DRAFT

WORKPLAN FOR

CONTROL OF RADIONUCLIDE LEVELS IN WATER DISCHARGES FROM THE ROCKY FLATS PLANT

as Required in
Section XII of
the Interagency Agreement

April 5, 1991

Prepared By:

U.S. Department of Energy
Rocky Flats Plant
Golden, Colorado

EG&G Rocky Flats
Environmental Restoration Program

DRAFT

WORKPLAN FOR

CONTROL OF RADIONUCLIDE LEVELS IN WATER DISCHARGES FROM THE ROCKY FLATS PLANT

as Required in
Section XII of
the Interagency Agreement

April 5, 1991

Prepared By:

U.S. Department of Energy
Rocky Flats Plant
Golden, Colorado

EG&G Rocky Flats
Environmental Restoration Program

"REVIEWED FOR CLASSIFICATION
By [signature]
Date 4/2/91"

Table of Contents

List of Tables

List of Figures

Appendices

Appendix Tables

Appendix Figures

List of Acronyms and Abbreviations

The following acronyms and abbreviations are used in the Workplan:

AIP	Agreement in Principle
AMDA	Acceptable Minimum Detectable Activity
BDD	Broomfield Diversion Ditch
CDH	Colorado Department of Health
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/s	centimeter per second
CHS	Colorado Health Standards
COE	U.S. Corps of Engineers
CRS	Colorado Revised Statutes
CUHP	Colorado Urban Hydrograph Procedure
CWA	Clean Water Act
CWAD	Clean Water Act Division
CWQCC	Colorado Water Quality Control Commission
DAF	Dissolved Air Flotation
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FERC	Federal Energy Regulatory Commission
FFCA	Federal Facilities Compliance Agreement
GAC	granular activated carbon
GC	gas chromatography
GOCO	Government-owned and contractor-operated facility
gpm	gallons per minute
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
H/S	Health and Safety
IAG	Interagency Agreement
IMECS	Interactive Measurement Evaluation and Control System
LANL	Los Alamos National Laboratory
MDA	Minimum Detectable Activity

mph	miles per hour
NIST	National Institute of Standards and Technology
NBL	New Brunswick Laboratory
NPDES	National Pollutant Discharge Elimination System
O & M	Operating and Maintenance
OU	Operable Unit
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
RFP	Rocky Flats Plant
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SEO	State Engineers Office
SOP	Standard Operating Procedure
STP	Sewage Treatment Plant
SWMP	Surface Water Management Plan
SWMU	Solid Waste Management Unit
UF	ultrafiltration
WET	Whole Effluent Toxicity
WQCD	Water Quality Control Division

Executive Summary

This Workplan, prepared in response to Section XII of the Interagency Agreement (IAG) dated January 22, 1991, addresses the *control of water discharges from Rocky Flats holding/detention ponds*. The Workplan describes analytical protocol and methods for determining radionuclide levels, summarizes statistical assessments of accumulated analytical results, and presents recommendations for additional radionuclide studies to better characterize the water quality of RFP discharges. The Workplan also describes current approaches for planning, approving, and conducting offsite discharges of water from the RFP terminal ponds (A-4, B-5, and C-2). Approaches for implementing discharge are reviewed, and methods for streamlining operations are proposed. Current treatment approaches and limitations are reviewed, and plans for future treatability studies are addressed.

Surface water impacted by Rocky Flats Plant (RFP) flows in three major drainages where it is directed into a series of downstream holding ponds. Offsite discharges of water are made from the terminal Ponds A-4, B-5, and C-2 in these drainages. The ponds provide storm-water runoff collection and control as well as capacity for detention of water contaminated by accidental spills and potentially requiring treatment prior to release. Accumulated water is detained so that adequate water quality analyses can be performed. The ponds are intended to be operated at 10 percent of capacity to provide surge protection in the event of storms or accidental spills and thus afford the collection and treatment options. Ponds are designed for operation in the normally near-empty condition to provide maximum holding capacity for accidental waterborne contaminant releases. When ponds are maintained in a near-full condition, minimal spill containment and storm-water runoff capacities are available, and saturation and weakening of the containment structures (originally intended for short-term or low-volume storage) occurs. Timely release of water is therefore necessary to comply with the NPDES discharge permit and to ensure dam safety.

At present, seven discharge points are allowed for RFP surface water by the National Pollutant Discharge Elimination System (NPDES) permit for the site. This site NPDES permit has been modified, in part, by the Federal Facilities Compliance Agreement (FFCA) with regard to the Sewage Treatment Plant (STP), although these modifications do not include additional requirements for monitoring radiological parameters.

Additional surface-water quality classifications and stream standards were established for RFP waters by the Colorado Water Quality Control Commission (CWQCC). Per the cooperative Agreement in Principle (AIP), the U.S. Department of Energy (DOE) and the State of Colorado agree (1) to perform joint monitoring of RFP waters to assure water quality, and (2) to confer regarding the safety of, and any requirements for, offsite water discharges.

Sampling (including split sampling) of waters prior to discharge is routinely conducted and the results are shared monthly with regulatory authorities and affected municipalities. Safety of discharges is established through the sampling program, and subsequent releases of water are conducted in accordance with additional requirements, such as biomonitoring, and under the auspices of CDH. However, several problems arise as a result of this operational mode and include delays in obtaining permission to begin or resume discharge in a timely and straightforward manner.

Currently available analytical methods do not allow real-time monitoring of radionuclides because (1) the chemical separations are intricate and time-consuming and (2) analytical counting times are lengthy. Analytical precision and accuracy are improved by extending counting times and/or increasing sample volumes, but the limitations of current technology do not allow substantial improvement in analytical turnaround times. Currently, analytical turnaround times of 61 days for offsite facilities are typical; these turnarounds complicate and confound the operational management of routine releases of water (of known quality). Measured values approach the lower limit of detection for radiometric methods. This limitation to real-time knowledge of water quality complicates decisions to initiate or resume discharge of impounded water.

Following sampling and prior to CDH concurrence, water is recirculated (returned to the source pond) until authorization is received to initiate discharge. During the approval period, the open ponds are subject to potential contamination by runoff from precipitation events and windborne deposition while analyses are being determined. Temporary water treatment systems are now in place at the point of final discharge. Treatment currently consists of sequential particulate filtration and granular activated carbon (GAC) adsorption unit operations. Work is underway to consolidate, refine, and improve the effectiveness of treatment. For reasons of space limitations and economy, future treatment will be centralized at Pond A-4. This consolidation will be accomplished with the aid of water transfers between ponds.

The Workplan describes past and proposed approaches for planning, approving, and conducting offsite water discharges from the RFP terminal ponds. Discharge management is also strongly affected by analytical, statistical, and water treatment issues. Analytical sensitivity of the methods employed to determine radionuclide concentrations is subject to intrinsic variability. The response in this Workplan is both to refine understanding of the limitations of analytical techniques and also to refine statistical understanding and interpretation of analytical values.

As to the former, analytical methods applicable to the specified radionuclides are recommended for validation in this Workplan. The effect of validation using multiple laboratories will be to determine (1) analytical precision and bias among laboratories and (2) robustness of the analytical method—its sensitivity to upset and interferences. As to the latter, further statistical study is proposed in the Workplan to isolate long term and seasonal trends, to identify outliers, to enhance definition and characterization of statistical distribution of the data and associated variability. An evaluation of available data is presented as preamble to illustrate the status of present understanding in this regard.

A third consequence of analytical and statistical shortcomings is evidenced in some of the treatability work to date, namely the unexpected performance of the filters which pre-treat flows to the granular activated carbon (GAC) units. The response incorporated into this Workplan is to improve characterization of the radionuclides, with enhanced analytical and statistical understanding, then perform bench- and pilot-scale treatment using technology now planned for the Sitewide Treatability Study Program. Technologies that will be considered include: precipitation, enhanced sedimentation, improved filtration, ion exchange, and membrane separation.

1.0 Introduction

The January 22, 1991, Interagency Agreement (IAG) to which the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Health (CDH) are signatory, requires among other things that DOE prepare a Workplan that is "designed to control the release of radionuclides" contained in surface waters periodically discharged from the terminal ponds at Rocky Flats Plant (RFP). The regulatory requirements are further set forth in the Work Statement, Attachment I to the IAG.

This Workplan, which is submitted to fulfill the requirements of Section XII of the IAG, addresses the following specific items:

- Sampling pond waters before discharges can commence.
- Sharing split samples with CDH and EPA.
- Proposing analytical methods for specified radionuclides for validation by EPA.
- Assessment of the water quality of discharges with respect to Colorado Water Quality Control Commission (CWQCC) standards.
- Sharing analytical data.
- Identifying appropriate treatment technologies.
- Developing and implementing treatment technologies.

1.1 Workplan Scope

This Workplan contains descriptions of current practices and anticipated activities designed to manage discharges of surface water from RFP and to limit/control the levels of radionuclides contained in these waters. Also included are sections on RFP background information and site characteristics, current surface-water management practices, protocols for sampling and analysis, analytical methodology and data assessment, operational and functional management structures, and current and anticipated treatment approaches.

1.2 Workplan Organization

This Workplan is organized into the following sections:

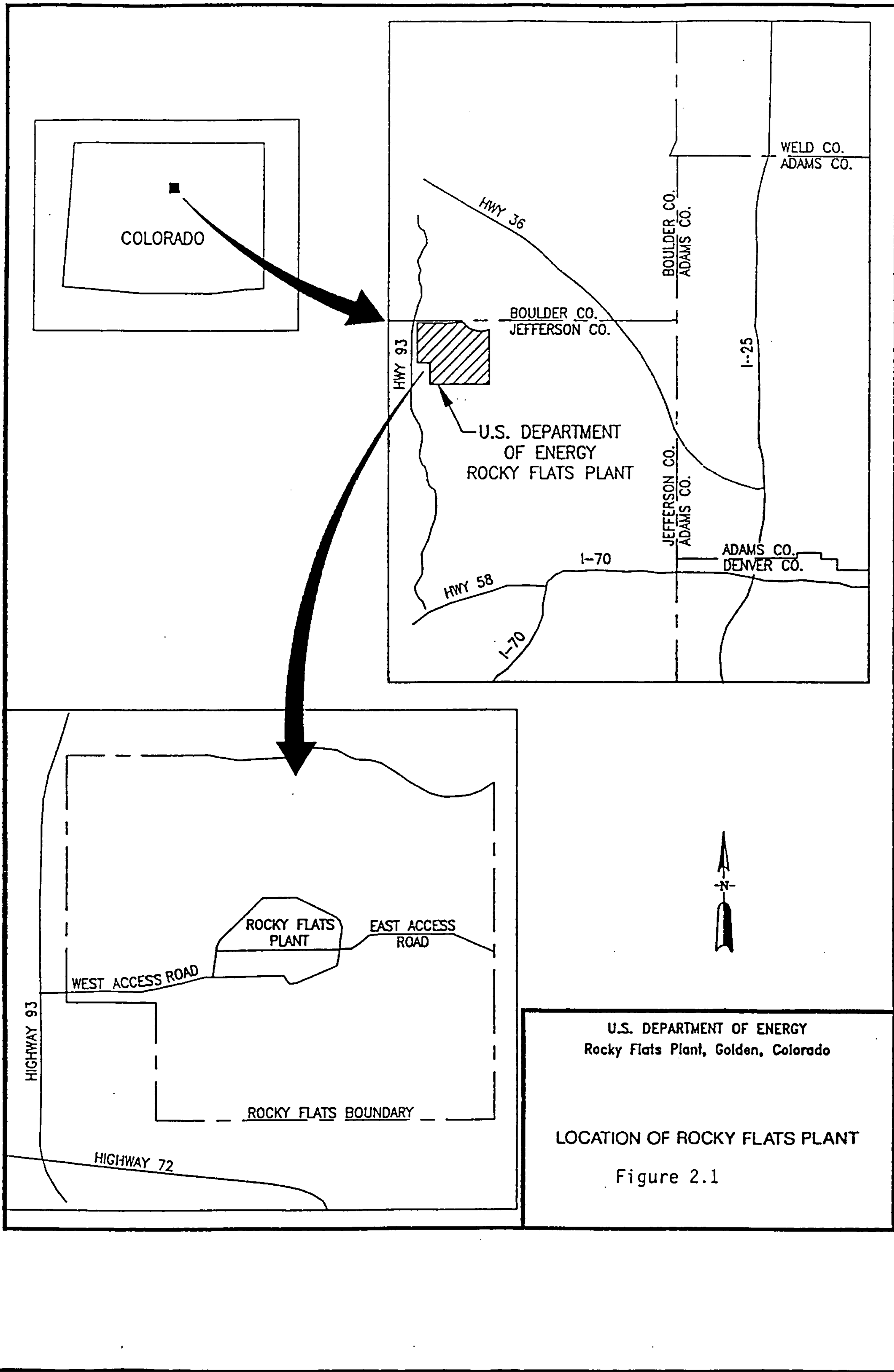
- General site background description, including geology, meteorology, and ground-water and surface-water features.
- Background to specific Workplan elements, including: (a) pond discharge management, (b) statistical study of measured radionuclide levels, and (c) laboratory methods employed.
- Need for further work elements, which are developed as Workplan elements from the background information presented.

2.0 RFP Background Information

2.1 Site Description

RFP is located approximately 16 miles northwest of downtown Denver, in Jefferson County, Colorado (Figure 2.1). RFP encompasses approximately 6550 acres of federally owned land and is a Government-owned and contractor-operated facility (GOCO) that has been operational since 1952. (DOE 1980) The plant is a DOE facility where metal components for nuclear weapons are manufactured from plutonium, uranium, beryllium, and stainless steel. Other production activities include chemical recovery and purification of recyclable transuranic radionuclides, metal fabrication and assembly, and related quality control functions. In addition, research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics are conducted at the plant. Parts manufactured at the plant are shipped offsite for final assembly. Primary plant structures and all production buildings are located within a 400-acre secure plant complex area. A 6150-acre buffer zone encircles the main plant complex.

Solid and liquid nonhazardous, hazardous, radioactive, and mixed radioactive wastes are generated in RFP manufacturing processes and operations. Current waste handling and disposal practices include onsite treatment and both onsite and offsite recycling of hazardous and mixed radioactive wastes, onsite storage, or shipment offsite for disposal



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

LOCATION OF ROCKY FLATS PLANT

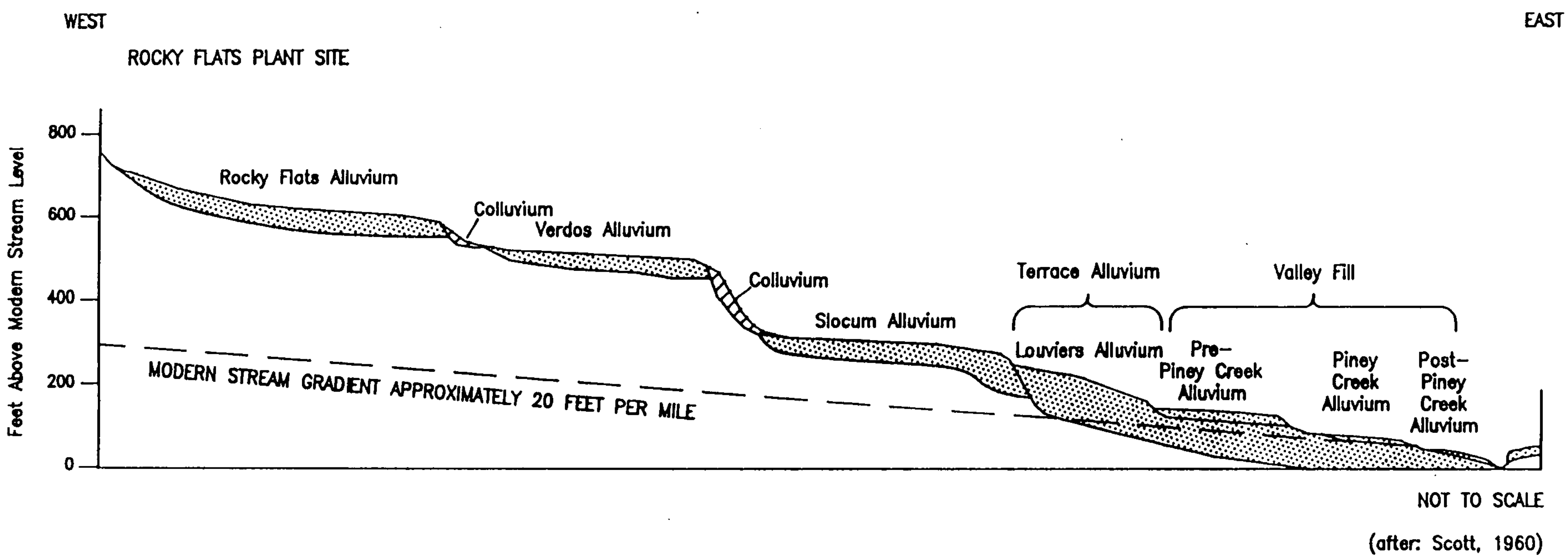
Figure 2.1

of hazardous and solid radioactive materials at another DOE facility. However, hazardous, mixed, and solid radioactive wastes have been disposed on the RFP site in the past. Nonhazardous wastes, such as cafeteria wastes, are disposed in an onsite landfill.

Preliminary assessments performed by RFP's Environmental Restoration (ER) Program identified some of the past onsite storage and disposal locations as potential sources of environmental contamination. A comprehensive list of all known and suspected sources of hazardous, radioactive, and mixed waste at RFP has been compiled. (Rockwell 1988a) This list includes descriptions and all known release information for all identified Resource Conversation and Recovery Act (RCRA) regulated units and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Solid Waste Management Units (SWMUs). The regulated and waste management units at RFP have been categorized into Operable Units (OUs) for further environmental investigation and remediation based on potential threats to human health and the environment. Waste management units that received hazardous waste after November 19, 1980, require RCRA closure plans. Land disposal units that received hazardous wastes after July 26, 1982, (regulated units) are also subject to RCRA interim status ground-water monitoring requirements prior to closure as well as post-closure care requirements. The RFP regulated units are described in detail in the RCRA Post-Closure Care Permit Application (Rockwell, 1988b). Under DOE Compliance Agreements, the ER Program has responsibility for complying with CERCLA/Superfund Amendments and Reauthorization Act (SARA), RCRA 3004u, and RCRA closure requirements.

2.2 Geology

RFP is located several miles east of the Colorado Front Range on the western margin of the Colorado Piedmont section of the Great Plains. (EG&G 1990b) The elevation is approximately 6000 feet above mean sea level. Topography of the plant site is relatively flat, as it is situated on an eroded mountain front pediment. The pediment surface is unconformably overlain by the Rocky Flats Alluvium, a formation consisting of fluvial alluvial fan deposits. As illustrated in Figure 2.2, a schematic representation of the erosional surfaces and alluvial deposits east of the Colorado Front Range, the Rocky Flats Alluvium is the oldest alluvial material deposited in the east-west profile. In the buffer zone to the north and south of the plant, surficial deposits are incised by modern channels such that the resulting topographic relief is up to 200 feet.



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

EROSIONAL SURFACES AND ALLUVIAL DEPOSITS EAST OF THE FRONT RANGE COLORADO

FIGURE 2.2

February, 1991

R33066.PJ-013091

The RFP site is situated on the western margin of the structurally asymmetric Denver Basin. The geologic section in the area ranges in age from Precambrian to Holocene, with Precambrian rocks occurring at a depth of approximately 12,000 feet. Structurally, the rocks of the central and eastern plant facility are relatively flat lying and are characterized by a north strike and an east to northeast dip of 1.25 degrees. Rocks dip steeply (45 to 50 degrees) in the western portion of the plant. Prominent north-south striking hogbacks exist west of Rocky Flats (see Figure 2.3).

Figure 2.4 is a generalized stratigraphic section of the Denver Basin bedrock. At Rocky Flats, the Tertiary rocks of the Green Mountain and Denver Formations were either not deposited or have been eroded. The Upper Cretaceous Arapahoe and Laramie Formations are directly overlain by the Rocky Flats Alluvium. The Rocky Flats Alluvium, the Arapahoe Formation, the Laramie Formation, and the Fox Hills Sandstone are of hydrogeologic concern and are shown in more detail in Figure 2.4. Because of their shallow depths and hydrostratigraphic units, the aquifers of primary consideration for potential contamination are the Arapahoe Formation and the surficial deposits of the Rocky Flats Alluvium, colluvium, and valley-fill alluvium. Lithologic and hydrogeologic characteristics of the surficial deposits and the bedrock are discussed in Appendix I.

2.3 Meteorology

The area surrounding the plant site has a semiarid climate characteristic of the Central Rocky Mountain Region. On the average, daily summer temperatures range from 55°F to 85°F and daily winter temperatures range from 20°F to 45°F. The low average relative humidity (46%) is a result of the blocking effect of the Rocky Mountains.

Forty percent of the 15-inch annual precipitation falls during the spring season (February through May), much of it as wet snow. Thunderstorms (June through August) account for an additional 30 percent. Fall and winter are drier seasons, providing 19 percent and 11 percent of the annual precipitation, respectively.

Because of the plant's location (4 miles east of the Rocky Mountain foothills), the area experiences chinook winds with gusts in the spring sometimes exceeding 100 miles per hour (mph). The net evaporation rate is approximately 40 inches per year (Surface Water Management Plan, 1990).

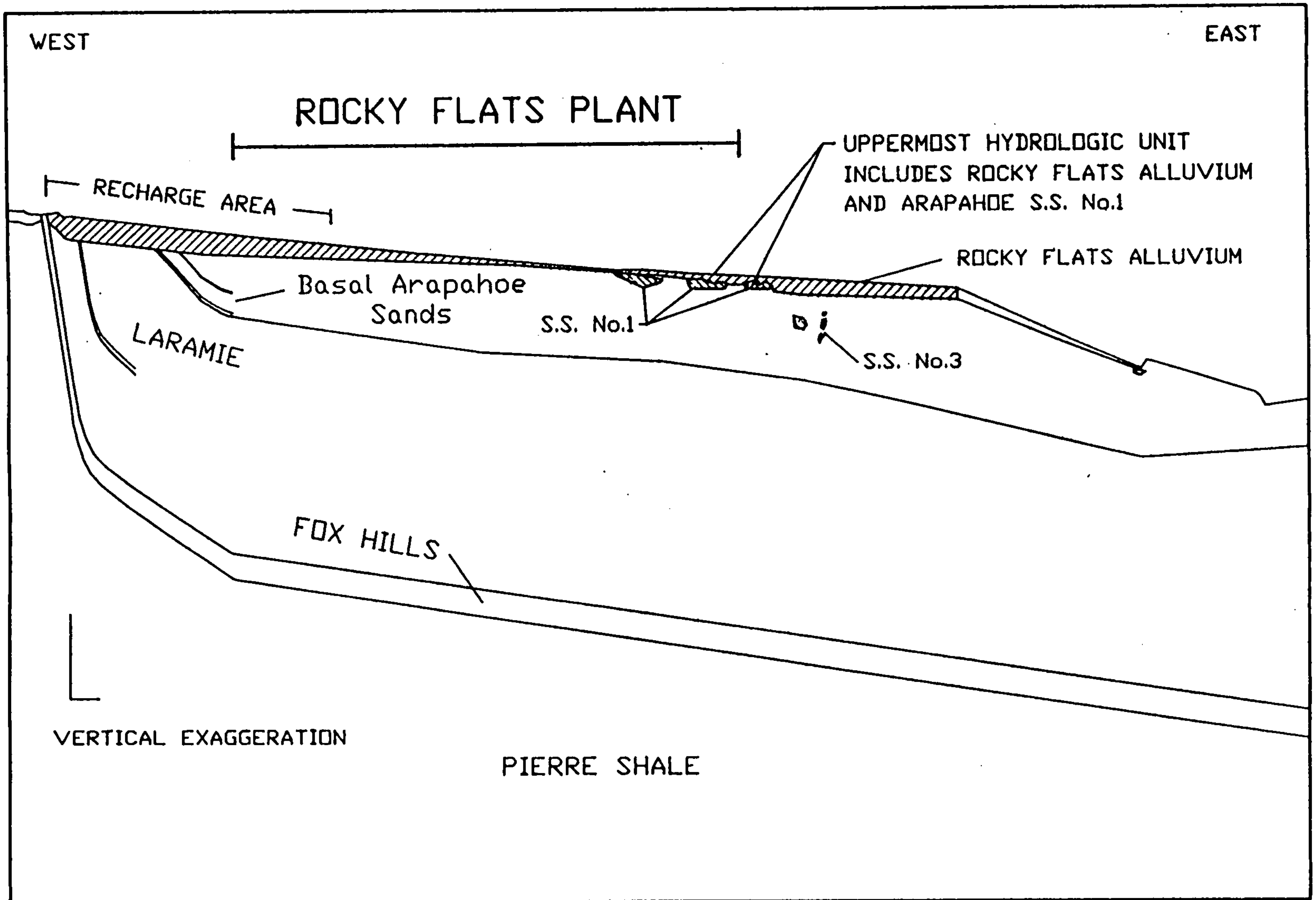
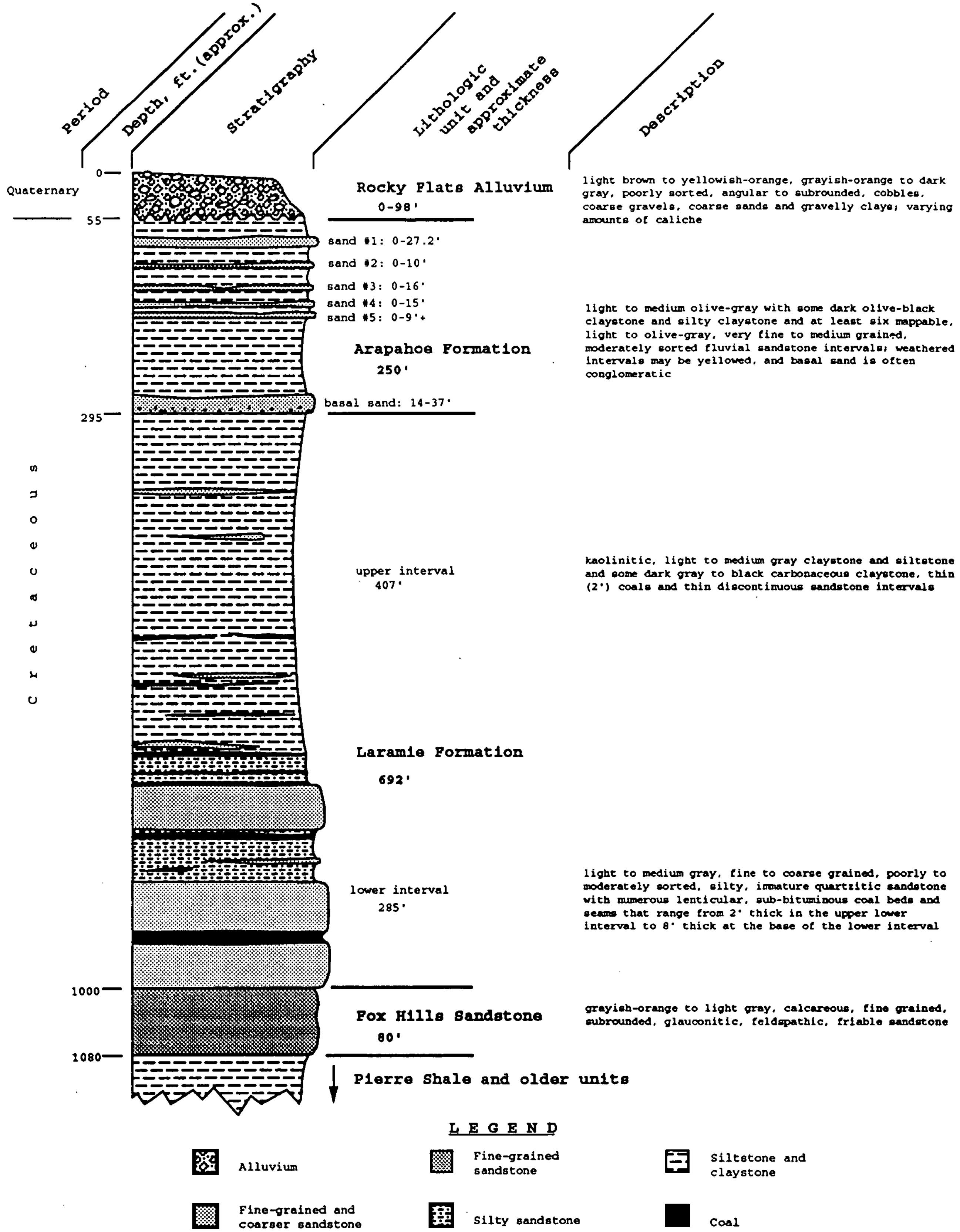


Figure 2.3

Figure 2.3 West to East Structural Cross Section



Generalized Stratigraphic Section of the Rocky Flats Plant

Figure 2.4

2.4 Surface-Water Hydrology

2.4.1 Natural Drainages

A generalized map of the principal drainage basins and surface-water features on the RFP site is presented in Figure 2.5. Three drainage basins and natural ephemeral streams traverse RFP, and surface-water flow across the site is generally from west to east. A topographic divide bisects the site along an east-west trend slightly south of Central Avenue (the approximate center line of the site). The Rock Creek drainage basin traverses and drains the northwestern portion of the plant site and is located in the buffer zone, entirely separate from the operational plant complex. This drainage is therefore generally unimpacted by plant operations or potential contaminant releases to surface water. Rock Creek flows to the northeast to its offsite confluence with Coal Creek. Preliminary surface water modeling of the Rock Creek basin, using the Colorado Urban Hydrograph Procedure (CUHP) (Urban 1985), indicates that the 2-year, 2-hour storm would result in a flood peak of approximately 55 cubic feet per second (cfs) at the outlet of the basin. To date, the largest flow observed during monthly monitoring at the outlet was less than 1 cfs.

The Woman Creek drainage basin traverses and drains the southern portion of the site. Although this basin is located primarily in the buffer zone, it does extend into the extreme southern boundary of the plant complex. An interceptor ditch (South Interceptor Ditch) is located between and parallel to Woman Creek and the southern boundary of the plant complex. The relatively small quantity of surface runoff that flows from the southern boundary of the plant complex toward Woman Creek is intercepted by this ditch. This intercepted flow eventually enters detention Pond C-2.

Surface runoff downgradient of the South Interceptor Ditch is tributary to Woman Creek, which flows east to Standley Lake, a water supply for the City of Westminster and for portions of the cities of Northglenn and Thornton. In 1990, water discharges from Pond C-2 were piped, in accordance with National Pollutant Discharge Elimination System (NPDES) (EPA 1984) bypass limitations set by EPA, to a diversion ditch that skirts Great Western Reservoir. Woman Creek also delivers some water offsite to Mower Reservoir. Preliminary modeling of the Woman Creek basin (using CUHP) shows that the 2-year, 2-hour storm would result in a flood peak of approximately 35 cfs at the basin outlet.

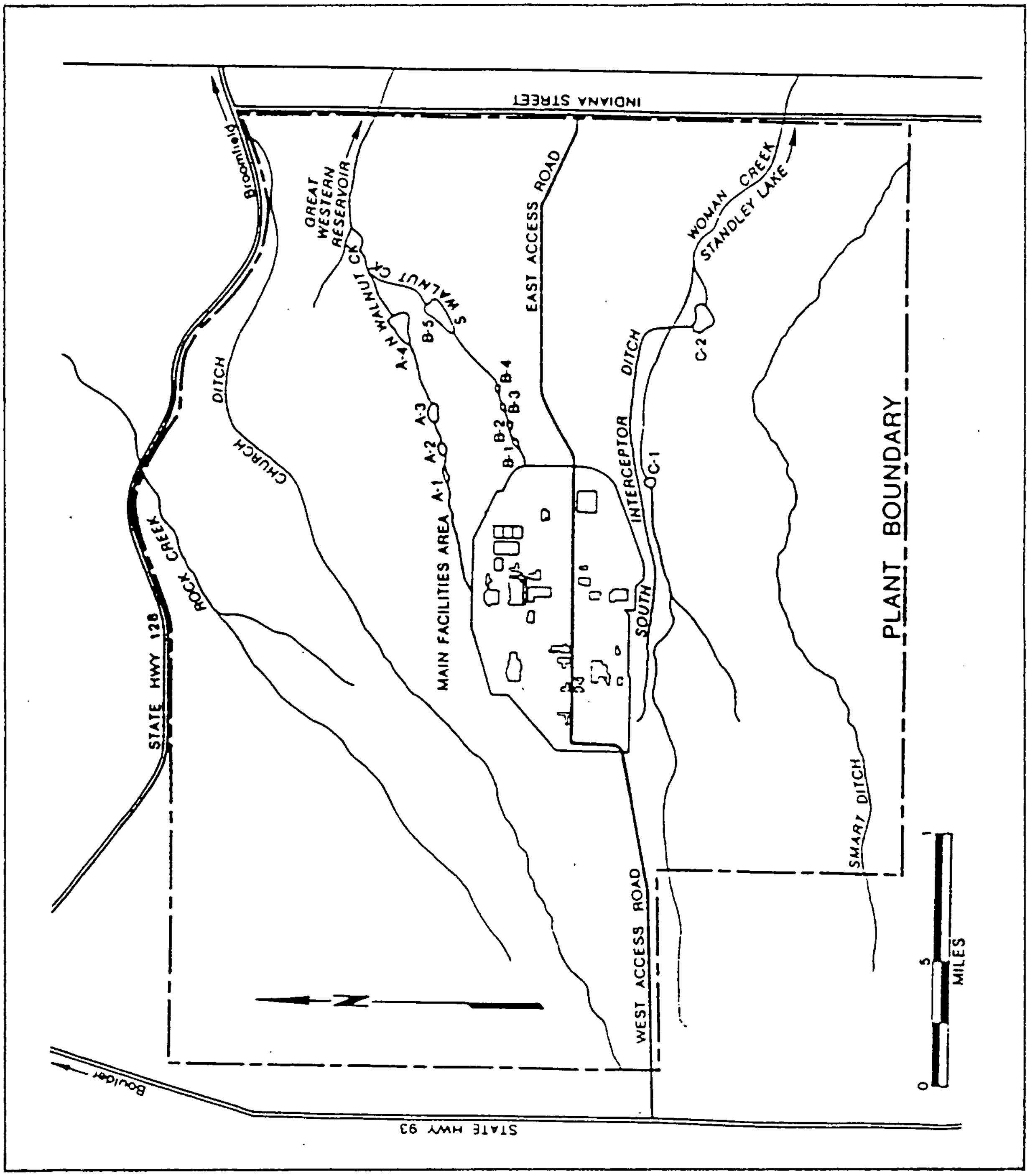


Figure 2.5 Surface Drainage

Another modeling effort using the Soil Conservation Service TR-20 hydrologic model indicates that the 25-year, 2-hour storm results in a flood peak of approximately 595 cfs at the outlet (EG&G 1990d). To date, the largest flow observed at the outlet from monthly monitoring was 8 cfs during the month of May.

The Walnut Creek drainage basin traverses the western, northern, and northeastern portions of the RFP site and receives runoff from the majority of the plant complex. Three ephemeral streams are actually tributary to Walnut Creek: Dry Creek, North Walnut Creek, and South Walnut Creek (which receives most of the runoff from the plant complex). These three forks of Walnut Creek join in the buffer zone (approximately 0.7 mile west of the eastern perimeter of RFP) and flow east offsite through a diversion ditch bypassing Great Western Reservoir, a water supply for a portion of the City of Broomfield and located approximately one mile east of this confluence. Preliminary modeling of this basin (using CUHP) indicates that the 2-year, 2-hour storm would result in a flood peak of approximately 50 cfs at the outlet of the basin. Modeling using TR-20 indicates that the 24-year, 2-hour storm results in a flood peak of approximately 1660 cfs at the outlet. To date, the largest flow observed at the outlet from monthly monitoring was 2 cfs during the month of September.

2.4.2 Ditches and Diversions

In addition to natural flows and the South Interceptor Ditch, there are seven ditches or diversion canals in the general vicinity of RFP. The Upper Church, McKay, Kinnear, and Reservoir Co. Ditches (diversions of Coal Creek) cross the site. Upper Church Ditch delivers water to Upper Church Lake and Great Western Reservoir. McKay Ditch also supplies water to Great Western Reservoir. Kinnear Ditch and Reservoir Co. Ditch divert water from Coal Creek and deliver it to Woman Creek and eventually to Standley Lake. Last Chance Ditch flows south of RFP and supplies water to Rocky Flats Lake and Twin Lakes. Smart Ditch diverts water from Rocky Flats Lake and transports it offsite to the east. The South Boulder Diversion Canal, located immediately west of the western RFP boundary, diverts water from South Boulder Creek and delivers it to Ralston Reservoir, a water supply for the City of Denver.

2.4.3 RFP Detention Ponds and Drainages

Dams, detention ponds, diversion structures, and ditches have been constructed at RFP to control the release of plant discharges and surface (storm water) runoff (see Figure 2.6). The ponds located downstream of the plant complex on North Walnut Creek are designated A-1 through A-4. Ponds on South Walnut Creek are designated B-1 through B-5. These A- and B-series ponds receive runoff from the plant complex. Ponds A-1, A-2, B-1, and B-2 are non-discharged (retention) ponds. Volumes are controlled at Ponds A-1 and A-2 by over-pond spray evaporation, and water from Ponds B-1 and B-2 is transferred to Pond A-2 after characterization. Pond B-3 receives treated effluent from the Sewage Treatment Plant (STP). Pond C-1 is located on Woman Creek and receives natural flows, and Pond C-2, located immediately south of Woman Creek (the creek is diverted to the north around the pond), receives flow from the South Interceptor Ditch as well as some natural flows from its immediate drainage basin. One retention pond (the Landfill pond) is located in an unnamed basin immediately downgradient of the present Landfill. The Landfill pond is operated in a zero discharge mode through spray evaporation. Any offsite discharges from the terminal ponds on Walnut Creek or Woman Creek (Ponds A-4, B-5, or C-2) are regularly monitored according to the requirements of the RFP NPDES permit (CO-0001333).

This NPDES monitoring and compliance reporting is the responsibility of the EG&G Rocky Flats Clean Water Act Division (CWAD). The NPDES permit currently requires monitoring of specific parameters at seven discharge points or outfalls (Table 2.1), and discharges at these points are normally in compliance with the permit. In addition to the specific NPDES monitoring requirements, all discharges to Walnut Creek and Woman Creek are monitored for plutonium, americium, uranium, and tritium concentrations.

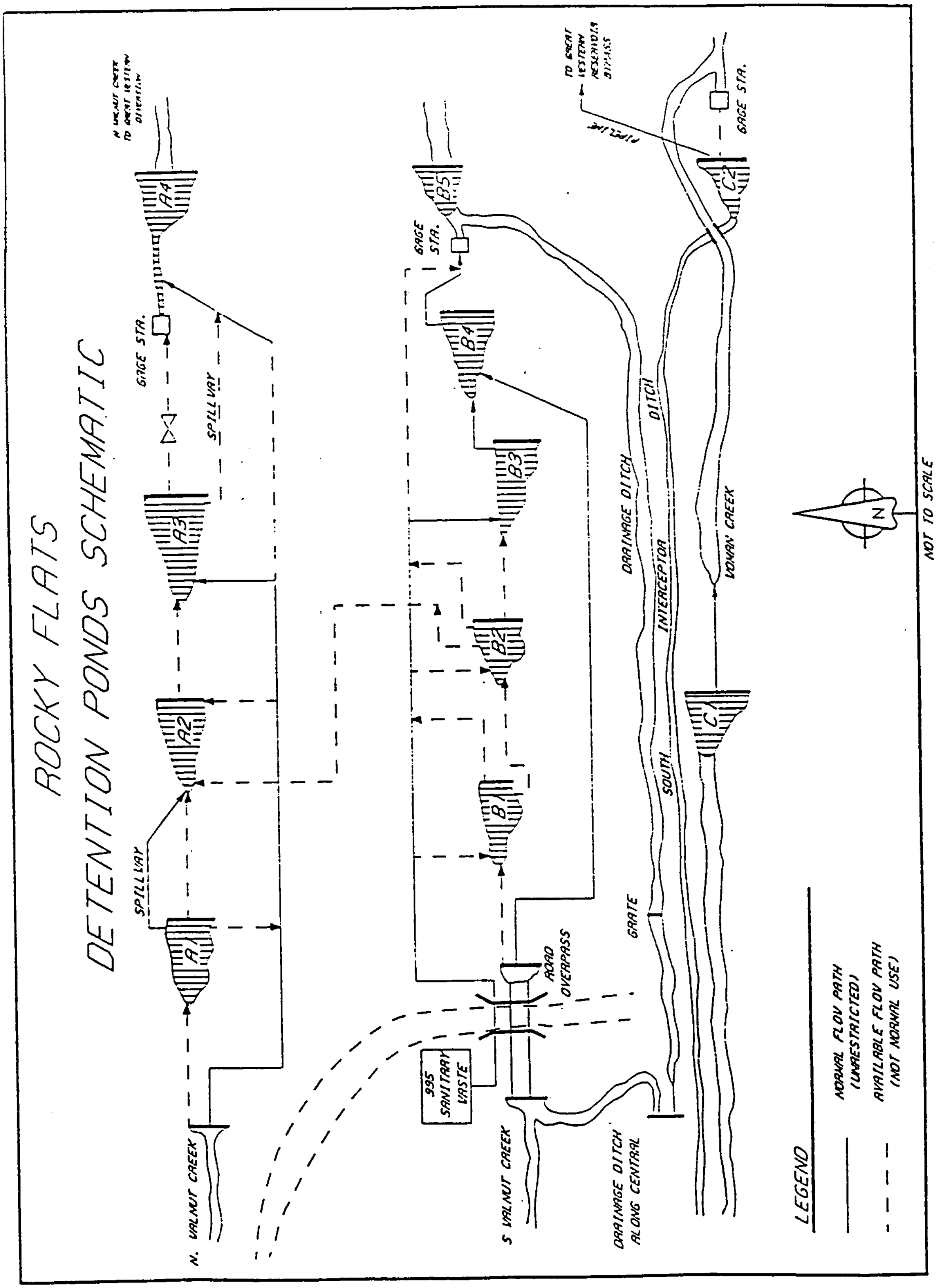


Figure 2.6 RFP Detention Ponds Schematic

Table 2.1

NPDES Permit Discharge Outfalls

Discharge Point	Location
001	Pond B-3
002	Pond A-3
003	Reverse Osmosis Pilot Plant (not operational)
004	Reverse Osmosis Plant (not operational)
005	Pond A-4
006	Pond B-5
007	Pond C-2

2.5 Regulatory Setting

2.5.1 Overview

This Workplan is a requirement set forth in the IAG dated January 22, 1991. The IAG is one of several regulatory actions affecting the management of surface water at RFP. A brief overview of the regulatory issues applicable to surface-water management programs at RFP is presented below.

Applicable federal and state regulations and DOE Orders governing oversight and management of industrial storm water and wastewater are complex and, in some cases, in apparent conflict with best management practice. Because of such conflicts, simultaneous adherence to regulations is a continuing challenge.

The primary laws governing RFP are the Atomic Energy Act, the Department of Energy Organization Act, and the federal Water Pollution Control Act (more often referred to as the Clean Water Act or CWA. These laws are augmented by secondary state and federal regulations. A number of agreements and collateral laws are also applicable.

The CWA, which applies to discharges of waters, is implemented in two ways. One manner of implementation is directed by EPA, which promulgates and enforces regulations for monitoring of liquid discharges. As part of the NPDES established by Section 402 of the CWA, either the EPA Administrator or states with approved programs will issue permits that control and limit the discharge of any pollutant to the waters of the United States. These permits are administered for Rocky Flats by EPA's Region VIII office in Denver, Colorado.

The second manner of implementation is through the Colorado Water Quality Control Act (Colorado Act), Colorado Revised Statutes (CRS) Section 25-8-101 to -703 (1982 and Supp. 1988). Although Colorado does not have the authority to directly control the contents of NPDES permits for federal facilities, it is required to develop its own stream classifications and water quality standards for the waters of the State. Colorado stream standards, which are generally basin-specific, are then reflected in the federal NPDES permit. This is the case for RFP. The State of Colorado is also required to certify that the NPDES permits issued by EPA comply with the promulgated water quality classifications and standards.

The Colorado Act authorizes the creation of the CWQCC, whose members are appointed by the Governor. The CWQCC decides and promulgates stream classifications and water quality standards for state watercourses. State waters are defined by CRS Section 25-8-103 (19) (1982) as "any and all surface and subsurface waters which are contained in, or flow in or through, this state, but do not include waters in sewage systems, waters in treatment works or disposal systems, waters in potable water distribution systems, or all water withdrawn until use and treatment have been completed."

The Water Quality Control Division (WQCD) of CDH administers and enforces the water quality control programs adopted by the CWQCC. In addition to acting as staff to the CWQCC during CWQCC proceedings, the main tasks of the WQCD, as they relate to Rocky Flats, are to (1) enforce the provisions of the Colorado Act, (2) monitor waste discharges into State waters, and (3) review and grant requests for certification under Section 401 of the CWA. The WQCD must certify EPA NPDES permits for Rocky Flats. In August 1989, CDH also established a separate Rocky Flats unit to monitor compliance with federal and State environmental laws. The separate unit is funded by DOE as part of the Agreement in Principle (AIP) (DOE 1989).

Table 2.2

Comparison of CWQCC Stream Standards for Radiochemistry

Radionuclide	CWQCC Big Dry Creek: Seg. 4, 5 Stream Standards (pCi/L)	CHS Statewide Standards (pCi/L)	SDWA Standards (pCi/L)
Americium-241	0.05	-	-
Curium-244	60	-	-
Neptunium-237	30	-	-
Plutonium	0.05	15	-
Uranium	5-10	40	(20-40)
Cesium-134	80	80	-
Radium-226 and 228	5	5	5
Strontium-90	8	8	-
Thorium-230 and 232	60	60	-
Tritium	500	20,000	-
Gross Alpha*	7-11	-	15
Gross Beta*	5-19	-	4 mrem/yr

Notes: The stream segments are defined as follows: (1) mainstem of Big Dry Creek, including all tributaries, lakes, and reservoirs, from the source to the confluence with the South Platte River, except for the specific listing in Segments 2, 3, 4, and 5; (2) Standley Lake; (3) Great Western Reservoir; (4) mainstems and all tributaries to Woman Creek and Walnut Creek from sources to Standley Lake and Great Western Reservoir, except for specific listings in Segment 5; and (5) mainstems of North and South Walnut Creek, including all tributaries, lakes, and reservoirs, from their sources to the outlets of ponds A-4 and B-5 on Walnut Creek and Pond C-2 on Woman Creek. All three ponds are located on RFP property.

*Lower standard applies to Woman Creek; higher standard applies to Walnut Creek.

pCi/L = picocurie per liter, mrem/yr = millirem per year, CHS = Colorado Health Standards (CDH 1989), SDWA = Safe Drinking Water Act.

2.5.3 NPDES Permit Requirements

The NPDES permit authorizes seven point-source discharges, of which three (Ponds A-4, B-5, and C-2) discharge into drainages leading offsite. The current NPDES permit expired in 1989 but was extended administratively by EPA when application for renewal was made in a timely manner. Issuance of the new permit is expected in late 1991.

There are no specific references or standards in the NPDES permit relative to the discharge of radionuclides, although there are two requirements relevant to general surface water management: (1) "there shall be no release of water from the final ponds within twenty-four hours following the precipitation event" and (2) "90% reserve holding capacity of the ponds shall be maintained." It is important to note that water management activities must be conducted in accordance with the NPDES permit, the only legally enforceable document controlling water discharges from RFP.

2.5.4 CWQCC Stream Standards

The CWQCC is responsible for establishing designated use classifications for waters of the State and then promulgating water quality standards that protect that use. At the December 1989 hearing, the CWQCC established new stream standards for Standley Lake and Great Western Reservoir and new segments and standards for their headwaters, creating Segment 5 in the North and South Walnut Creek drainages, ending at the dams for RFP Ponds A-4 and B-5; Pond C-2 also considered part of Segment 5. Segment 5 feeds Segment 4, which includes the drainage below the RFP dams to the reservoirs. Segment 5 is classified Agricultural and Recreational Class 2.

The new water quality standards for Segment 5 are "goal qualifier," based on existing concentrations or "ambients" for the radionuclides. Final standards will be determined at the end of a three-year monitoring period in 1993. To meet the monitoring requirement for the 1993 standards setting, a water quality monitoring program will be required at possible future points of compliance and at the raw water supply, as its origins are in natural deposits known to contain radionuclides and subject to impact by seasonal precipitation events.

3.0 Current Surface-Water Management Practices

General site characteristics were described in previous sections of this Workplan. This section provides more detail on the subjects specifically addressed in the Workplan. The information presented in the following paragraphs covers four topics:

- Pond operations, including maintenance of pond levels in accordance with the NPDES permit to afford spill containment volume and treatment of water prior to discharge.

- Management of pond discharge. These activities include pre-discharge operations, sampling and analysis, approval routes, and management of upset conditions that require suspension and resumption of discharge.

- Statistical evaluation of all currently available information on radionuclide concentrations in pond water from 1988 to date.

- Identification, screening, development, and implementation of treatment.

3.1 Pond Operations

Water is used at RFP for domestic purposes and process applications. Water used in process applications is not released; it is treated and reused within the process loop to largely evaporative loads. Approximately 10 to 15% of the flow to the sanitary system is from miscellaneous industrial sources, such as cooling tower blowdown, final rinse water from stainless-steel part cleaning, and treated photographic wastes (after silver recovery). RFP does not have senior water rights and holds no claim to complete consumptive use of water under current contractual arrangements. Water entering the plant and not consumed in beneficial use is returned to the stream, following treatment, to benefit downstream users. The desire of downstream entities to prevent discharge of water from RFP into their water supplies will probably affect this practice, but the implications of total zero discharge on the rights of downstream users have not been explored in depth.

The RFP pond system accumulates water flows of two basic types, treated sanitary and domestic effluent (wastewater) and precipitation runoff (return flows). Historically, the B-series ponds collected mainly treated sanitary effluent with some seasonal runoff, and the A- and C-series ponds accumulated precipitation runoff and other return flows. This source distinction is important because the seasonal nature of the two flow types determines, in part, the available pond operational modes. Because the A- and C-series ponds accumulate runoff and other return flows, their fill rates are seasonal (high in spring and falling to zero in the winter months). The lower B-series ponds, however, accumulate persistent flows of treated STP effluent. These flows increase during the spring runoff but continue substantially throughout the winter. Different strategies are required to manage flows, provide water detention and sampling, and conduct required water treatment at different time periods.

3.1.1 Pond Surveillance

RFP ponds serve three main purposes: monitoring and control of water quality, spill control, and storm water detention. Pond operations are separable into two basic functions, maintaining the impoundments and managing the water they accumulate. Normal operational activities include:

- Logging pond status information, including pool elevation and water inflow and outflow.
- Recording dam safety information, including piezometer levels, and visually inspecting embankments and side slopes for cracking or sloughing.
- Controlled downstream release of Ponds A-3, A-4, B-3, B-5, and C-2, in accordance with applicable NPDES requirements, to maintain capacity for future flows.
- Operation of evaporation systems at the Landfill Pond and Ponds A-1 and A-2 to reduce water levels and maintain those ponds in a zero-discharge mode.
- Transfer of water among ponds to equilibrate rainfall capacities, conduct spray evaporation, or facilitate water treatment operations.
- Recovering water samples to evaluate and demonstrate water quality.
- Discharges of ponds in accordance with the RFP NPDES permit.
- Operation of treatment systems at terminal Pond A-4, as required, to assure water quality.

RFP ponds are operated in a manner consistent with best management practices regarding dam safety while ensuring the highest quality water releases to downstream users. In addition to pond management programs that ensure high quality water, RFP conducts an integrated dam safety program to minimize the risk of dam failure and the accompanying uncontrolled release of contaminated sediments and large quantities of impounded water. Pond pool elevations (and dam piezometer levels at Pond B-5 only) are recorded three times per week, although the frequency is increased when heavy precipitation occurs or continually high pool levels are present. Additional assurances of dam integrity are provided by visual inspections of embankments and side slopes for cracking or sloughing. RFP dams and safety practices are routinely reviewed by the U. S. Army Corps of Engineers and others.

If an emergency situation involving excessive water levels develops, a draft *Contingency Plan for Unplanned Releases and Emergency Discharges from Rocky Flats Detention Ponds A-4, B-5, C-2* identifies actions and responsibilities for corrective measures. (EG&G 1990e) The Contingency Plan also outlines action levels and procedures and prescribes notification procedures to be followed in the event of an emergency situation. The Contingency Plan provides a detailed set of actions to be followed in providing controlled release of water from the affected pond(s).

3.1.2 Pond Locations and Descriptions

Ponds A-1, A-2, B-1, and B-2 have been in service since the early days of plant operation and are currently operated in a zero-discharge mode. The Landfill Pond, which was built in 1974, is also operated in the zero-discharge mode. Ponds B-1 and B-2 are used to collect upsets or suspect flows from the STP. Ponds A-1 and A-2 collect seep and culvert flows and some precipitation runoff from the northern area of the plant site. Spray evaporation at the Landfill Pond and over Ponds A-1 and A-2 is conducted when meteorological conditions and pond levels are appropriate. Equalization of catchment volumes is accomplished by transferring water among the upper ponds. Pool levels at these ponds are maintained as low as possible to provide capacity for spill control and to prevent uncontrolled spillway release of water due to unexpectedly heavy precipitation.

Downgradient of Ponds A-1 and A-2, Pond A-3 collects and initially detains most of the runoff from the northern plant areas, whereas water from the STP bypasses Ponds B-1 and B-2 to enter B-3 directly (Figure 2.6). Pond A-3 is operated in the "detain, sample, analyze, release" mode at a frequency determined by inflow versus catchment volume. Impoundment construction in these cases (Ponds A-3 and B-3) allows safe accumulations of routine pool levels in excess of 50 percent of capacity. Releases from both ponds are regulated by, and discharges are performed in accordance with, the RFP NPDES permit.

Pond A-3, which collects the substantial portion of the North Walnut Creek and northern plant site runoff, is released periodically to Pond A-4. Sampling is conducted prior to release to ensure high-quality water. Timing of this release is dependent on anticipated inflow of storm-water runoff, current pool level of both Ponds A-3 and A-4, and the existence of operable treatment facilities at Pond A-4. The goal is to equalize the retained volumes in both ponds such that neither pond is maintained for extended periods of time at greater than 50 percent of capacity.

Pond B-3 accumulates treated sanitary effluent from the STP and must be routinely discharged. Pond B-3 receives persistent daily flows from the STP (approximately 250,000 gallons per day) and because of its limited capacity (600,000 gallons), it must be released to Pond B-4 (a flow-through pond not used for water detention) and Pond B-5. Water from Pond B-3 was predominantly controlled by spray irrigation until regulatory concerns resulted in a moratorium on that practice in early 1990. (The issue of spray irrigation could be revisited as part of the total pond management update, as that method of water elimination can be a valuable management tool.) Pond B-3 is also a NPDES discharge point and releases daily during daylight hours in accordance with the requirements of the permit. Biomonitoring, including Whole Effluent Toxicity (WET) testing, is being conducted using ceriodaphnia and fathead minnows per the requirements of the FFCA.

Ponds A-4, B-5, and C-2 were constructed and placed into service in the early to mid-1980s. These ponds are the terminal ones in each pond series and represent the last opportunity for monitoring and controlling possible contaminants. The terminal ponds are designed as detention structures to be drawn down routinely to the 10 percent pool level. These ponds are designed to contain the 100-year rainfall, and maximal capacity for storm-water detention is provided when pool levels are kept low. Treatment systems designed for removal of organic and certain inorganic (and radionuclide) contaminants are available for the terminal ponds and can provide conditioning of water prior to discharge.

3.2 Pond Discharge Management

The detailed procedures that are followed to initiate, terminate, and resume discharge from the terminal ponds are presented in this section. The narrative is augmented by flow charts showing approval routes (Figures 3.1 and 3.2).

3.2.1 Overview and Justification

There are three main goals in effective pond management: (1) to ensure adequate control of runoff through detention of a major storm event; (2) to ensure high-quality water discharges through routine monitoring and treatment for likely contaminants prior to release; and (3) to provide spill control and containment. These goals have guided pond operations for many years, but they were expanded in scope as a result of the events following the chromic acid incident (February 1989) and EPA/FBI investigations. As a result of allegations of water contamination by exotic and hazardous chemicals, increased monitoring and assessment of RFP waters were subsequently dictated via the Agreement in Principle (AIP). In addition, the allegations resulted in CDH and EPA involvement as well as concern expressed by downstream water users, further resulting in expanded requirements for reporting and control by the pond operations program. Agreement to allow CDH to sample and analyze water from the terminal ponds prior to discharge was originally established by a 1979 Memorandum of Understanding between DOE and CDH.

Since temporary water quality stream standards were proposed (June 1989) for the upper reaches of Walnut Creek and Woman Creek (originating in RFP controlled areas), treatment of water prior to release has been conducted to meet standards. *Since the mid-1989 time frame, water released from RFP terminal ponds has met the new, more stringent discharge standards.* The quality of pre-release and discharged water has been closely monitored by RFP and its subcontractors as well as by regulatory agencies.

The newer stream standards necessitate extensive analyses for minute quantities of possible contaminants and radionuclides and also substantially increase the lead time required to conduct a water release. The impact of this change has been an increase in the effort (and cost) of demonstrating high-quality water.

3.2.2 Pre-Discharge Evaluation

The decision to initiate pond discharge occurs after assessing anticipated runoff/-recharge flows and current pool levels (Figures 3.1 and 3.2). Because the presence of contaminants cannot be established without analysis, samples of pond water must be acquired as early as possible. The need to pursue sampling as early as possible conflicts with the goal of acquiring representative measurements of discharge contaminant levels,

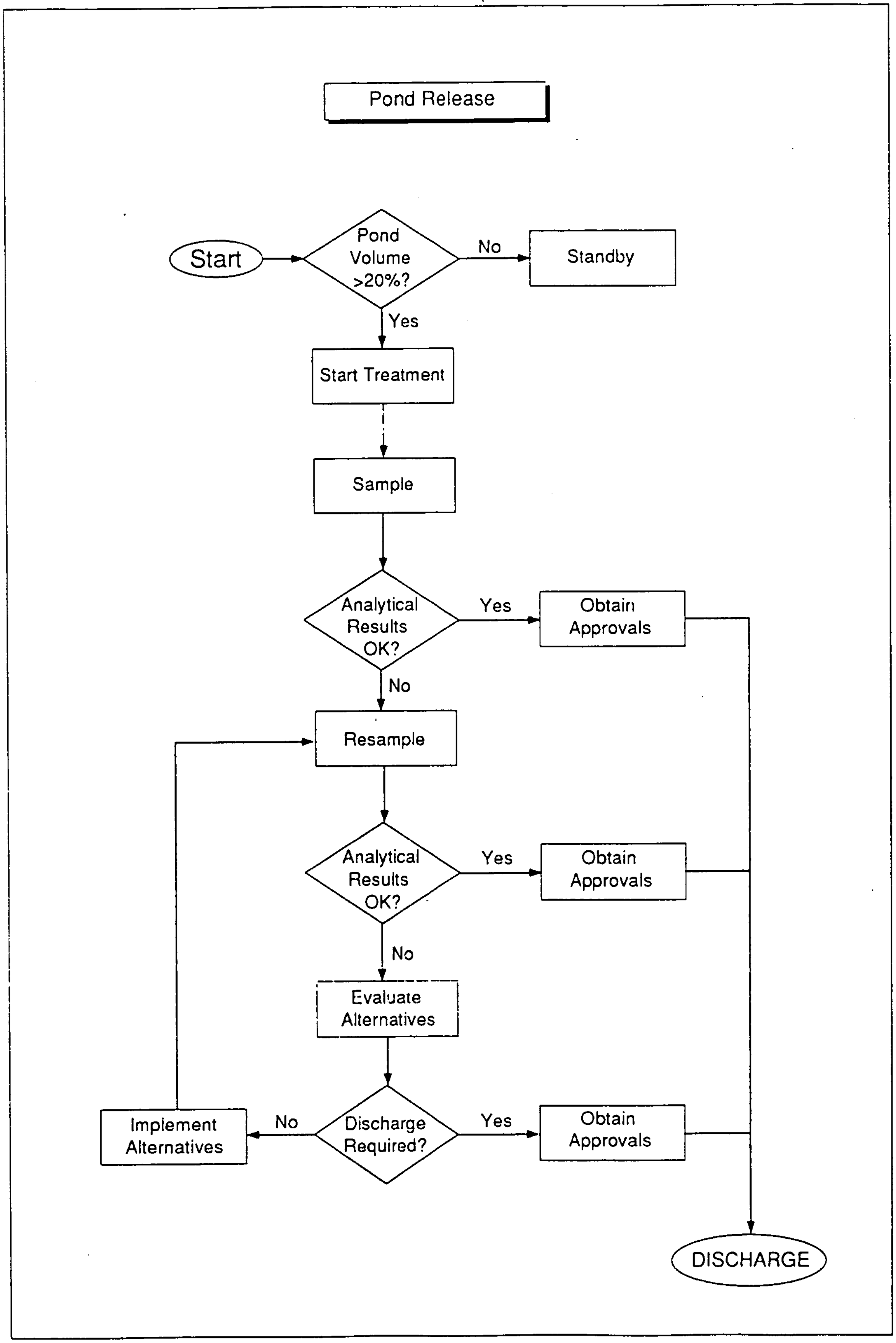


Figure 3.1 Discharge Management Flow Chart I

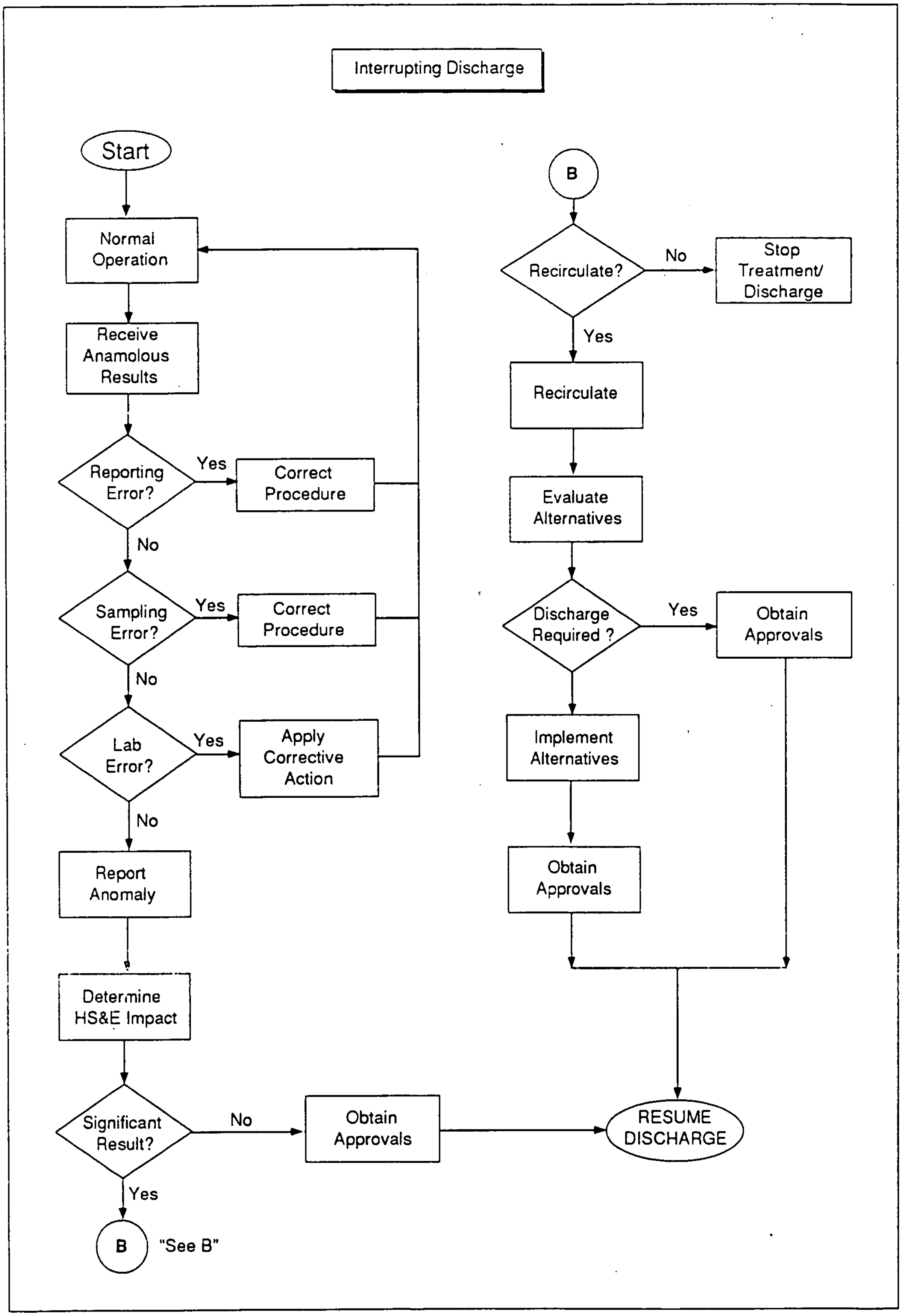


Figure 3.2 Discharge Management Flow Chart II

as the pond content may vary with fresh inflow following sampling. As the minimum time for processing *onsite* radiochemical samples (i.e., analytical turnaround) is two to three weeks and *offsite* turnaround is 61 days, adequate sampling lead time must be available before release is required.

Unavoidable delays in receiving analytical results represent a key operational difficulty and present considerable challenges during high runoff periods. The single major prerequisite for release of RFP pond water is substantiating the absence of contaminants in discharged water. Because the outcome of sample analyses is not predictable, any treatment facilities must be operational at the time of sampling to allow collection of both raw and treated water samples. This approach prevents delays in initiating discharge due to stray contaminants when the only available samples are of raw water.

3.2.3 Treatment Limitations

The availability of water treatment is desirable in the event that contaminants are detected in RFP terminal pond waters. However, the remote location of the terminal ponds and freezing seasonal temperatures make existing open-air operations difficult for four months of the year. Liquid water is required for conveyance to the treatment operation, and substantial operational difficulties can be encountered when water is near the freezing point. Treatment systems are initially operated in the recirculating (returning water to the source pond) mode, and samples are drawn from raw and treated water.

After sample collection, treatment can be suspended to conserve resources and minimize waste generation. However, in the absence of flow, unheated treatment system components can quickly foul in sub-freezing conditions and may become inoperable before permission to discharge is obtained. Heated enclosures that cover the treatment facilities and that pass Health and Safety and NEPA review are being installed to improve winter operability.

3.2.4 Water Sampling and Analysis

Reporting Practices for Radiochemical Data

RFP analyzes literally thousands of samples annually for low-level radiochemistry in gas, liquid, and solid matrices. (Rockwell 1988b; EG&G 1990c) Water samples are collected and analyzed according to established protocols by two or three independent analytical organizations. Analytical results are returned in a form:

Sample Result = Estimated Mean Analyte Concentration ± Measurement Uncertainty

The reported sample result of mean analyte concentration is an estimate which should always be qualified by the measurement uncertainty or precision. Accuracy is achieved by reducing uncertainty and bias in the analytical method.

Another key factor is that of minimum detectable activity (MDA); this factor is extremely important to quantitation of low-level analytes. Method variability and other method-specific parameters are used to determine a MDA, which depends on the radiochemical analyte and matrix being analyzed. MDA is formally defined by the relationship:

$$MDA = (4.65S_B + 3/(T_S E_S Y))/aV$$

where,

- S_B = standard deviation of the population of appropriate blank values (d/m)
- T_S = sample count time (m)
- E_S = absolute detection efficiency of the sample detector
- Y = chemical recovery for the sample
- a = conversion factor (d/m per unit activity)
- V = sample volume or weight.

Current MDA's (pCi/liter) for RFP 123 Laboratory water analysis* are:

Analyte	1-liter Sample	5-liter Sample	Percent Recovery
Pu-239	0.078	0.016	> 30
Pu-239	0.094	0.019	30
Am-241	0.082	0.017	> 30
Am-241	0.094	0.019	30

* Calculations assume an average detector efficiency of 20% and a 12 hour sample count time.

RFP generally reports all valid data resulting from water and environmental sampling programs, whether or not they fall below the MDA. (Rockwell 1988b; EG&G 1990c) Therefore, readers should take careful note of both reported measurement uncertainties and relevant MDAs when interpreting reported analytical values.

Advantages to reporting all actual data include (1) accuracy and propriety of technical approach, (2) availability of tracking and trending options which identify meaningful changes, and (3) identification of any bias in reported data; these advantages far outweigh any disadvantages of potential misinterpretation.

In assessing or establishing the meaning of analytical results; however, it is important to recognize the limitations of the analytical and statistical methods and how these impact any conclusions drawn from data. Established scientific method requires that all valid data be considered in formulating conclusions. Recognizing that analytical measurements are subject to imperfections, approximations, interferences, and errors, data from analytical procedures are generally evaluated by statistical methods to discard outliers or anomalous data values.

Importantly, as the estimated sample mean approaches some lower limit, the measurement uncertainty associated with that sample value approaches or overwhelms the magnitude of the measured value. The uncertainty or variability must be considered in evaluating the significance of the reported value. Certainly data falling near or below the reported uncertainty level or MDA should be viewed with caution since these data will have a high relative variability. Comparisons between any such data values should also be made with caution; appropriate statistical tests should be applied to determine the significance of any numerical differences.

Extensive analyses for radionuclides are conducted on water from terminal ponds under consideration for discharge. Pond water is analyzed for the radiochemical parameters to the detection limits listed in Table 3.1.

Table 3.1

Detection Limits for Radiochemical Parameters in Water Samples*

Parameter	Detection Limit (pCi/L)
Gross Alpha	2
Gross Beta	4
Tritium	400
Plutonium-239,240*	0.01
Uranium-233,234	0.6
Uranium-235	0.6
Uranium-238	0.6
Americium-241*	0.02
Strontium-89,90	1
Cesium-134	1
Radium-226	0.5
Radium-228	1
Curium-244	1
Neptunium-237	1
Thorium-230,232	1

Analytical Method Limitations

Standard radiochemical analyses utilize characteristics of the radioactive decay process, itself, in identifying and quantifying radionuclides. As such, practical lower limits of

* Detection limits (DLs) are sensitive to sample volume; listed DLs are characteristic of 5-liter sample volumes, whereas, the majority of current and historical data were acquired using 1-liter samples whose corresponding DLs were *five* times higher. Apparent inconsistencies with Workplan Section 3.2.4 MDA values for Pu and Am are due to rounding.

detection for radionuclides are limited by the activity of the sample. The concentration of radionuclide in the sample is calculated from the relationship,

Quantity of Radionuclide = Count Rate / Constant

where the "constant" is related to the half-life of the specific radio-isotope. Current MDAs for plutonium and americium depend on, among other factors, the volume of sample collected. Normal MDAs for routine water samples evaluated by RFP are shown above. Currently, the majority of samples for plutonium and americium analyses are one liter in volume for which MDAs of 0.08 pCi/L are appropriate (See Section 3.2.4). The accuracy and reliability of routine plutonium and americium data below this value are questionable.

Within practical constraints detection limits can be lowered by utilizing larger sample volumes and longer counting times. The advantages of this increased sensitivity are generally offset by the time and resource requirements for handling larger sample volumes and the increased risk of sample contamination during the extended analytical procedure. The current onsite RFP analytical scheme optimizes sample throughput and turnaround using a one liter sample volume.

The following analytical methods are used to analyze surface-water samples collected at RFP:

1. *Gross Alpha and Beta* - Method 302, "Gross Alpha and Beta Radioactivity in Water," *Standard Methods for the Examination of Water and Wastewater,* 13th Ed., American Public Health Association, New York, New York, 1971.

2. *Radium-226* - Method 305, "Radium 226 by Radon in Water," ibid.

3. *Strontium-89,90* - Method 303, "Total Strontium and Strontium 90 in Water," ibid.

4. *Cesium-134* - ASTM D-2459, "Gamma Spectrometry in Water," *1975 Annual Book of ASTM Standards, Water and Atmospheric Analysis,* Part 31, American Society for Testing and Materials, Philadelphia, Pennsylvania, 1975.

5. *Uranium* - ASTM D-2907, "Microquantities of Uranium in Water by Fluorometry," ibid.

6. *Tritium* - "Developed and Modified Method for Tritium," *Procedures for Radiochemical Analysis of Nuclear Reactor Aqueous Solutions,* H.L. Krieger and S. Gold, EPA-R4-73-014. U.S. EPA, Cincinnati, Ohio, May 1973.

7. *Neptunium-237* - "Developed and Modified Method for Neptunium," ibid.

For the following elements, no reference method was located within the texts specified by 40 CFR 141.25. The following analytical methods, drawn from EPA laboratory publications and DOE procedures, are used at RFP:

1. *Radium-226,228* - "Determination of Radium-226 and Radium 228 in Water, Soil, Air, and Biological Tissue," *Radiochemical Analytical Procedures for Analysis of Environmental Samples,* U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, March 1979.

2. *Thorium-230,232*- "Isotopic Determination of Plutonium, Uranium, and Thorium in Water, Soil, Air, and Biological Tissue," ibid.

3. *Plutonium* - ibid.

4. *Americium* - "Americium-241 and Curium-244 in Water, Radiochemical Method," *Department of Energy Environmental Survey Manual,* 4th Ed., U.S. DOE, Washington, D.C.

5. *Curium-244* - ibid.

Both raw and treated pond water samples are analyzed by three independent parties, including CDH. Collected samples are split and preserved as appropriate for transport to onsite and offsite laboratories. Currently, key pre-discharge samples (and many others) are analyzed independently by CDH, RFP, and an offsite contractor to RFP. Offsite contracted laboratories currently use RFP's General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (9/14/90 Rev. 1.1).

Accurate determinations of extremely low radionuclide concentrations require prolonged sample turnaround times; for many parameters, these time frames exceed two weeks for onsite determinations and are frequently greater than 61 days for offsite laboratories. Until analytical results are received, any water passing through the treatment systems is recirculated (without discharge) to the source pond.

3.2.5 Approval to Discharge

According to provisions of the AIP, assessment of water quality must be performed by CDH before discharges from the treatment systems can be routed downstream. CDH concurrence is directed to the Department of Energy/Rocky Flats Office, which subsequently directs EG&G and the current treatment system operators (under the direction of EG&G) to initiate downstream release. CDH concurrence on discharge is provided in written form after sufficient water quality data are available to indicate that the water is of high quality and meets all requirements for release to Walnut Creek or Woman Creek. CDH concurrence typically requires that additional treatment and testing be completed.

DOE has agreed to abide by CWQCC stream standards without stipulating any authority on the part of CDH or EPA to regulate radionuclide discharges from the facility. EPA is contacted for written approval for any diversion of water from Woman Creek to Walnut Creek or the Broomfield Diversion Ditch (BDD). During periods of treatment system operation, gross alpha and gross beta screenings are performed to identify changes in water quality. Additional sampling for specific radionuclides is performed to characterize the quality of water during discharge, and these results are reported at monthly information exchange meetings attended by representatives of the State, RFP, local municipalities, and other interested parties.

3.2.6 Current Discharge Mode

Water from Pond B-5 is transferred to Pond A-4 for treatment, and discharges from Pond A-4 are currently treated and outfall into Walnut Creek. Although the water routinely met CWQCC standards, all CDH discharge concurrences, to date, have required treatment (Section 3.4.1). The effluent is voluntarily diverted to the BDD, beginning on the east side of Indiana Street. Water from Pond C-2 is treated and conveyed overland and northeast by pipeline to the BDD. The onsite, piped diversion was approved by EPA, and the water release to the BDD was negotiated with the City of Broomfield. The diversion pipeline from the Woman Creek to Walnut Creek drainage was completed at the request of the City of Westminster (which wanted no RFP water entering Standley Lake). The BDD is not tributary to Walnut Creek and outfalls into Big Dry Creek below Great Western Reservoir; therefore, the Reservoir was not impacted by discharges of Ponds A-4, B-5, or C-2. Water from the diversion pipeline entered the BDD, which was already in place; however, EPA approval to convey the Pond C-2 to BDD ended December 1990.

3.2.7 Interruption or Suspension of Discharge

Operational personnel routinely track water quality parameters for anomalies in treatment operations or analytical results that can force temporary or prolonged shutdown of discharge. Anomalous analytical results indicating possible exceedence of discharge standards trigger notification of CDH, EPA, and the downstream cities of Broomfield, Westminster, Thornton, Northglenn, and Arvada and may result in immediate suspension of discharge. Recirculation to the source pond is the preferred alternative until confirmation of results is received. This option, which will be used when single "hits" or suspect analytical results that may be resolved quickly are encountered, should be adequate for protection of downstream water consumers while avoiding delays in resuming treatment and discharges.

When anomalous or elevated analytical results are reported, any number of causes (laboratory error, sample contamination, reporting error) are possible. The result may also be accurate. The anomaly is investigated to verify or discount it through a combination of quality assurance and quality control checks and re-evaluation of any remaining sample. Analytical procedures are checked and additional sample portions are analyzed to determine if laboratory error or sample contamination occurred. Additionally, comparison with results from sample splits with one or more of the independent laboratories may be available. Multiple samples and analyses of water samples are desirable to ensure confidence in parameter measurements.

Ideally, contaminant levels verified above standards in treated water would require re-evaluation of treatment measures before discharge is resumed. However, continuous inflow to the ponds does not permit indefinite complete suspension of discharge, and the decision to release water may be necessary to protect the structural integrity of the dams.

3.2.8 Pond Level Operational Goal

Operational approach will vary slightly with seasonal runoff, with March to June as the most critical time period. The general approach is to reduce the risk of dam weakening by maximizing the time that pond levels are low (preferably at or below 10 percent of capacity). This appears simple in principle, but maintenance of pond volumes below 20 percent of capacity is difficult in practice because of (1) the time required to obtain discharge approval for and (2) frequent interruptions of discharge, which often result in a restart of the entire sampling, analysis, and approval cycle. When these delays are frequent and of significant duration, pond levels routinely exceed permitted levels and those directed by dam safety considerations. Streamlining the discharge approval process control is necessary if RFP waters are to be controlled in an effective manner.

3.2.9 Termination of Successful Discharge

Successful treatment operations are normally terminated when the residual pond water volume is at or below 10 percent of capacity. Cessation of flow when pond levels are low is one measure taken to minimize sediment scouring, resuspension, and transport.

3.3 Statistical Study of Radionuclide Levels

3.3.1 Basis and Scope of Study

Regulatory agencies and members of the public have shown concern over potential impacts of RFP operations on the quality of surface water in the vicinity of RFP. In response to this concern, RFP conducted a statistical assessment of available data for radiochemical contaminants (plutonium, uranium, and americium, gross alpha, and gross beta) in water to identify differences between impacted and unimpacted water sources. (Bauer 1990)

Levels of radiochemical contaminants in samples collected from several surface-water sources in 1988, 1989, and 1990 were analyzed by standard statistical methods. Mean and median concentrations for radiochemistry in the various sources were compared to reveal differences among the locations. Water quality data were compiled and compared for the following locations:

- Pond A-4
- Pond B-5
- Pond C-1
- Pond C-2
- RFP Building 124 raw water (drawn from the Denver Water Department's South Boulder Diversion Canal)
- Walnut Creek (at Indiana Street)

3.3.2 Summary of Statistical Results

Although more data are required to improve confidence in the conclusions, statistical evaluations of average radiochemical levels in water from the six locations (above) indicate minor differences in levels of radiochemical contaminants among the various water sources. Results are explored more fully in Appendix II, but are summarized as:

1. Mean plutonium levels in Pond C-2 appear higher than the remaining five locations; this result is likely due to the moderate sample size for Pond C-2 data, which includes three rather large values. Mean plutonium concentrations at the five remaining locations are not statistically different from one another.

2. No statistically significant differences existed for the mean americium concentrations among the six locations.

3. The mean uranium concentration in Pond A-4 is significantly higher than the mean uranium concentration at the Walnut Creek sampling location, which is statistically higher than the remaining locations.

Selected results of statistical assessments of plutonium, americium, and uranium concentrations in subject RFP surface waters are summarized in Tables 3.2, 3.3, and 3.4.

Table 3.2
Average Plutonium Concentration

LOCATION	Number of Samples	Mean Concentration (pCi/L)	Grouping*
Pond C-2	21	0.025	A
Walnut Creek	68	0.013	B
Pond C-1	101	0.012	B
Pond B-5	54	0.006	B
124 Raw	33	0.006	B
Pond A-4	45	0.005	B

* Means sharing a common letter in the grouping column are not statistically different from one another.

Table 3.3
Average Americium Concentration

LOCATION	Number of Samples	Mean Concentration (pCi/L)	Grouping*
Walnut Creek	68	0.010	A
Pond B-5	56	0.009	A
Pond A-4	45	0.008	A
Pond C-2	21	0.007	A
Pond C-1	103	0.007	A
124 Raw	32	0.003	A

* Means sharing a common letter in the grouping column are not statistically different from one another.

Table 3.4
Average Uranium Concentration

LOCATION	Number of Samples	Mean Concentration (pCi/L)	Grouping*
Pond A-4	47	5.20	A
Walnut Creek	67	4.37	B
Pond C-2	21	3.51	C
Pond B-5	56	3.07	C
124 Raw	32	1.27	D
Pond C-1	105	1.18	D

* Means sharing a common letter in the grouping column are not statistically different from one another.

Common practice in comparisons of this sort is to separate populations into groups which show no statistical differences in the parameter of interest. Means sharing a common letter in the grouping column (above) are not statistically different from one another. Groupings highlight statistically significant differences, if any, in mean concentrations between locations. For example, the Table 3.2 mean plutonium concentration for Pond C-2 (group A) is significantly higher than the remaining five locations (group B). The mean plutonium concentrations at the five remaining locations are not statistically different from one another. As an aid in comparing mean plutonium concentrations, and those for the other radionuclides, the histograms (Appendix II, Figures II-1 through II-5) should consulted. These histograms help illustrate significant differences between the means.

Few statistically significant differences in the average concentrations of radiochemical constituents occur between upstream and downstream sources near RFP. Ponds A-4 and B-5 show no difference from RFP raw water in mean plutonium and americium levels, whereas, Pond C-2 water shows a higher mean plutonium level than other locations. A possible explanation is that historical data for Pond C-2 were acquired during periods of high spring runoff.

Some Walnut Creek locations (groups A and B in Table 3.4) show higher mean uranium levels; the reason for this is not readily apparent. It should be noted that the geology of the RFP area contains numerous deposits of natural uranium and significant differences are likely due to inhomogeneous distributions of these natural deposits.

3.3.3 Assessment RFP Water vs. CWQCC Stream Standards

CWQCC has set the stream standards listed in Table 3.5 for water at Walnut Creek and Indiana Street and at outfalls of Ponds A-4, B-5, and C-2:

Table 3.5

CWQCC Stream Standards for Big Dry Creek, Segment 4

Radionuclide*	Standard (pCi/L)
Plutonium	0.05
Americium	0.05
Uranium	10/5**
Gross Alpha	11/7**
Gross Beta	19/5**
Tritium	500
Curium-244	60
Neptunium-237	30

* Statewide standards for Cesium-134, Radium 226 and 228, Strontium 90, Thorium 230 and 232 also apply.
** First standard is for Walnut Creek, the second for Woman Creek (including Pond C-2) drainage.

CWQCC stream standards were determined for RFP by statistical evaluation of ambient water data and established to limit degradation in water quality. These standards were derived from ambient water quality data collected from the Walnut Creek and Woman Creek locations during the approximate time period of January 1984 through May 1989. The standards were calculated as the mean of the data plus two standard deviations (i.e., the 95 percent confidence level) and assumed normal data distributions. As a consequence of this approach, exceedences of the standards would be expected approximately one-half of the 5 percent (i.e., only for the upper tail of a two-tailed distribution) or 2.5 percent of the time per analyte. However, the skewed, non-normal nature of the data will likely result in a considerably greater percentage of exceedences; distribution-free analysis of the actual water quality data indicates actual exceedences for plutonium occur roughly 7 percent of the time (see below).

Available data on plutonium, americium, and uranium levels for RFP raw water and surface waters in surrounding areas were compiled for 1988 through 1990. Comparisons were made to assess the relative quality of local water sources in relation to CWQCC stream standards for Segment 4 of the Big Dry Creek Basin. The goal of the comparisons was to assess the relative quality of RFP water and other local water sources in relation to the CWQCC stream standards. Although results are preliminary and the analysis rather simplistic, significant percentages of single-sample exceedences are found for plutonium and americium (but not for uranium) levels in offsite water.

This result is most likely an artifact of analyses conducted near the minimum detectable activity (MDA)(as evidenced by *negative* concentrations) and natural variability expected from the definition of the CWQCC standards around the 95% confidence interval. Comparisons are shown in Tables 3.6 through 3.8. (Additional comparisons of various RFP and non-RFP waters to the CWQCC stream standards appears in Appendix II.)

Table 3.6

Comparison of Plutonium Concentrations in Surface Waters and in Surrounding Areas* (1988-Present)

Location	Number of Samples	Mean Pu-239,240 (pCi/L)	No. Samples ≥0.05 pCi/L
RFP Raw Water	11	0.002	0
Total	**11**	-----	**0%**
Arvada	11	0.000	0
Boulder	34	0.001	0
Broomfield	35	0.004	1
Denver	11	-0.002	1
Golden	11	0.002	0
Great Western	35	0.004	1
Lafayette	11	-0.002	0
Louisville	11	-0.002	0
Standley Lake	35	0.002	1
Thornton	11	0.008	1
Westminster	35	-0.001	0
Others**	12	0.006	1
Totals	**263**	-----	**2.3%**

* Values taken from RFP monthly reports.
** Includes the South Boulder Diversion Canal, Ralston Reservoir, Dillon Reservoir, and Boulder Reservoir.

Table 3.7

Comparison of Americium Concentrations in Surface Waters and in Surrounding Areas* (1988-Present)

Location	Number of Samples	Mean Am-241 (pCi/L)	Samples ≥0.05 pCi/L
RFP Raw Water	11	0.004	0
Total	**11**	-----	**0%**
Arvada	11	0.016	1
Boulder	35	0.002	0
Broomfield	35	0.002	0
Denver	11	0.013	3
Golden	11	0.002	0
Great Western	35	0.002	0
Lafayette	11	0.004	0
Louisville	11	0.004	0
Standley Lake	35	0.004	0
Thornton	11	0.026	2
Westminster	35	0.005	1
Others**	12	-0.003	0
Totals	**264**	-----	**2.7%**

* Values taken from RFP monthly reports.
** Includes the South Boulder Diversion Canal, Ralston Reservoir, Dillon Reservoir, and Boulder Reservoir.

Table 3.8

Comparison of Uranium Concentrations in Surface Waters and in Surrounding Areas* (1988-Present)

Location	Number of Samples	Mean U-234,238 (pCi/L)	No. Samples ≥10 pCi/L	No. Samples ≥5 pCi/L
RFP Raw Water	11	0.97	0	0
Total	**11**	-----	**0%**	**0%**
Arvada	11	0.43	0	0
Boulder	35	0.30	0	0
Broomfield	35	0.93	0	0
Denver	11	0.91	0	0
Golden	11	0.98	0	0
Great Western	35	1.53	0	0
Lafayette	11	0.12	0	0
Louisville	11	0.09	0	0
Standley Lake	35	1.73	0	0
Thornton	11	1.55	0	0
Westminster	35	0.62	0	0
Others**	12	0.89	0	0
Totals	**264**	-----	**0.0%**	**0.0%**

* Values taken from RFP monthly reports.
** Includes the South Boulder Diversion Canal, Ralston Reservoir, Dillon Reservoir, and Boulder Reservoir.

3.3.4 Conclusions of Statistical Study

Radionuclide levels in water discharged from RFP routinely meets CWQCC stream standards based upon the 30-day running average (see Appendix II). These radionuclide levels are approximately 0.1 to 1.28 percent of the applicable health-based Derived Concentration Guides (DCGs) specified by DOE Order 5400.5, "Radiation Protection of the Public and the Environment." These DCGs are based on recommendations of national and international advisory groups, and on radiological protection standards set by other federal agencies.

Analysis to date on existing data indicates extremely low concentrations of radionuclides in water both influent to and effluent from RFP and with the exception of the slightly elevated plutonium levels in Pond C-2 water and uranium levels in some Walnut Creek locations, radionuclide levels show only minor differences among the sampling sites. Frequency distributions for the radionuclide data show non-normal characteristics that suggest careful consideration of actions or reactions based on single-value exceedences is appropriate.

In addition, if CWQCC stream standards for the RFP-specific segments of the Big Dry Creek basin were applied to other water sources decidedly unimpacted by RFP, routine exceedences of radionuclide standards would be expected to occur on a regional or statewide basis.

3.4 Current Treatment Approach

3.4.1 Current Treatment

In March 1990, RFP began treating collected surface water in an attempt to meet proposed CWQCC water quality stream standards for Segment.4 of Big Dry Creek Basin. As noted above, the new stream standards included radiochemical standards for plutonium, americium, uranium, gross alpha, and gross beta as well as other radionuclide standards incorporated into the IAG.

In response to the new radiochemical standards, RFP initiated an evaluation of treatment technologies potentially applicable to the removal of radiochemical contaminants from pond water. This initial evaluation, which included both literature reviews and vendor contacts, concluded that the primary radionuclides of concern (plutonium and americium) were most likely associated with suspended particulate or colloidal material (organics, silicates) in the ponds (Orlandini 1990; Penrose 1990; EG&G 1990a). Therefore, RFP believed that reductions in radionuclide concentrations would result from treatment utilizing a filtration system capable of removing a significant percentage of the total suspended solids (particulate matter greater than 0.45 micron). This would theoretically result in a corresponding reduction in radionuclide levels.

<u>Simple Filtration/Filter Bag Evaluations</u>

Preliminary field evaluations of 0.5 micron-rated polyester filter bags, using actual pond water at a flow rate of approximately 200 to 300 gallons per minute (gpm), indicated that concentrations of indicator parameters (gross alpha and gross beta) were effectively reduced. Based on the performance of the filter bags in this limited test and the impending dam safety considerations, a full-scale treatment operation utilizing systems of 10 micron, 5 micron, and 0.5 micron filter bags placed in series was implemented.

After a period of system operation in the field, it became apparent that the anticipated reduction in the levels of gross alpha and gross beta (and the related reduction in plutonium and americium) were not being effected by the bag filtration process. Upon further review, it also became apparent that the total suspended solids were not being reduced to the levels suggested by the 0.5 micron bag rating.

Further field evaluations using alternative filter socks and filter housings manufactured by other suppliers were conducted. Initial indications are that the effectiveness of the filtration system can be measurably increased by upgrading both the filter socks and the filter housings. However, it remained unclear whether continued treatment for removal of suspended solids to the 0.5 micron range using filtration alone would bring about a corresponding reduction in the level of the radionuclides of concern.

Contracted Radionuclide Removal Study

A parallel study was initiated through an RFP contractor to evaluate all technologies, and combinations of technologies, that could result in the required radionuclide removal rates. (IT 1990) The evaluation focused on removal of dissolved uranium and considered the size of the treatment system, quantity and manageability of waste generated, and overall cost. (The partitioning of plutonium and americium contaminants between particulate, colloidal, and dissolved phases in RFP pond water is currently unknown. Evaluators utilized knowledge and experience of uranium removal to simulate removal of dissolved actinides.) The following is a summary of the study conducted by the contractor and based on literature and vendor contacts.

Twelve alternatives were evaluated with regard to performance, costs, and waste generation. Of these, six utilize ultrafiltration (UF) as a final polishing step for removal of uranium. The six UF alternatives were evaluated and were found to be comparable in performance, except for the final unit operation, to the alternatives using ion exchange. In order to simplify the overall evaluation, a separate comparison was made between UF and ion exchange based on the presence of dissolved uranium. Ion exchange was recommended for further work.

Treatment methods for conditioning pond water include technologies such as settling/clarification, dissolved air flotation, and filtration. Conditioning would be followed by carbon adsorption for removal of organic contaminants and ion exchange or UF for uranium removal. A list of the favored methods follows:

- Parallel plate separator, followed by polishing with sand filtration.
- As immediately above, followed by polishing with cartridge filtration.
- Sand filtration, with the backwash of the sand filter being treated by a sludge thickener and filter press, followed by polishing with cartridge filtration.
- Dissolved air flotation, followed by polishing with sand filtration.
- As immediately above, followed by polishing with cartridge filtration.
- Sand filtration, with the backwash of the sand filter being treated by a dissolved air flotation unit and filter press, followed by polishing with cartridge filtration.

This treatment train assumed no chemical precipitation would be used. A chemical precipitation process should be considered in conjunction with, or as an alternative to ion exchange in developing future treatment trains for evaluation. Thus, conditioning could treat precipitated as well as suspended radionuclides which occur in the influent. Evaluation of these alternatives to select preferred methods is dependent on further bench- and pilot-scale testing. A summary of proposed treatment evaluations is presented in Section 4.4.1 of this Workplan.

3.4.2 Treatment Method Development

Bench-Scale Tests

Bench-scale tests in the form of jar tests were performed in late July 1990. The basic tests on Pond B-5 water samples were performed to determine effective doses of coagulant and flocculant needed to cause sedimentation of the suspended solids. Tests were conducted on Pond B-5 water samples, as available data indicated that Pond B-5 typically had the highest concentration of suspended solids among Ponds A-4, B-5, and C-2. The jar tests showed that a dose of cationic coagulant at 60 parts per million (ppm) followed by a 0.5 to 1.0 ppm dose of anionic flocculant allowed a large, light sediment to form. The addition of clay caused rapid settling.

Speciation and Low-Detection Limit Study

Water collected from Pond B-5 in August 1990 was supplied to Los Alamos National Laboratory (LANL) for special isotope-specific radiochemical analyses designed to determine accurate contaminant levels. LANL performed bench-scale evaluations of radionuclide removal by particulate filtration, especially when augmented by clay/flocculant addition (Triay 1991). While the analytical results are still preliminary, the study concluded the following:

1. Plutonium and americium levels measured by routine analytical alpha spectrometry were in agreement with results of these special analyses which used mass spectrometry. These early results suggest that high precision mass spectrometry confirms the accuracy of routine alpha spectrometry.

2. Plutonium and americium levels in raw water samples were reduced significantly by filtration with 0.45 micron filters.

3. Plutonium and americium levels in raw water were reduced even further (below filtration alone) by preceding the filtration with addition of clay and cationic flocculant.

4.0 Workplan to Control Radionuclides

Workplan Issues

Workplan development is currently hindered by incomplete engineering data and analytical methodology. As the Workplan is implemented, fact finding, data analysis, and further engineering study and evaluations will improve understanding of technical issues and result in a refined technical approach.

Understanding the problem definition/goals/methods issue is relevant and crucial to preparing this Workplan for control of radionuclide discharges from Rocky Flats. Thus, the following *must* be in place or available to develop the Workplan: (1) the problem must be defined/quantified, (2) realistic control guides or goals must be established, and (3) the tools/methods to address the problem (i.e., control and treatment technology to remove contaminants presenting a real concern) need to be technically feasible or available. However, with the exception of certain radionuclide-specific discharge standards and the goal of minimal releases, none of the other pre-Workplan elements are adequately defined. Issues regarding these elements are further discussed below.

As is recognized in the IAG directive, the importance of analytical methodology is obvious both to define the level of contamination and to evaluate treatment methods. Two issues arise in evaluating radionuclides in water: representative sampling and quality of the estimate of the analyte concentration. The best analytical method provides only an *estimate of the analyte concentration in the sample provided to the laboratory.* In dynamic systems such as the RFP ponds, analyte concentrations can have temporal and spatial variability, and representative sampling becomes an important issue. Generally, analytical results from samples are assumed to be representative of their source and inaccuracies due to sample inhomogeneities or holdup are negligible; however, this is not necessarily the case with sub-pCi/L radionuclide determinations. Because existing evidence indicates the particulate/colloidal nature of the radionuclide contaminants, variability due to sample sedimentation and mixing phenomena in the water source can be substantial.

Available analytical methodology severely limits development and implementation of a Workplan designed to control radionuclides at the levels required. There are simply no standard analytical methods for *routine and accurate* determination of radioactivity in the less than 0.05 pCi/L regime. A key limitation from a technical standpoint is the uncertainty associated with counting low levels of radioactivity whose decay rate is determined by natural laws. This limitation can be partially overcome by (1) improving counting sensitivity, (2) increasing sample sizes/volumes, (3) replicating analyses, and/or (4) increasing count times. However, these approaches are also not without problems, as other key problems and interferences may arise, including increased turnaround time, cross-contamination, and laboratory errors.

Perhaps the single most fundamental, technical determination to consider in evaluating the need for treatment, corrective action, or remediation of contamination is quantitation of actual contaminant levels and their comparison to ambient or natural background levels. Only by comparison to ambient levels in local areas removed from potentially impacted zones can the *need* for action be established. This evaluation is important to establishing the need for treatment, as without background characterization, neither action levels nor treatment requirements/standards can be established.

Workplan Organization

The following sections form the core of RFP Workplan which describes the actual plans and work proposals designed to accomplish control of radionuclide levels in discharges of water from RFP. The core Workplan is separated accordingly to address the four elements specified in IAG Section XII. These four elements are:

- Workplan Element #1: Control of Release of Radionuclides (4.1)
- Workplan Element #2: Assessment of Water Quality (4.2)
- Workplan Element #3: Analytical Methods (4.3)
- Workplan Element #4: Treatment Technologies (4.4)

4.1 Workplan Element #1: Control of Release of Radionuclides

[The] Workplan [shall be] designed to control the release of radionuclides specified herein. The Workplan will require DOE to sample before any offsite discharges from onsite ponds occur. In accordance with the Agreement in Principle, the Workplan will require that split samples be made available to EPA and CDH...DOE will report the results of the sampling and analyses to EPA and the State.

Until such time as treatment proven to be effective in removing radionuclides from water has been developed, the only means by which their release can be controlled is through control of the water that contains them. Therefore, this section of the Workplan addressed two subjects: (1) the methods of control of release of waters from the RFP site and (2) the development and demonstration of treatment methods.

4.1.1 Pond Management Equipment

Operations and surveillance personnel are alert to equipment maintenance and are continually developing enhancement opportunities. System improvements are routinely implemented as funding is available. Recent projects designed by RFP include augmentation of pumping capacity and spray nozzle efficiency to facilitate evaporation at Pond A-2 and at the Landfill Pond. Piping modifications to permit spray pumps to be used for inter-pond transfers and better flow measurement devices to permit more accurate monitoring of transfers are in progress, as is consideration of expansion of spray evaporation to Pond B-2. No schedule for implementation of these projects has been developed.

4.1.2 Dam Safety

Annual inspections of the surface-water detention dams are conducted by the U.S. Army Corps of Engineers jointly with the State Engineers Office (SEO) and Federal Energy Regulatory Commission (FERC). Additional routine monitoring is conducted by RFP operations and surveillance personnel.

The latest report on dam safety, which was prepared in November 1990, incorporated inspection results obtained throughout 1990 by DOE, the State, and FERC and contains more than 90 recommendations related to specific dams. These recommendations were listed according to priorities for implementation. Among the recommendations, only three were categorized as urgent (Priority 2):

1. Downstream slope stabilization and toe protection for Dam B-1
2. Fill crack in Dam B-5
3. Monitor crack area at Dam B-5

Implementation of appropriate response actions for all recommendations was initiated fourth quarter 1990. The geotechnical evaluation required for Item 1 was initiated and will be completed by fourth quarter 1992. Item 2 will be completed by fourth quarter 1991. Item 3 was implemented and is an ongoing activity.

Priorities 3 and 4 are, respectively, "important" or "routine" as reflecting good dam safety practice. All are scheduled for implementation or further study, and many are contingent upon fiscal constraints.

4.1.3 Runoff vs. Pond Level Model

A computer (speadsheet) based model of annualized pond levels as a function of normal (expected) precipitation and anticipated discharge rates was developed in the first quarter of 1990. An improved empirical model for predicting pond inflow and pond levels from parameters current and anticipated temperature, precipitation, and runoff factors will be completed by second quarter 1992.

4.1.4 Weather-Proofed Treatment Enclosures

The current treatment operation utilizes treatment systems relocated and consolidated at Pond A-4. Water from both Ponds B-5 and C-2 will be piped to this single facility for treatment prior to discharge. Because the major winter water flows accumulate in Pond B-5 from persistent releases from the STP through Ponds B-3 and B-4, water is conveyed from Pond B-5 to Pond A-4 via a transfer line. A heated enclosure is being constructed to shelter treatment operations and provide weather protection at the centralized facility. The Pond C-2 to B-5 conveyance will be accomplished using an extension of the existing conveyance from Pond C-2 to the BDD. Conveyance and enclosure improvements will be completed by fourth quarter 1991.

4.1.5 Sampling and Reporting Requirements

<u>Sampling Program</u>

RFP will maintain an ongoing program for sampling and analysis for radionuclides in its terminal ponds (i.e., Ponds A-4, B-5, and C-2). This sampling program will assess the quality of discharge water with respect to the CWQCC stream standards for radionuclides.

RFP will develop a sampling program that provides maximum parametric and temporal coverage within the constraints of available laboratory capacity and fiscal limitations. RFP will share the results of its monitoring program with CDH, EPA, and local municipalities at the information exchange meetings and will publish this information in a timely manner.

RFP will conduct regular monitoring of terminal pond water quality for the following parameters: gross alpha, gross beta, plutonium, americium, tritium, and uranium. RFP will collect composite samples, made up of daily grab samples, for each weekday period (Monday through Friday) and each weekend period (Saturday and Sunday). RFP will compare this 5/2 schedule to results from 7-day composites and to results from straight grab samples to determine the most appropriate method for routine sampling of water for radiochemical parameters. Each composite sample will be collected in sufficient volume to allow at least one re-analysis of each parameter, the total volume being dependent on the composite schedule used. Samples held for possible re-analysis will be archived for at least 30 days following the receipt of analytical results for that portion of the sample originally analyzed. All other parties collecting compliance samples of the RFP terminal ponds will similarly collect and retain sufficient sample volumes to allow re-analysis.

Split Sampling

RFP will coordinate onsite sampling efforts with CDH and other regulatory agencies, through appointed representatives, to assure that samples collected are identical among the various parties. Difficulties in access encountered by any party as a result of plant security measures will be resolved with RFP Security as they occur. RFP will not be under any specific obligation to analyze these split samples on a regular basis but will archive them for the purpose of providing confirmatory analyses for the regulatory agency as needed. These split samples will be retained by RFP for a period of at least 30 days following the receipt of results of samples collected by the regulatory agency.

Representative Sampling

Representative samples will be collected by RFP from waters to be discharged from the terminal ponds. At a minimum, these will include samples of water that have passed through any operational treatment system prior to discharge. In cases where water from one terminal pond is conveyed to another terminal pond prior to release, regular samples of water from the first pond prior to its mixing with water in the receiving pond will also be collected. In cases where pond discharges are expected to be curtailed for substantial periods, CDH and RFP will negotiate continuing pond treatment on a recirculating basis for the purpose of data collection.

Waters from the terminal ponds will be analyzed by RFP and any other entities collecting terminal pond waters, using methods capable of detecting radiological parameters with sufficient accuracy and precision and at sufficiently low detection levels to provide reliable comparison with the CWQCC standards. These methods are proposed for EPA validation in Section 4.3 of this Workplan. Until such time as EPA has completed the validation process for these or other radiochemical methods, the analytical methods that have been determined adequate up to present will be continued.

4.1.6 Application of CWQCC Stream Standards

Using a 30-Day Running Average

Determinations of whether or not data from the terminal ponds exceed the CWQCC standards will be made, in the case of data collected by RFP, using an average of values collected over the most recent 30-day period for which data are available (this value is referred to herein as the "running 30-day average"). If the running 30-day average exceeds any of the CWQCC standards for water being discharged, RFP will confer regarding the advisability of continued discharge and may halt the discharge. If water being transferred from one terminal pond to another exceeds the running 30-day average for any of these CWQCC standards, RFP will immediately notify CDH of this exceedence and will confer regarding the advisability of continued transfer of this water and/or continued discharge of treated water.

Single-Sample Exceedences

In those cases where individual samples of water collected from the terminal ponds contain levels of radionuclides that exceed the standards set by the CWQCC, but the 30-day running average is not exceeded, RFP will immediately notify CDH of the single-sample exceedence but will not be obligated to cease discharge or otherwise modify its pond water management. RFP will immediately re-analyze any pond water samples that indicate an exceedence of the CWQCC standards and will report the results of this re-analysis to CDH upon receipt. RFP will also report to CDH accidents or incidents on plant site that may have the potential to cause exceedences of the CWQCC standards in the ponds or downstream discharges and consult with CDH regarding the advisability of continued discharge.

Notifications

Concurrent with the notifications made to CDH, per the above discussion, RFP will make similar notifications to EPA and to local municipalities. RFP will also notify CDH, EPA, and local municipalities of significant changes in its discharge regime resulting from operational considerations.

Resuming Discharge

Prior to resumption of discharge in those cases where discharge has been halted as a result of operational considerations (as opposed to potential water quality concerns), RFP and CDH will review water quality data for compliance with CWQCC standards, using the running 30-day average as a measure of exceedences. CDH will grant concurrence for RFP to resume discharge from its terminal ponds if the running 30-day average is within the CWQCC standards and notify CDH, EPA, and local municipalities of the resumption of discharge.

If discharge from the terminal ponds has been halted as a result of potential water quality concerns, such as an exceedence of a 30-day average for one of the CWQCC standards, RFP will conduct a thorough internal investigation of the causes of the exceedence and institute measures as appropriate to remediate the exceedence and/or prevent its recurrence. Prior to resumption of discharge, RFP will present the results of its investigation to CDH and propose remedial measures as appropriate. CDH will review the information submitted by RFP and may, at its discretion, give permission to RFP to resume discharge or request further information and/or corrective actions on the part of RFP. Discharge may be resumed by RFP at such time as the running 30-day average for all monitored radiological parameters returns to levels at or below those of the CWQCC standards.

Regulatory Concurrence

CDH will analyze the results of pond water samples that it has collected with respect to the CWQCC standards. CDH will notify RFP of the receipt of individual sample results that exceed CWQCC standards. CDH and RFP will subject the samples in question to re-analysis, using portions of split samples previously archived. CDH will consult with RFP at this time regarding the advisability of continued discharge.

In those cases where exceedences of the running 30-day average for one or more radiological parameters are noted, but levels of water in the ponds cause concerns relating to dam safety, the RFP procedures for pond discharge under dam safety conditions will be followed. Decisions regarding continuation or cessation of discharge under such circumstances will be made in consultation with CDH and the State Engineer.

4.1.7 Analytical Quality Control

Analytical protocol requires routine checks of methods to assure data quality. The minimum detectable activity (MDA) for each analyte isotope depends on: detector background, analytical recovery, detector efficiency, and sample counting time as well as the volume of water sampled. Estimations of these parameters are calculated using historical data and are routinely updated for the entire set of laboratory detectors. The standard deviation of analytical blank measurements is the predominant factor and is based on the matrix blanks included in each batch processed. The reported MDA should be interpreted as that of the process and not that of a single measurement, as data from all detectors are used for estimation. Quality control checks of analytical methodology will continue on a routine basis.

4.1.8 Discharge Management

Effective management of the RFP surface-water system requires consideration of several important functional and operational aspects, including current pond levels, seasonal variation in precipitation, anticipated meteorological conditions, soil moisture levels and runoff factors, analytical turnaround time, acquisition of the most representative samples, treatment system capacity, and approval times.

The overall objectives of pond water discharge management are: (1) to ensure high-quality water discharges, (2) to maintain the structural integrity of the detention dams, and (3) to provide storm-water or spill detention. An operational plan for pond water discharge management, which incorporates these factors, formalizes responsibilities, and triggers appropriate response actions to assure proper control of pond levels and discharges of pond water will be used. This Discharge Plan is presented below.

<u>Pond Water Discharge Plan</u>

(1) As the quantity of pond water in a pond increases, approaching 20% of the total pond capacity, EG&G will request that DOE schedule pre-discharge sampling with CDH. Time of sampling will be coordinated with CDH to assure proper split sampling. The decision to initiate sampling at approximately 20% of capacity will depend on a number of factors, including (1) the anticipated rate of water inflow into each specific pond, (2) the anticipated analytical turnaround time,

and (3) the time required for review of the data and subsequent authorization of the discharge by DOE. The factors that will influence the pond influent rate are (1) STP discharge rate for Pond B-5, (2) any ongoing pond-to-pond transfers, and (3) anticipated precipitation (and associated runoff) rates. EG&G personnel will evaluate these parameters to determine the date that pre-discharge samples will be collected.

(2) Typically, EG&G will request that the analytical laboratories expedite the analyses of the pre-discharge samples to meet the turnaround time requirement. Although data for some parameters are available within days, receipt of all data typically requires four to six weeks (with current plutonium and americium standards of 0.05 pCi/L). Collected data will be reviewed by EG&G personnel and will be provided to DOE and CDH along with discharge recommendations. Authorization for offsite discharge will be granted by DOE with concurrence by CDH. DOE will also provide written notification to the City of Broomfield, giving specifics of the discharge. This information will be provided 48 hours prior to discharge as the discharges will be diverted around Great Western Reservoir by the City of Broomfield. EG&G personnel will also maintain contact with the City of Broomfield during the discharge to ensure that the integrity of the BDD is maintained.

(3) EG&G will request that treatment/discharge of pond water continue at a specified rate governed by the treatment capacity available and/or required. Any alterations to the treatment operations or the discharge rates will be reviewed by EG&G management and approved by DOE prior to implementation.

(4) Maintaining the discharge will require simultaneous evaluation of a number of variables. These factors include, but are not limited to, current pond level (routinely measured by EG&G), available treatment/transfer operations and rates, anticipated total precipitation and rates, soil conditions and expected surface runoff rates, anticipated meteorological conditions, effects of the meteorological conditions on the treatment operations and discharge (water flow through the BDD), operational and variations requested by outside interests (CDH, local municipalities), unexpected analytical results that indicate a possible exceedence of discharge standards, variations in the natural ecology of the pond system and the associated changes in the physical (algal quantities) and

chemical (pH, ammonia, manganese) parameters. All of these factors will be reviewed and evaluated by EG&G personnel on almost a daily basis to determine the correct response actions required for the current conditions. All modifications to the treatment operation and/or discharge will require management concurrence and DOE approval.

4.2 Workplan Element #2: Assessment of Water Quality

The Workplan will require that DOE assess the water quality with respect to the recently promulgated CWQCC standards.

Complete assessment of water quality with regard to standards involves a number of issues, some of which have been partially addressed in established and ongoing programs and some concerns that have not yet been resolved. The topics relevant to the scope of this task are (1) compilation of background information sufficient to establish the true ambient levels both onsite and offsite waters and (2) sorting and statistical analysis of data required to determine significance and verify the importance of observed variations in radionuclide concentrations in surface waters.

This Workplan element is divided into three subsections (1) acquisition of additional data, (2) evaluation of analytical results, and (3) statistical assessment of data. Descriptions of the activities to be pursued under these headings follow.

4.2.1 Additional Data Collection

Virtually no isotope-specific radiochemical data exist in literature references for sub-picocurie levels of waterborne radionuclides. CWQCC stream standards for RFP are unique in their requirement for routine monitoring of sub-picocurie plutonium and americium levels. Since stream standards of this nature have not been applied previously, there exists no database of water quality data for comparison.

RFP currently conducts an extensive water analysis program which routinely samples at onsite and offsite locations for plutonium, americium, uranium, and tritium. RFP will design and implement additional monitoring programs to characterize the ambient concentrations of the radionuclides for which the CWQCC has promulgated stream standards. This effort will consist of both onsite and offsite studies and may require statewide (or nationwide) sampling programs. Data for analytes specified by CWQCC and statewide standards will be collected on a routine or non-routine basis according to the following categories which include:

- Routine analytes including americium-241, plutonium, gross alpha, gross beta, tritium, and uranium. (Ongoing.)
- Non-routine site-specific analytes including curium-244 and neptunium-237. (Initiate third quarter 1991.)
- Non-routine statewide analytes including cesium-134, radium-226 and 228, strontium-90, thorium-230 and 232. (Initiate late 1992.)

The need for and frequency of continued monitoring for non-routine categories of analytes will be revisited as data become available and the continuation of monitoring will be evaluated in consultation with CDH. For parameters for which no evidence can be gathered to demonstrate presence in the surface waters of RFP, such sampling and analysis will be assigned low priority and annual testing to demonstrate the presence or absence of such contaminants will be considered adequate.

4.2.2 Evaluation of Analytical Results

RFP will sort available data into comparable categories, taking into account analytical methodology changes that have an effect on detection limits and deviation, and assess the data for further needs prior to application of statistical methods. Programs designed to acquire the necessary remaining data will be implemented as appropriate.

RFP will initiate a study to determine the appropriate method for sampling of pond and discharge waters for radionuclides, including assessment of the following issues:

- Filtered versus nonfiltered samples, and the effects of centrifuging on radiological content.
- Variability associated with grab and composite sampling, and the degree of representation of total pond concentrations by various collection schedules and methods.
- Assessment of the similarity of results obtained through new radiochemical analytical methods compared to those already in use, and the impact of

initiating regular use of different methods (such as co-precipitation or gamma spectroscopy) on uncertainty and variability in laboratory results. This effort will include studies to determine the variation between separate laboratories so that alternative sources of analytical results may be developed as a contingency for those times when facilities whose data form the baseline for trending analysis are not available.

- Water quality variation with season of the year.

4.2.3 Statistical Study of Data

RFP initiated study of water quality data, using appropriate statistical methods in first quarter 1991 with available 1990 data; results of this study will be available by second quarter 1991. RFP will utilize these results to initiate followup statistical studies also in second quarter 1991. Possible derivative studies include:

- Trending within the data, such as seasonality or direct relationship to incoming waters from sources outside of RFP.
- Appropriate application of the CWQCC standards to discharge waters such that downstream users are protected without impairment of the ability of RFP to operate in a safe and effective manner. This may include later re-evaluation of the proposed 30-day running average as adequate data are compiled to indicate a more appropriate method for determining when an exceedence of the CWQCC standards has occurred and what the appropriate course of action should be at the time such an exceedence is discovered.
- Effectiveness of treatment methods as they are revised and implemented.

4.3 Workplan Element #3: Analytical Methods

The Workplan will establish validated analytical methods as identified by EPA and the State, including as appropriate, the methods delineated in 40 CFR 141.25, to determine concentrations of the parameters below. For parameters for which no validated standard analytical method exists, DOE will propose an analytical method for EPA and State approval.

Analytical methods should have sensitivity, accuracy, and precision sufficient to determine radionuclide concentrations at or below the promulgated stream standards; the standards adopted for radionuclides are listed in Table 4.1.

Table 4.1

CWQCC Stream Standards for Radiochemistry in Segment 4 of Big Dry Creek Basin (pCi/L)

Radiochemical Parameter	Woman Creek	Walnut Creek
Gross Alpha	7	11
Gross Beta	5	19
Plutonium-239,-240	0.05	0.05
Americium-241	0.05	0.05
Tritium	500	500
Uranium	5	10
Curium-244	60	60
Neptunium-237	30	30
Cesium-134	80	80
Radium-226,-228	5	5
Strontium-90	8	8
Thorium-230,-232	60	60

4.3.1 Analytical Methods Proposed for Validation

No analytical methods for radiochemical analysis of *environmental-level* (i.e., sub-pCi/L) samples have been validated by EPA. Therefore, methods for analysis of all parameters listed will be utilized and are proposed for validation. The methods suggested are drawn from a number of sources identified in 40 CFR 141.25 (when listed for the elements of concern above and capable of detection limits sufficient to determine compliance with the standards) and are proposed as follows as appropriate subjects for EPA validation:

1. *Gross Alpha and Beta* - Method 302, "Gross Alpha and Beta Radioactivity in Water," *Standard Methods for the Examination of Water and Wastewater,* 13 Ed., American Public Health Association, New York, New York, 1971.

2. *Radium-226* - Method 305, "Radium 226 by Radon in Water," ibid.

3. *Strontium-89, 90* - Method 303, "Total Strontium and Strontium 90 in Water," ibid.

4. *Cesium-134* - ASTM D-2459, "Gamma Spectrometry in Water," *1975 Annual Book of ASTM Standards, Water and Atmospheric Analysis,* Part 31, American Society for Testing and Materials, Philadelphia, Pennsylvania 1975.

5. *Uranium* - ASTM D-2907, "Microquantities of Uranium in Water by Fluorometry," ibid.

6. *Tritium* - "Developed and Modified Method for Tritium," *Procedures for Radiochemical Analysis of Nuclear Reactor Aqueous Solutions,* H.L. Krieger and S. Gold, EPA-R4-73-014, U. S. EPA, Cincinnati, Ohio, May 1973.

7. *Neptunium-237* - "Developed and Modified Method for Neptunium," ibid.

For the following elements, the following analytical methods, drawn from EPA laboratory publications and DOE procedures, are proposed for validation by EPA:

1. *Radium-226 and 228* - "Determination of Radium-226 and Radium 228 in Water, Soil, Air, and Biological Tissue," *Radiochemical Analytical Procedures for Analysis of Environmental Samples,* U.S. EPA Environmental Monitoring and Support Laboratory, Las Vegas, Nevada, March 1979.

2. *Thorium-230 and 232*- "Isotopic Determination of Plutonium, Uranium, and Thorium in Water, Soil, Air, and Biological Tissue," ibid.

3. *Plutonium* - Ibid.

4. *Americium* - "Americium-241 and Curium-244 in Water, Radiochemical Method," *Department of Energy Environmental Survey Manual,* 4th Ed. U.S. DOE, Washington, D.C.

5. *Curium-244* - ibid.

4.3.2 Proposed Real-Time Monitoring Methodology

While no real-time analytical methods are available to monitor radiochemistry at environmental (sub-pCi/L) levels in water, RFP will consider the use of indicator parameters to provide continuous control of water quality and water treatment processes. The election of this option is based on correlations (still in the draft stage) that link concentrations of radionuclides to suspended solids trends/levels in surface water. (EG&G 1990a) Early results of laboratory-scale studies by Los Alamos National Laboratory indicate filtration through 0.45 micron media produces a measurable reduction in the levels of plutonium and americium in the water. Additionally, publicly owned water treatment facilities utilize turbidity—"cloudiness" due to suspended solids—measurement as an indicator of water quality. These data suggest monitoring can be accomplished by following removal efficiency for micron-sized particles.

Particle counting technology is well developed for other applications, commercial products being readily available and methods being reasonably well understood. Importantly, *this monitoring option (i.e., particle counting) does not provide a direct measure of radionuclide concentrations—it is only an indicator of water quality.* Further development will be required to prove this technology effective for real-time monitoring of radionuclides in RFP surface water discharges. Early evaluations of the particle counting methodology were initiated second quarter 1990. Development testing of the technology for monitoring radiochemical parameters will be completed by first quarter 1992.

4.4 Workplan Element #4: Treatment Evaluations and Proposals

The Workplan will require DOE to identify potential treatment technologies to be utilized in the event that water quality for the terminal ponds exceeds the State standards. If no existing technologies adequate to achieve the standards are identified, DOE will use reasonable efforts to develop and implement such technologies. If achieving water quality that does not exceed the standards requires additional treatment or development of additional technologies, the parties agree to negotiate appropriate modifications to the Workplan, including schedules.

CWQCC stream standards for RFP are unique in the requirement for routine attainment of sub-picocurie plutonium and americium levels. Virtually no information on treatment of sub-picocurie levels of waterborne radionuclides exists in literature references. Since stream standards of this nature have not been applied previously, no database of water treatment methodologies exists for reference.

The following Workplan sections include proposals in three areas: (1) characterizing the physicochemical nature and sources of the radiochemical contaminants, (2) improving and refining the current treatment approach, and (3) developing, testing, and implementing new treatment approaches, as required.

4.4.1 Characterizing Radionuclides

Further information is expected from study of upstream sources of contamination. These source studies will assess possible in-stream re-suspension and removal mechanisms and downstream fates of radionuclides prior to the terminal ponds. Studies first initiated through Los Alamos National Laboratory will be conducted to characterize radionuclides in terms of solubility, complexation and sorption properties These properties will potentially influence the choice of treatment methods.

The first step in treatment is understanding the nature, occurrence, and sources of the targeted contaminants. The following tasks will develop a better appreciation of the nature and extent of radiochemical contaminants in the RFP surface-water system.

<u>Speciation and Quantitation of Radiochemical Species</u>

This task will characterize the chemical/physical forms of and quantitate low-level radiochemical contaminants in pond water. The study will identify factors important to changes in the solubility, complexation, and adsorption of radiochemical contaminants. This information will be used (1) to implement a working model for the behavior and speciation of the radiochemical constituents, and (2) to assist in developing, refining, and implementing specific treatment approaches applicable to removal of low-level radiochemical contaminants from pond water. This task will start third quarter 1991 and require three to five years to complete.

Radiochemical Source Identification and Control

This task will identify sources and transport mechanisms that result in radiological contaminants in RFP pond water. Existing pond water data will be used, along with topographic, soils, and vegetation data to assess the potential for and magnitude of erosional transport of radiochemical contaminants from watersheds to the ponds. Agricultural runoff/erosion models will be used to provide estimates of the frequency, timing, and magnitude of runoff and erosion events and the associated contaminant transport. Climatological data and water temperature profiles will be used to identify any resuspension of radiochemical deposits in bottom sediments caused by planktonic blooms, seasonal turnover events, or high winds that might mix the water column. This task will start third quarter 1991 and require three to five years to complete.

This effort will be accompanied by identification and testing of appropriate control technology to eliminate exceedences of CWQCC standards. Based on the source of the radiological contaminants and the method of transport, control measures for both upstream and in-pond sources will be recommended.

4.4.2 Improving Current Treatment

RFP currently provides treatment to remove certain waterborne contaminants from RFP pond water prior to discharge. Treatment includes particulate filtration and granular activated carbon. Analysis of available data indicates that the current operation is minimally effective at removing radiochemical contaminants, which are thought to be associated with colloids/particulates in the micron to sub-micron size range. Although current filtration/GAC treatment will be continued, as necessary, to remove GAC-adsorbable waterborne contaminants, further improvements to the current treatment approach to correct the deficiencies in radionuclide removal will be conducted following the Workplan tasks identified below.

- Consolidating operations into a weather-proofed facility
- Providing piped conveyances for Pond B-5 and Pond C-2 water to the Pond A-4 Treatment Facility
- Evaluating improved bag filters and filter bodies
- Evaluating sand and drum filters

These improvements are currently underway with completion expected by the end of third quarter 1991. Analytical methods to verify treatment effectiveness remain the key factor limiting treatment method development. These same analytical limitations will persist for routine monitoring of radionuclide levels in full-scale operations.

4.4.3 Developing Future Treatment

Identifying Treatment Options

The Sitewide Treatability Study Plan (TSP) (EG&G 1990f) describes technologies that are potentially applicable to radionuclide removal from water and recommends those for testing where additional design information is needed. Technologies relevant to radionuclide removal include sedimentation/precipitation (1) aided by coagulation/flocculation, (2) augmented possibly by oxidation/reduction, or (3) combined with co-precipitation. In addition, the TSP includes membrane filtration as a means of phase separation. The forthcoming TSP Workplan, scheduled for June 1991, will likely contain other options applicable to radionuclide removal. Mechanical equipment options have also been identified; these include parallel plate separators, granular media filters, and dissolved air flotation (DAF) units.

Additional background data are expected from the implementation of interim remedial actions (IRAs) at high priority OUs, notably OU2 which is scheduled to commence initial operations in the second quarter of 1991.

Developing New Treatment Methodology

This program, if required, will consist of bench- and pilot-scale process evaluation as well as considering specific equipment investigations.

Bench-Scale Test

This task will involve jar tests of sedimentation and coagulation processing using coagulants/flocculants and clays for application to Pond A-4 water samples. Work will parallel that conducted for Pond B-5 water. Recommendations on precipitants, additives, dosage, and treatment means are expected from this work. An initial three-month program will be started second quarter 1991.

Equipment Evaluation

Depending upon the results of bench-scale work, vendor evaluation of processing equipment will be considered. Possible approaches will include sand filters, lamella separators, and dissolved air flotation (DAF) units.

Pilot-Plant Testing

A pilot plant testing program will be undertaken as necessary to demonstrate process performance on a scale for which final design will be reliable. A 12-month field-test program will be used to cover annual variations. A total program duration of 24 months is planned.

References

Reports/Studies

DOE 1980: *Final Environmental Impact Statement, Rocky Flats Plant Site*, U.S. Department of Energy, DOE/EIS-0064, April 1980.

Bauer 1990: Draft Report: *Comparison of Radiochemical Concentrations in RFP Waters,* J.F. Bauer, D.R. Weier, EG&G Rocky Flats, Rocky Flats Plant, Golden, Colorado, July 24, 1990.

EG&G 1990a: *Background Geochemical Characterization Report: Rocky Flats Plant for 1989*, EG&G Rocky Flats, Rocky Flats Plant, Golden, Colorado, December 21, 1990.

EG&G 1990b: Draft *Geologic Characterization Report for U. S. DOE - Rocky Flats Plant*, EG&G Rocky Flats, Rocky Flats Plant, Golden, Colorado, January 3, 1990.

EG&G 1990c: *Rocky Flats Plant Site Environmental Report for 1989,* RFP-ENV-89, EG&G Rocky Flats, Rocky Flats Plant, Golden, Colorado, December 1990.

EG&G 1990d: *Draft Rocky Flats Surface Water Management Plan*, EG&G Rocky Flats, Rocky Flats Plant, Golden, Colorado, March 1991.

IT 1990: *Evaluation of Treatment Alternatives for Stormwater in Ponds A-4, B-5, and C-2,* prepared by IT Corporation, Englewood, Colorado, under IT Project Number 304919, November 1990.

Orlandini 1990: "Colloidal Behavior of Actinides in an Oligotrophic Lake," K.A. Orlandini et al., *Environ. Sci. Technol.* **1990**, *24*, 706.

Penrose 1990: "Mobility of Plutonium and Americium through a Shallow Aquifer in a Semiarid Region," W.R. Penrose et al. *Environ. Sci. Technol.* **1990**, *24*, 228.

Rockwell 1988a: *RCRA Post-Closure Care Permit Application*, Rockwell International, Rocky Flats Plant, Golden, Colorado, October 1988.

Rockwell 1988b: *Rocky Flats Plant Site Environmental Report for 1988,* RFP-ENV-88, Rockwell International, Rocky Flats Plant, Golden, Colorado, May 1989.

Thomas 1981: *Radionuclide Concentrations in Reservoirs, Streams and Domestic Waters Near the Rocky Flats Plant Installation*, PNL-2919, UC-11, C.W. Thomas, D.E. Robertson, April 1981.

Triay 1991: Draft Report, *Utilization of a Flocculation Technique to Remediate Surface Waters*, I.R. Triay, D.W. Efurd, Los Alamos National Laboratory, INC Division, Los Alamos, New Mexico, March 1991.

Procedures/Plans

Urban 1985: *Colorado Urban Hydrograph Procedure,* Urban Drainage and Flood Control District, 1985.

EG&G 1990e: Draft *Contingency Plan for Unplanned Releases and Emergency Discharges from Rocky Flats Plant Terminal Detention Ponds A-4, B-5, C-2*, EG&G Rocky Flats, Rocky Flats Plant, Golden, Colorado, March 1990.

EG&G 1990f: Draft *EG&G Rocky Flats Sitewide Treatability Studies Plan*, Version 1.2, EG&G Rocky Flats, Rocky Flats Plant, Golden, Colorado, September 1990.

Guidance Documents

CWQCC 1990: *Colorado Water Quality Control Commission Classification and Numeric Standards: South Platte River Basin, Laramie River Basin, Republican River Basin, Smokey Hill River Basin* , Version 3.8.0, February 5, 1990, "Stream Classifications and Water Quality Standards" for Region 3, Big Dry Creek Basin, p.12a-c of 27.

CDH 1989: *State of Colorado Water Standards: Surface Water Regulations, Groundwater Regulations, Impoundment Regulations (Proposed)*, The Basic Standards and Methodologies for Surface Water, Colorado Department of Health/Water Quality Control Commission, August 7, 1989.

EPA 1984: *Authorization to Discharge Under the National Pollutant Discharge Elimination System,* Permit CO-0001333, November 26, 1984, expired (but administratively extended past) June 30, 1989.

DOE 1989: *Agreement in Principle,* Between the U.S. Department of Energy and the State of Colorado, Attachment A, Section 3, June 28, 1989.

CSBH 1985: *Rules and Regulations Pertaining to Radiation Control,* Revision 5, Colorado State Board of Health, December 30, 1985.

Appendix I

ROCKY FLATS GEOLOGIC CHARACTERIZATION

Site characterization activities have been conducted at RFP over approximately the past 30 years. Drilling programs were initiated in 1960 and have continued to the present. Prior to 1990, remedial investigations were conducted by Rockwell International. These investigations included electromagnetic, resistivity, and magnetometer geophysical surveys; a soil-gas survey; a soil sampling program; ground-water and surface-water sampling programs; hydrogeologic tests; and an air monitoring program.

Subsequent to initial remedial investigations, RFP initiated a project to develop a more complete and accurate geologic characterization of the RFP. A comprehensive literature review was conducted, samples were re-evaluated using standardized procedures, further laboratory testing was completed, and seismic data were acquired and evaluated. Interim results of this ongoing study are presented in the Draft Geologic Characterization for the Rocky Flats Plant (EG&G 1990). These interpretations are subject to change or modification on the basis of the information gathered during the Phase II Geologic Characterization.

<u>Surficial Deposits (Rocky Flats Alluvium, Quaternary)</u>

All of the surficial deposits at RFP consist of clay, silt, sand, gravel, cobbles, and boulders. Clasts are angular to subrounded; overall, the sediments are poorly sorted. The source of these deposits is primarily the Precambrian quartzite to the west as well as younger sedimentary bedrock and other surficial deposits. The Rocky Flats Alluvium ranges from 10 to more than 98 feet in thickness but is generally less than 50 feet thick.

<u>Bedrock Geology</u>

The Cretaceous Arapahoe Formation is a continental fluvial deposit 250 feet thick in the central portion of RFP. The dominant lithology is claystone; however, at least six sandstone units within the Arapahoe Formation have been correlated and preliminarily mapped. Individual channel trends for three of the six intervals are presented in the Draft Geologic Characterization Report (EG&G, 1990). Each channel trend should be considered a potential contamination path. This is especially significant if a channel sandstone crops out at the surface or subcrops unconformably beneath the Rocky Flats Alluvium.

Maps constructed as part of the Draft Geologic Characterization (EG&G, 1990) illustrate that the A-series ponds may have been constructed on a projected Arapahoe Formation sandstone (Kass #4) channel trend. Specifically, cross-section C - C' of the Draft Geologic Characterization illustrates that under Ponds A-3 and A-4, the Kass #4 interval subcrops at or very near the unconformity located at the base of the Rocky Flats Alluvium. The extent to which a sandstone channel poses a threat as a contamination pathway is currently being further evaluated.

Because of the fluvial nature of the depositional environment, individual channel sandstones may have lenticular geometries. Subsequently, fluid flow through sandstones in a particular channel could be inhibited by the internal nature of the channel system. At this time, the extent of sandstone continuity within each channel is not fully understood. As new control is integrated into the overall geologic characterization, trends of individual channels and internal channel geometries will be better defined.

<u>Aquifer Definition and Ground-Water Flow Rates</u>

The "uppermost aquifer" refers to the Rocky Flats Alluvium and the subcropping Arapahoe Sandstone #1 (Figure 2.2). Data from the 1990 Draft Geologic Characterization and hydrologic tests performed from 1986 to 1989 revealed that these two units are in hydraulic connection and together constitute an unconfined system. Measurements recorded during these tests indicate that the Rocky Flats Alluvium has an average hydraulic conductivity of approximately 6×10^{-5} centimeters per second (cm/sec). The hydraulic conductivity of the uppermost Arapahoe sandstone has been determined to be 8×10^{-5} cm/sec. Arapahoe claystones have much lower hydraulic conductivities (approximately 10^{-7} to 10^{-8} cm/sec) for both weathered and unweathered claystones. In stream drainages surrounding RFP, similar alluvial/bedrock relationships exists; however, the "uppermost aquifer" in these cases refers to the colluvium and/or valley fill overlying Arapahoe sandstones 3, 4, or 5.

In the subsurface, the Arapahoe sandstones numbers 3, 4, and 5 are confined (Figure 2.4) These aquifers have hydraulic conductivities of approximately 10^{-6} cm./sec.

Appendix II

STATISTICAL STUDY OF RADIONUCLIDE LEVELS

Scope of Study

This section presents a summary and statistical evaluation of radionuclide concentration data taken at discharge and other relevant locations during the period January, 1988 to August, 1990. More specifically, plutonium, americium, and uranium data are presented along with gross alpha and gross beta values for the terminal ponds, Walnut Creek, and influent water locations. Data from January, 1984 through December, 1987 have not been included in order to provide a consistent basis of comparison for this report. The uncertainties associated with laboratory results are also investigated, in response to concern regarding magnified effects at the low levels at which the CWQCC water quality standards are set.

Basis of Study

Radionuclide data has been compiled for water samples collected from Walnut Creek at Indiana Street and the A-4, B-5, C-1, and C-2 ponds from January 1984 through August 1990. This data consists of plutonium, americium, and uranium concentrations measured in samples from these locations. In addition, the same data have been collected, for the period January 1988 through August 1990, for the raw water supply entering RFP Building 124.

The initial plan was to make comparisons of the mean concentration levels of radionuclides measured in samples from all six locations. However, the raw water supply was not sampled over the same time period as the other five locations, which led to an initial comparison of the mean radionuclide concentration levels for data collected prior to January 1988 to data collected after January 1988. This analysis revealed that, at several of the locations, the mean radionuclide concentration levels were statistically, significantly lower for samples collected after January 1988. The lower mean concentration levels observed could be either a result of modified measurement methods or an actual decrease in the concentration levels. For this reason, only the data collected since December 1987 were used in the comparisons that follow.

Comparisons Among Locations

Comparisons of mean concentration levels between the six different locations, were performed using an analysis of variance and Duncan's multiple range test. This procedure will determine if statistically significant differences exist among the locations sampled. The first comparison is made on the mean plutonium concentration levels and the results are shown in Table II-1.

Table II-1

Average Plutonium Concentration

LOCATION	Number of Samples	MEAN Pu Concentration (pCi/l)	GROUPING	Standard Deviation
Pond C-2	21	0.025	A	0.032
Walnut Creek	68	0.013	B	0.030
Pond C-1	101	0.012	B	0.021
Pond B-5	54	0.006	B	0.019
124 Raw	33	0.006	B	0.020
Pond A-4	45	0.005	B	0.019

Common practice is to use a grouping column to display statistically significant differences of mean plutonium concentrations between the six locations. Means sharing a common letter in the grouping column are not statistically different from one another. For example, Pond C-2 (group A) has a statistically significant higher mean plutonium concentration than the remaining 5 locations (group B). The mean plutonium concentrations at the five remaining locations are not statistically different from one another. As an aid in comparing mean plutonium concentrations, and those for the other radionuclides, the histograms (Figures II-1 through II-6) should consulted. These histograms help illustrate significant differences between the means.

A second comparison for americium levels among the six different locations are shown in Table II-2. The corresponding histograms for americium and the other radionuclides are given in Figures II-1 to II-3.

Table II-2

Average Americium Concentration

LOCATION	Number of Samples	MEAN Am Concentration (pCi/l)	GROUPING	Standard Deviation
Walnut Creek	68	0.010	A	0.016
Pond B-5	56	0.009	A	0.018
Pond A-4	45	0.008	A	0.024
Pond C-2	21	0.007	A	0.023
Pond C-1	103	0.007	A	0.015
124 Raw	32	0.003	A	0.018

Since all of the means share a common grouping column, no statistically significant differences exist for the mean americium concentrations among the six locations.

A comparison of mean uranium concentrations is presented in Table II-3.

Table II-3

Average Uranium Concentration

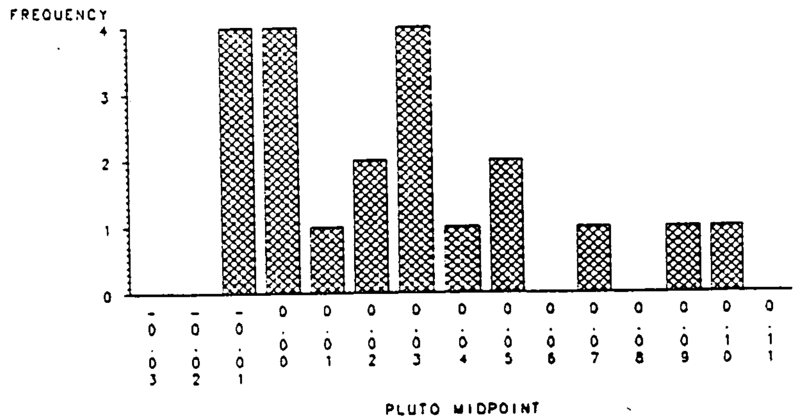
LOCATION	Number of Samples	MEAN U Concentration (pCi/l)	GROUPING	Standard Deviation
Pond A-4	47	5.20	A	1.87
Walnut Creek	67	4.37	B	2.24
Pond C-2	21	3.51	C	1.36
Pond B-5	56	3.07	C	1.55
124 Raw	32	1.27	D	1.14
Pond C-1	105	1.18	D	0.81

The mean uranium concentration in Walnut Creek is significantly lower than the mean uranium concentration in Pond A-4, and statistically higher than the remaining locations.

Although there is not as much historical data available for both gross alpha total and gross beta total concentrations, a comparison can still be made for data collected from

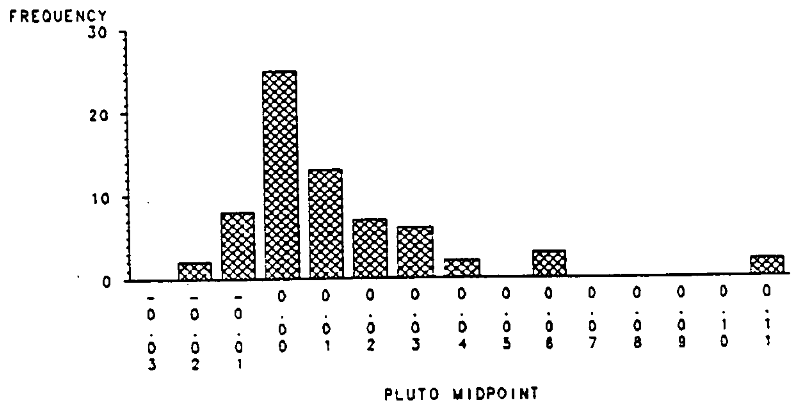
PLUTONIUM CONCENTRATION FOR POND C2

FOR SAMPLES COLLECTED SINCE 12/1/87



PLUTONIUM CONCENTRATION FOR WALNUT CREEK

FOR SAMPLES COLLECTED SINCE 12/1/87



PLUTONIUM CONCENTRATION FOR POND C1

FOR SAMPLES COLLECTED SINCE 12/1/87

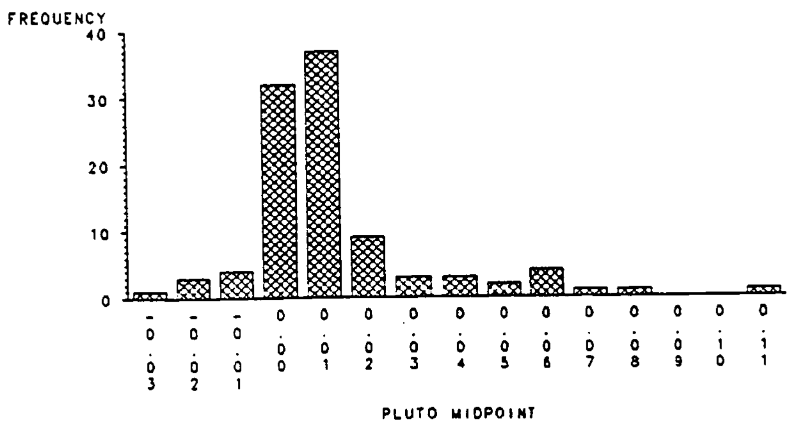
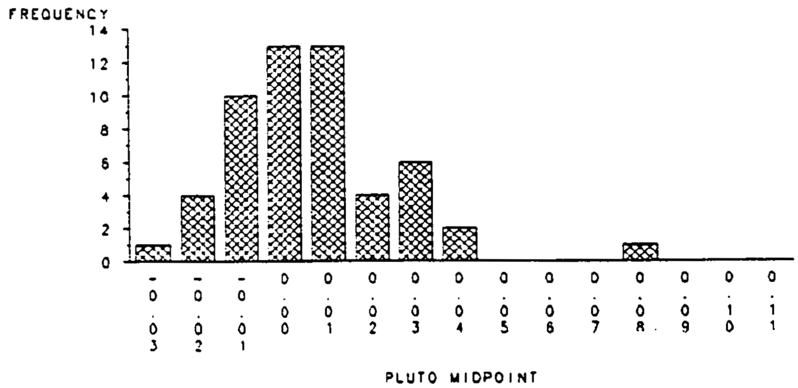


Figure II-1a Average Plutonium Concentration

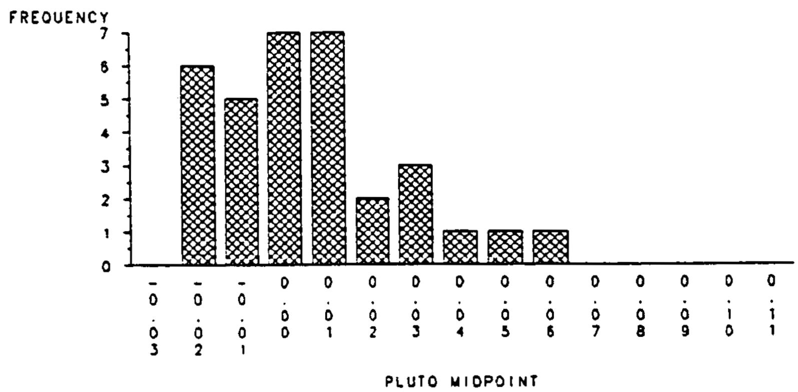
PLUTONIUM CONCENTRATION FOR POND B5

FOR SAMPLES COLLECTED SINCE 12/1/87



PLUTONIUM CONCENTRATION FOR RAW124

FOR SAMPLES COLLECTED SINCE 12/1/87



PLUTONIUM CONCENTRATION FOR POND A4

FOR SAMPLES COLLECTED SINCE 12/1/87

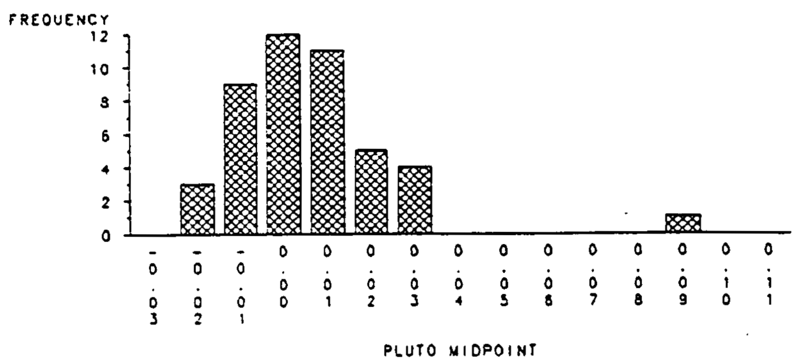
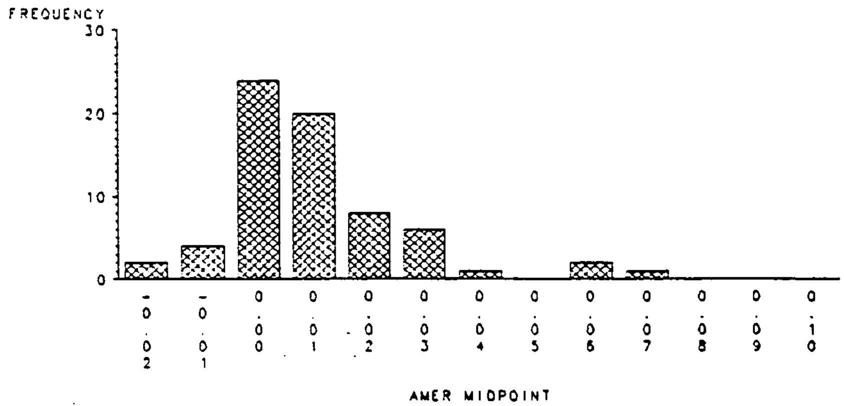


Figure II-1b Average Plutonium Concentration

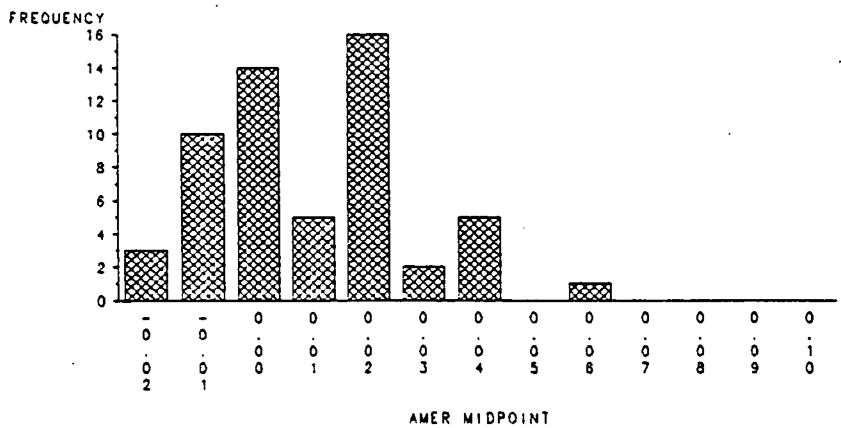
AMERICIUM CONCENTRATION FOR WALNUT CREEK

FOR SAMPLES COLLECTED SINCE 12/1/87



AMERICIUM CONCENTRATION FOR POND B5

FOR SAMPLES COLLECTED SINCE 12/1/87



AMERICIUM CONCENTRATION FOR POND A4

FOR SAMPLES COLLECTED SINCE 12/1/87

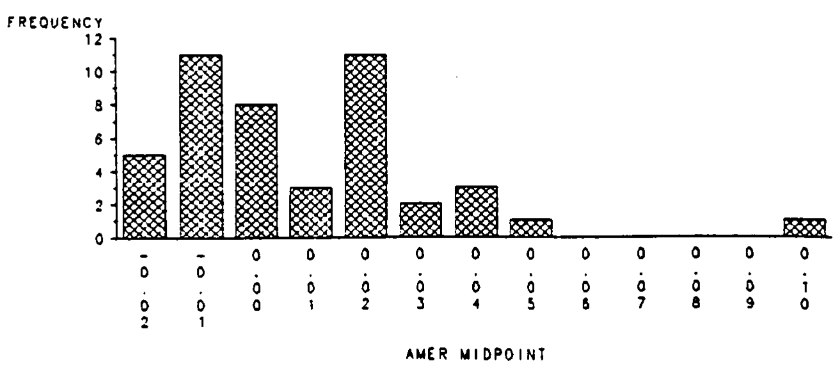
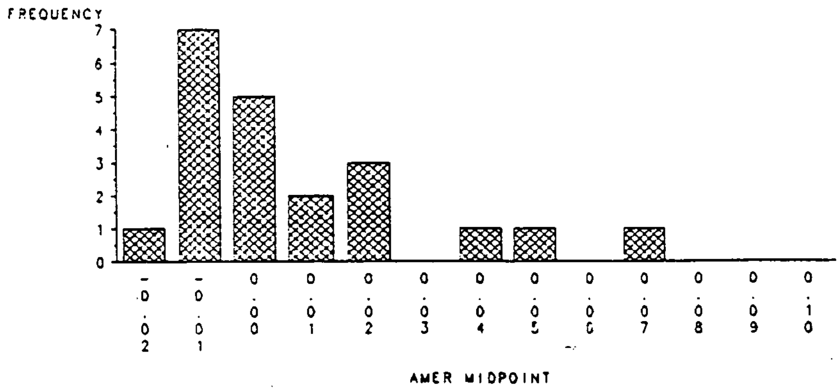


Figure II-2a Average Americium Concentration

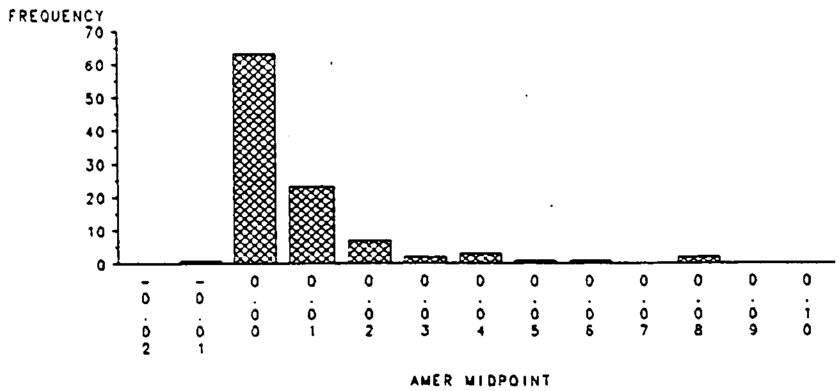
AMERICIUM CONCENTRATION FOR POND C2

FOR SAMPLES COLLECTED SINCE 12/1/87



AMERICIUM CONCENTRATION FOR POND C1

FOR SAMPLES COLLECTED SINCE 12/1/87



AMERICIUM CONCENTRATION FOR RAW124

FOR SAMPLES COLLECTED SINCE 12/1/87

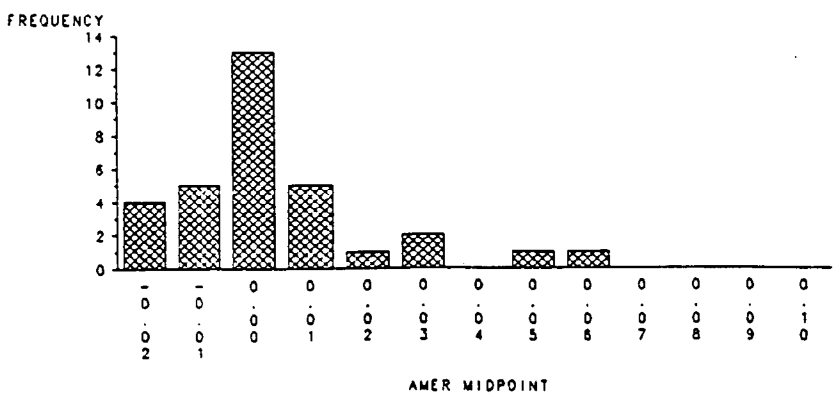
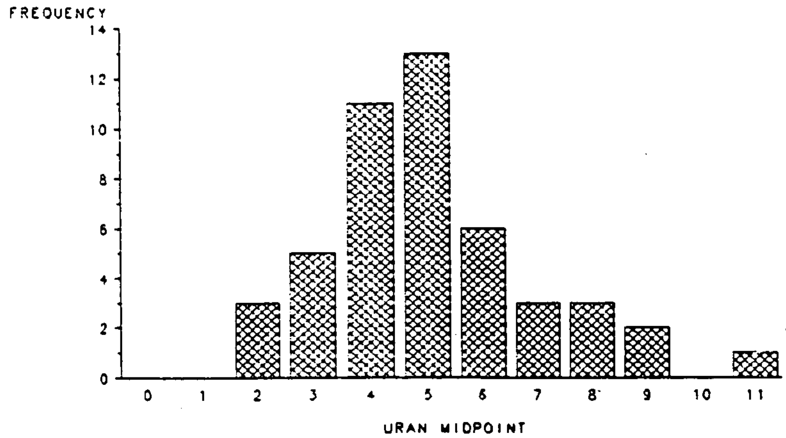


Figure II-2b Average Americium Concentration

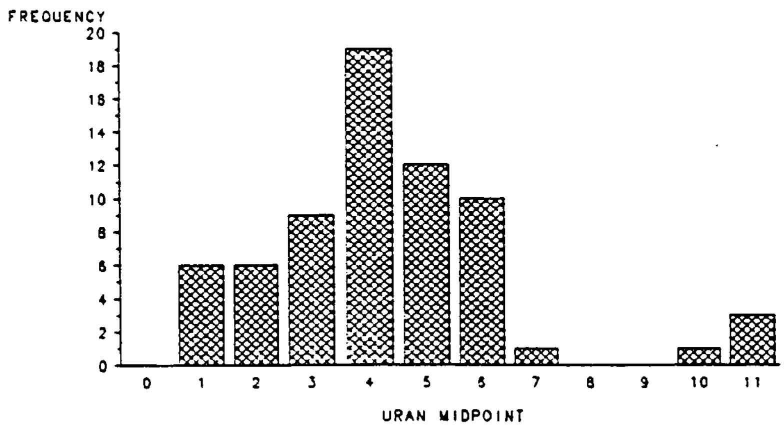
URANIUM CONCENTRATION FOR POND A4

FOR SAMPLES COLLECTED SINCE 12/1/87



URANIUM CONCENTRATION FOR WALNUT CREEK

FOR SAMPLES COLLECTED SINCE 12/1/87



URANIUM CONCENTRATION FOR POND C2

FOR SAMPLES COLLECTED SINCE 12/1/87

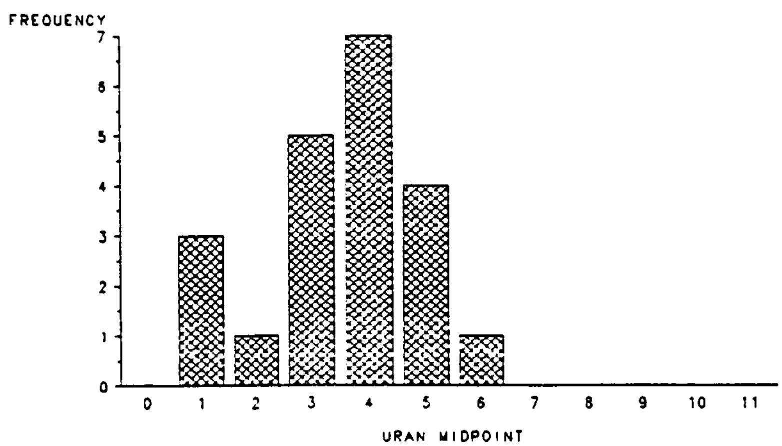
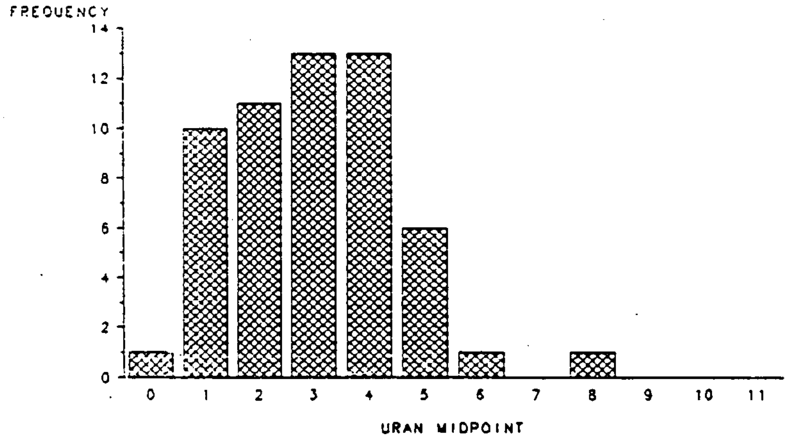


Figure II-3a Average Uranium Concentration

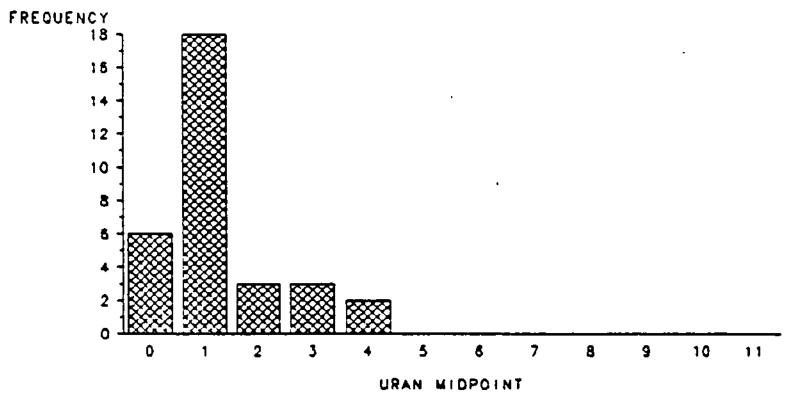
URANIUM CONCENTRATION FOR POND B5

FOR SAMPLES COLLECTED SINCE 12/1/87



URANIUM CONCENTRATION FOR RAW124

FOR SAMPLES COLLECTED SINCE 12/1/87



URANIUM CONCENTRATION FOR POND C1

FOR SAMPLES COLLECTED SINCE 12/1/87

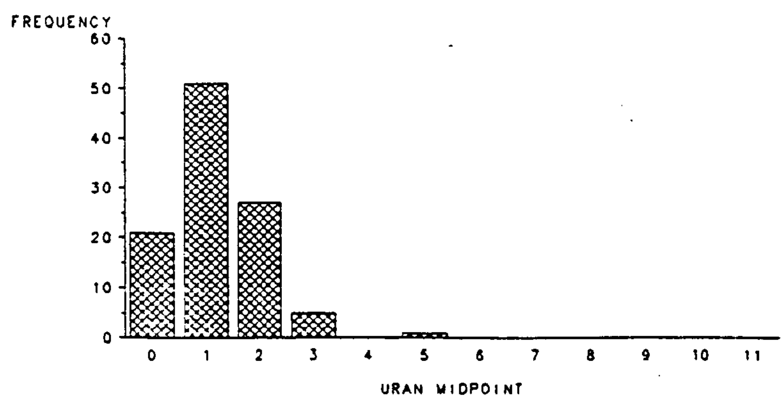


Figure II-3b Average Uranium Concentration

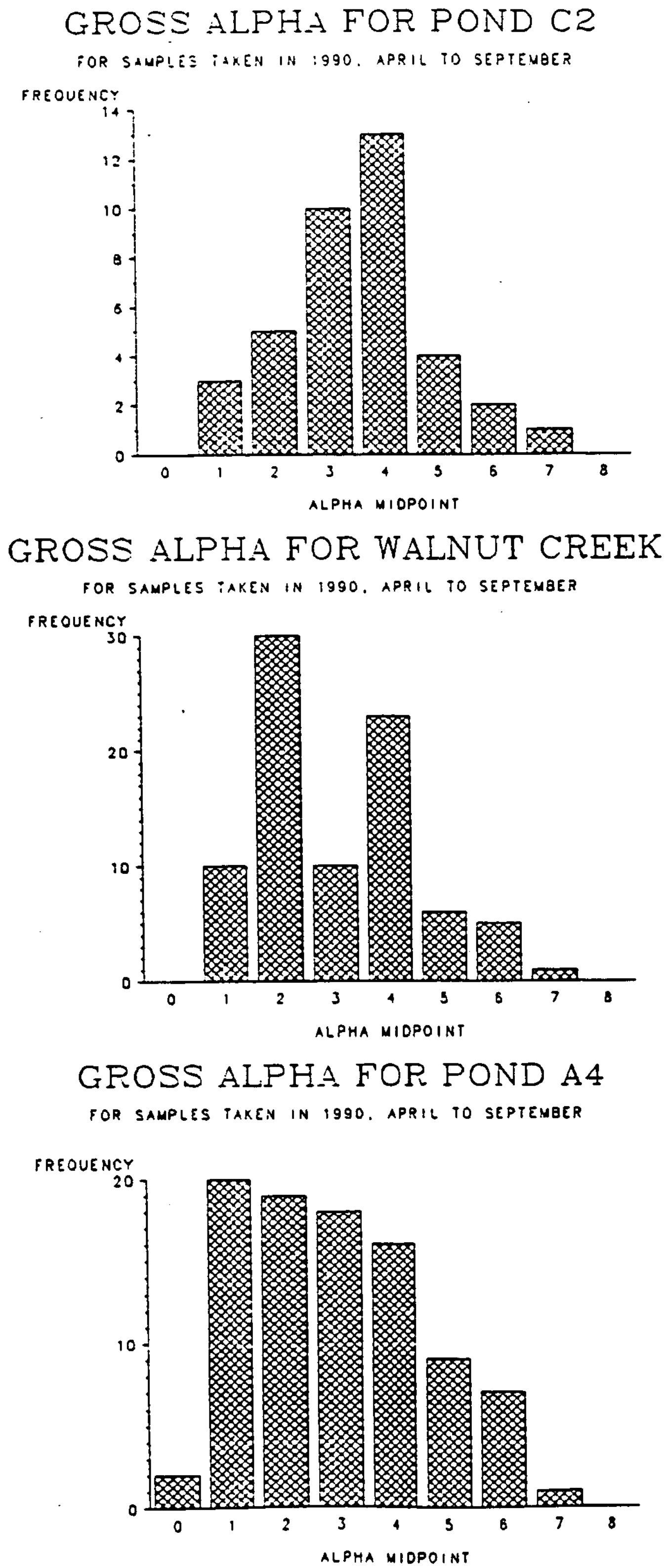
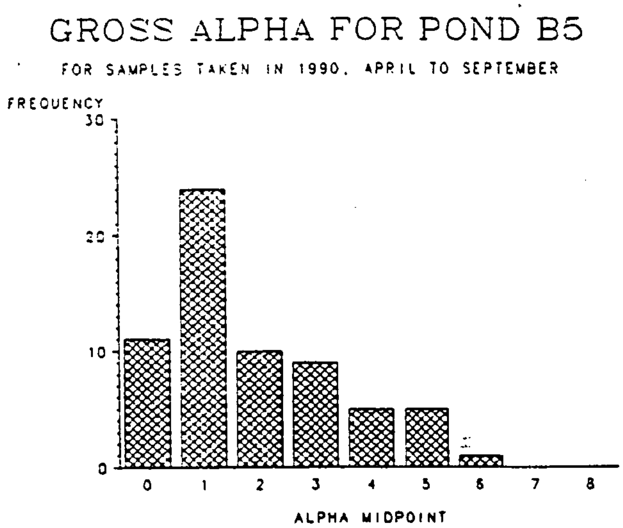
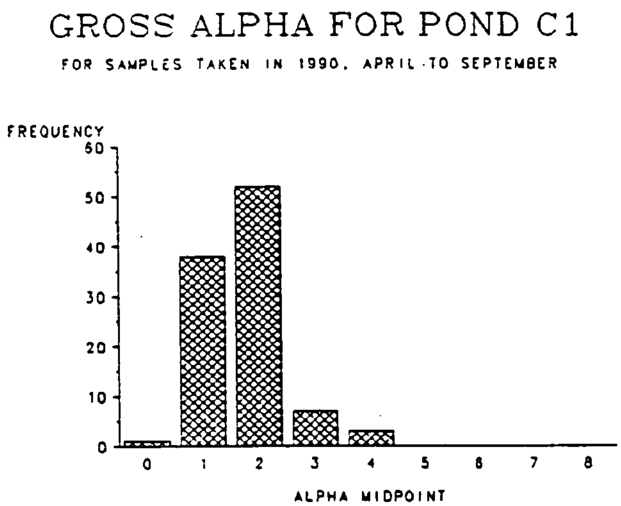


Figure II-4a Average Gross Alpha Concentration





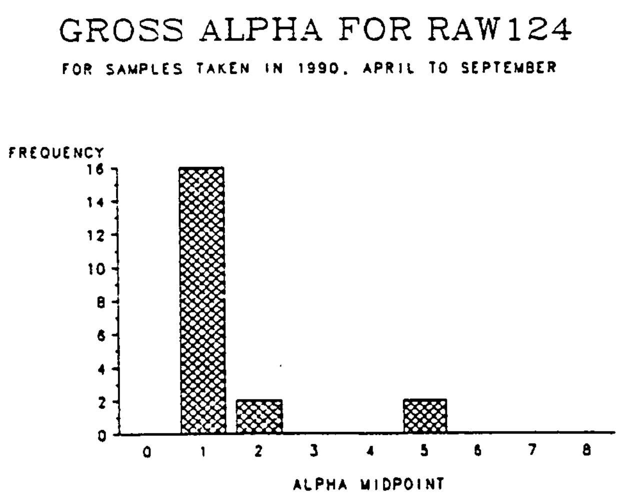


Figure II-4b Average Gross Alpha Concentration

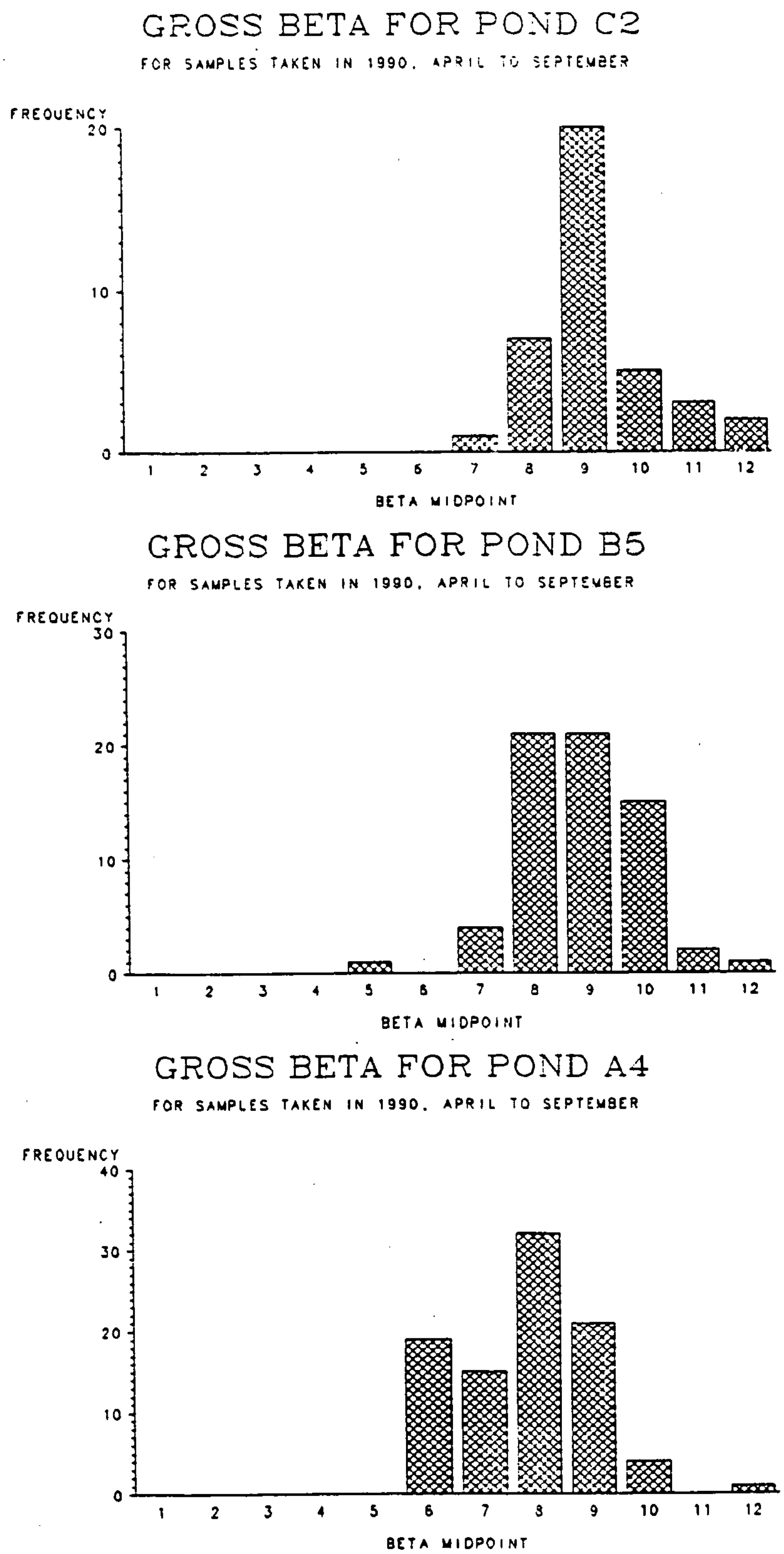


Figure II-5a Average Gross Beta Concentration

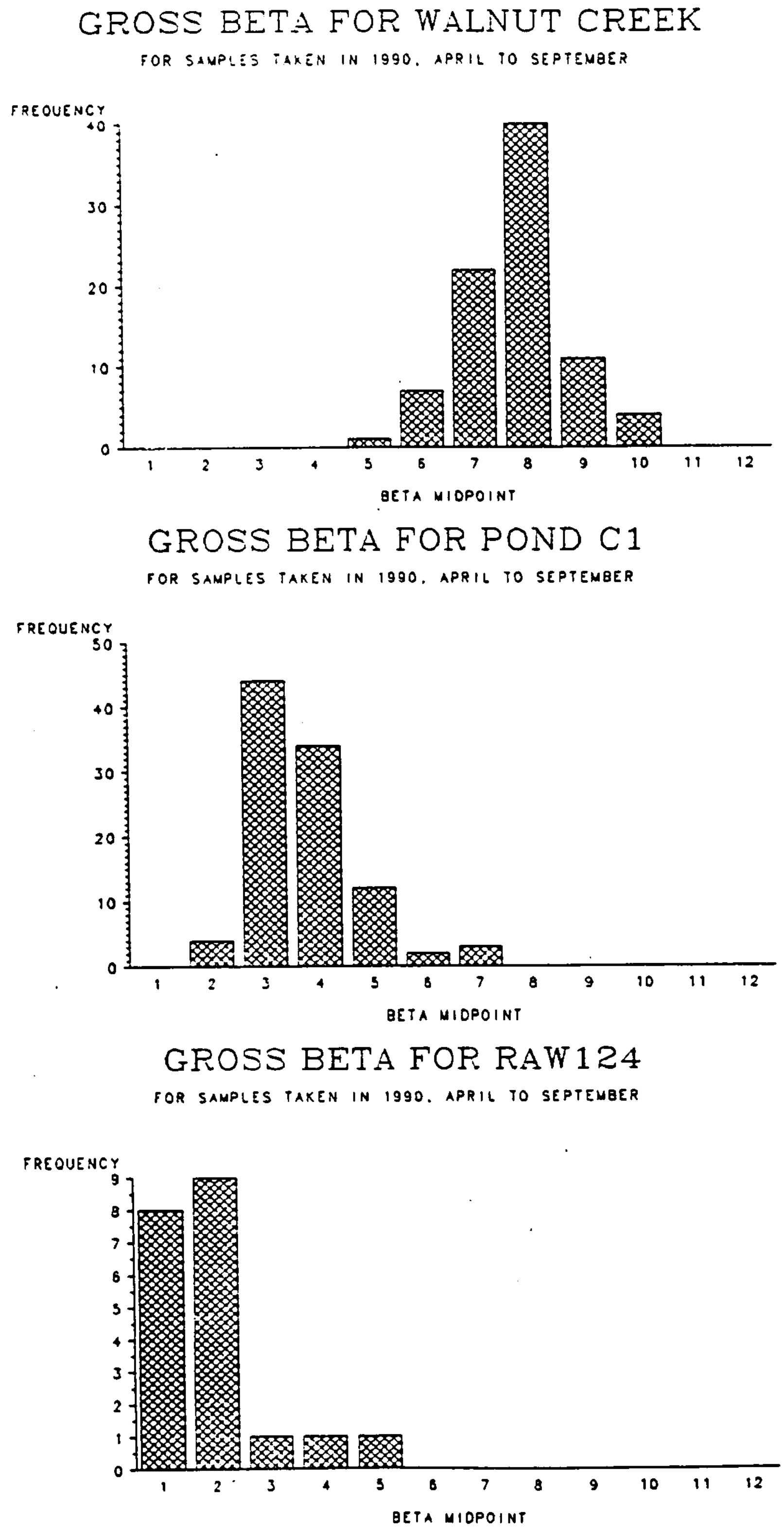


Figure II-5b Average Gross Beta Concentration

April 1990 through September 1990. The mean gross alpha results are shown in the Table II-4. Corresponding histograms are shown in Figures II-4 and II-5.

Table II-4
Average Gross Alpha Concentration

LOCATION	Number of Samples	MEAN Gross Alpha Concentration (pCi/l)	GROUPING	Standard Deviation
Pond C-2	38	3.53	A	1.37
Walnut Creek	85	3.04	B	1.46
Pond A-4	92	2.93	B	1.65
Pond B-5	65	1.90	C	1.55
Pond C-1	101	1.73	C	0.74
124 Raw	20	1.46	C	1.26

The mean gross beta total concentrations are shown in Table II-5.

Table II-5
Average Gross Beta Concentration

LOCATION	Number of Samples	MEAN Gross Beta Concentration (pCi/l)	GROUPING	Standard Deviation
Pond C-2	38	9.21	A	1.09
Pond B-5	65	8.85	A	1.19
Pond A-4	92	7.87	B	1.72
Walnut Creek	85	7.76	B	0.98
Pond C-1	99	3.73	C	1.01
124 Raw	20	1.89	D	1.08

Generally, the testing for gross alpha and gross beta levels would be performed as a screening tool. When elevated results are obtained, follow-up tests for specific radionuclides could be performed to determine whether the gross alpha or gross beta results are true indicators of elevated isotope-specific radionuclide content. When the radionuclides are tested regularly, the value of additional gross alpha and gross beta testing is questionable.

Impact of the CWQCC Standards

CWQCC has promulgated stream standards shown in Table 4.1 for monitoring points at Walnut Creek at Indiana Street and Ponds A-4, B-5, and C-2. CWQCC stream standards were determined for RFP by statistical evaluation of ambient water data, and established to limit degradation in water quality. These standards were derived from ambient water quality data collected from the Walnut Creek and Woman Creek locations during the approximate time period of January 1984 through May 1989. Stream standards were calculated as the mean of the data plus two standard deviations (i.e., the 95% confidence level) and assumed normal data distributions. As a consequence of this approach, exceedences of the standards should be expected approximately one-half of the 5% (i.e., only for the upper tail of a two-tailed distribution) or 2.5% of the time per analyte.

Setting aside the normal distribution assumption for radionuclide data and instead using simple counting statistics, the standards for the plutonium, americium, and uranium are found to approximate the 93rd percentile range, that is, the data analyzed for each radionuclide tend to exceed standards about 7 percent of the time. The implications of applying such standards simultaneously to multiple radionuclides several times a month should be carefully considered. For example, if a 93rd percentile standard were used for all five radionuclides discussed, at least one would exceed its standard 30.4 percent of the time, i.e., all would be below their standards only about 70 percent of the time.* When several such samples are analyzed, the chances of exceedence approaches certainty. Thus exceedence of a 93rd percentile stream standard should be expected as a common event, and treated with guarded concern when uncovered.

---

* The calculation of the probability that at least one of the five radionuclides exceeds its standard is based on the assumption that the measurements are independent, with a probability of success (i.e., a measurement that is below a set standard) equal to 0.93. The probability of multiple independent events being successes is calculated by multiplying the individual probabilities of success.

For the example shown (five independent events, each with a probability of success equal to 0.93), the probability of all five measurements being successes is:

$$0.93^5 = 0.696 \text{ or } 69.6\%$$

The probability that at least one of the measurements is a failure (exceeds its standard) is then: $1 - (0.93)^5 = 0.304$ or 30.4%

Uncertainties Associated with Radionuclide Levels

For each sample tested, uncertainties associated with the concentration measurement are reported by the laboratory. In fact, the uncertainties are calculated as a function of the measurement itself. In the following analysis, the plutonium measurements and their associated uncertainties are investigated. To examine the relationship between the uncertainties and the measurements, uncertainties were converted to a percentage of the associated concentration measured (i.e., normalized). After this conversion, an analysis of variance gave the results shown in Table II-6.

Table II-6
Analytical Uncertainty Variance

LOCATION	Number of Samples	Normalized Uncertainty x100%	GROUPING
Pond A-4	45	774	A
Pond B-5	54	557	A
Ponds C-1 & C-2	119	260	B

The interpretation of this table is the same as that in the previous tables. This table shows that the mean uncertainty as a percentage of the measurement is statistically lower in the C-series ponds than in the Ponds A-4 and B-5. These differences are presently unexplained, as the same laboratory methodology is used for all samples.

A possible explanation is that, in general, the uncertainty as a proportion of the concentration measurement will increase significantly as the concentration measurement nears zero. This is illustrated by the graph in Figure II-6 for Pond C-1. As the higher concentration levels were in the Ponds C-1 and C-2 location, with generally lower values in Ponds A-4 and B-5, differences in uncertainties could result.

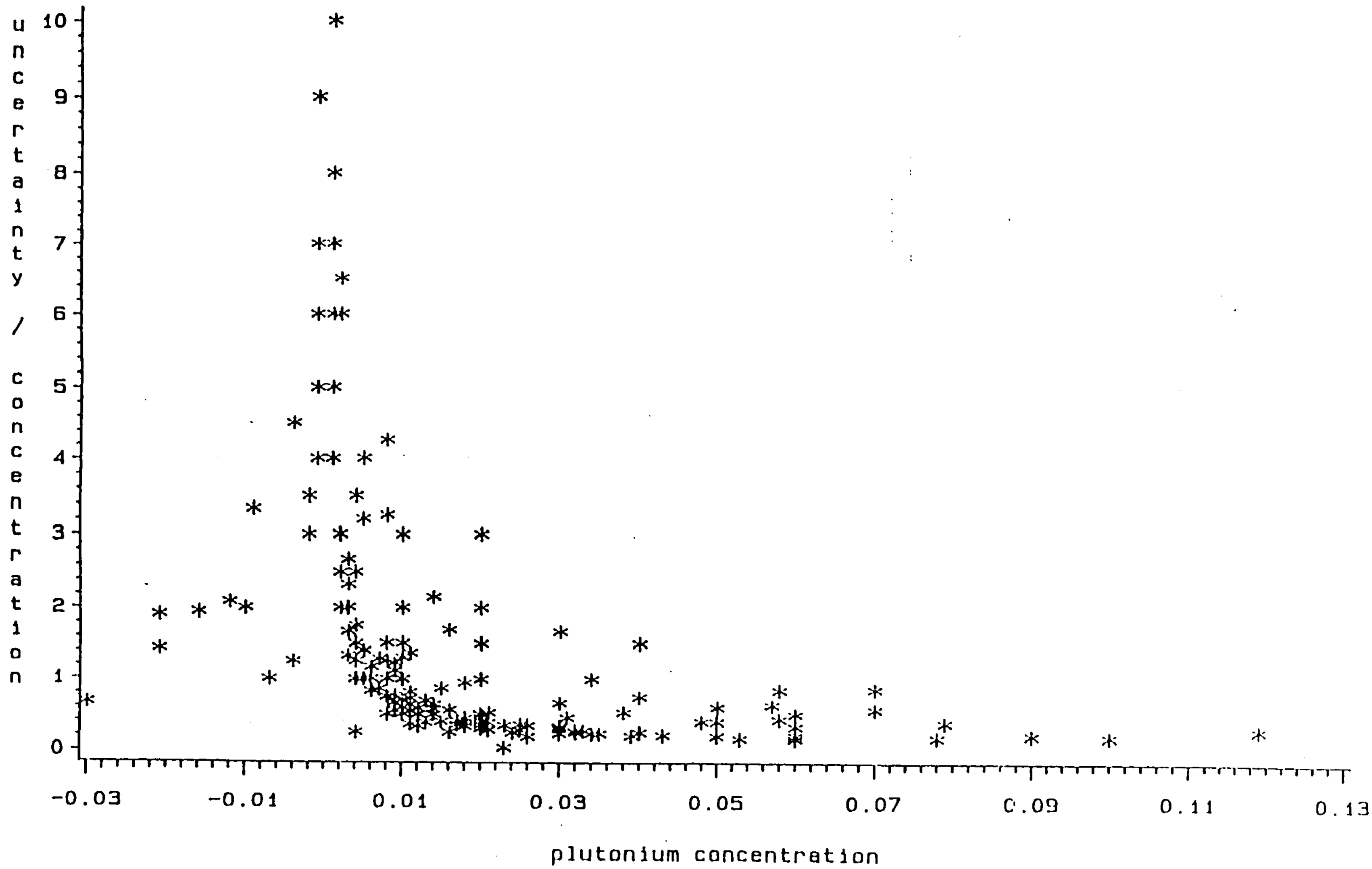
Comparison of RFP and Non-RFP Water to CWQCC Standards

Available data on plutonium, americium, and uranium levels in water for 1988 through 1990 were compiled and compared to CWQCC stream standards and other local water sources. The goal of the comparisons was to assess the quality of RFP water and other local water sources in relation to the CWQCC stream standards. Although results are preliminary and the analysis rather simplistic, significant percentages of

Figure II-6 Analytical Uncertainty Variance

POND C-1 PLUTONIUM UNCERTAINTIES

(Uncertainty / Concentration) vs. Concentration



single-sample exceedences are found for plutonium and americium data from *both* onsite and offsite water. This result is most likely an artifact of analyses conducted near the MDA (as evidenced by *negative* concentrations) and natural variability expected from the definition of the CWQCC standards around the 95% confidence interval. Comparisons are shown in Tables II-7 through II-9.

The purpose of comparing exceedences is to establish their ubiquity relative to the CWQCC stream standards (for Segment 4 of Big Dry Creek Basin) if these were applied to other watercourses. With reference to Tables II-7 through II-9, it would be statistically incorrect to compare simply the relative frequency of exceedences as an indicator of water quality. Instead, comparisons of means or medians of the analyte populations (as described in Section 3.3.2 of this Workplan) would be appropriate when evaluating water quality from different sources.

Table II-7
Comparison of Plutonium Concentrations for
RFP and Surrounding Areas* (1988-Present)

Location	Number of Samples	Mean Pu-239,240 (pCi/L)	No. Samples ≥0.05 pCi/L
Pond A-4 (Untreated)	13	0.009	1
Pond B-5 (Untreated)	23	0.013	1
Pond C-1 (Untreated)	113	0.012	8
Pond C-2 (Untreated)	7	0.045	3
Totals	**156**	-----	**8.3%**
Pond A-4 (Treated)	59	0.001	0
Pond B-5 (Treated)	39	0.000	0
Pond C-2 (Basin)	15	0.013	1
Pond C-2 (Treated)	13	0.012	0
Totals	**126**	-----	**0.8%**
RFP Raw Water	11	0.002	0
Arvada	11	0.000	0
Boulder	34	0.001	0
Broomfield	35	0.004	1
Denver	11	-0.002	1
Golden	11	0.002	0
Great Western	35	0.004	1
Lafayette	11	-0.002	0
Louisville	11	-0.002	0
Standley Lake	35	0.002	1
Thornton	11	0.008	1
Westminster	35	-0.001	0
Others**	12	0.006	1
Totals	**263**	-----	**2.3%**

* Values taken from RFP monthly reports. Treated values for Ponds A-4 and B-5 include all discharges since August 1989.
** Includes the South Boulder Diversion Canal, Ralston Reservoir, Dillon Reservoir, and Boulder Reservoir.

Table II-8
Comparison of Americium Concentrations for RFP and Surrounding Areas* (1988-Present)

Location	Number of Samples	Mean Am-241 (pCi/L)	Samples ≥0.05 pCi/L
Pond A-4 (Untreated)	13	0.015	0
Pond B-5 (Untreated)	25	0.014	0
Pond C-1 (Untreated)	115	0.007	3
Pond C-2 (Untreated)	7	0.025	1
Totals	**160**	-----	**2.5%**
Pond A-4 (Treated)	61	0.009	6
Pond B-5 (Treated)	39	0.005	1
Pond C-2 (Basin)	15	-0.001	0
Pond C-2 (Treated)	13	-0.001	0
Totals	**128**	-----	**5.5%**
RFP Raw Water	11	0.004	0
Arvada	11	0.016	1
Boulder	35	0.002	0
Broomfield	35	0.002	0
Denver	11	0.013	3
Golden	11	0.002	0
Great Western	35	0.002	0
Lafayette	11	0.004	0
Louisville	11	0.004	0
Standley Lake	35	0.004	0
Thornton	11	0.026	2
Westminster	35	0.005	1
Others**	12	-0.003	0
Totals	**264**	-----	**2.7%**

* Values taken from RFP monthly reports. Treated values for Ponds A-4 and B-5 include all discharges since August 1989.
** Includes the South Boulder Diversion Canal, Ralston Reservoir, Dillon Reservoir, and Boulder Reservoir.

Table II-9
Comparison of Uranium Concentrations for
RFP and Surrounding Areas* (1988-Present)

Location	Number of Samples	Mean U-234,238 (pCi/L)	No. Samples ≥10 pCi/L	No. Samples ≥5 pCi/L
Pond A-4 (Untreated)	13	5.59	1	7
Pond B-5 (Untreated)	25	3.42	0	4
Pond C-1 (Untreated)	118	1.13	0	1
Pond C-2 (Untreated)	8	2.78	0	0
Totals	**164**	-----	**0.6%**	**7.3%**
Pond A-4 (Treated)	60	3.37	0	19
Pond B-5 (Treated)	39	2.29	0	0
Pond C-2 (Basin)	15	3.18	0	2
Pond C-2 (Treated)	13	3.76	0	1
Totals	**127**	-----	**0.0%**	**17.3%**
RFP Raw Water	11	0.97	0	0
Arvada	11	0.43	0	0
Boulder	35	0.30	0	0
Broomfield	35	0.93	0	0
Denver	11	0.91	0	0
Golden	11	0.98	0	0
Great Western	35	1.53	0	0
Lafayette	11	0.12	0	0
Louisville	11	0.09	0	0
Standley Lake	35	1.73	0	0
Thornton	11	1.55	0	0
Westminster	35	0.62	0	0
Others**	12	0.89	0	0
Totals	**264**	-----	**0.0%**	**0.0%**

* Values taken from RFP monthly reports. Treated values for Ponds A-4 and B-5 include all discharges since August 1989.
** Includes the South Boulder Diversion Canal, Ralston Reservoir, Dillon Reservoir, and Boulder Reservoir.

Conclusions to Statistical Study of Radionuclides in Water

Radionuclide levels in water discharged from RFP routinely meets CWQCC stream standards based upon the 30-day running average. These radionuclide levels are approximately 0.1 to 1.28 percent of the applicable health-based Derived Concentration Guides (DCGs) specified by DOE Order 5400.5, "Radiation Protection of the Public and the Environment." DCGs are based on recommendations of national and international advisory groups, and on radiological protection standards set by other federal agencies.

Analysis to date on existing data indicates extremely low concentrations of radionuclides in water both influent to and effluent from RFP. While some differences in mean levels of radionuclides at the various sampling locations are shown, most times they do not differ from the plant's raw water supply. With the exception of the plutonium concentrations found in Pond C-2, there are no statistically significant differences in mean plutonium or americium concentrations among the locations. However, statistically significant differences in mean uranium, gross alpha, and gross beta concentrations do exist among the locations.

The CWQCC standards do not approximate the 97.5 *percentile (the intended results of* using the mean plus two sigma) because the data are not normally distributed. Distribution-free statistics show the plutonium, americium, and uranium standards approximate the 93rd percentile range. Repeatedly applying multiple standards that approximate 93rd percentiles will result in exceeding standards on a regular basis. Reaction to and concern regarding such exceedences should take this expectation into consideration.

Routine exceedences of CWQCC stream standards (for Segment 4 of Big Dry Creek Basin) occur when these standards are applied to waters not affected by RFP. When comparing RFP water to other sources, comparisons of means or medians of the analyte populations is appropriate when evaluating water quality from different sources.

The observed levels in uncertainties for plutonium concentrations are most likely a result of the difference in the plutonium level measured. As the level of plutonium measured becomes lower, its associated uncertainty as a proportion of the measurement becomes higher.