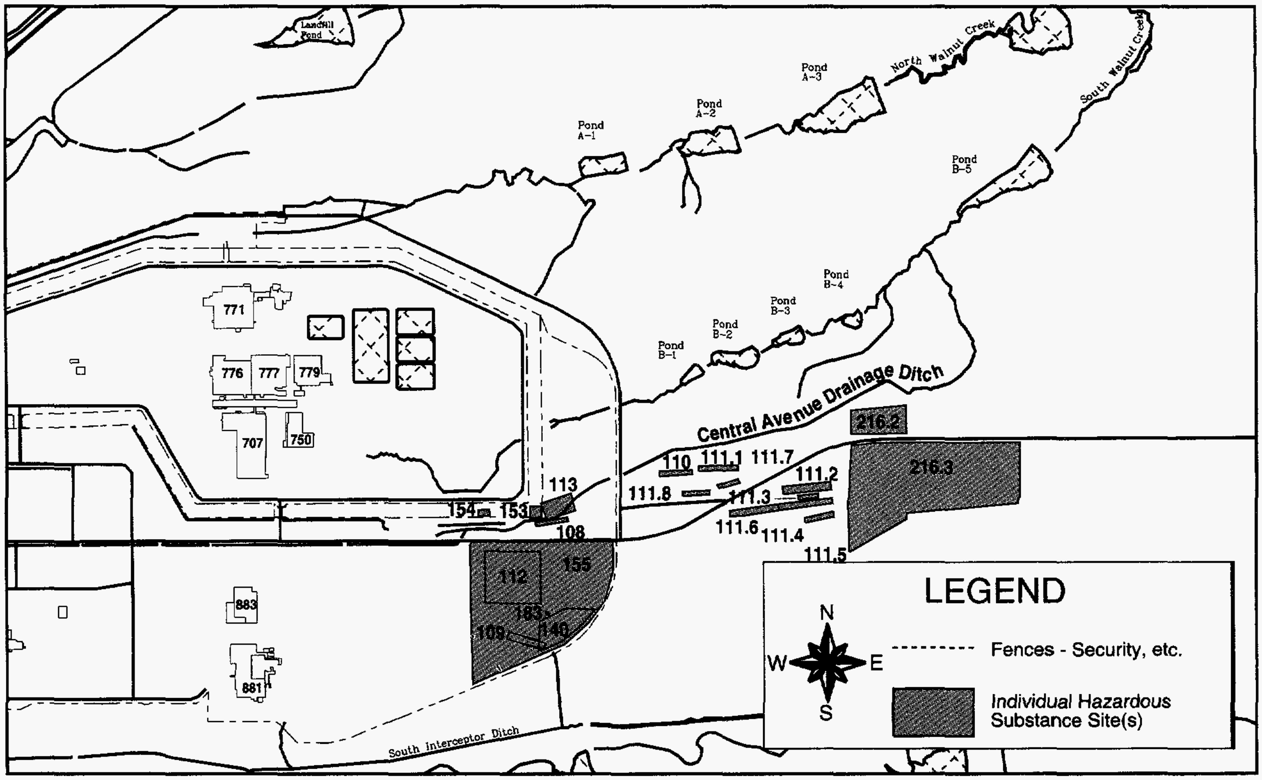


Figure 4-2. OU 2 - 903 Pad, Mound, and East Trenches

Major Contaminants

The major contaminants identified in OU 2 include VOCs, uranium, plutonium, and americium.

Individual Hazardous Substance Sites

IHSS	Site Name	IHSS	Site Name
108	Trench T-1	111.8	Trench T-11
109	Trench T-2	112	903 Drum Storage Area
110	Trench T-3	113	Mound Area
111.1	Trench T-4	140	Reactive Metal Destruction
111.2	Trench T-5	153	Oil Burn Pit No. 2
111.3	Trench T-6	154	Pallet Burn Site
111.4	Trench T-7	155	903 Lip Area
111.5	Trench T-8	183	Gas Detoxification Area
111.6	Trench T-9	216.2	East Spray Field - Center Area
111.7	Trench T-10	216.3	East Spray Field - South Area

Assessment

Routine groundwater investigations conducted at Rocky Flats have indicated the presence of VOCs in the alluvial and bedrock groundwater in the vicinity of OU 2 areas. A portion of the surface water contamination results from a seep located where groundwater emerges at the surface. If not collected, water from the seep eventually flows to Walnut Creek and then to a series of detention ponds. Water in the ponds is treated and sampled prior to release to ensure compliance with the current Site NPDES permit and other applicable standards.

Interim Remedial Action

A program of remedial investigations, feasibility studies, and remedial actions is underway at OU 2. The Surface Water IM/IRA initiated collection, treatment, and discharge of seep and surface water in the source area of contamination. In 1991, operation of a field-scale treatability unit (FTU) began for the South Walnut Creek drainage. The effectiveness of the treatment process was evaluated at three source locations: the influent to the FTU, several points within the FTU, and the discharge point. Approval was granted from the regulatory agencies to discontinue collection and treatment of two of the three sources because they are at or below Applicable or Relevant and Appropriate Requirements (ARARs). Alternative methods of collection and treatment are being evaluated for the remaining source.

By the end of 1994, the OU 2 Surface Water IM/IRA FTU had treated approximately 24.8 million gallons of surface water collected from the seep stations. Sampling will be reduced at the FTU because most of the extensive and costly sampling was performed to support the Final Phase II Treatability Study Report completed in January 1994. After completion of the field-scale treatability tests, the FTU is expected to remain in service until the OU 2 final remediation is operational.

Under an agreement with the regulatory agencies, a second IM/IRA was established in late 1991 for subsurface contamination. This Subsurface IM/IRA Decision Document encompasses the East Trenches Area and evaluates interim remedial technology actions for removal of residual free-phase VOC contamination. The VOC-removal action involves *in-situ,* vacuum-enhanced vapor extraction technology. The information generated from this IM/IRA will aid in the selection and design of final remedial actions for similar sites. The pilot test plan for the first stage of this project was completed in 1992. A mobile soil vapor extraction (SVE) system was installed at the East Trenches Area and operational tests were run in 1993. The Final Field Report for Detailed Soil Vapor Survey was completed in March 1994. The system is currently operating under post-pilot test conditions.

A pilot test for SVE as specified in the Subsurface IM/IRA was completed in June 1994, and extended operations were completed in December 1994. The Final Pilot Test Report for Test Site No. 1 was issued to the regulatory agencies in November 1994. The SVE Test Sites Nos. 2 and 3 will be deleted and a new technology for remediating Trench T-3 will be implemented.

The Phase II remedial investigation of OU 2 characterized the nature and extent of contamination in surface soils, subsurface soils, and groundwater. Work is continuing on the Draft Phase II RFI/RI Report, and several alternative technologies have been evaluated to date. The Final OU 2 Phase II RFI/RI Report is due to the regulatory agencies in September 1995.

OU 3 - OFFSITE AREAS

Description

OU 3 is composed of four IHSSs: offsite surface soils and three public water supplies near Rocky Flats (Figure 4-3). Remedial activities are divided into two main categories. In the first category, the IAG directs activities according to CERCLA that involve characterizing the nature and extent of possible contamination in the OU 3 areas and conducting an HHRA. The second category responds to a 1985 settlement agreement among DOE, former plant operators (Rockwell International and the Dow Chemical Company), local governments, and private landowners. The 1985 Settlement Agreement requires remediation actions to reduce plutonium concentrations in the land adjacent to the eastern boundary of Rocky Flats (Remedy Lands). Remedial activities in response to the settlement agreement began in 1985 and involved tilling the contaminated areas to reduce the surface plutonium concentrations and to stabilize the areas by revegetation.

Major Contaminants

The major contaminants identified in the OU 3 investigation are low-level radionuclides (plutonium and americium) that decrease with distance from the eastern boundary of Rocky Flats.

Individual Hazardous Substance Sites

IHSS	Site Name
199	Contamination of the Land Surface (including the Remedy Lands)
200	Great Western Reservoir
201	Standley Lake
202	Mower Reservoir

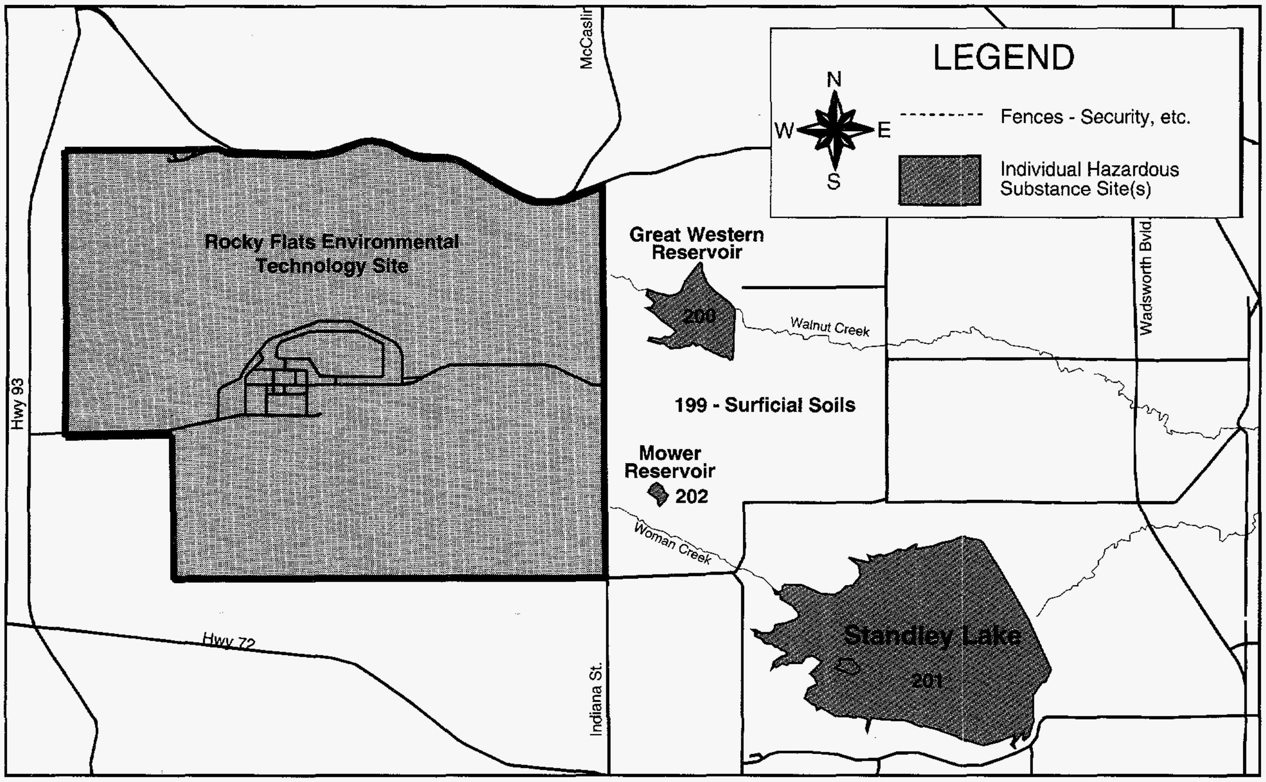


Figure 4-3. OU 3 - Offsite Areas

Assessment

In 1991, the Final Past Remedy Report and the Final Historical Information Summary/Preliminary HHRA Report were completed. These reports presented a summary of historical data and an HHRA for contaminated offsite soils associated with OU 3. In 1992, the Final Phase I RFI/RI Work Plan was completed. The field investigation consisted of soil, sediment, and water sampling in and around Great Western Reservoir, Mower Reservoir, and Standley Lake. Additionally, a portable wind tunnel was utilized to quantify the resuspension potential of OU 3 surface soils. The wind tunnel field work was completed during 1993. Resuspension potential is a component in the inhalation pathway that is assessed as part of the HHRA. Laboratory results for the wind tunnel tests were received in December 1994 and will be incorporated into the Draft Phase I RFI/RI Report expected to be completed later in 1995.

Additional field work outlined in the field investigation work plan includes the installation of three ultra-high-volume air samplers to be installed around the Standley Lake area. Two of three proposed ultra-high-volume air monitoring stations were installed in 1994. Installation of the remaining air monitoring stations and one meteorological monitoring station is planned for 1995. The presence of the nesting eagle pair near Standley Lake continues to impact the installation and operation of these stations. The data generated from the air and meteorological monitoring stations will be used to develop the Draft Phase I RFI/RI Report. This report will contain an assessment of the nature and extent of contamination as well as a baseline risk assessment. The data evaluation, identification of exposure scenarios, selection of exposure parameters, and ecological effects assessment portions of the risk assessment are proceeding.

Remediation and revegetation activities are currently required on approximately 250 of the 350 acres of the land covered under the lawsuit agreement. Remedial activities are not required on the remaining 150 acres until requested by the owner. Of the total acreage, 100 acres are in active revegetation. In 1991, approximately 80 acres of disturbed soil from the 1985 remediation tilling were revegetated with a native seed mix and mulched to protect the soil surface. The area is monitored for weed control and revegetation success. To date, the soil is being revegetated with limited success. A survey of the Remedy Lands was performed in May 1994 by Jefferson County Weed Management personnel and a weed control specialist. In June 1994, herbicide was applied within designated areas to reduce populations of undesirable weed species. It is anticipated that continued efforts at weed control will create more favorable growing conditions for the revegetated grasses. The overall schedule for this activity is determined by the year-to-year success of the revegetation effort and requirements of the landowners.

As part of the ongoing assessment process, a technical memorandum (Chemical of Concern Identification) and a CDPHE Chemical of Concern Conservative Screen letter report were submitted to the regulatory agencies in September 1994.

OU 4 - SOLAR PONDS

Description

OU 4 consists of one IHSS located in the northeast part of the Protected Area and includes five solar evaporation ponds (Figure 4-4). In the late 1950s, the ponds were used to store and evaporate low-level radioactive process water containing high concentrations of nitrates and treated acidic wastes. The ponds were relined with various upgraded materials as technology improved through the 1960s and 1970s; however, leakage from the ponds into the soil and groundwater was suspected. In 1971, interceptor trenches were installed to collect and recycle groundwater contaminated by the ponds and to prevent natural seepage and pond leakage from entering North Walnut Creek. These trenches were upgraded in 1981 to the current, larger interceptor trench system (ITS), which continuously returned groundwater to the solar evaporation ponds. Process water has not been pumped into the ponds since 1986, and with the diversion of the ITS water to storage tanks in 1993, groundwater is no longer returned to the ponds.

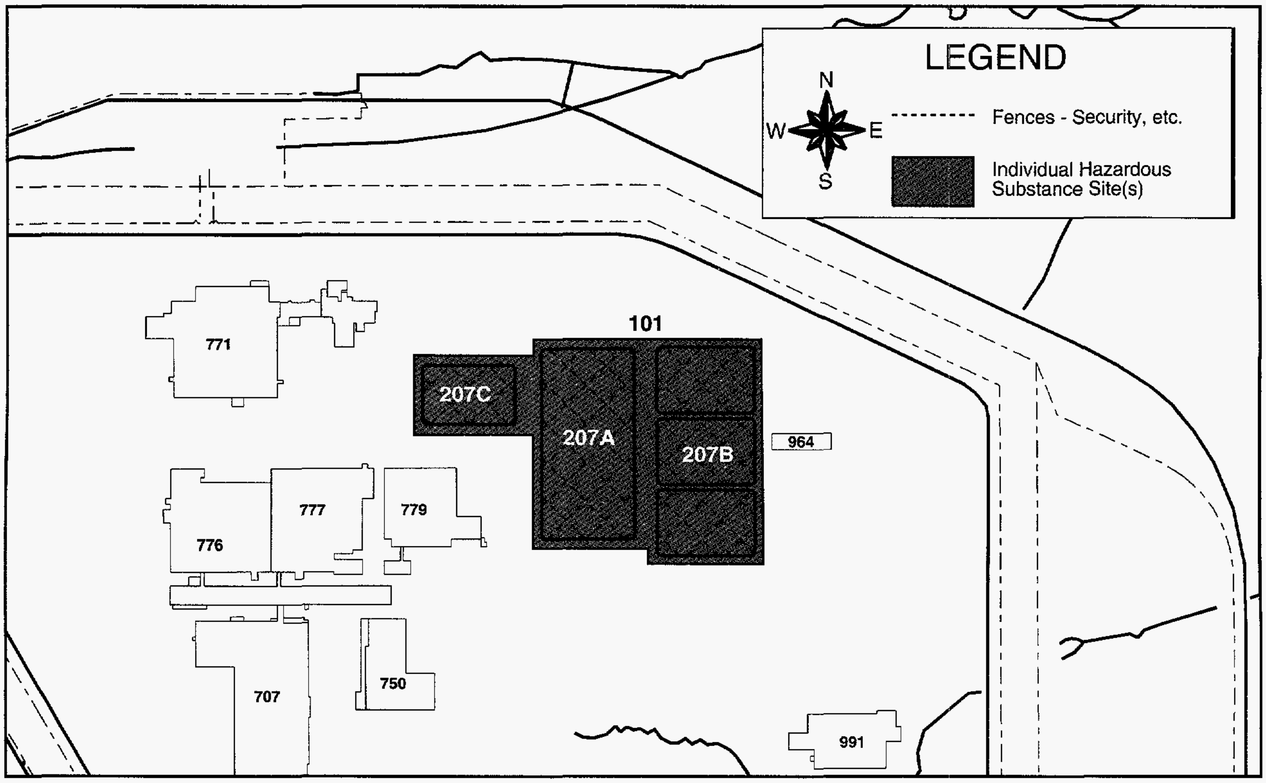


Figure 4-4. OU 4 - Solar Ponds

Major Contaminants

The major contaminants identified in OU 4 include nitrates, chromium, uranium, cadmium, americium, and plutonium.

Individual Hazardous Substance Site

IHSS	Site Name
101	Solar Evaporation Ponds: 207A, 207B Series (North, Center, South), and 207C

Assessment

The OU 4 remedial efforts focus on four technical areas: (1) disposition of pondcrete and pond sludge processing as required by the FFCA; (2) water management/ treatment by means of the IM/IRA; (3) the OU 4 assessment and remedial action per the IAG; and (4) pad operations, storage, and disposal activities necessary to meet RCRA interim status and permit requirements for storage of pond wastes at Rocky Flats. Water and pond sludge management is a necessary precursor to OU 4 assessment and remediation. Pad operations are necessary support activities, at least until the noncertified pondcrete is processed and disposed.

The scope of work supporting the four technical areas was limited to the following activities.

- Remove water and sludge from the ponds
- Remove and store pond sludge in compliance with all applicable Regulations
- Assess the nature and extent of contamination at the ponds
- Complete a RCRA closure of the impoundments
- Remediate the ponds (source and soils) as required
- Remediate groundwater as required

Uncertainty surrounding several aspects of the OU 4 closure and remediation effort led DOE to reevaluate this approach. These factors include availability of the planned disposal site in Nevada, high cost of storing processed sludge, risk of a change in waste acceptance criteria, high cost projections for the total program, and recent changes in state regulations. Work continues to place pond sludge in temporary storage tanks in order to minimize or eliminate the potential for environmental contamination while preserving the possibility of pursuing more feasible alternatives for final disposition of the wastes.

Pond sludge removal operations in four of the five solar evaporation ponds were completed in May 1994. Operations to remove the sludge in Pond 207C began in August 1994 and are expected to be completed in January 1995, thereby ending the storage of sludge and process wastes in the solar evaporation ponds.

Interim Remedial Action

The Draft Phase I IM/IRA Decision Document proposing pond closure remedies was provided to the regulatory agencies in May 1994. Dispute resolution was initiated under provisions in the IAG in July 1994 to resolve differences concerning the design of an engineered barrier for isolated placement of pond sludge and pondcrete. The dispute ended in the same month with no formal agreement being made. Instead, the State of Colorado has allowed DOE to continue planning the remediation alternative of placing treated pond sludge and pondcrete under the engineered barrier. The State has opted to reserve comment until after the public comment period of the Draft Phase I IM/IRA Decision Document which is scheduled to begin in February 1995.

The preferred remedy utilizes an engineered barrier designed for 1,000-year integrity and would include contaminated soil, processed pond waste, and debris. Multiple layers of natural materials would be used to prevent contaminant migration due to leaching and would serve as a barrier for burrowing animals and tree roots. This remedy is designed to protect human health and the environment while being more fiscally responsible than other remedial options. The proposal will recommend the use of newly promulgated RCRA regulations designed to improve corrective actions.

OU 5 - WOMAN CREEK

Description

OU 5 is composed of 11 IHSSs in the Woman Creek Priority Drainage, which drains surface water, including runoff, from the extreme southern part of the Industrial Area (Figure 4-5). The water eventually flows into Mower Reservoir or is diverted around Great Western Reservoir by means of the Broomfield Diversion Ditch. Contamination of the OU 5 areas is largely attributed to previous landfill operations, stormwater runoff into holding ponds, and ash pit operations. Media affected include soils, sediments, surface water, groundwater, and air.

Major Contaminants

The major contaminants identified in OU 5 include solvents, paints, paint thinner, oil, pesticides, cleaners, beryllium, uranium, depleted uranium, plutonium, graphite, ash from plant waste, metals, nitrates, and nonradioactive hazardous chemical waste.

Individual Hazardous Substance Sites

IHSS	Site Name
115	Original Landfill
133.1	Ash Pit 1
133.2	Ash Pit 2
133.3	Ash Pit 3
133.4	Ash Pit 4
133.5	Former Incinerator Area
133.6	Concrete Wash Pad
142.10	Retention Pond: C-1
142.11	Retention Pond: C-2
196	Water Treatment Plant Backwash Pond
209	Surface Disturbances southeast of Building 881

Assessment

The Phase I RFI/RI statement of work, proposals, and contract negotiations were completed in 1990. The Final Phase I RFI/RI Work Plan received conditional approval from the regulatory agencies in 1991. Phase I RFI/RI field work, except for routine water well and well point monitoring, was completed in 1993.

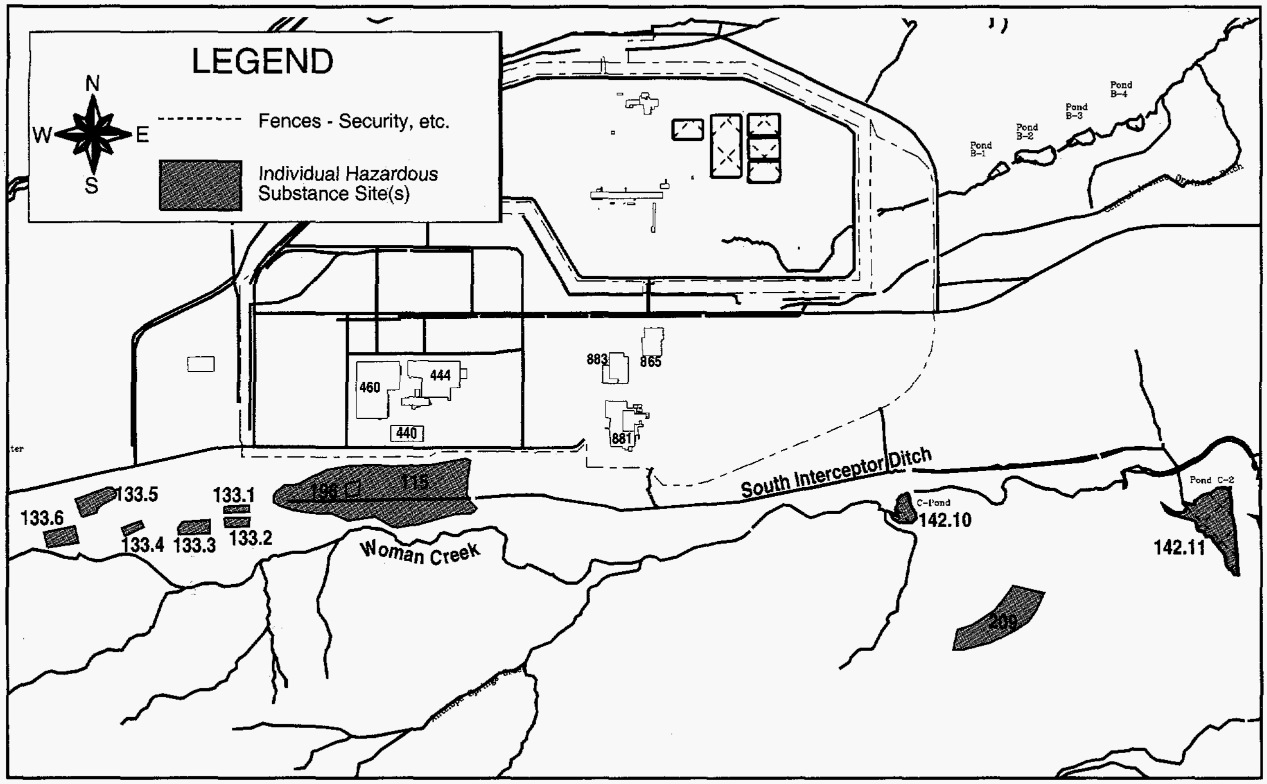


Figure 4-5. OU 5 - Woman Creek

The effect from the work stoppage issued by the regulatory agencies in August 1993 (see Overview of this section) impacted the schedule and budget for the OU 5 RFI/RI Report. Work on the HHRA for OU 5 (which includes the data aggregation, identification of chemicals of concern, development of exposure scenarios, and groundwater monitoring activities) continued once the stop work order was lifted in April 1994. The methodology for completing the Walnut Creek and Woman Creek environmental evaluations was revised, and they are now grouped by watersheds resulting in a more reasonable approach for assessing the drainage systems.

In August 1994, a program of additional sampling and analysis was approved by the regulatory agencies and was incorporated into the Final Phase I RFI/RI Work Plan. If the final disposition is to leave the waste in place, the original landfill and the filter backwash pond would require additional groundwater sampling, air monitoring, and a geotechnical investigation of the long-term stability of the original landfill.

The initial Time-Domain Electromagnetic Survey revealed anomalies associated with the ash pits and concrete wash pad. These areas required further investigation which included groundwater and air monitoring. The IHSS 209 and the two recently identified surface disturbances underwent surface radiological surveys and surface soil sampling.

After a potential fault line was identified under the landfill, a fourth deep borehole was added to the scope to further characterize the area. In October 1994, work began on the FS to present preliminary remediation goals, general response actions, corrective/remedial action objectives, and the detailed screening of alternatives.

OU 6 - WALNUT CREEK

Description

OU 6 consists of 19 IHSSs in the Walnut Creek Drainage, which drains the surface water from the northern half of Rocky Flats, including the runoff from a large portion of the Industrial Area (Figure 4-6). OU 6 activities also include 16 groundwater monitoring wells which have been installed throughout the Walnut Creek drainage area to monitor the alluvial aquifer.

Major Contaminants

The major contaminants suspected to be in OU 6 include americium, plutonium, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs).

Individual Hazardous Substance Sites

IHSS	Site Name
141	Sludge Dispersal
142.1	Retention Ponds: A-1 Pond
142.2	Retention Ponds: A-2 Pond
142.3	Retention Ponds: A-3 Pond
142.4	Retention Ponds: A-4 Pond
142.5	Retention Ponds: B-1 Pond
142.6	Retention Ponds: B-2 Pond
142.7	Retention Ponds: B-3 Pond
142.8	Retention Ponds: B-4 Pond
142.9	Retention Ponds: B-5 Pond
142.12	Newly Identified A-5 Pond
143	Old Outfall
156.2	Soil Dump Area
165	Triangle Area
166.1	Trench A
166.2	Trench B
166.3	Trench C
167.1	North Area - Spray Field
216.1	East Area - Spray Field

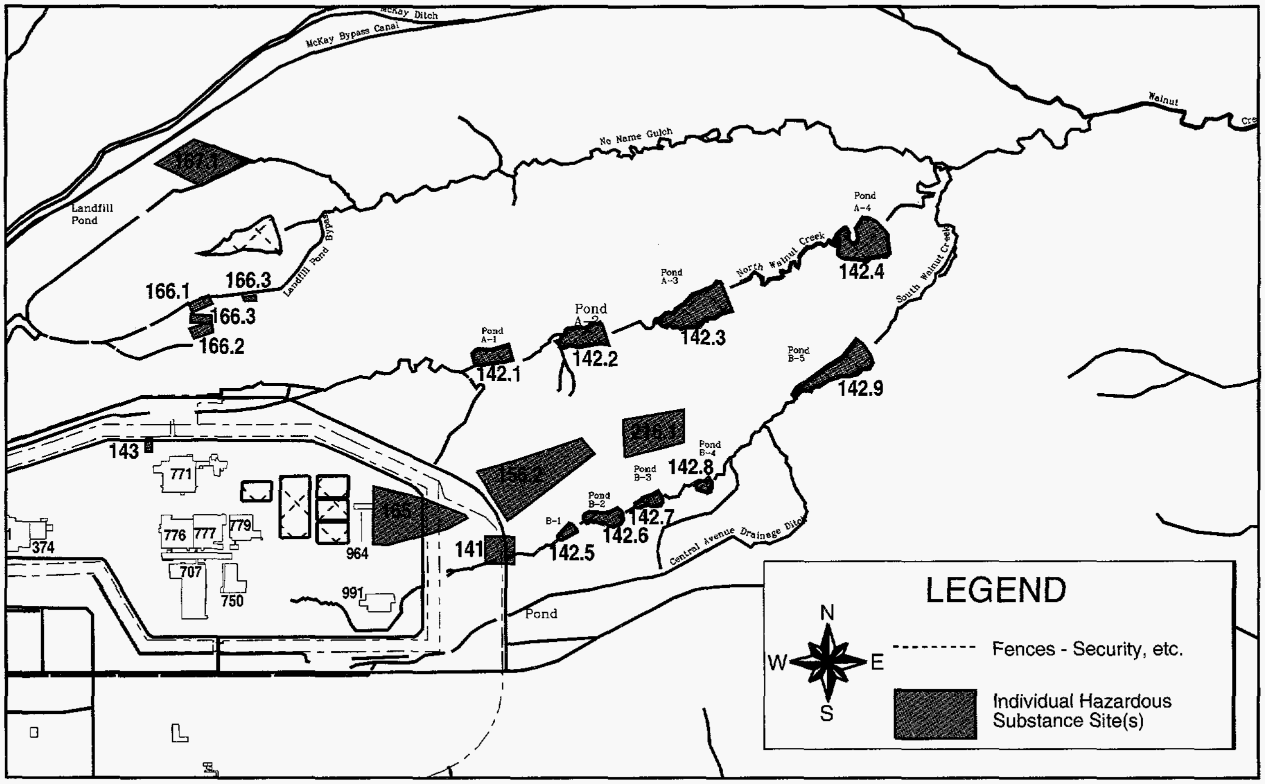


Figure 4-6. OU 6 - Walnut Creek

Assessment

The field work portion of the Phase I RFI/RI Work Plan was completed, and data analysis began in 1993. The Final Phase I RFI/RI Report is due to the regulatory agencies in 1996. The remaining activities necessary to complete this report include surface-water, air, and groundwater modeling, nature and extent delineation, and risk assessment.

Work on the HHRA for OU 6 (which includes the surface-water, air, and groundwater modeling activities) continued once the stop work order was lifted in April 1994. The methodology for completing the Walnut Creek and Woman Creek environmental evaluations was revised, and they are now grouped by watersheds, which represents a more reasonable approach for assessing the drainage areas.

A PCBs sampling project was completed in July 1994 and an evaluation of the data was completed in October 1994. Analytical results reported from the laboratory PCBs tissue analysis showed slightly elevated levels of PCBs in the tissues of fathead minnows from B-4 Pond. Sampling results from bass in A-3 Pond and from fathead minnows in A-4 and B-5 Ponds showed only trace amounts of PCBs. Results from the surface-sediment sampling revealed no detectable levels of PCBs in Ponds A-4 or B-5, indicating that it is not likely that sediments derived from Rocky Flats activities are contributing PCBs to any offsite reservoirs in downstream ecosystems. These results will be incorporated into the Phase I RFI/RI Report.

Development of the source-area maps and area-of-concern maps was completed and presented to the regulatory agencies in September 1994. Maximum exposure areas were identified and a conservative screening process was implemented to remove source areas from the HHRA scope or transfer them to another OU. The following source areas were removed by the screening process: IHSS 142.5, IHSS 142.9, IHSS 142.12, IHSSs 166.1 through 166.3, and IHSS 216.1. There will be four areas of concern evaluated in the HHRA: (1) North Walnut Creek drainage, (2) South Walnut Creek drainage, (3) an area between the drainages, and (4) an area north of the landfill. The Old Outfall (IHSS 143) did not pass the conservative screen. Based on the preliminary conservative screen results, this IHSS may be transferred to OU 8 for future risk assessment and potential remediation. This is primarily because of its location within the Protected Area and its proximity to OU 8.

In October 1994, work began on a FS to present preliminary remediation goals, general response actions, and remedial action objectives.

OU 7 - PRESENT LANDFILL

Description

OU 7 is composed of four IHSSs associated with the Present Landfill. The contaminated areas are located north of the Industrial Area near an unnamed tributary of North Walnut Creek (Figure 4-7). The landfill began operation in 1968 and was originally constructed to provide for disposal of the nonradioactive and nonhazardous wastes generated at Rocky Flats. In 1973, tritium was detected in leachate from the landfill. During the mid-1980s, extensive investigations were conducted on the waste streams (types) placed into the landfill; consequently, hazardous wastes and hazardous constituents were identified. Although currently operating as a nonhazardous sanitary landfill, the facility is managed as an inactive hazardous waste disposal unit undergoing RCRA closure.

The Inactive Hazardous Waste Storage Area, located in the southwest corner of the landfill, was used between 1986 and 1987 for temporary storage of hazardous waste. To maintain the landfill pond at an acceptable volume to prevent discharge, spray evaporation of landfill pond water was applied to the north and south of the landfill pond (IHSSs 167.2 and 167.3). The practice of spray evaporation was discontinued in 1993.

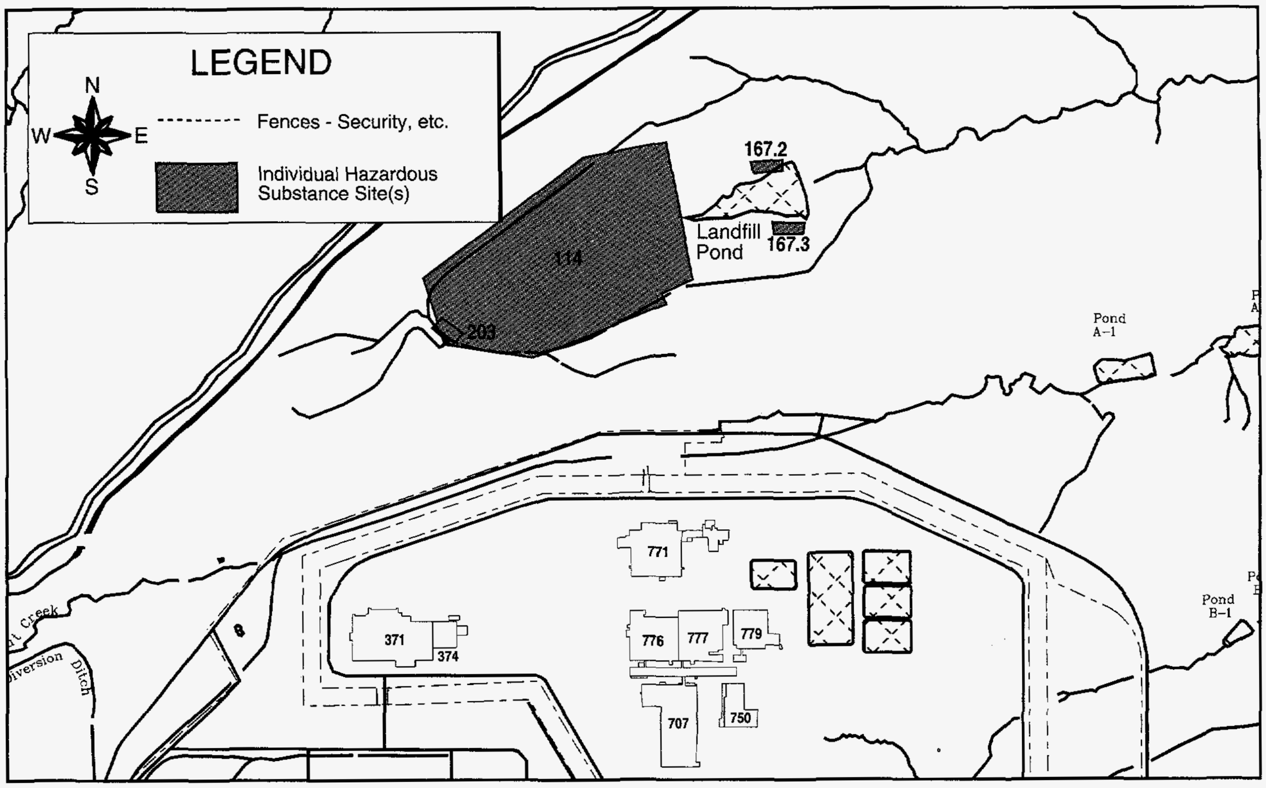


Figure 4-7. OU 7 - Present Landfill

Major Contaminants

The major contaminants identified in OU 7 from historical records and preliminary assessments include radionuclides, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs) and metals at various concentrations.

Individual Hazardous Substance Sites

IHSS	Site Name
114	Landfill Waste, Leachate/Groundwater, Soils Beneath the Landfill, and Sediment/Water in East Landfill Pond
203	Soils at the Inactive Hazardous Waste Storage Area
167.2	Soils at North Area - Spray Field
167.3	Soils at South Area - Spray Field

Assessment

Preparation and review activities for the Draft Phase I RFI/RI Work Plan were completed in 1990 and the Final Phase I RFI/RI Work Plan was approved in 1991. Implementation of the Work Plan began in 1993. In April 1994, final documents supporting the rebaselining of OU 7 were approved by the regulatory agencies. The regulatory agencies agreed to rescope and accelerate the administrative portion of the OU 7 remediation process by combining the approval of the Phase I RFI/RI Report with the Phase II RFI/RI Work Plan. These documents were approved by the regulatory agencies in September 1994. Mobilization for the Phase II RFI/RI field work began in October 1994 and the Phase II RFI/RI field work was completed in December 1994.

In August 1994, the regulatory agencies ruled that the Landfill Leachate Collection Project would be completed as an accelerated action using a proposed action memorandum to support the remediation effort. The proposed action memorandum (PAM) was approved by the regulatory agencies in December 1994. The PAM is being modified to be more compatible with the final remedy.

An IM/IRA Decision Document is being developed to meet the IAG CMS/FS requirements. The document is expected to be submitted to the regulatory agencies in August 1995.

OU 8 - 700 AREA

Description

OU 8 consists of 24 IHSSs inside and around former production areas in the 700 Area of Rocky Flats (Figure 4-8). Contamination sources within the various IHSSs include aboveground and underground tanks, equipment washing areas, and releases inside buildings that potentially affect areas outside the buildings. Contaminants from these sources may have been introduced into the environment through spills on the ground surface, underground leakage and infiltration, and through precipitation runoff.

Major Contaminants

The identified contaminants vary widely between the IHSSs, and range from nonradioactive organic and inorganic compounds (acids, bases, solvents, and petroleum products) to low-level radioactive mixed waste.

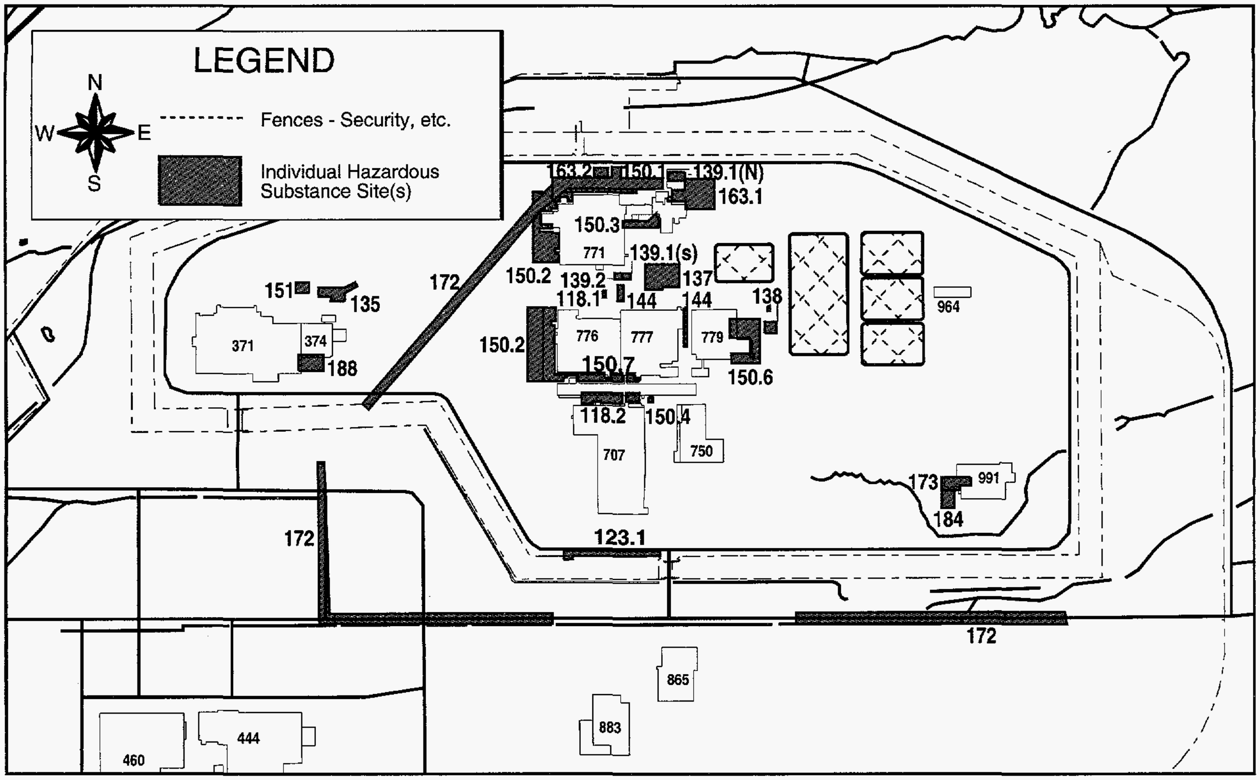


Figure 4-8. OU 8 - 700 Area

Individual Hazardous Substance Sites

IHSS	Site Name
118.1	Solvent Spills West of Building 730
118.2	Solvent Spills South of Building 776
123.1	Valve Vault 7 Southwest of Building 707
135	Cooling Tower Blowdown - Northeast of Building 374
137	Cooling Tower Blowdown - Buildings 712 and 713
138	Cooling Tower Blowdown - Building 779
139.1N	Hydroxide Tank Area - Buildings 771 and 774; Sodium Hydroxide Tank and Steam Condensate Tanks
139.1S	Hydroxide Tank Area - Buildings 771 and 774; Potassium Hydroxide Tank
139.2	Hydrofluoric Acid Tank Area - Building 714
144	Sewer Line Breaks near Building 730 (Tanks 776 A-D) and between Buildings 777 and 779
150.1	Radioactive Site North of Building 771
150.2	Radioactive Site West of Buildings 771 and 776
150.3	Radioactive Site between Buildings 771 and 774
150.4	Radioactive Site East of Building 750

IHSS	Site Name
150.6	Radioactive Site South of Building 779
150.7	Radioactive Site South of Building 776
150.8	Radioactive Site (Combined as Part of IHSS 150.6)
151	Fuel Oil Leak - Tank 262 North of Building 374
163.1	Radioactive Site North of Building 771
163.2	Radioactive Site North of Buildings 771 and 774
172	Central Avenue Waste Spills
173	Radioactive Site - 900 Area (Storage Vaults near 991)
184	Radioactive Site - Building 991 Steam Cleaning Area
188	Acid Leak Southeast of Building 374

Assessment

The Final Phase I RFI/RI Work Plan for OU 8 was submitted to the regulatory agencies in December 1992 for approval. The dispute over risk assessment methodology was resolved in September 1994 and the Final Phase I RFI/RI Work Plan was approved by the regulatory agencies in October 1994.

Field work for the nonintrusive portions of the Phase II RFI/RI investigation began in October 1994. This work included radiation surveys, surficial soil sampling, asphalt and concrete sampling, vertical profile sampling, and soil gas sampling. By the end of 1994, this work was approximately 85 percent complete with all field work scheduled to be completed by early 1995.

Work proceeded in 1994 on data compilation and interpretation, as well as preparation of an addendum to the Final Phase I RFI/RI Work Plan regarding the investigation of foundation drains and other data compilation. The draft addendum was completed and submitted to the regulatory agencies in November 1994. In addition, accelerated actions were identified and planned for implementation in 1995. This work was undertaken as part of the Risk Reduction Program and will allow better access to the OU 8 IHSSs for investigation and, if required, remediation. As part of the first phase of accelerated actions, several storage tanks were identified for removal.

The IM/IRA Decision Document for the Industrial Area OUs was approved by EPA in November 1994 and by CDPHE in December 1994. The procurement process for equipment and subcontractor support was then initiated.

OU 9 - ORIGINAL PROCESS WASTE LINES

Description

OU 9 is composed of 22 IHSSs located throughout the Industrial Area (Figure 4-9). The original process waste lines once carried the majority of the Rocky Flats process wastes to holding areas for treatment during production. This system included 30,000 feet of buried pipeline with 66 designated pipe sections and 40 single and multiple storage tank sites. Three other areas of suspected process waste leakage are also included as part of OU 9. The system was placed into operation in 1952 with additions being made through 1975, and was replaced between 1975 and 1984 by the new process waste system. Some tanks and lines from the original system were incorporated into either the new process waste system or the fire water-deluge collection system. The original system is known to have transported or stored various aqueous process wastes containing low-level radioactive materials, nitrates, caustics, and acids. Small quantities of other liquids were also introduced in the system, including medical decontamination fluids, miscellaneous laboratory liquids, and laundry effluent.

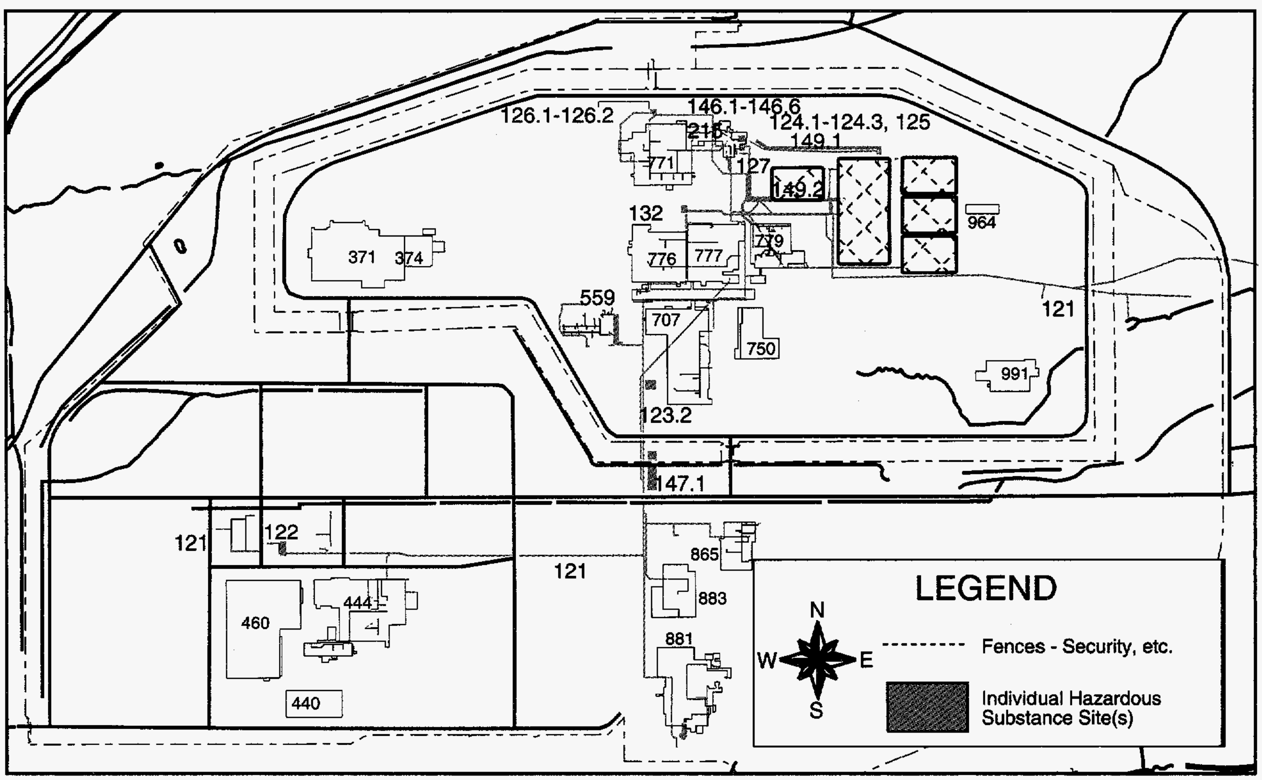


Figure 4-9. OU 9 - Original Process Waste Lines

Major Contaminants

Potential contaminants identified at OU 9 include VOCs, other organic compounds, inorganic compounds, uranium, plutonium, americium, and tritium.

Individual Hazardous Substance Sites

IHSS	Site Name
121	Original Process Waste Line
122	Underground Storage Tanks South of Building 441
123.2	Valve Vault West of Building 707
124.1	Tank East of Building 774 (Site #1)
124.2	Tank East of Building 774 (Site #2)
124.3	Tank East of Building 774 (Site #3)
125	Holding Tank East of Building 774
126.1	Out-of-Service Process Waste Tanks in Building 728
126.2	Out-of-Service Process Waste Tanks in Building 728
127	Process Waste Line between Building 774 and the Sanitary Wastewater Treatment Plant
132	Underground Storage Tanks beneath Building 730
146.1	Underground Concrete Process Waste-Holding Tank South of the Original Building 774 (Site #1)
146.2	Underground Concrete Process Waste-Holding Tank South of the Original Building 774 (Site #2)
146.3	Underground Concrete Process Waste-Holding Tank South of the Original Building 774 (Site #3)
146.4	Underground Concrete Process Waste-Holding Tank South of the Original Building 774 (Site #4)
146.5	Underground Concrete Process Waste-Holding Tank South of the Original Building 774 (Site #5)
146.6	Underground Concrete Process Waste-Holding Tank South of the Original Building 774 (Site #6)
147.1	Process Waste Line North of Building 881
149.1	Pipe between Building 774 and the 207 Solar Evaporation Ponds (Site #1)
149.2	Pipe between Building 774 and the 207 Solar Evaporation Ponds (Site #2)
159	Radioactive Site - Building 559
215	Concrete Mixed Waste Storage Tank near Building 771

Assessment

The Final Phase I RFI/RI Work Plan for OU 9 was approved by the regulatory agencies in 1992. The Work Plan includes inspection and sampling of the tanks and pipelines that are accessible and soil sampling to determine the extent of contamination on the vadose zone. The soil sampling will be performed using intrusive methods where known or suspected releases occurred near pipe joints and valves, at approximately 100- to 200-foot intervals along the pipelines and by installing borings around the outdoor tanks. Soil characterization studies will determine the need for soil removal and/or treatment.

Two technical memoranda regarding field sampling plans for outside tanks and pipelines were submitted to the regulatory agencies in 1994.

OU 10 - OTHER OUTSIDE CLOSURES

Description

OU 10 is composed of 15 IHSSs, 13 of which are scattered throughout the Industrial Area and 2 within the Buffer Zone near the present landfill (Figure 4-10). Contamination resulted from spills of oils and chlorinated solvents and storage of waste drums, surplus building materials, and solid mixed wastes from the solar evaporation ponds (pondcrete/saltcrete).

Major Contaminants

The major contaminants identified at OU 10 are organic compounds, inorganic compounds, metals, and low-level radioactive mixed wastes.

Individual Hazardous Substance Sites

IHSS	Site Name
129	Oil Leak
170	Property Utilization & Disposal (PU&D) Container Storage Yard - Waste Spills
174a	PU&D Container Storage Yard - Drum Storage Area
174b	PU&D Container Storage Yard - Dumpster Storage Area
175	Swiggerton & Walberg Container Storage Facility - Building 980
176	Swiggerton & Walberg Contractor Storage Yard
177	Drum Storage Area - Building 885
181	Cargo Container Area - Building 334
182	Drum Storage Area - Buildings 444 and 453

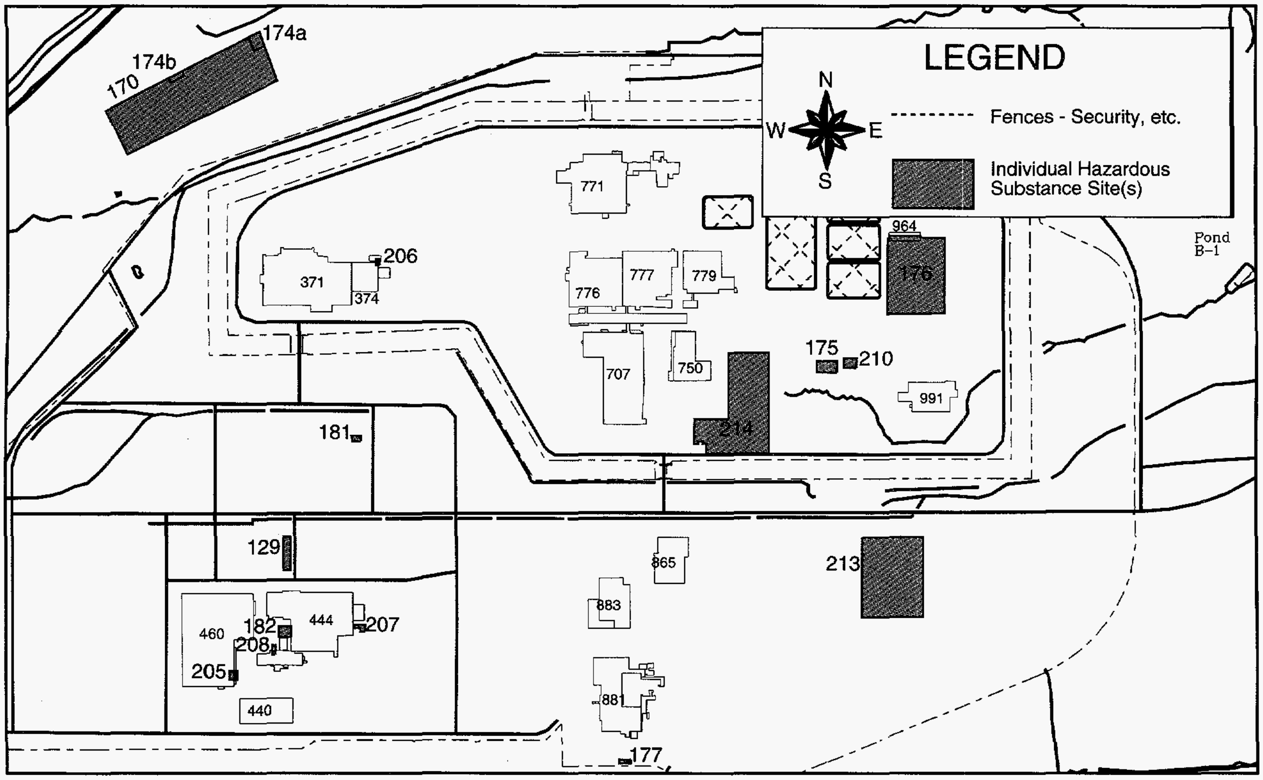


Figure 4-10. OU 10 - Other Outside Closures

IHSS	Site Name
205	Sump #3, Acid Side - Building 460
206	Inactive Hazardous Waste Tank
207	Inactive Acid Dumpsters - Building 444
208	Inactive Waste Storage Area - Buildings 444 and 447
210	Cargo Carrier (RCRA Unit 16) - Building 980
213	Pondcrete Storage (RCRA Unit 15) - 904 Pad
214	Pondcrete and Saltcrete Storage (RCRA Unit 25) - 750 Pad

Assessment

The Final Phase I RFI/RI Work Plan for OU 10 was approved by the regulatory agencies in 1992. All of the Phase I nonintrusive characterization and assessment activities were completed in 1994, after the dispute with the regulatory agencies over risk assessment methodology was resolved. These activities were required by the Work Plan and included the collection of surficial soil samples, soil gas surveys, and *in-situ* gamma radiation surveys.

A preliminary draft technical memorandum regarding nonintrusive sampling for OU 10 was submitted to RFFO in December 1994. This document summarizes the initial data assessments and, once approved, will serve as the primary guidance for development and implementation of the OU 10 Phase II RFI/RI Work Plan.

A request was made to the regulatory agencies for administratively transferring IHSS 176 to OU 4 because the waste will not be removed in the near term. This area could be better managed under OU 4 and would relieve DOE of the responsibility of conducting a Phase I assessment of this IHSS as part of OU 10. No final approval was granted for this request by the regulatory agencies in 1994.

OU 11 - WEST SPRAY FIELD

Description

OU 11 is composed of one IHSS, the West Spray Field, which is located immediately west of the main facilities area (Figure 4-11). The West Spray Field was in operation from 1982 to 1985. During operation, excess liquids from the solar evaporation ponds 207B North and Center (i.e., contaminated groundwater in the vicinity of the ponds and treated sanitary sewage effluent) were pumped periodically to the West Spray Field for spray application. The spray field boundary covers an area of approximately 105 acres, of which approximately 38 acres received direct application of potentially hazardous waste.

Major Contaminants

The major contaminants identified in OU 11 include metals, nitrates, inorganic compounds, uranium, plutonium, americium, and tritium.

Individual Hazardous Substance Site

IHSS	Site Name
168	West Spray Field

Assessment

Approval of the Final Phase I RFI/RI Work Plan was received from the regulatory agencies in 1992. However, OU 11 field activities were rescoped to combine the Phase I and II field investigations, and negotiations are underway to streamline the final action process. These actions are expected to result in an accelerated schedule, including the deletion of several IAG milestones and should provide a significant cost savings.

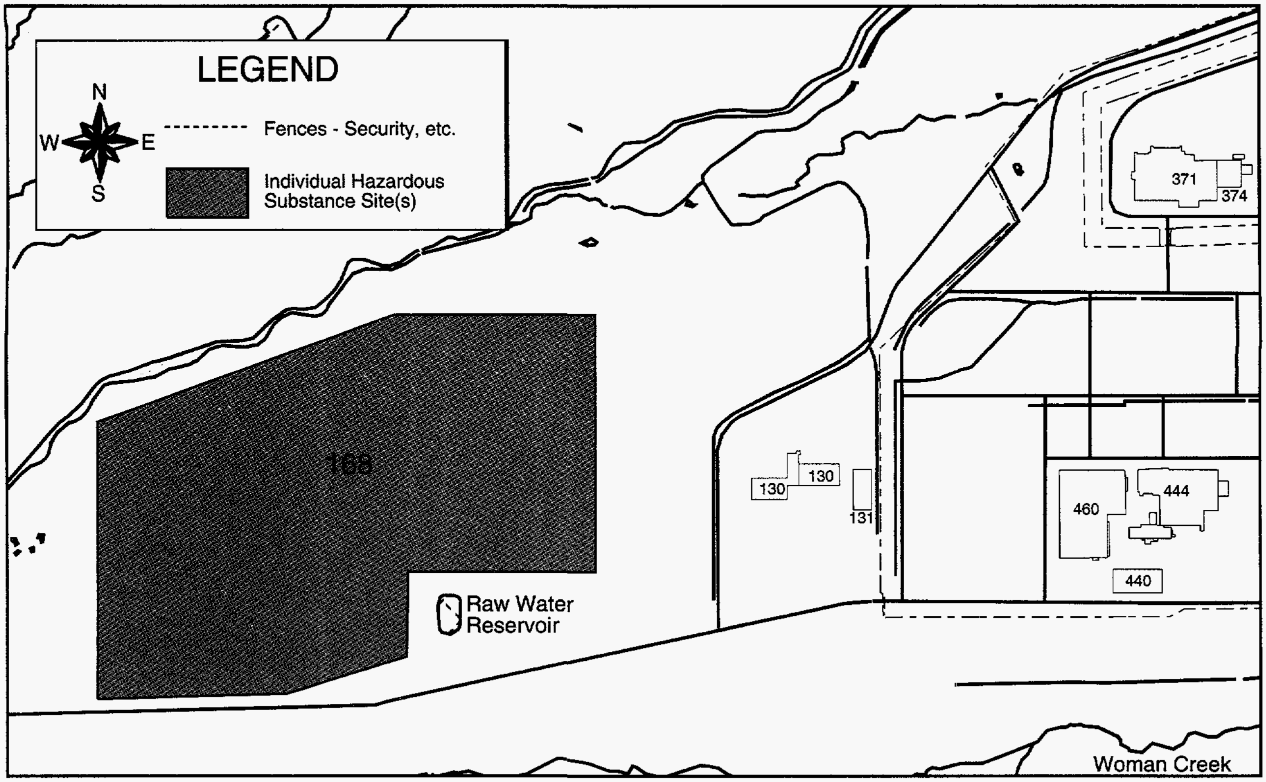


Figure 4-11. OU 11 - West Spray Field

A technical memorandum regarding the field sampling plan and data quality objectives was approved by the regulatory agencies in June 1994. The Phase I RFI/RI field investigation was completed in August 1994 and analytical results were received in December 1994. Work has been completed on a revised environmental evaluation which will be incorporated into the combined phases of the RFI/RI Report.

OU 12 - 400/800 AREA

Description

OU 12 is composed of 10 IHSSs located in and around the 400 and 800 Areas of Rocky Flats (Figure 4-12). The areas under investigation were believed to be contaminated from cooling tower pond operations, chemicals from fiberglass operations, previous leaks, and solvent spills.

Major Contaminants

Potential contaminants identified at OU 12 include radionuclides (uranium), beryllium, VOCs, other organic compounds, and inorganic compounds.

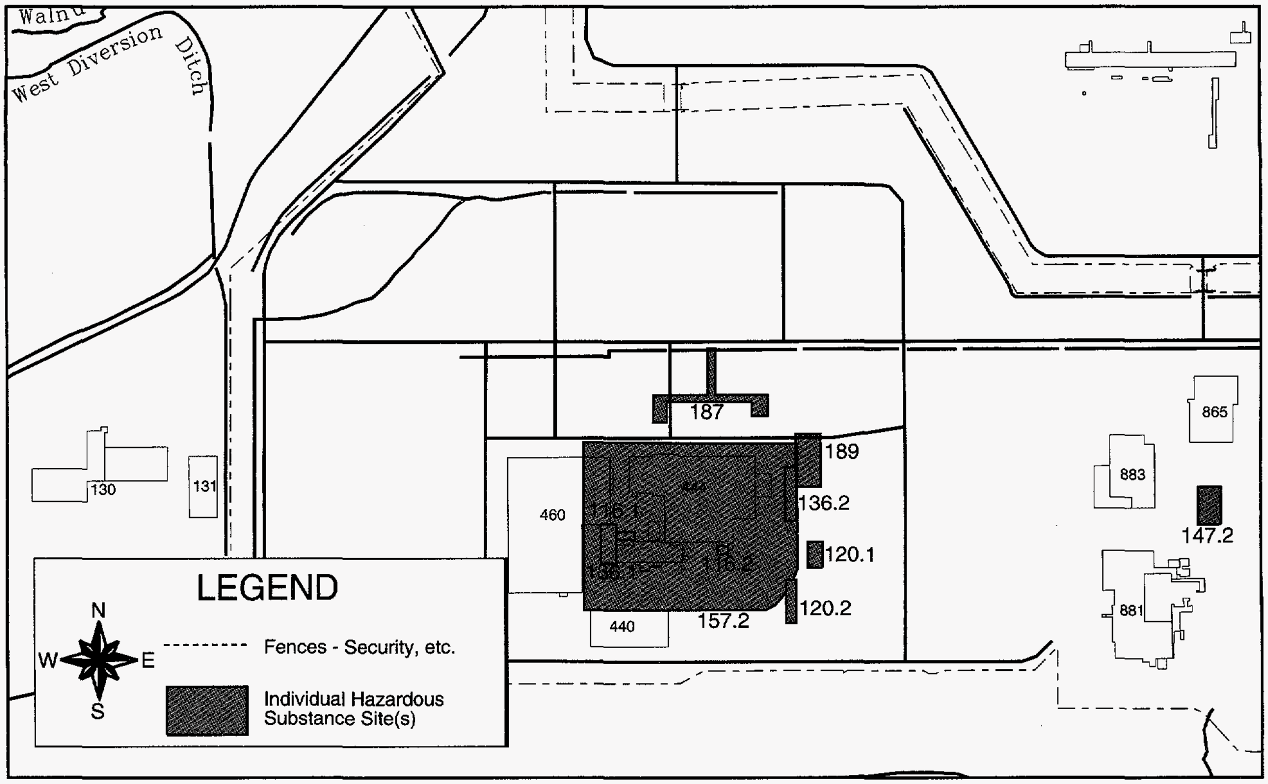


Figure 4-12. OU 12 - 400/800 Area

Individual Hazardous Substance Sites

IHSS	Site Name
116.1	West Loading Dock Area - Solvent Spills
116.2	South Loading Dock Area - Solvent Spills
120.1	Fiberglassing Area North of Building 664
120.2	Fiberglassing Area West of Building 664
136.1	Cooling Tower Ponds Northeast of Building 460
136.2	Cooling Tower Ponds Southwest of Building 460
147.2	Building 881 - Conversion Site
157.2	Radioactive Site - South Area
187	Two Acid Leaks
189	Multiple Acid Spills

Assessment

An Operational Readiness Review for OU 12 was completed, and nonintrusive field activities (as identified in the Phase I RFI/RI Work Plan) were authorized by internal review committees to begin in February 1994. Staking activities were completed by the end of February 1994. A total of 244 surficial soil samples from paved and unpaved areas were taken by the end of May 1994. Utility clearances for soil gas work began in June 1994, and a total of 186 soil gas samples were taken by the end of October 1994. Radiation surveys were conducted during July 1994 and the laboratory radiation analysis was completed in December 1994.

Development of a technical memorandum regarding surface-water and sediment field sampling was submitted to the regulatory agencies in October 1994 and approval of the document is expected in January 1995. The purpose of this sampling is to characterize the migration of surface-water and sediment contamination within the Industrial Area.

All Phase I nonintrusive field activities for OU 12 were completed during 1994 and a large amount of data was gathered. A preliminary draft technical memorandum summarizing the nonintrusive field data is expected to be completed in February 1995. Work was initiated to evaluate this data.

OU 13 - 100 AREA

Description

OU 13 consists of 15 IHSSs located within the 100 Area of Rocky Flats (Figure 4-13). These IHSSs include former storage areas for chemicals, radioactive waste, and scrap metal. Other sources of contamination resulted from oil burning pits, lithium metal destruction areas, and solvent burning sites where wastes were destroyed.

Major Contaminants

Potential contaminants identified at OU 13 include VOCs, other organic compounds, inorganic compounds, plutonium, uranium, americium, and tritium.

Individual Hazardous Substance Sites

IHSS	Site Name
117.1	Chemical Storage - North Site
117.2	Chemical Storage - Middle Site
117.3	Chemical Storage - South Site
128	Oil Burn Pit #1
134	Lithium Metal Destruction Site
148	Waste Spills
152	Fuel Oil Tank
157.1	Radioactive Site - North Area

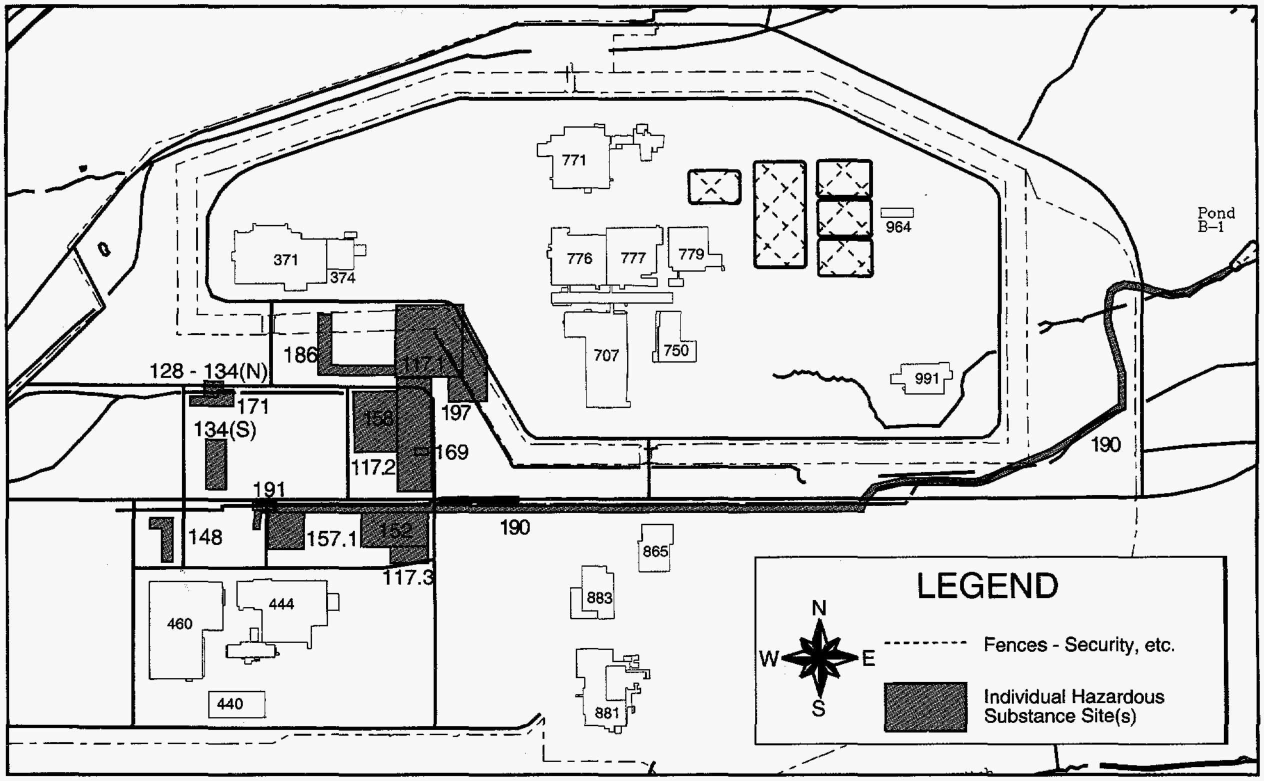


Figure 4-13. OU 13 - 100 Area

<u>IHSS</u>	<u>Site Name</u>
158	Radioactive Site - Building 551
169	Waste Peroxide Drum Burial
171	Solvent Burning Ground
186	Valve Vault 12
190	Caustic Leak
191	Hydrogen Peroxide Spill
197	Scrap Metal Site

Assessment

The Draft Phase I RFI/RI Work Plan for OU 13 was approved by the regulatory agencies in 1992. Surficial soil sampling was completed in July 1994 and sodium iodide surveys were completed in August 1994. Global Positioning System (GPS) surveying in OU 13 began in November 1994. The GPS, when implemented, will expedite the process of surveying sampling locations. By the end of 1994, surficial soil data validation was 85 percent complete. Soil gas investigations were 90 percent complete in IHSSs 128, 134, and 171. Soil gas investigations were at various stages of completion: IHSSs 117.1 (70 percent complete), 117.2 (60 percent complete), and 158 (40 percent complete).

A draft technical memorandum regarding the field sampling plan was submitted to the regulatory agencies in March 1994 and approved in November 1994. Development of another technical memorandum began which will summarize the nonintrusive field work and recommend Phase II activities for the remedial investigation intrusive field work.

OU 14 - RADIOACTIVE SITES

Description

OU 14 consists of eight IHSSs located throughout the Industrial Area of Rocky Flats (Figure 4-14). The contaminated areas originate from spills of radioactive materials and include low-level radioactive waste and low-level, mixed radioactive waste.

Major Contaminants

Potential contaminants identified at OU 14 are radionuclides including uranium, plutonium, americium, and tritium.

Individual Hazardous Substance Sites

IHSS	Site Name
131	Radioactive Site - 700 Area (Site #1)
156.1	Radioactive Soil Burial - Building 334 Parking Lot and Soil Dump Area
160	Building 444 Parking Lot
161	Building 664
162	Radioactive Site - 700 Area (Site #2)
164.1	800 Area - Concrete Slab
164.2	800 Area - Building 886 Spills
164.3	800 Area - Building 889 Storage Pad

Assessment

The Draft Phase I RFI/RI Work Plan for OU 14 was submitted to the regulatory agencies in 1992. Nonintrusive field work for the Phase I field investigation was completed in 1994. This included approximately 350 surface soil samples, 100 soil gas samples, and high-purity germanium surveys. Sodium iodide surveys are scheduled to be completed in January 1995.

A draft technical memorandum regarding the field sampling plan was submitted to the regulatory agencies in March 1994 and approved in November 1994. Development of another technical memorandum began which will summarize the

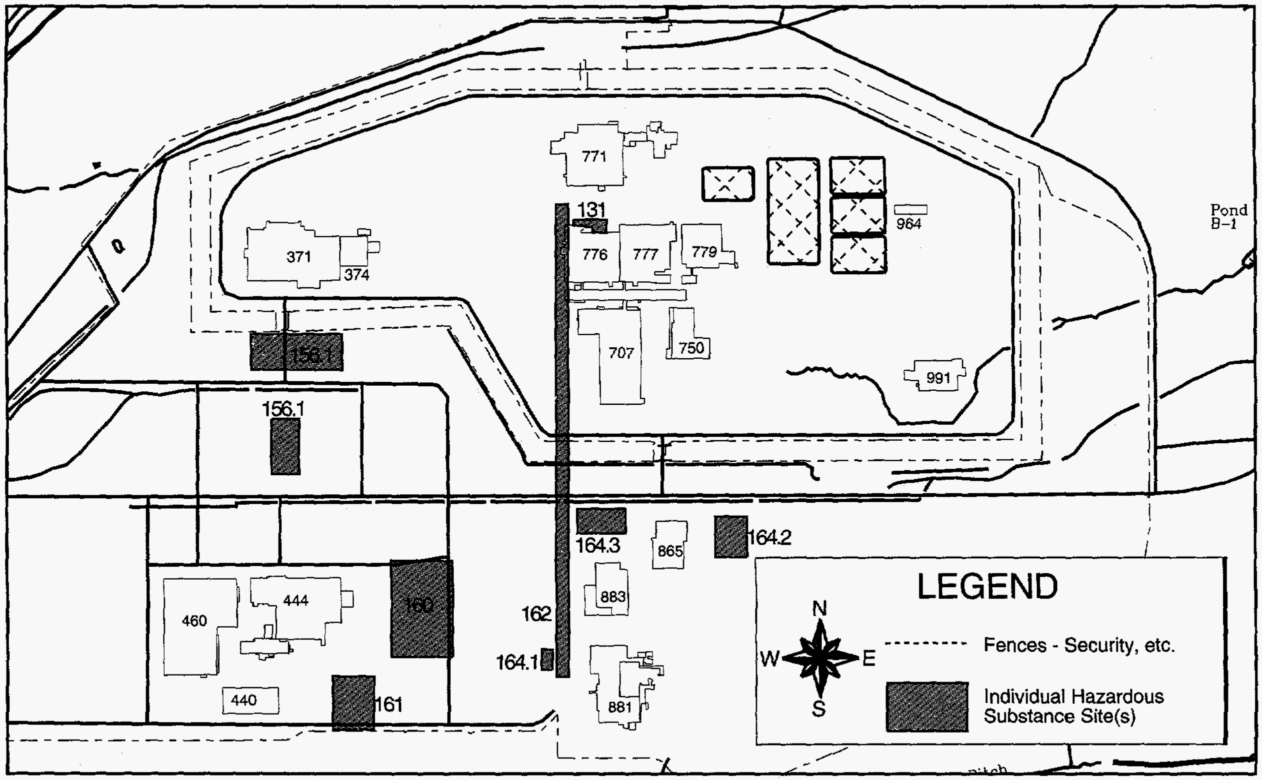


Figure 4-14. OU 14 - Radioactive Sites

nonintrusive field work and recommend Phase II activities for the remedial investigation intrusive field work.

OU 15 - INSIDE BUILDING CLOSURES

Description

OU 15 consists of six IHSSs located within buildings at Rocky Flats where hazardous materials and radionuclides were either stored or processed (Figure 4-15). Types of waste include oil, coolants, chlorinated solvents, and waste metals and paints contaminated with solvents. No known spills or releases have occurred at OU 15.

Major Contaminants

Potential contaminants identified in OU 15 include chlorinated hydrocarbons, beryllium, and uranium as indicated by historical reports.

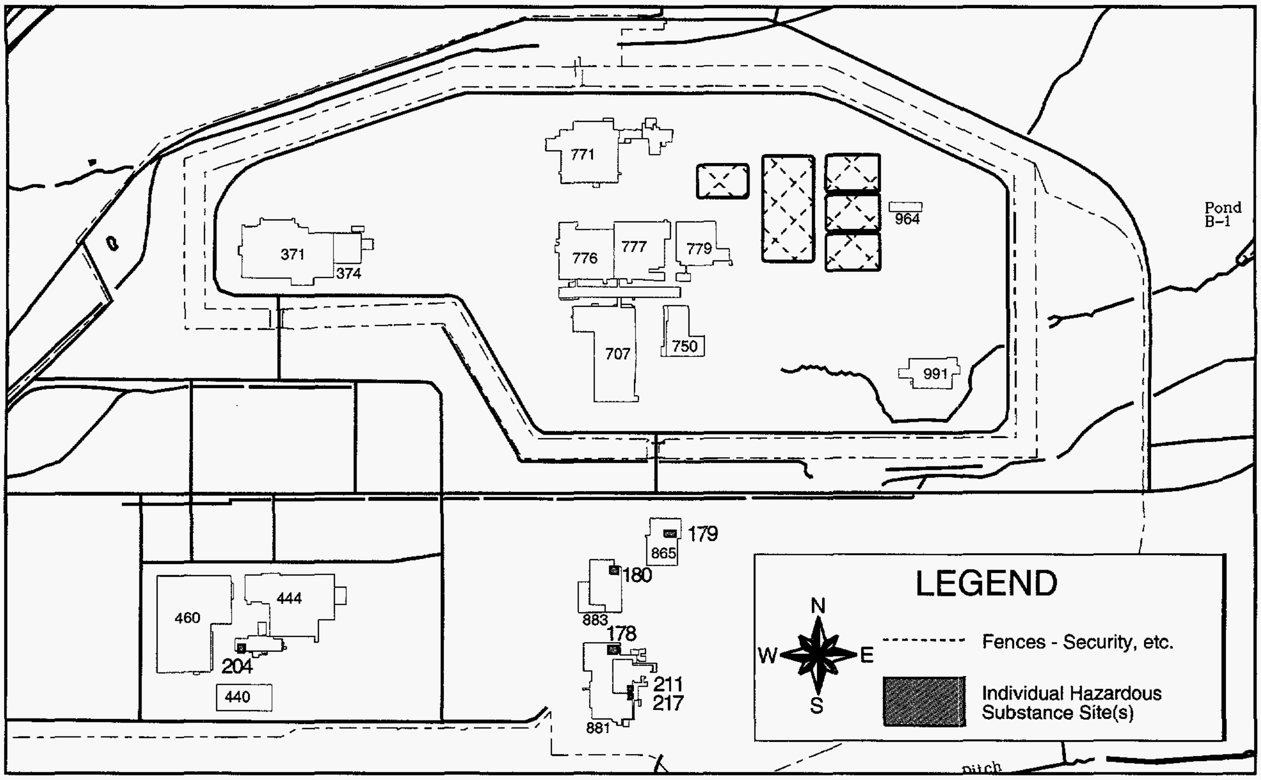


Figure 4-15. OU 15 - Inside Building Closures

Individual Hazardous Substance Sites

IHSS	Site Name
178	Drum Storage Area - Building 881
179	Drum Storage Area - Building 865
180	Drum Storage Area - Building 883
204	Original Uranium Chip Roaster (RCRA Unit 45) - Building 447
211	Drum Storage Area (RCRA Unit 26) - Building 881
217	Cyanide Bench - Scale Treatment (RCRA Unit 32) - Building 881

Assessment

The Final Phase I RFI/RI Work Plan was conditionally approved by the regulatory agencies in 1992. During scoping meetings in 1992 for the Phase I RFI/RI Work Plan, the regulatory agencies agreed to combine the Closure Plan and the RFI/RI processes. In effect, the Clean Closure Performance Standard (6 CCR 1007-3 Part 265.111) was used as the ARARs for the hazardous materials in OU 15, and 29 CFR 1000.46 was used as the ARARs for the radionuclides for OU 15.

The Phase I and II RFI/RI field work was completed in 1994. Technical memoranda addressing field sampling activities and baseline risk assessment also were completed in 1994. The Draft Phase I RFI/RI Report presenting the results of the sampling efforts was developed and submitted to the regulatory agencies in July 1994. The draft report was approved and the Final Phase I RFI/RI Report was submitted to the regulatory agencies in December 1994. Work proceeded with the development of the Preliminary Draft Proposed Plan used to define a remedial action selection.

OU 16 - LOW-PRIORITY SITES

Description

OU 16 was composed of five IHSSs located throughout the Industrial Area of Rocky Flats (Figure 4-16). The assessment activity consisted of preparing a No Further Action Justification Document, a Proposed Plan/Draft RCRA Permit Modification, and a Corrective Action Decision/Record of Decision (CAD/ROD). The No Action CAD/ROD was adopted by DOE and the regulatory agencies in October 1994, and officially closed OU 16. Under the terms of the IAG, this marks the first closure of an OU at Rocky Flats.

Major Contaminants

Potential contaminants at OU 16 included solvents, antifreeze, steam condensate, and nickel carbonyl.

Individual Hazardous Substance Sites

IHSS	Site Name
185	Solvent Spill
192	Antifreeze Discharge
193	Steam Condensate Leak - 400 Area
194	Steam Condensate Leak - 700 Area
195	Nickel Carbonyl Disposal

SITEWIDE ACTIVITIES

A variety of plans, procedures, reports, studies, and other tasks are required by the IAG to support environmental restoration activities at Rocky Flats. These include treatability studies, historical release reporting, community relations plans, the Administrative Record Program, and the Rocky Flats Environmental Database and Environmental Sample Management Program. The 1994 activities in these IAG task areas are described below.

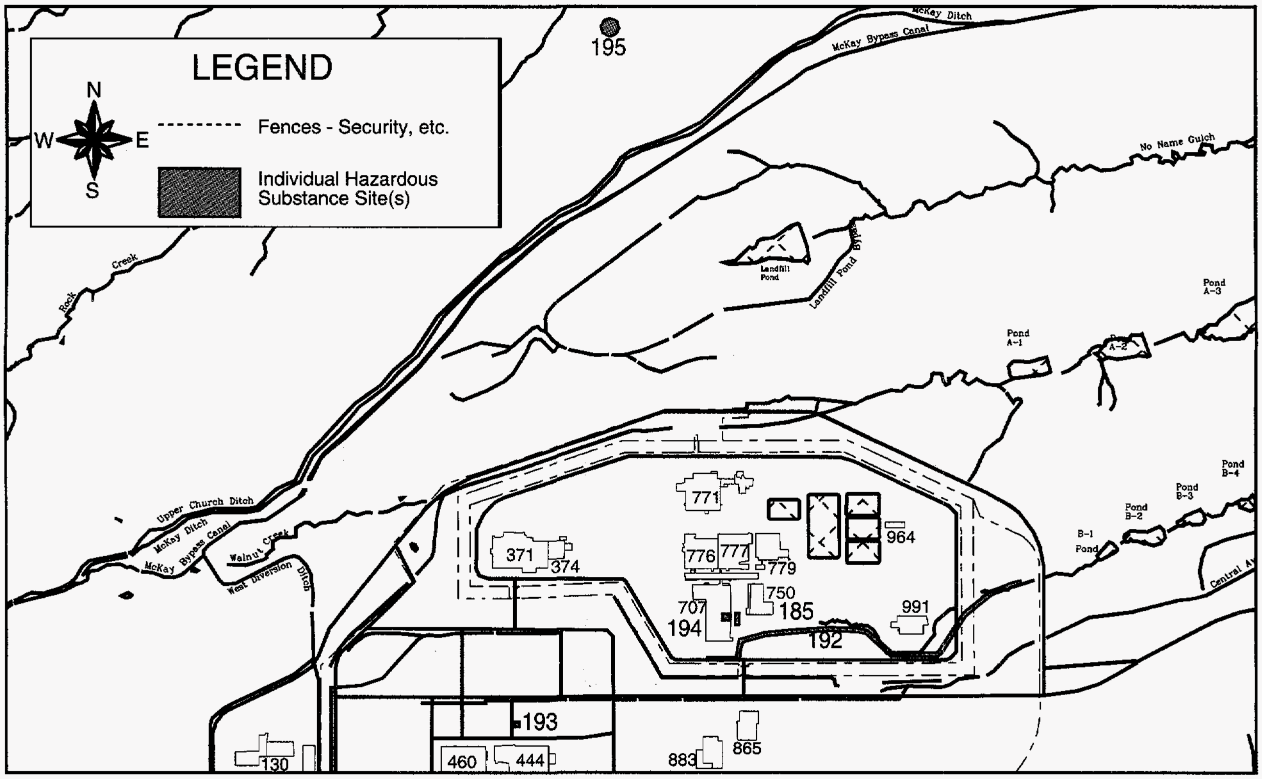


Figure 4-16. OU 16 - Low-Priority Sites

Treatability Studies

A number of important soil and water treatment studies were completed in 1994 as part of the Sitewide Treatability Studies Program. These studies provided information on the relative cost, treatment effectiveness, and waste generation of possible remediation technologies for use at Rocky Flats. This information will be available for use during the Feasibility Study stage for each OU prior to the ROD for which the technologies are applicable.

The soil treatment studies completed include high-gradient magnetic separation, physical separation, solvent extraction, and polymer encapsulation. Additionally, the soil bioremediation, chemically enhanced steam stripping, and soil washing studies were begun. These studies are expected to be completed in 1995 and will conclude the Sitewide Treatability Studies Program (as required by the IAG). The water treatment studies completed include ion exchange, adsorption, and potassium ferrate precipitation.

Future treatability studies will be performed as appropriate when potentially applicable remediation and/or stabilization technologies are identified.

Historical Release Report

The Historical Release Report (HRR) is a comprehensive document which catalogues all known contaminant releases to the environment since the beginning of operations at Rocky Flats. The document is updated on a quarterly basis to report recent events or previously unknown findings of prior events. As of January 1995, ten updates of the HRR have been transmitted to the regulatory agencies.

Community Relations Plan

The Community Relations Plan (CRP) was updated, reviewed, and approved by the regulatory agencies. The updated CRP will be distributed in early 1995. All requirements associated with the CRP were completed on schedule during 1994. Major activities during 1994 included:

- Monthly coordination meetings conducted with the regulatory agencies.
- Six Environmental Restoration Update newsletters issued to the public.
- Four quarterly public information meetings conducted (as required by the IAG).
- Technical Review Group meetings conducted regularly to provide public input on draft work plans and other documents (members include representatives from local municipalities and local environmental groups).
- All required documents placed in the Rocky Flats Public Reading Room and other public repositories.
- Numerous tours, presentations, and briefings conducted (as required by the CRP).
- Public involvement increased through the Citizens Advisory Board which met regularly to review environmental restoration information and to provide recommendations.

Administrative Record Program

The Administrative Record (AR) Program serves two primary purposes. First, it contains the documents that will be considered or relied on as the basis for the selection of the response action for each OU. Judicial review of any issue concerning the adequacy of the response action is limited to the AR. Secondly, it acts as a vehicle for public participation in selecting a response action, as the AR contains documents that reflect the participation of the public as well as the appropriate lead agency's consideration of the public concerns.

The AR program began in 1990, and currently encompasses files for each of the current sixteen discrete OUs, as well as a sitewide file which is also part of the basis for the ROD of each OU. The AR consists of approximately 5,200 documents totaling 267,000 pages and is growing constantly as hundreds of documents are reviewed each week for inclusion. Microfiche copies of the AR and its descriptive index are updated quarterly and distributed to the four public repositories, which are open for public viewing and document reproduction.

Rocky Flats Environmental Database and Environmental Sample Management Program

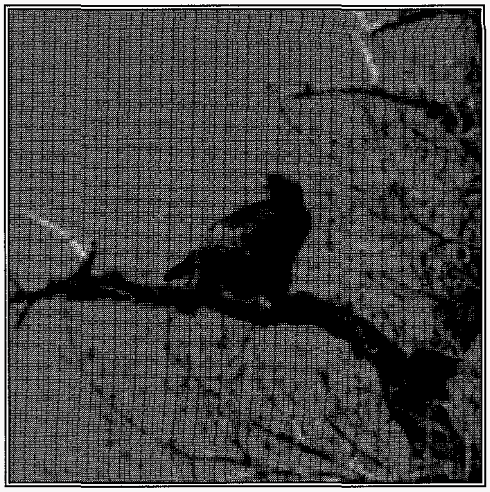
The Rocky Flats Environmental Database continued to expand in 1994 as additional Site characterization and monitoring data were incorporated. An upgraded system was installed to help accommodate the additional load. System operational testing will be completed prior to migration of the data.

A pre-upload data screening and formatting program was developed to detect data quality problems, and the sample tracking database was improved to provide direct cost linkage to individual samples and identify missing data.

The analytical requirements for the environmental and waste programs were combined to streamline the laboratory subcontractor auditing and procurement functions. Onsite radiological screening of environmental samples was implemented to reduce the potential for inappropriate sample shipment.

5.0 WASTE MANAGEMENT

GOALS



The goal of waste management activities at Rocky Flats is to reduce, eliminate, or mitigate environmental liabilities by managing waste safely and effectively. There are four primary sources of waste: (1) existing inventories from past generation, (2) waste from environmental restoration and decontamination/ decommissioning (D&D) activities, (3) waste from facility stabilization and maintenance activities, and (4) materials generated by waste management and treatment activities.

WASTE MANAGEMENT PROCESS

The management of waste generally involves a five-step process: generation, characterization, treatment, storage, and disposal. This process is not necessarily sequential for all waste streams. For example, a waste type may need to be treated before and after storage to comply with dual criteria for acceptance as both storage and disposal waste. Another waste type may not need to be treated or stored, but sent directly to disposal after generation. The following is a discussion of elements of the waste management process as they pertain to issues and concerns specific to Rocky Flats.

Waste Generation

Nine types of waste are generated and/or stored at the Site: residues, mixed residues, transuranic (TRU) waste, TRU-mixed waste, low-level waste, low-level mixed waste, hazardous waste, other regulated waste, and sanitary waste. Table 5-1 defines these waste types.

Waste Characterization

Waste characterization encompasses waste sampling and analysis, development of analytical methods, and the documentation and verification of waste streams. Much of the waste generated in the past was characterized solely by process knowledge (i.e., a judgement based on a person's experience with a particular process or operation). This often resulted in overly conservative waste categorization and exacerbated the waste storage problems at the Site.

Table 5-1
Waste Types at Rocky Flats

Waste Type	Definition
Residues	Residues are plutonium-contaminated waste materials, once held in reserve at Rocky Flats pending plutonium recovery operations. They are now classified as TRU and TRU-mixed waste.
Mixed Residues	Residues with a hazardous waste constituent. These wastes must be managed in accordance with both appropriate radioactive waste regulations and hazardous waste regulations.
Transuranic (TRU)	TRU waste is defined as any waste contaminated with alpha-emitting radionuclides with a half-life greater than 20 years, in concentrations greater than 100 nanocuries per gram (nCi/g). TRU waste forms include combustibles, plastics, light metals, and liquids.
TRU-Mixed	TRU-mixed waste contains both transuranic and hazardous waste constituents.
High-Level	Highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing, and any solid waste derived from the liquid which contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.
Low-Level	Low-level waste is defined as any radioactive waste that is not classified as TRU waste, high-level waste, or spent nuclear fuel. The concentration of alpha-emitting radionuclides in low-level waste is less than 100 nCi/g, with no specified minimum level of activity. Low-level waste forms include combustibles, plastics, light metals, and liquids, as well as treated waste forms such as pondcrete (cemented solar evaporator pond sludge), saltcrete (cemented aqueous process waste salts), and sewage sludge.
Low-Level Mixed	Low-level mixed waste contains both low-level and hazardous waste constituents.
Hazardous	Hazardous wastes are materials defined as hazardous because they are listed in state or federal regulations or exhibit hazardous characteristics such as reactivity, corrosivity, ignitability, and toxicity.
Other Regulated	Rocky Flats generates several other regulated wastes, including asbestos-containing material, polychlorinated biphenyls (PCBs), and medical wastes.
Sanitary	Sanitary waste is any waste generated at Rocky Flats that is not controlled as hazardous, radioactive, or mixed waste, and therefore may meet the Rocky Flats criteria for disposal in the Rocky Flats landfill.

For this reason, laboratory analysis is vital to waste characterization. The analytical laboratories at Rocky Flats were originally set up to support production activities. The demand for analytical support under a cleanup and conversion mission will be considerably higher. Significant additional space must be located within existing Rocky Flats facilities, or greater capability established at an offsite location to support the increasing demand.

Waste Treatment

Treatment of waste is defined as any method, technique, or process designed to change the physical, chemical, or biological character or composition of the waste so as to: (1) neutralize the waste, (2) recover energy or material resources from the waste, (3) render the waste nonhazardous or less hazardous, (4) reduce the volume of the waste, or (5) achieve compliance with Land Disposal Restrictions (LDRs) for ultimate disposition. Rocky Flats is regulated as a treatment facility because these activities are being performed as part of the cleanup mission.

Treatment technologies and facilities are not currently available to treat some regulated waste forms, primarily those which are restricted by the LDRs under RCRA. Some of the key issues at Rocky Flats associated with treatment are: (1) available treatment technologies for low-level mixed waste streams do not achieve consistent compliance with the LDRs; (2) alternate plans do not exist for treating TRU-mixed waste for land disposal if, when the Waste Isolation Pilot Project (WIPP) opens, it opens without a (requested) variance from the LDRs as part of its permit; (3) treatment facilities are not available for mixed wastes – many of them are still in development; and (4) Rocky Flats lacks treatment options for combustible residues and for some of the waste forms that will result from D&D activities.

Site researchers are working with DOE, EPA, CDPHE, and other state and federal agencies to identify the best existing and potential future treatment technologies. The Site's most widely used and most promising future technologies are described in Table 5-2.

Waste Storage

Storage activities encompass the holding of waste for a temporary period, at the end of which the waste is treated, disposed of, or stored elsewhere. The storage situation for each waste type at Rocky Flats as of March 1994 is presented in Table 5-3. Radioactive wastes, both low-level and TRU, are packaged in special containers for storage and/or shipment. Typical containers are 55-gallon drums and plywood crates. These drums and crates are strictly regulated, as is the waste that goes into them. Some of these regulations are listed below.

- No free liquids are permitted in a waste storage drum or crate. Any can, bottle, or beaker that held liquid must be thoroughly dried before it can be packaged. If the possibility for condensation inside a container exists, an absorbent is packed inside the drum or crate to soak up moisture.
- Only wastes that can be stored together safely can be packaged together. All of the chemicals and materials used at Rocky Flats are analyzed and characterized to keep unstable mixtures out of waste packages.
- Sharp objects must be blunted or padded to keep them from puncturing the waste container.
- Empty compressed gas cylinders or other pressurized containers must be completely vented before being packaged in a drum or crate.

Table 5-2
Waste Treatment Technologies

Present Treatment Methods	Description
Cementation	Liquid and semi-liquid (sludge) wastes are being produced during cleanup activities. These materials are dried and mixed with cement to solidify and stabilize them for storage. The resulting immobilized waste forms are packaged and stored pending disposal.
Compaction	Solid wastes packed in drums may be stored "as is," but drums that contain compactable material may be put through the Site's Supercompactor, a huge version of the crushers used to recycle aluminum cans. The Supercompactor reduces drums to dense "pucks" that are 66% smaller than their original size, saving valuable permitted storage space at Rocky Flats and reducing transportation and disposal volumes.
Future Treatment Methods	**Description**
Polymer Encapsulation	The process would use "off-the-shelf" components to enclose mixed waste in polyethylene. Technicians have had excellent results using recycled plastic, actually treating waste with waste.
Low-Temperature Thermal Desorption	This process would heat waste to less-than-combustion temperatures to drive off volatile organic chemicals (VOCs), a hazardous component common in mixed waste. After treatment, the remaining material would no longer be considered mixed waste and would meet disposal requirements for radioactive waste. The organic chemicals are captured for future destruction.
Microwave Solidification	This process would use the same microwave energy that heats frozen dinners to fuse a mixture of waste and vitreous material into stable, glass-like blocks.
Supercritical Carbon Dioxide (CO_2) Extraction	This process is based on the powerful dissolving qualities of gases heated above and compressed beyond their critical temperature and pressure. In this state, CO_2 exists as a single fluid phase, with the low viscosity of a gas and the solvent properties of a liquid. These two qualities permit the supercritical fluid to pass easily through waste materials, dissolving and extracting large amounts of organic compounds in the process. CO_2 is commonly used because it has a high solvability for a broad range of organics and works effectively at relatively low pressures for critical fluids.

- A record of the contents of each waste container travels with each container from packaging through sealing, storage, and shipment.

- Representatives from waste disposal facilities commonly visit Rocky Flats to assess waste management systems and ensure that any waste containers destined for their facilities meet with all of their requirements.

At present, the Site's most voluminous waste type (low-level mixed) must be kept in interim storage pending the permitting of the Nevada Test Site (NTS) disposal facility or another suitable commercial alternative. Waste is continually being generated as necessary baseline operations are performed at the Site. Scheduled remediation activities will create increasingly burdensome demands on already burdened storage facilities. In order for cleanup to proceed, a large amount of additional long-term, low-level mixed waste storage capacity may need to be constructed at Rocky Flats.

Table 5-3
Waste Storage

Waste Type	Inventory in yd^3	Storage at Rocky Flats
Residues and Mixed Residues	1,094	Drums and vaults in various buildings.
Transuranic (TRU)	366	Drums in various buildings.
TRU-Mixed	1,034	Drums in various buildings.
Low-Level	6,109	Drums, tanks, and cargo containers on pads and in various buildings.
Low-Level Mixed	15,451	Drums, tanks, and cargo containers on pads and in various buildings.
Hazardous	186	Drums in various buildings and pads; shipped offsite to approved facility for disposal.
Other Regulated	112	Drums in various buildings; disposal in offsite landfills and incinerators, or in the Rocky Flats landfill.
Sanitary	0	Short-term accumulation followed by disposal in the Rocky Flats landfill.

Similarly, TRU waste is being stored pending the scheduled 1998 opening of the WIPP in New Mexico. Waste-storage and disposal issues at Rocky Flats are under analysis as various program managers are still in the process of estimating the volumes of waste they will generate. Meanwhile, the Site is pursuing approval from commercial facilities to dispose of radioactive and radioactive mixed waste.

Waste Disposal

Disposal is defined as the intentional placement of waste into or on any land or water where the waste will remain after closure of the facility. Federal law prohibits improper disposal of hazardous waste. Compliant onsite waste storage areas are reaching allowable volume limits and offsite disposal facilities are not available for many of the waste types stored at Rocky Flats. Sanitary waste (nonradioactive and nonhazardous) is the only waste that currently may be disposed of at Rocky Flats. Issues surrounding disposal of waste types of concern are presented in Table 5-4.

Most of the radioactive waste generated at Rocky Flats is temporarily stored onsite, awaiting shipment to a more permanent location. NTS is the designated disposal site for low-level waste generated at Rocky Flats. In February 1994, NTS resumed acceptance of low-level waste shipments on a limited basis. The resumption of shipments followed an extensive audit by NTS inspectors of the waste handling and packaging practices at Rocky Flats. Future audits will be conducted to ensure that Rocky Flats continues to meet the acceptance criteria set forth by Waste Acceptance Criteria (WAC). Low-level waste is being shipped at least once a month by a

Table 5-4
Waste Disposal

Waste Type	Offsite Disposal Target	Issue
Residues and Mixed Residues	Central repository for stabilized residues	No national policy for central repository identified.
TRU and TRU-Mixed	WIPP	WIPP not open until FY98.
Low-Level	NTS and commercial facilities	Future agreements with NTS must ensure acceptance of the large projected quantities of waste.
Low-Level Mixed	NTS and commercial facilities	Not ready to ship until treatment facility constructed in FY05. (Exception: saltcrete and limited waste from environmental restoration activities to be shipped to a commercial facility in FY95.)

commercial carrier on interstate highways. Shipments will continue until the inventory of low-level waste at Rocky Flats is exhausted.

After a nationwide search that began in the 1950s, the WIPP facility in New Mexico was chosen to become the permanent resting place for TRU and TRU-mixed waste generated at Rocky Flats. WIPP is located at an underground salt deposit wherein waste containers can be stored in an environment that has been nearly moisture-free and geologically stable for 225 million years. The salt provides good radiation shielding, is easy to mine, and over time it will actually "flow" around the waste containers.

WASTE MANAGEMENT ASSUMPTIONS

Successful waste management involves effective planning and problem solving. Assumptions and contingency planning play an important role in this process. Table 5-5 presents the primary assumptions associated with waste management efforts at Rocky Flats.

WASTE MANAGEMENT PROGRAMS

The Waste Management Programs at Rocky Flats are implemented to support the goal of reducing, eliminating, or mitigating environmental liabilities. Eight waste programs are described in this section and are listed below.

- Waste Minimization
- Waste Stream and Residue Identification and Characterization (WSRIC)
- Resource Conservation and Recovery Act (RCRA)
- Land Disposal Restriction (LDR) Waste Compliance
- Radioactive Waste

Table 5-5
Waste Management Assumptions

Assumption	Possible Alternative Assumption	Impact of Using Alternative Assumption	Contingency
NTS will continue to receive low-level waste from Rocky Flats; a commercial facility will approve receipt of Rocky Flats low-level mixed waste by 12/95.	NTS refuses to receive low-level waste from Rocky Flats; a commercial facility does not approve receiving low-level mixed waste.	Further NEPA and safety analysis for the additional storage capacity; significant dollar impacts may occur.	1. Store onsite. 2. Identify other commercial sites.
Disposal site waste acceptance criteria (WAC) will not change in FY95.	Change in WAC.	Significant dollar impacts may occur if repackaging and recertification become necessary.	Allow additional onsite storage capacity until recertification to revised WAC is done.

- Residue Management
- Medical/Infectious Waste
- Sanitary Waste

Waste Minimization Program

The scope of the Waste Minimization Program emphasizes reduction or elimination of hazardous substances, pollutants, waste, and other contaminants at the source through process modifications or changes in process materials. Waste materials that cannot be eliminated from generation are recycled (i.e., used, reused, or reclaimed) where feasible.

The program includes the investigation of new decontamination techniques and waste treatment/reduction technologies. Although waste treatment is not formally recognized by EPA as waste minimization, it is considered a waste reduction technique by DOE. Waste Minimization Program activities are evolving continually as new technologies are developed and as the Site transition plans and objectives change. Several accomplishments for 1994 are listed below.

- A recycling program to reprocess used photographic fixer solution to recover silver was established; more than 1000 gallons of the solution were reprocessed.

- Approximately 6,150 lead acid batteries were recycled.

- Approximately 390 tons of office paper were recycled.

- Approximately 44 tons of cardboard were recycled.

- Approximately 2,700 toner cartridges were recycled.

- The Waste Minimization Program received an award for outstanding pollution prevention and waste minimization efforts. Rocky Flats was one of 14 national recipients presented with the award by the Deputy Secretary of Energy.

Waste Stream and Residue Identification and Characterization Program

The Waste Stream and Residue Identification and Characterization (WSRIC) Program is responsible for documenting the identification and characterization information provided by waste generators for all waste streams, residues, backlog waste, and nonroutine waste generated at Rocky Flats. The primary objectives of the program are listed below.

- Documentation of process knowledge

- Evaluation of new and previously unidentified waste processes

- Continued verification of current waste-generating processes

- Documentation of analytical characterization of routine and nonroutine waste streams

Backlog waste that was conservatively classified prior to 1992 as hazardous and mixed waste was reassessed to characterize waste more accurately. The waste was evaluated using both process knowledge and analytical laboratory data. This effort resulted in the reclassification of 15 percent of the hazardous and mixed waste backlog as nonhazardous, nonmixed waste.

There are approximately 300 WSRIC building books in use at Rocky Flats. These books are used by waste generators to ensure proper characterization, management, and packaging of waste. The books accurately describe current waste-generating processes in the various buildings and provide characterization and LDR information. The books are distributed on a controlled basis and the contents are reverified on an annual basis. Representatives from both NTS and WIPP have endorsed the WSRIC Program, and waste from Rocky Flats is being shipped to NTS utilizing the WSRIC process knowledge information. All waste generators at Rocky Flats are trained in the WSRIC Program.

The WSRIC Program also provides guidance for waste sampling and analysis. Information from waste analyses is incorporated into the WSRIC building books to support process knowledge characterizations.

Resource Conservation and Recovery Act Program

Rocky Flats has been working towards compliance with RCRA since the early 1980s. After many years of negotiations among DOE and the regulatory agencies (EPA and CDPHE) concerning the application of RCRA to DOE facilities, the first comprehensive requests for RCRA interim status and a RCRA operating permit at Rocky Flats for hazardous and low-level mixed waste were submitted to the regulating agencies in 1986. RCRA regulation of TRU-mixed waste followed in 1987 and regulation of mixed residues resulted in 1989. The goal of the RCRA Program is to ensure that Rocky Flats can meet and maintain compliance with all RCRA requirements.

The program implements activities for managing the closure process of approximately 700 RCRA units. The units include areas contaminated with hazardous wastes, underground storage tanks, and above-ground hazardous waste tanks. Several major accomplishments of the RCRA Program since 1991 are listed below.

- Issuance of the RCRA Part B operating permit in 1991 and CDPHE approval of approximately 20 permit modifications.
- Publication of a Site-specific RCRA requirements reference manual.
- Development of a sitewide computer-based training program and an extensive classroom training/on-the-job qualification program for RCRA waste management personnel.
- Implementation of a database and a successful system to authorize, modify, and delete RCRA satellite and 90-day units.
- Periodic surveillance of RCRA-regulated units at Rocky Flats by independent inspectors.
- Development of a highly knowledgeable professional staff which performs regulatory reviews and interpretations, and provides sitewide guidance on all aspects of RCRA.

Some of the RCRA Program activities completed in 1994 are listed below.

- A compliance program plan for managing hazardous waste was developed to institute an effective methodology for achieving sustained compliance with RCRA requirements.

- Eleven operating permit modification requests were prepared and submitted to CDPHE (see Table 2.7-1 in Section 2, Compliance Summary, for a complete listing of 1994 RCRA permitting activity).

- Six permit modification requests were approved by CDPHE (see Table 2.7-1 in Section 2, Compliance Summary, for a complete listing of 1994 RCRA permitting activity).

The Rocky Flats RCRA Contingency Plan (Part VI of the Part B Permit) is designed to minimize the hazards to human health and the environment from fires and explosions, or any unplanned sudden or gradual release of a hazardous waste or hazardous-waste constituent to the environment (i.e., air, soil, surface water, or groundwater). The Contingency Plan was revised twice in 1994 as a result of permit modifications. The response actions outlined in the permit must be followed for all incidents involving a hazardous waste or material which, when discharged, becomes a hazardous waste. In addition, the following situations require notifications and reports to be submitted to CDPHE and EPA Region VIII.

- A release of a hazardous waste that results in an injury requiring more than first aid treatment.

- A spill or leak of hazardous waste to the environment (i.e., air, soil, or surface water outside of a building) greater than one pint or one pound.

- A fire that involves a hazardous waste management unit or the release of hazardous waste.

- Situations other than those outlined above that can result in the implementation of the RCRA Contingency Plan (at the discretion of the Emergency Coordinator).

- A spill, leak, or other release of a hazardous waste inside a building that exceeds a reportable quantity as defined in 40 CFR Part 302, or a release from a hazardous waste tank system that is not removed from secondary containment within 24 hours. (These incidents require only notification and a brief report and do not require a Contingency Implementation Report.)

In 1994, RCRA Contingency Implementation Reports were required for 13 incidents as compared with 10 incidents in 1993 (see Table 2.7-2 in Section 2, Compliance Summary, for a complete listing of the 1994 incidents). The Contingency Plan Implementation Reports were forwarded to CDPHE and EPA Region VIII. The reports described the nature and magnitude of the releases, the actual or potential threat to human health and the environment, and the corrective actions taken to remediate the affected areas and/or systems.

Land Disposal Restriction (LDR) Waste Compliance Program

The Federal Facility Compliance Agreement (FFCA) II for LDR waste superseded FFCA I and was signed by DOE and EPA in 1991. The FFCA II was entered into by DOE and EPA to provide a two-year period for DOE to demonstrate achievements toward compliance with the LDR regulations. Although FFCA II expired in 1993, Rocky Flats is implementing programs initiated under FFCA II to achieve LDR compliance and to establish the baseline and framework required for compliance with the Federal Facility Compliance Act (FFC Act) of 1992. Rocky Flats is pursuing the requirements of FFCA II as if it were still in effect and is implementing programs initiated under FFCA II to achieve LDR compliance. Additionally, Rocky Flats has complied with the requirements of the FFC Act, including submittal of the Mixed Waste Inventory Report[1] in 1993 and the Draft Site Treatment Plan in August 1994.

Mixed waste is currently stored at Rocky Flats in a manner that is inconsistent with the LDR provisions because of an acknowledged lack of treatment capacity for such wastes either at DOE facilities or in the commercial sector. As a result, DOE and EPA entered into the FFCA which provided time for Rocky Flats to systematically address and achieve full compliance with the LDR regulations. The agreement itself does not place Rocky Flats into compliance; however, it does provide a mechanism for DOE to take a variety of steps toward resolution of the LDR issues.

The goal of the LDR Waste Compliance Program is to ensure that Rocky Flats manages all hazardous and mixed waste in compliance with LDR regulations, the FFCA, and the FFC Act. Comprehensive treatment systems and waste management systems are being developed and implemented in order to achieve this goal. Compliance will be achieved in three concurrent phases.

Phase One is administrative in nature and includes submittal of required program documents that outline and describe the mechanisms to achieve full compliance.

Phase Two includes the development of management approaches and technologies suitable for treating radioactive mixed waste to meet the appropriate LDR treatment standards. Significant achievements for Phase Two in 1994 are listed below.

- Characterization for LDR determination continued. Backlog waste was reassessed for several mixed waste forms; roasted oxide was characterized as LDR compliant; sampling and analysis were conducted on saltcrete, fluidized-bed incinerator (FBI) ash, and FBI oil; and a characterization strategy was developed for RCRA-listed waste forms (F-list).

- Plans were continued for RCRA treatment at new onsite facilities. Technology development activities were continued; several tests were completed to evaluate polymer solidification and macroencapsulation for application under the Debris Rule; and expedited treatment evaluations were initiated.

- Plans were continued for offsite RCRA treatment at existing/planned facilities.

- Plans were continued for TRU-mixed waste disposal without further treatment. Approximately 600 TRU and TRU-mixed waste drums were vented and aspirated; an inventory was performed of TRU and TRU-mixed waste exceeding the decay heat limits for the WIPP Transuranic Package Transporter (TRUPACT-II) shipping package.

- Plans were continued for treating TRU-mixed waste to meet WIPP waste acceptance criteria requirements. A detailed logic diagram was developed to support the compliance schedule and a siting study was initiated for a TRU-mixed treatment system.

Phase Three implements the management approaches and technologies in the operating treatment facilities and will propose schedules for treatment of the mixed waste forms subject to the LDR. As comprehensive treatment technologies are developed to the point of technology selection, treatment facilities will be developed either at Rocky Flats or elsewhere, or treatment will be done at existing offsite facilities for those waste forms that have not been reclassified as LDR compliant. Treatment facilities for processing TRU-mixed waste not certified for disposal at WIPP will be developed to characterize, repackage, and if necessary, pretreat TRU-mixed waste into WIPP-certifiable waste forms.

Radioactive Waste Program

The goal of the Radioactive Waste Program is to provide development, implementation, and maintenance of programmatic systems to manage radioactive and radioactive mixed waste at Rocky Flats. These systems support efforts to ensure that the management of this waste meets all DOE, federal, state, and Site requirements. The program covers all activities regarding radioactive and radioactive mixed waste including characterization, packaging, treatment, storage, certification, transportation, and either offsite disposal or long-term offsite storage.

The following activities and accomplishments were completed in 1994.

- A total of 10,878 cubic feet of low-level waste was shipped to NTS.

- A total of 4,032 cubic feet of low-level sewage sludge waste was shipped to the Hanford Site.

- A total of 608 TRU and TRU-mixed waste drums were vented and aspirated.
- Headspace gas sampling of 280 TRU-mixed waste drums was completed.
- A comprehensive waste management plan was completed and delivered to DOE in September. The plan provides an integrated assessment of waste management system requirements to support the future Site mission activities.
- The system for managing low-level waste at Rocky Flats successfully passed a Hanford assessment which allows the Site to continue disposal of low-level sewage sludge and low-level asbestos contaminated waste at the Hanford Site.

Residue Management Program

The Residue Management Program provides the central focus for the management of residues stored at Rocky Flats. The immediate focus of the program is to achieve RCRA permit status for the residue storage areas. The long-term focus is to provide safe and efficient storage that is in compliance with all federal and state regulations.

Several activities associated with the Residue Management Program are listed below.

- Permitting support for the RCRA Part B Permit covering vaults and glovebox storage units, which constitutes the remainder of mixed residue units requiring permits.
- Consolidation of mixed residues stored in vaults and gloveboxes.
- Technical support, permitting guidance, and compliance oversight for mixed residue storage and elimination.
- Closure for mixed residue units that are no longer intended for storage of hazardous waste.
- Laboratory analysis for further hazardous waste characterization of mixed residues.

All requirements identified in the February and August 1994 judicial orders regarding the ongoing Sierra Club lawsuit on mixed residues were delivered to CDPHE. A RCRA Part B Permit covering 21 units for storage of all mixed residues in 55-gallon drums is expected to be issued in January 1995. Issuance of the permit for the remaining vault and glovebox units is expected in late summer 1995.

Medical/Infectious Waste Program

The goal of the Medical/Infectious Waste Program is to manage infectious waste at Rocky Flats. This waste is regulated under federal laws, Colorado State law, state guidelines, and Site policies. The program also applies to waste generated offsite for which Rocky Flats is responsible (e.g., local hospitals that may generate radioactively contaminated infectious waste while providing medical attention to a contaminated employee).

Waste that is determined to be infectious is treated and rendered noninfectious prior to disposal. Waste that is determined to be nonradioactive and noninfectious will be disposed in the Rocky Flats sanitary landfill. Some of the activities associated with the Medical /Infectious Waste Program are listed below.

- Establish an offsite contract for treatment and disposal of nonradioactive infectious waste.
- Identify all requirements and responsibilities for waste generators at the Site.
- Write and maintain procedures and plans for the Medical/Infectious Waste Program both on and offsite.
- Participate in all emergency preparedness and support activities related to the established memoranda of understandings with local area hospitals.

Sanitary Waste Program

The Sanitary Waste Program involves the operation of the WWTP and the sanitary landfill at Rocky Flats. The WWTP safely disposes of wastewater for the Site in compliance with all state and federal regulations. The WWTP receives sanitary wastewater through the plant sewer system and the wastewater is treated through a series of unit operations. The solid portion is ultimately packaged for offsite shipment to an approved disposal facility. The liquid effluent is treated to meet appropriate NPDES permit requirements and discharged. During 1994, a total of 47,181,000 gallons of wastewater was treated at the WWTP.

The landfill provides Rocky Flats with disposal capability for all solid, nonradioactive sanitary waste in compliance with all appropriate state and federal regulations. Solid sanitary waste is collected from various buildings at Rocky Flats and is transported to the landfill for disposal. The waste is first placed in the active portion of the landfill where it is inspected for forbidden items (i.e., batteries, chemicals, etc.), surveyed for radioactivity, compacted, and then covered with soil. During 1994, a total of 12,045 cubic yards of solid waste was disposed at the landfill.

A new sanitary landfill, designed to the latest federal and state regulations, is under development at Rocky Flats. The landfill will be located in the Buffer Zone northwest of the Industrial Area. The Title II engineering design was completed in June 1994 and the construction contract was awarded in October 1994. Both Jefferson County and CDPHE reviewed and approved the permit application (Certificate of Designation) in September 1994. The landfill is expected to be operational in 1997.

Reference

1. EG&G Rocky Flats, Inc., *Mixed Waste Inventory Report,* Golden, Colorado, April 1993.

6.0 RADIATION DOSE ASSESSMENT

OVERVIEW

The radiation dose assessment for Rocky Flats is based on monitoring data from air, water, and soil sampling programs. The 1994 radiation dose from Site activities to the maximally exposed public individual is estimated to be less than 0.1 millirem effective dose equivalent (EDE). By comparison, the average person in the United States receives approximately 300 millirem EDE from natural background radiation sources. The average dose in Denver, depending on the assumptions used and the sources included, typically is estimated to be in the range of 350 to 830 mrem EDE.

The maximally exposed individual is a hypothetical member of the public who, because of proximity to the Site and living habits, could receive the highest possible radiation dose from radionuclides released from the Site. In this dose assessment, the upper-bound of three independent pathways are summed for the purpose of representing the dose received by this hypothetical individual. However, the three individual pathways contributing to this composite dose represent three different locations and do not accurately reflect current uses of the media assessed. Therefore, one individual could not actually receive this dose because it would require being in different places at the same time to be able to receive the highest dose of each separate pathway.

Radiation Protection Standards for the Public

Standards for protection of the public from radiation are based on the concept of radiation dose. This concept provides a means for quantifying the biological effect or risk of ionizing radiation. In this report, the term "dose" is used broadly to refer to the radiation protection concepts of dose equivalent and effective dose equivalent, which are described later. In the United States, the unit commonly used to express radiation dose is the "Roentgen equivalent man," or rem, and its subdivided unit, the millirem (1 rem = 1,000 mrem). The comparable International System (SI) *(Le Système International D'Unités*) 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 one-year exposure to radiation 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. In February 1990, DOE adopted the revised radiation protection standards for DOE environmental activities.[1] These standards incorporate guidance from the National Commission on Radiation Protection (NCRP), the International Commission on Radiological Protection (ICRP), and the Clean Air Act, which require the EPA to set NESHAP, as stated at 40 CFR 61, Subpart H.[2] Effective December 15, 1989, EPA revised NESHAP limits for airborne emissions of radionuclides (Rad NESHAP) for DOE facilities.[3] These new limits apply to air emissions from Rocky Flats in 1994 and are incorporated into the revised DOE standards. Table 6-1 summarizes the revised DOE radiation protection standards for the public and the revised NESHAP standards.

Rocky Flats Radioactive Materials

The radioactive materials included in estimating radiation dose to the public from the Site's activities are plutonium, uranium, americium, and tritium. Materials in the Site environs are the combined result of residual fallout deposition from global atmospheric nuclear weapons testing and releases from the facility. Uranium, a naturally occurring element, is present in elevated concentrations in many parts of Colorado (compared to national averages) and has been used in Site operations in various isotopic ratios. Tritium, which is both naturally occurring and artificially produced, is sometimes handled in operations at Rocky Flats.

In the dose assessment performed for Calendar Year 1994, the primary contributor to the projected radiation dose was internal exposure to alpha radiation emissions from

Table 6-1
DOE Radiation Protection Standards for the Public

ICRP-RECOMMENDED STANDARDS FOR ALL PATHWAYS:

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

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

10 mrem/year EDE

Note: In addition to the numerical dose standards listed above, it is the objective of DOE to maintain potential exposures to members of the public to ALARA levels.

water ingestion of plutonium, uranium, and americium. Radiation doses that members of the public might receive as a result of the Site's activities are much less than those doses received from sources of naturally occurring radiation by three orders of magnitude, and are well below regulatory limits applicable to exposure of the public.

The 1994 radiation dose assessment used several modified assumptions regarding potential pathways of exposure to the public than reported in previous annual Site Environmental Reports. The 1994 assumptions are intended to reflect potential exposure conditions from potentially complete pathways more accurately.

CALCULATING RADIATION DOSE

Radiation Dose

In this 1994 dose assessment, radiation dose was calculated by multiplying radionuclide concentrations in air, water, and soil by DOE-prescribed intake rates (for internal exposures) or exposure times (for external exposure to penetrating radiation). These products were then multiplied by the appropriate radiation dose conversion factors as follows:

Radiation Dose =	***(Radionuclide Concentration or the Exposure Rate) X (Intake Rate over the Exposure Time Interval or the Exposure Time Interval) X (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 calculated and then multiplied by a modification factor based on the type and energy of the ionizing radiation involved. Under this scheme, one millirem of dose equivalent from alpha radiation should 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, when selected tissues are irradiated nonuniformly.

In 1985 DOE adopted radiation protection standards for the public based on the concept of EDE. The December 15, 1989, 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. This dose assessment uses EDE as the basis for radiation protection of the public. It also includes some individual organ dose equivalents for comparison with previous annual Site Environmental Reports.[4]

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 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) associated with one mrem of EDE is comparable to the risk associated with one mrem of whole body dose equivalent. Likewise, one mrem of EDE from natural background radiation would have the same health risk as one mrem of EDE from artificially produced sources of radiation, regardless of which organ(s) receive(s) the dose.

Radionuclide Concentration or Activity

Radionuclide concentrations, activity, or source terms (i.e., activity release rates) used in calculating dose can be determined from the analysis of actual samples and measurements in the environment taken at locations of interest. Alternatively, these concentrations can be calculated by modeling. The most significant application of the latter technique is for atmospheric dispersion, where detection limits or sampling constraints preclude direct measurement.

In the following dose assessment, actual environmental measurements near locations of interest are used to determine compliance with the DOE regulatory limit for all pathways. These measurements are used to calculate annual average concentrations or activities of radioactive materials in air and soil at the Site boundary.

As required by 40 CFR 61, subpart H, an EPA-approved computer code is used to determine compliance with Rad NESHAP limits for the air pathway only. The EPA-approved code, CAP88-PC, includes air dispersion modeling of measured air emissions from buildings and contaminated land areas, and dose conversion factors for calculating final radiation dose.

Intake Rate and Exposure Time

Intake rates of radioactive materials used to represent air inhalation for one year are prescribed by DOE.[5] The rate intake for air is based on recommendations of the ICRP.[6] The breathing rate for an individual for one year is 8400 cubic meters. The

EPA provides recommendations for soil ingestion rates in *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (RAGS).[7] Care must be taken in selecting representative values of radionuclide activities in soils for a maximally exposed resident, otherwise unreliable estimates will result.

At 100 mg/day, the ingestion rate for soil suggested by RAGS, this potential pathway is second in significance only to the hypothetical water-ingestion pathway. The water-ingestion pathway assumes an intake of 2 liters per day on days when exposure is possible (i.e., on days in which discharge occurs).

Radiation Dose Conversion Factors

Radiation dose conversion factors used for determining compliance with DOE standards for all pathways are prescribed by DOE.[8] Dose conversion factors for internal exposures are based on recommendations of the ICRP.[9] Dose conversion factors for external exposures to penetrating radiation are based on a methodology developed at Oak Ridge National Laboratory (ORNL),[10] with modifications by the original author.[11]

Plutonium handled at Rocky Flats is a mixture of plutonium isotopes having different atomic masses, which may also include americium-241. Relative abundances of plutonium and americium isotopes in plutonium typically used at the Site were used to compute composite dose conversion factors for plutonium and americium in air and for plutonium in water and soil. The relative abundances used in developing the composite dose conversion factors were based on the isotopic activity fractions of plutonium-239 and -240. These are the isotope activities measured in the Site's environmental monitoring sample analyses.

Fractions of ingested radionuclides absorbed from the gastrointestinal tract and lung clearance classes for inhaled radionuclides were selected to maximize the associated internal dose conversion factors and the resulting radiation dose. By so choosing, it is likely that the dose computed for the inhalation pathway is greater than any actual received dose. Each internal dose conversion factor is for a 50-year dose commitment from one year of chronic exposure. That is, the dose that an individual could receive for 50 years from one year of chronic intake of radioactive material is calculated. The dose conversion factors used in this assessment are listed in Table 6-2. These dose conversion factors incorporate the intake rates and exposure times as discussed above.

Table 6-2
Dose Conversion Factors Used in Dose Assessment Calculations for 1994

INHALATION [Rem * Milliliter / Microcurie] [a,b]

Organ	Pu -239/240
Effective Dose Equivalent	5.71×10^{12}
Liver	2.22×10^{13}
Bone Surfaces	1.04×10^{14}
Lung	1.08×10^{13}

SOIL INGESTION [Rem * Gram / Picocurie] [a,g]

Organ	Pu -239/240	Am-241
Effective Dose Equivalent	1.77×10^{-4}	1.64×10^{-4}
Liver	6.58×10^{-4}	6.21×10^{-4}
Bone Surfaces	3.21×10^{-3}	2.96×10^{-3}
Lung	(f)	(f)

WATER INGESTION [Rem * Milliliter / Microcurie] [a,c]

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

GROUND-PLANE IRRADIATION [Rem * Square Meter / Microcurie] [d]

Organ	Pu -239/240	Am-241
Effective Dose Equivalent	4.80×10^{-5}	2.99×10^{-3}
Liver	4.53×10^{-6}	1.78×10^{-3}
Bone Surfaces	1.62×10^{-5}	3.69×10^{-3}
Lung	9.78×10^{-6}	2.01×10^{-3}

a. Inhalation, water, and soil ingestion dose conversion factors were adapted from DOE/EH-0071 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 2.66×10^2 milliliters per second (ml/s) for 1 year was assumed and incorporated into the dose conversion factor.
c. A water intake rate of 2×10^3 ml (2.1 quarts) per day for 1 year was assumed.
d. Ground-plane irradiation dose conversion factors were adapted from DOE/EH-0070. For Pu -239/240, the higher of the factors for the two isotopes was used. A 1-year exposure period was assumed.
e. The liver receives no significant dose from this pathway.
f. The lung receives no significant dose from this pathway.
g. A soil ingestion rate of 100 milligrams per day for 1 year was assumed and incorporated into the dose conversion factor.

The EPA-approved computer code CAP88-PC, used to determine compliance with the NESHAP standard for the air pathway, incorporates EPA's own approved dose conversion factors. Measured plutonium emissions were modeled for three isotopes of plutonium: 238 through 240. Specific analyses for plutonium-241 and -242 are not performed on environmental samples, but these isotopes contribute insignificantly to the 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. The conservative CAP88-PC default values for lung clearance class and gastrointestinal uptake fraction from lung-cleared material were used when running this code.

1994 RADIATION DOSE ASSESSMENT

Assumptions Modified for 1994 Assessment

DOE Order 5400.5 encourages the use of realistic, but conservative, approaches to dose assessment. The approach documented in this 1994 report is somewhat more realistic than previous reports, reflecting pathways of exposure with a greater likelihood of occurring in the vicinity of the Site. Consequently, the reported doses to the public in this report are significantly smaller than doses reported in previous years. The 1994 report approach continues to employ conservative assumptions for intake rates, exposure duration, solubility of radioactive contaminants, and location of significant exposure. Conservatism is increased by not subtracting background (i.e., nonsite related contributions) radioactive contaminants in air and soil concentrations and water concentrations for radionuclides other than uranium. Pathways of limited validity, such as raw surface-water consumption as a drinking supply and soil ingestion based on many assumptions regarding land use, are also included in this conservative approach.

The principal difference between the 1994 and past years' dose assessments is the selection of the hypothetically complete pathway. A surface-water pond having daily use has been replaced with a surface water pond being used only on days that discharge actually occurred. Discharged water is not directly consumed and is usually the only flow in the receiving reach of Big Dry Creek. Nor is there any drinking-water use of surface water on Big Dry Creek or in the downstream reach of the South Platte all the way to its confluence with the North Platte in Nebraska.

Beginning in 1991, direct ingestion of soil was added to the assumptions for exposure and dose, consistent with recommendations by the EPA for performance of risk assessments.[12]

Previous pathway assessments in the *Environmental Impact Statement, Rocky Flats Plant Site*[13] indicate that swimming and consumption of foodstuffs are relatively insignificant contributors to public radiation dose. Swimming and fishing are limited in the area, and most locally consumed food is produced at considerable distances from the Site. A pathway analysis review performed under contract to Rocky Flats by the Colorado State University (CSU) Department of Radiological Health Sciences affirmed the relative insignificance of these pathways.[14] This affirmation is a consequence of an extremely small fraction of radionuclides being available for uptake in several key steps of these pathways.

The results of the 1994 assessment of dose to the public from Site activities indicate that the radiation dose to the maximally exposed individual in the public is estimated to be 0.08 to 0.1 mrem (0.8 to 1 x 10^{-3} mSv) EDE. The upper end of this range does not subtract background uranium concentrations in the discharged water assumed to be consumed. The lower value results when background concentrations of the uranium in the raw water received from the South Boulder Interceptor Ditch are subtracted. The collective population dose to a distance of 80 kilometers (km) (50 miles) is estimated as 0.26 person-rem (2.6 x 10^{-3} person-sievert [person-Sv]). These calculated radiation doses are conservative estimates that serve as an upper-bound estimate of any radiation doses actually received by the public from Rocky Flats.

Maximum Site Boundary Dose

A dose assessment for 1994 was conducted for the Rocky Flats property boundary and several offsite locations to a distance of 83 km (52 miles). DOE Order 5400.5[15] requires that doses calculated for demonstration of compliance with applicable standards "...be as realistic as practicable. Consequently, all factors germane to dose determination should be applied. Alternatively, if available data are not sufficient to evaluate these factors or if they are too costly to determine, the assumed parametric values shall be sufficiently conservative so that it is unlikely that individuals would actually receive a dose that would exceed the dose calculated using the values assumed."

In this 1994 report, realistic but conservative assumptions are made for dose assessment in conformance with the DOE Order 5400.5 guidance. Environmental monitoring data are used from sample locations closest to areas of residence. The substitution of onsite data over offsite data for air and soil, and the assumption of drinking water where there is none, also serve to overestimate the dose to the public. The nearest housing to Rocky Flats is located near the southeast boundary of the Site. Sampling locations were chosen near this boundary but generally upwind or upgradient of existing housing, and between the housing and the Site processing facilities. 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.

The ground-plane exposure rate of penetrating radiation exposure from contaminated soil areas are based on measured concentrations of plutonium and an assumed ratio of 0.20 for the americium-241 to plutonium-239/240 activity. Inhalation source terms for the 1994 dose assessment were based on plutonium-239/240 concentrations measured in ambient air samples. Although it is known that some of the plutonium in soil and air is from residual fallout from past global atmospheric weapons testing, for the purposes of this dose assessment it is assumed that all plutonium originated from Rocky Flats.

The maximum Site boundary dose assessment assumes that an individual is present continuously at the perimeter of Rocky Flats. The assumption of an individual residing continuously at the plant boundary serves to provide a conservative upper bound on any radiation dose to a member of the public that might originate from the Site.

The plutonium inhalation source term of 1.4×10^{-17} µCi/ml (5.1×10^{-7} Bq/m^3) was the annual average concentration of plutonium-239 and -240, as measured at the S-38 location in the perimeter ambient air sampling network (Figure 3.2-1). The S-38 location is the closest plant perimeter air sampling location upwind of housing located nearest to Rocky Flats in the southeast direction.

In addition to soil, groundwater, surface water, perimeter air and stack sampling, 14 Thermoluminescent Dosimeters (TLDs) are placed around the Site perimeter and an additional 21 are located around the industrialized portion of the Site (Figure 3.2-1). While there are 10 TLDs placed in local communities (Figure 3.2-2), the perimeter measurements are lower than the values generated at either of the other sets of TLDs and are indistinguishable from natural background.

Diversion of surface-water effluents around Great Western Reservoir and Standley Lake began in 1989 and 1990, and these waters now flow from Walnut Creek to Big Dry Creek and subsequently to the South Platte River. Big Dry Creek's contribution to the total flow in the South Platte River was less than 0.2 percent based on South Platte River flow, as measured at the Henderson, Colorado, gaging station during water year 1993 (October 1992 through September 1993).[16]

The drainage above and including the Site is a small fraction of the total area and source of water to the Big Dry Creek drainage. While very low, this fraction is even lower in significance considering that there is no drinking-water supply use of the South Platte River from the confluence of Big Dry Creek along the entire reach to the confluence of the North Platte River in Nebraska. This is true primarily due to the high salinity, TDS, and nitrate in the South Platte River which make the water unsuitable for human consumption without expensive specialized treatment. Examined historically, stock watering and irrigation uses of the South Platte have not contributed to dose significantly.

More significant with respect to waterborne offsite dose is the nonsite anthropogenic dose due to the release of radionuclides from hospitals. Typically, iodine-131 is intermittently measurable in the South Platte River as a result of therapeutic administration. This observation was most recently confirmed after the decline in global radioiodine following the Chernobyl release in 1989. A measurable quantity of hospital-released radioiodine, (8 pCi iodine-131 per liter in milk) was identified, and after detecting radioactive iodine in milk, was traced to cows watered on the South Platte River. While not difficult to quantify, the dose received to the public from such releases is also vanishingly small, especially when compared to natural background radiation.

Municipal water supplies near Rocky Flats do not serve the residents living nearest to the Site. For these residents, drinking water is derived from well water or bottled water. No offsite drinking-water wells have been contaminated with radioactive materials as a result of Site activities. Extensive characterization of background radionuclide concentrations in groundwater and the hydrogeologic regime of the Site and vicinity continues. Moreover, there is no likelihood that americium or plutonium will be mobile in groundwater within the ranges of chemical conditions found in local groundwater. There is no direct hydrologic connection between Site aquifers and any wells used by neighboring residents. Uranium, which is mobile in groundwater, typically is found in sufficient concentrations with sufficient variability and heterogeneity to suggest long-term (i.e., over geologic time) distribution in the environment. This characteristic variability thwarts any attempt to identify or distinguish a component attributable to Site sources of uranium in offsite local groundwater.

Tritium, while mobile in groundwater, is a relatively insignificant contributor to dose at low concentrations because the radiation it emits is only a very low energy beta particle attenuated over a short distance, does not concentrate in any organ, and has a short residence time in the body. Therefore, it has a relatively small dose conversion factor. Due to atmospheric testing of weapons during the 1950s and 1960s by the U.S., Russia, and China, global enrichment of tritium above cosmogenic levels in surface water and surficial groundwater is also high enough to thwart any effort to identify locally characteristic elevated levels in groundwater attributable to Site activities.

Notwithstanding the actual lack of completeness of a surface-water pathway for exposure to the public, the volume-weighted radionuclide activities of released waters were used to determine a hypothetical dose. The consumption of two liters per day by an individual is assumed for each day that releases occurred. This approach differs from that taken in previous years (using daily consumption of water in Pond C-2) because Pond C-2 is in a secured area inaccessible to the public and because there was no discharge from Pond C-2 in 1994.

Notwithstanding the limited potential for exposure by means of a groundwater pathway, results from a boundary well having detectable levels of plutonium and americium have been selected to evaluate dose from hypothetical consumption. The low recharge characteristic of the boundary well is inconsistent with use as a drinking water supply. The solubility of plutonium in ambient groundwater is lower than the detection limit. The most likely explanation for the presence of plutonium is that the well was contaminated by surficial materials during its placement.

Direct ingestion of contaminated soil as a potential exposure pathway was added to the Site radiation dose assessment in 1991. Inclusion of this pathway is consistent with approaches to risk assessment suggested by the EPA in RAGS.[17] An intake rate of 100 mg/day is assumed for this pathway, as suggested in RAGS. The plutonium-239/240 concentration in soil from onsite sampling location 2-126 (Figure 3.5-1) was taken as conservatively representative of soil for residences nearest the Site. Americium-241 was presumed to be 20 percent of the plutonium-239/240 concentration, based on a maximal ingrowth of americium-241 from plutonium-241 in typical Rocky Flats' plutonium.[18] The 1994 sample analysis indicated plutonium-239/240 concentration in soil at the 2-126 location is 0.18 pCi/g (6.7×10^{-3} Bq/g) (Figure 3.5-1 and Table 3.5-1 in Section 3.5, Soil Monitoring.) The presumed or inferred americium-241 concentration is 3.6×10^{-2} pCi/g (1.3×10^{-3} Bq/g), based on a coefficient of 0.20.

At doses currently computed for other pathways, the theoretical contribution to the total dose is sensitive to the validity of input values used. Of less certainty is whether the intake rate suggested in RAGS is valid as an intake rate for local residents.

Ground-plane irradiation by external penetrating radiation from contaminated soil areas is included as a potential pathway of exposure, although it is a relatively small contributor to dose. External penetrating radiation associated with radioactive material of importance at the Site is generally of low energy and intensity. The ground-plane irradiation source term used for this assessment is again based on the plutonium activity in soil measured at the onsite 2-126 location and an assumed soil density of one gram per cubic centimeter (g/cm^3), and a sampling depth of 5 cm used to determine areal concentration. The plutonium-239/240 areal source term is 9.0×10^{-3} μCi/m^2 (3.3×10^{2} Bq/m^2). The americium source term is estimated to be at 1.8×10^{-3} μCi/m^2 (67 Bq/m^2), as noted above.

Table 6-3 summarizes the radionuclide activities used for calculating the estimate of maximum radiation dose to an individual member of the public from all the identified potential pathways of exposure. From the concentrations and dose conversion factors given in Table 6-4, a 50-year dose commitment of 0.8 to 0.1 mrem

Table 6-3
Radioactivity Concentrations Used in Maximum Site Boundary Dose Calculations for All Pathways in 1994

Air (μCi/ml)	Soil (pCi/g)		Surface Deposition ($\mu Ci/m^2$)		Water (μCi/ml)			
Pu -239/240	Pu -239/240	Am -241	Pu -239/240	Am -241	Pu -239/240	Am -241	U -233/234*	U-238*
1.4×10^{-17}	2.3×10^{-1}	4.6×10^{-2}	1.15×10^{-2}	2.3×10^{-3}	2×10^{-12}	3.0×10^{-12}	0	1×10^{-11}

*After subtracting background

Table 6-4
50-Year Committed Dose Equivalent from One Year of Chronic Intake/Exposure of Maximally Exposed Composite Individual in 1994

Location	Effective Dose Equivalent (mrem)	Liver (mrem)	Bone Surfaces (mrem)	Lung (mrem)
Maximum Site Boundary	0.08 to 0.1	2×10^{-1}	2	2.6×10^{-3}

(0.8 to 1 x 10^{-3} mSv) is calculated as the EDE from all pathways. The bone surfaces receive the highest calculated individual organ dose, 2.0 mrem (2.0 x 10^{-2} mSv) (Table 6-4).

The DOE radiation protection regulatory limit for members of the public for all pathways for extended periods of exposure is 100 mrem/yr (1 mSv/yr) EDE.

The maximum Site boundary dose in 1994 represents 0.1 percent of the standard for all pathways for EDE. DOE Order 5400.5 requires that potential exposures to members of the public be as low as reasonably achievable (ALARA). The 0.1 percent value is sufficiently low that the objective in ALARA is met without significant additional effort. ALARA typically involves setting investigative thresholds to examine means for reducing exposure. The fraction by which this dose falls below the regulatory limit is substantially lower than typical ALARA threshold increment practices followed either by industry or licensing and compliance authorities.

Radiation Dose from Air Pathway Only

EPA-approved methodology[19] is used to demonstrate compliance with NESHAP standards for radioactive emissions. As of December 15, 1989 the EPA standard, based on meteorological/dose modeling of air emissions, uses either the AIRDOS or CAP88-PC computer code. Table 6-5 lists the 1994 radionuclide air emissions used

Table 6-5
Radionuclide Air Emissions for Input to CAP88-PC Computer Code in 1994

Radionuclide(s)	Air Emission Activity (Ci)
Building Emissions:	
H-3 (Tritium)	3.3×10^{-3}
Pu-238	1.8×10^{-8}
Pu -239/240	4.2×10^{-5}
U -233/234	2.4×10^{-6}
U-238	1.9×10^{-6}
Am-241	1.2×10^{-5}
Estimated Soil Resuspension:	
Pu-239/240	3.6×10^{-5}
Am-241	5.9×10^{-6}
U-233/234	5.4×10^{-7}
U-235	7.0×10^{-8}
U-238	4.0×10^{-8}

as input to the CAP88-PC computer code. These emissions include air effluent release values from Site buildings for the year as discussed in Section 3.2 and an estimate of resuspension of contaminated soil from Site OUs.

Estimates of soil resuspension include OUs 1, 2, and 4 through 14. The resuspension rate developed from the OU 2 903 Pad area field studies was used for the added OUs. These other OUs have lesser soil contamination levels and soil activity data for them is more limited than for the 903 Pad area. The estimates of air contamination by resuspension should only be considered preliminary. Estimates of these rates will be further refined as Site characterization is completed.

Meteorological data for 1994 was entered into the CAP88-PC calculations. CAP88-PC default values for lung clearance class and gastrointestinal uptake fractions were used when running the code. The CAP88-PC default assumption of a 1-μm activity median aerodynamic diameter (AMAD) particle size is used from which a maximum uptake from inhalation may be expected.

The CAP88-PC computer code calculated an EDE from building air emissions of 1×10^{-3} mrem (1×10^{-7} mSv) to the maximally exposed individual residing approximately 2.45 miles from the Site emissions points. The EDE from estimated soil resuspension was calculated as 1.3×10^{-3} mrem (1.3×10^{-5} mSv) to the maximally exposed individual residing approximately 2.1 miles from the 903 Pad area.

Collective Population Dose

DOE Order 5400.5 requires the assessment of collective population radiation dose to a distance of 80 km (50 miles) from the center of a DOE facility.[20] For this report, the dose is reported either to 50 miles from the perimeter or 52 miles from the center of the Site.

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 1994 collective population dose to the public within a radius of 50 miles of Rocky Flats, the assessment was limited to airborne emissions of radioactive materials from the Site as the major contributor to population dose.

Only two public raw water supplies, Great Western Reservoir and Standley Lake, can receive water directly from drainages crossing Rocky Flats. All surface-water effluent from the Site was diverted around these water supplies during 1994. Soil contamination decreases rapidly with distance from the Site. Most residential areas within this radius are likely to have new topsoil, sod, or otherwise modified soil conditions; agricultural areas represent a relatively small fraction of total land use area which is typical of only a small population.

Population estimates provided by the Denver Regional Council of Governments (DRCOG), the State of Colorado, and some local municipalities and counties near Rocky Flats were used to determine the 1994 population residing within 52 miles of the center of the Site. An area defined by a circle of 52-mile radius was drawn with the center being located in the heart of the industrial area at the Site and was divided into 16 equal sectors, each originating at the center of the circle and centered around the 16 principal compass directions, with segments formed by the intersection of these sectors and 5 radial distances of 1-mile increments for 1 to 5 miles, 10-mile increments for 10 to 40 miles, and a 12-mile increment for 40 to 52 miles (Figure 6-1). The census tract data of DRCOG lacked the necessary spatial resolution for reasonable segment population estimates. Interpolation of populations from DRCOG transportation zones based on land use segment data of the population-wheel zones was performed, using aerial photographs taken in the fall of 1994.

The estimates of 1994 segment populations are given in Figure 6-1. These census-based estimates are for political jurisdictions and do not correspond to the geographical boundaries of the segments. Therefore, the population estimates of Figure 6-1 should be considered to be the best approximations available for 1994. The total population of the area within a radius of 52 miles of Rocky Flats is estimated at 2,236,243 people.

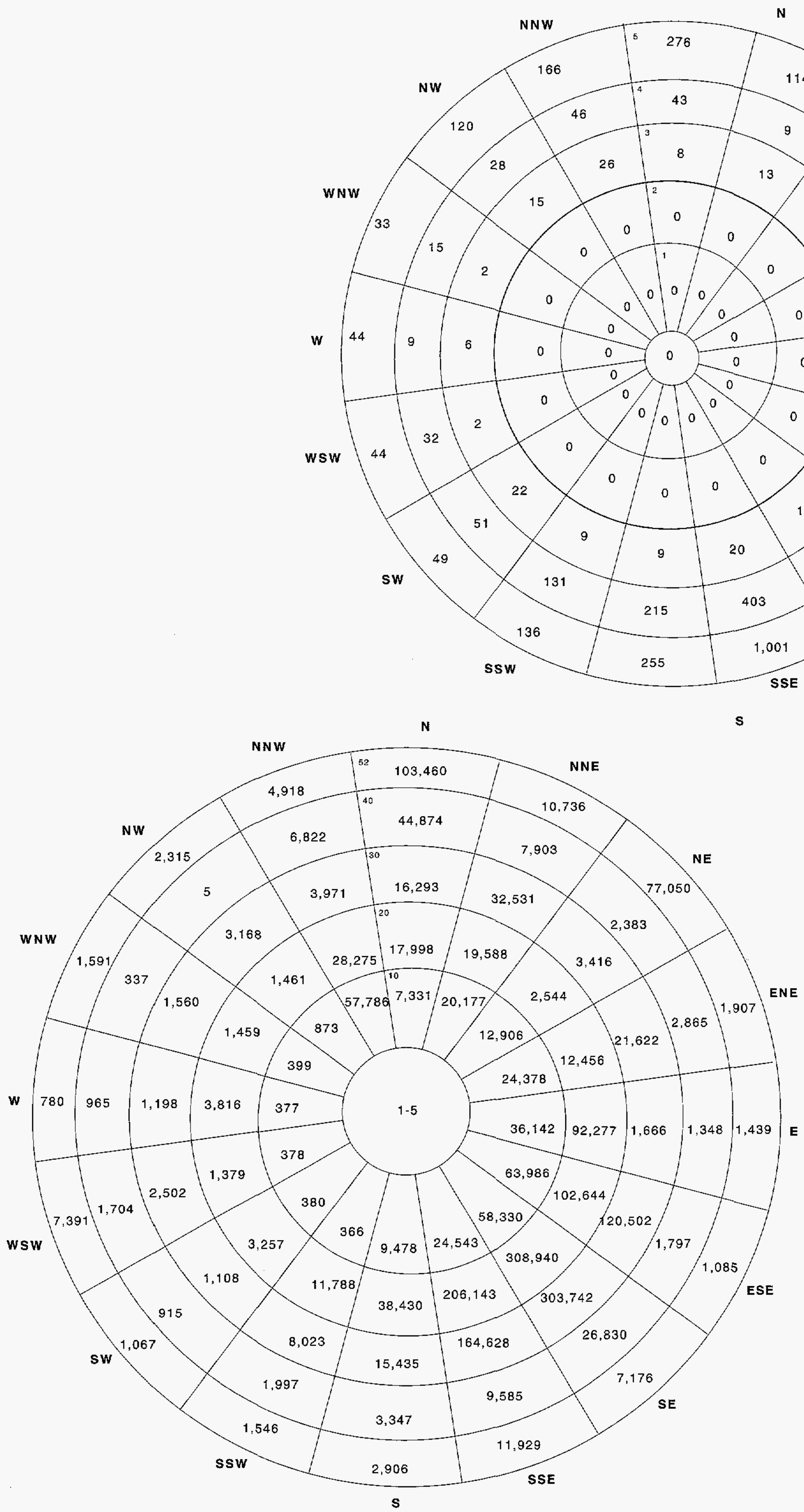


Figure 6-1. 1994 Demographic Estimates for Areas 0-1 and 5-52 Miles from Rocky Flats

The EPA atmospheric dispersion/radiation dose calculation computer code CAP88-PC was used to calculate the collective population dose within 52 miles of the center of the Site. CAP88-PC is the code used by Rocky Flats to demonstrate compliance with NESHAP requirements, as promulgated at 40 CFR 61, Subpart H.[21] Meteorological data collected during 1994, population estimates as discussed above, building air effluent radioactivity data, and estimates of soil resuspension radioactivity were entered into the CAP88-PC code. EDEs were calculated by CAP88-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 each segment.

Multiplying the population (number of persons) within a segment by the average individual dose (in rem or sievert, 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 miles around the Site, as presented in Table 6-6 for 1994. The collective population dose within 50 miles of the Site was calculated using the code CAP88-PC as 0.26 person-rem (2.6×10^{-2} person-Sv). Significantly, the majority of this collective population dose results from estimated contaminated soil resuspension from the OUs at the Site. Cleanup activities tend to elevate the resuspension rate after which the source terms and rates should decline. A very small contribution (3×10^{-3} person-rem [3×10^{-5} person-Sv]) is attributable to building air emissions for 1994.

Natural Background Radiation Dose

EDEs from Rocky Flats may be compared to a range of the annual EDE from natural background radiation[22] (Table 6-7) for the Denver area. This range is currently estimated to be over 350 mrem (3.5 mSv) but may exceed 800 mrem (8.0 mSv), depending on the assumptions used to compute it. The wide range in this estimated background is dependent on local variability in radon concentration and on differing methods which are still evolving among members of the scientific community for assessing all background sources.

Naturally occurring, medical, and consumer product sources contribute more than 99 percent of the average radiation dose that a person living in the United Stated receives each year (Figure 6-2). 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 one percent of the average radiation dose to a person living in the United States.

Table 6-6
Calculated Radiation Dose to the Public from 1 Year of Chronic Intake/Exposure from Rocky Flats in 1994

MAXIMUM INDIVIDUAL DOSE:	
All Pathways[a]	0.08 to 0.1 mrem Effective Dose Equivalent (EDE)
Building air emissions[b]	1×10^{3} mrem (1×10^{-5} mSv) EDE
Estimated soil resuspension[c]	1.3×10^{-3} mrem (1.3×10^{-5} mSv) EDE
COLLECTIVE POPULATION DOSE TO 80 km (50 mi):	
Building air emissions[b]	0.11×10^{-3} person-rem (1.1×10^{-3} person-Sv) EDE
Estimated soil resuspension[c]	0.15 person-rem (1.5×10^{-3} person-Sv) EDE
Total	0.26 person-rem (0.1×10^{-2} person-Sv) EDE
ESTIMATED TOTAL POPULATION WITHIN 80 km (50 mi):[d]	2.2×10^{6} persons
DOE RADIATION PROTECTION STANDARDS FOR THE PUBLIC:[e]	
All Pathways[f]	100 mrem (1 mSv) EDE, normal operations 500 mrem (5 mSv) EDE, temporary increase (only with prior approval of DOE EH-2)
Air Pathway only[g]	10 mrem (1×10^{-1} mSv) EDE
ESTIMATED ANNUAL NATURAL BACKGROUND INDIVIDUAL RADIATION DOSE FOR THE DENVER METROPOLITAN AREA: [h]	350 mrem (3.5 mSv) to more than 800 mrem (8 mSv) EDE
ESTIMATED ANNUAL NATURAL BACKGROUND COLLECTIVE POPULATION DOSE WITHIN 80 km (50 mi):	7.8×10^{5} person-rem (7.8×10^{3} person-Sv) EDE

a. Calculated using environmental monitoring input data.
b. Calculated using CAP88-PC modeling of estimated and measured building air emissions.
c. Calculated using CAP88-PC modeling of estimated soil resuspension from OUs 1-12.
d. Based on estimates from information provided by the State of Colorado, the Denver Regional Council of Governments, and local municipalities.
e. From DOE Order 5400.5. Excludes medical sources, consumer products, residual fallout from past nuclear accidents and weapons tests, and naturally occurring radiation sources.
f. Based on recommendations of the International Commission on Radiological Protection (ICRP) and the National Council on Radiation Protection and Measurements (NCRP).
g. Based on EPA Clean Air Act National Emission Standards for Hazardous Air Pollutants.
h. *See Table 6-7 for further explanation of natural background radiation dose in the Denver Metropolitan area.*

Note: In addition to the numerical dose standards listed above, it is the objective of DOE to maintain potential exposures to members of the public to ALARA levels.

Table 6-7
Estimated Annual Natural Background Radiation Dose for the Denver Metropolitan Area[a]

Source	Effective Dose Equivalent (mrem)
Cosmic Radiation[b]	50
Cosmogenic Nuclides	1
Primordial Nuclides - External[c]	63
Primordial Nuclides - Internal[d]	239 - 717
Total for One Year (rounded)	353 - 831

a. National Council on Radiation Protection and Measurements, Exposure of the Population of the United States and Canada from Natural Background Radiation, NCRP Report No. 94, Bethesda, Maryland, December 30, 1987.
b. Includes regional increase over U.S. average as a result of the greater elevation of the Denver area.
c. Includes regional increase over U.S. average as a result of the higher concentrations of uranium and thorium in soil in the Denver area.
d. Includes a range from the U.S. average indoor radon dose contribution to a value three times as high, although some sources place the average radon concentration in the Denver area to be up to five times the national average. This value likely will increase when regional indoor radon differences for the Denver area are determined.

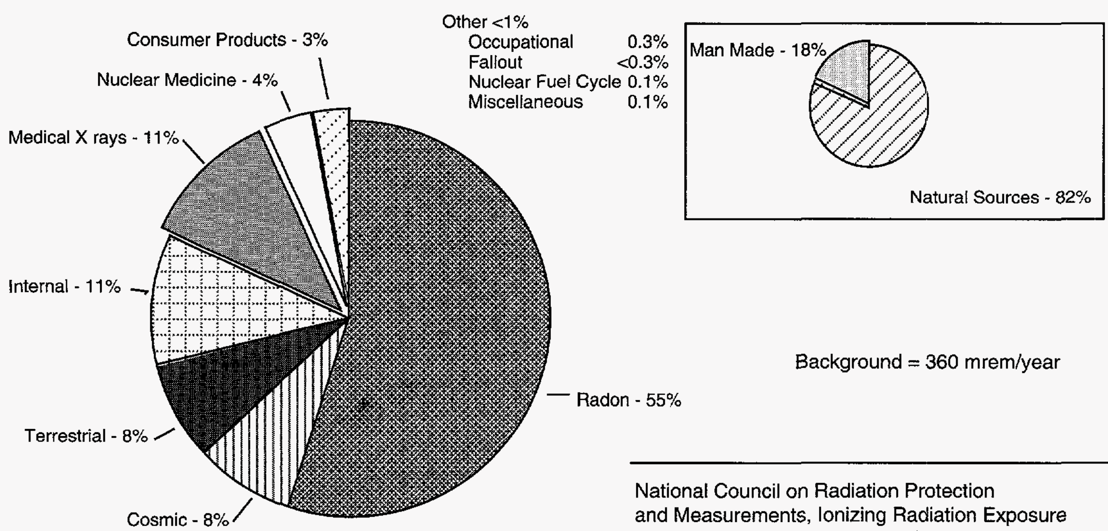


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Figure 6-2. Contribution of Various Sources to the Total Average Radiation Dose to the United States Population

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7.0 QUALITY ASSURANCE

Continuous improvement in the comprehensive environmental programs at Rocky Flats is the goal of Quality Assurance (QA). Continuous improvement measures help ensure that work is performed in a manner that protects worker and public health and safety, provides the quality of products and services necessary to meet program and project objectives, minimizes risk and environmental impacts, and helps ensure that programs are conducted in accordance with all applicable regulatory requirements. This section provides a detailed description of QA measures in place at Rocky Flats.

OVERVIEW

In 1992, the Environmental Management (EM) Department was reorganized to separate environmental restoration and environmental monitoring functions into two organizational units. Environmental Restoration Management (ERM) became responsible for restoration activities, while Environmental Protection Management (EPM) maintained responsibility for various environmental monitoring, permitting, and reporting activities performed at Rocky Flats.

Both ERM and EPM implement the Rocky Flats Quality Assurance Program and the Quality Assurance Manual (QAM) through their own respective Quality Assurance Plans. The Quality Assurance Plan Description[1] (QAPD) is used as the foundation QA document for ERM activities. The Sitewide Quality Assurance Project Plan[2] (QAPjP) implements the requirements in the IAG between DOE, EPA, and CDPHE, and reflects the guidance of EPA's Interim Guidelines and specifications for preparing QAPjPs (QAM5-005/80). The QAPD is a flowdown from the site QAM and incorporates the requirements of the IAG, QAM, and DOE Order 5700.6C (which superseded DOE Order 5480.6B). The QAPD is structured in accordance with the American Society of Mechanical Engineers NQA-1, Quality Assurance for Nuclear Facilities.[3]

The Environmental Protection Management Plan[4] (EPMP) is the quality assurance plan for EPM. DOE Order 5400.1, General Environmental Protection Program, establishes QA requirements that apply to all DOE environmental monitoring and surveillance programs. The QAM consists of 22 quality requirements that are potentially applicable to all Rocky Flats programs, including environmental restoration and monitoring programs.

QA Requirements

QA requirements are established by DOE, Rocky Flats, CDPHE, and EPA and apply to EPM and ERM activities. Both DOE Order 5400.1 and the QAM reference QA requirements of DOE Order 5700.6C. DOE Order 5700.6C endorses the 10 QA criteria and still implements the 18 QA criteria and supplemental requirements of the American Society of Mechanical Engineers NQA-1, Quality Assurance for Nuclear Facilities.[5] The IAG requires DOE to prepare and implement a QA Project Plan for the ERM program activities which incorporates EPA Guidelines and Specifications for Preparing Quality Assurance Project Plans[6], as implemented through the QAPjP.

QA Program

Development of the QA process for environmental activities was initiated in 1990. The process identified QA requirements that applied to environmental programs and projects, and established methods, controls, and responsibilities for meeting those requirements.

The ERM QAPD and the EPM EPMP implement DOE Order 5700.6C and fulfill the program-specific components for their respective organizations. Both of these plans consist of a statement regarding the respective organizations' commitment to quality and sections which address the applicable and specific quality requirements of the QAM.

The following are some of the concepts and requirements for each QA Plan.

- A graded approach is used to apply QA to environmental programs and projects, based on the risk of harm to health or safety of humans, the ecosystem, or the environment.

- Procedures are prepared, reviewed, and approved for every environmental activity affecting quality.

- Organizational structures, functional responsibilities, levels of authority and interfaces are provided.

- Individuals responsible for performing the work are responsible for achieving and maintaining quality.

- Written personnel qualifications, training/indoctrination activities, and position descriptions are prepared for all personnel.

- Responsibility for work may be delegated to other organizations, but ultimate responsibility is retained by the organization originally assigned.

- Verification of overall quality is performed by qualified persons independent of the work performed.

- Environmental activities, including those performed by subcontractors and suppliers, are subject to audit and surveillance by the Site QA Organizations, which is in a department independent from environmental organizations.

- Processes and activities will include mechanisms for the prevention of problems and improvement of quality.

The EPM EPMP describes the roles, responsibilities, and interfaces of EPM as well as the means for achieving and ensuring quality of work and work products. Lower level EPM procedures on project plan development, training, inspections, and document review were issued in 1993. Six administrative procedures on program implementation (among them, document review, program plan development, training and nonconformance reporting) were issued in 1994. QA requirements for data collection, sampling, and chain of custody requirements are contained in lower level procedures which implement specific programs. Branch Management Plans provide an overview of the programs and projects within each branch; regulatory drivers, brief descriptions of the programs, and a listing of implementing procedures are also outlined. Activities performed by EPM which support ERM meet the QA requirements specified in the QAPjP and QAPD.

The ERM QA process integrates quality requirements established by DOE, Rocky Flats, EPA, and CDPHE. The ERM QA process consists of maintaining and implementing: (1) the QAPD, (2) the Sitewide QAPjP for CERCLA RI/FS and RCRA FI/CMS activities, 3) administrative and operating procedures, and (4) other work-controlling documents as needed. The procedures provide control and direction for the performance of routine operations or processes, ranging from program administration to technical data acquisition and data reduction. ERM procedures are being developed to implement environmental programs in accordance with requirements of the IAG.

The QAPjP was approved by EPA and CDPHE in 1991 and the QAPD was revised in 1994. The QAPjP is supplemented by data quality objectives specified in project-specific workplans. Quality-affecting elements such as data quality objectives, quality control, and methods may also be found in technical memoranda, work plans, and sampling and analysis plans. Additional national standards are being used to ensure adequate quality of services and deliverables, including ANSI/ASQC E4-1944[7] and EPA Guidelines.

Analytical Laboratories

Environmental chemistry analyses are performed both at onsite and offsite laboratories. These include the Bioassay/Environmental Laboratories located in Building 123 and the Organic, Inorganic, General Chemistry, and Radio Chemistry Laboratories located in Building 881.

The Analytical Laboratories Quality Assurance Plan and the General Radiochemistry and Routine Analytical Services Protocol (GRRASP)[8] provide comprehensive guidance to ensure the quality of environmental data. These documents include descriptions of the laboratory organization, functions, responsibilities, policies, and programs that comprise the overall QA program. Highlights of the program are provided below.

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

Detailed quality control (QC) for the reliability of analytical data is provided in each 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 controls ensures reproducible, quality measurements. Traceable standards are prepared both independently and within the laboratory. Statistical evaluation in the form of precision and accuracy of the control samples determines the acceptability of the sample batch data relative to the data quality specifications agreed upon with the customer. If any samples require reanalysis, those samples are included in another QC batch.

Any unusual condition observed during sample collection, analysis, or QA review that may affect the results is reported to appropriate management officials. QA provides written notification to management to suspend the analytical operation, pending review and corrective actions, when process control charts or other statistical evaluations indicate that the process is not in control (i.e., out of control).

The Analytical Laboratories at Rocky Flats participate in a number of independent blind sample programs to control and assess analytical measurements. More than 275 blind samples are submitted monthly to the laboratories for the Site Interactive Measurement Evaluation and Control System. This program provides feedback on analyses as well as monthly reports and meetings to review analytical results. Performance samples from EPA for the NPDES program are analyzed and evaluated annually. Environmental samples from the USGS are evaluated biannually. The laboratories participate in radiochemistry programs conducted by the EPA Environmental Monitoring Systems Laboratory and the DOE Environmental Measurements Laboratory (EML). The laboratories also purchase a suite of water samples from an independent commercial laboratory for a bimonthly program administered by the laboratory QA officers. Results of these programs demonstrate the high level of competency of the Analytical Laboratories.

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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 (μCi).** 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.
>
> **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) EDE.

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

dose. In this report,the term dose is used broadly to refer to the radiation protection concepts of dose equivalent and effective dose equivalent below.

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 years.

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).

effective dose equivalent (EDE). A calculated value used to allow comparisons of total health risk, based on cancer mortality and genetic damage, from exposure of different types of ionizing radiation to different body organs. It is calculated by first calculating the dose equivalent to those organs receiving significant exposures, multiplying each organ dose equivalent by a health risk weighting factor, and then summing those products. One milllirem EDE from natural backround radiation would have the same health risk as one millirem EDE from an artificially produced source of radiation.

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 pre-selected 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 sievert = 100 rem).

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.

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^{1}	0	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/l (water)	10^{-9}	µCi/ml (water)	µCi/ml (water)	10^{9}	pCi/l (water)
pCi/m^2 (air)	10^{-12}	µCi/cc (air)	µCi/cc (air)	10^{12}	pCi/m^3 (air)

TRADITIONAL AND INTERNAL SYSTEMS OF RADIOLOGICAL UNITS

(Traditional units are in parentheses.)

Quantity	Name	Symbol	Expression in Terms of Other Units
absorbed dose	Gray	Gy	J/Kg^{-1}
	(rad)	rad	10^{-2} Gy
activity	Becquerel	Bq	1 dps
	(curie)	Ci	3.7×10^{10} Bq
dose equivalent	Sievert	Sv	J/Kg^{-1}
	(rem)	rem	10^{-2} Sv
exposure	Coulomb per kilogram		C/Kg^{-1}