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FINAL

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

As Required in
Section XII of the
Statement of Work to
the Interagency Agreement
(January 22, 1991)

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

ENVIRONMENTAL MANAGEMENT PROGRAM

SEPTEMBER 1991

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List of Acronyms and Abbreviations

The following acronyms and abbreviations are used in the Workplan

A I P	Agreement in Principle
A M D A	Acceptable Minimum Detectable Activity
B D D	Broomfield Diversion Ditch
C D H	Colorado Department of Health
C E R C L A	Comprehensive Environmental Response, Compensation and Liability Act
C F	Coagulation/Filtration
C F R	Code of Federal Regulations
c f s	cubic feet per second
cm/s	centimeter per second
C E R C L A	Comprehensive Environmental Response, Compensation and Liability Act
C H S	Colorado Health Standards
C O E	U S Corps of Engineers
C R S	Colorado Revised Statutes
C U H P	Colorado Urban Hydrograph Procedure
C W A	Clean Water Act
C W A D	Clean Water Act Division
C W Q C C	Colorado Water Quality Control Commission
D A F	Dissolved Air Flotation
D C G	Derived Concentration Guide
D O E	U S Department of Energy
E P A	U S Environmental Protection Agency
E R	Environmental Restoration
F E R C	Federal Energy Regulatory Commission
F F C A	Federal Facilities Compliance Agreement
G A C	granular activated carbon
G C	gas chromatography
G O C O	Government-owned and contractor-operated facility
g p m	gallons per minute
G R R A S P	General Radiochemistry and Routine Analytical Services Protocol
H/S	Health and Safety
I A G	Interagency Agreement

IMECS	Interactive Measurement Evaluation and Control System
IX	Ion Exchange
LANL	Los Alamos National Laboratory
LS	Lime Softening
MDA	Minimum Detectable Activity
mph	miles per hour
NEPA	National Environmental Policy Act
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
RO	Reverse Osmosis
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

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

Approved By

______________________ ___/___/___
Name *(Date)*

Executive Summary

This Workplan is prepared in response to Section XII of the Statement of Work to the Interagency Agreement (IAG) dated January 22, 1991 and addresses the *control of radionuclides in water discharges from Rocky Flats holding/detention ponds* The Workplan describes sampling methods, analytical protocol, methods, and limitations 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 from Rocky Flats Plant (RFP) flows in three major drainages where it is directed into a series of downstream holding ponds 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 Seven discharge points are allowed for RFP surface water by the National Pollutant Discharge Elimination System (NPDES) permit for the site Three of these sources (A-4, B-5, and C-2) can discharge offsite and are the discharge points at issue in this Workplan Accumulated water is detained so that adequate water quality analyses can be performed The ponds are designed 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 When ponds are maintained in a near-full condition, minimal spill

containment and storm-water runoff capacities are available Timely release of water is necessary to comply with the NPDES discharge permit and to ensure dam safety

Surface-water quality classifications and stream standards were established in 1989 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 However, several problems arise as a result of the numerical radionuclide stream standards (i e , plutonium and americium) which are set near the limits of analytical detection

Unfortunately, available analytical methods cannot provide real-time monitoring of radionuclides at these low levels because (1) the chemical separations are intricate and time-consuming and (2) analytical counting times are lengthy The typical analytical turnaround times of 61 days confound the operational management of routine releases of water (of known quality) This analytical issue complicates the required discharge of water because of effort and time required to demonstrate water quality, and to obtain approval to begin or resume discharge Measured values approach the lower limit of detection for the standard methods and, therefore, require statistical interpretation to increase confidence This limitation to real-time knowledge of water quality complicates decisions to initiate or resume discharge of impounded water The response in this Workplan is to refine both the technical understanding of the limitations of analytical techniques and the statistical understanding and interpretation of analytical values

Following sampling and prior to to initiation of discharge, the open ponds are subject to potential contamination by runoff from precipitation events and windborne deposition while awaiting analytical results 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 The response incorporated into this Workplan is to improve characterization of the radionuclides, enhance present treatment system capability, and then consider bench- and pilot-scale treatment technology Technologies that will be considered include adsorption, precipitation, sedimentation, filtration, ion exchange, and membrane separation

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

Approved By

______________________ ___ / ___ / ___
Name (Date)

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 Statement of Work (SOW), Attachment 2 to the IAG

This Workplan, which is submitted in fulfillment of the the requirements of Section XII of the Statement of Work/Attachment 2 of the IAG, addresses the following specific items

- Description of current surface-water management system including configuration, and water control strategy and practices
- Sampling pond waters prior to and during discharges
- Sharing split samples with CDH and EPA
- Establishing analytical methods for radionuclides
- Reporting and sharing analytical data
- Assessing water quality with respect to Colorado Water Quality Control Commission (CWQCC) standards
- Proposing improvements in analytical methods for radionuclides
- Identifying, developing, and implementing treatment technologies

1 1 WORKPLAN SCOPE

This Workplan describes current practices and anticipated activities for managing discharges of surface water from RFP, and for limiting/controlling 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

Following this introductory section the Workplan document is divided into major sections organized in the following way

- General site background description, including geology, meteorology, and ground-water and surface-water features (Section 2)
- Background and available information on specific Workplan elements (Section 3)
- Description of further needs developed as Workplan elements (Section 4)
- Ancillary information including references, appendices, and quality assurance documentation

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

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______________________ ___ / ___ / ___
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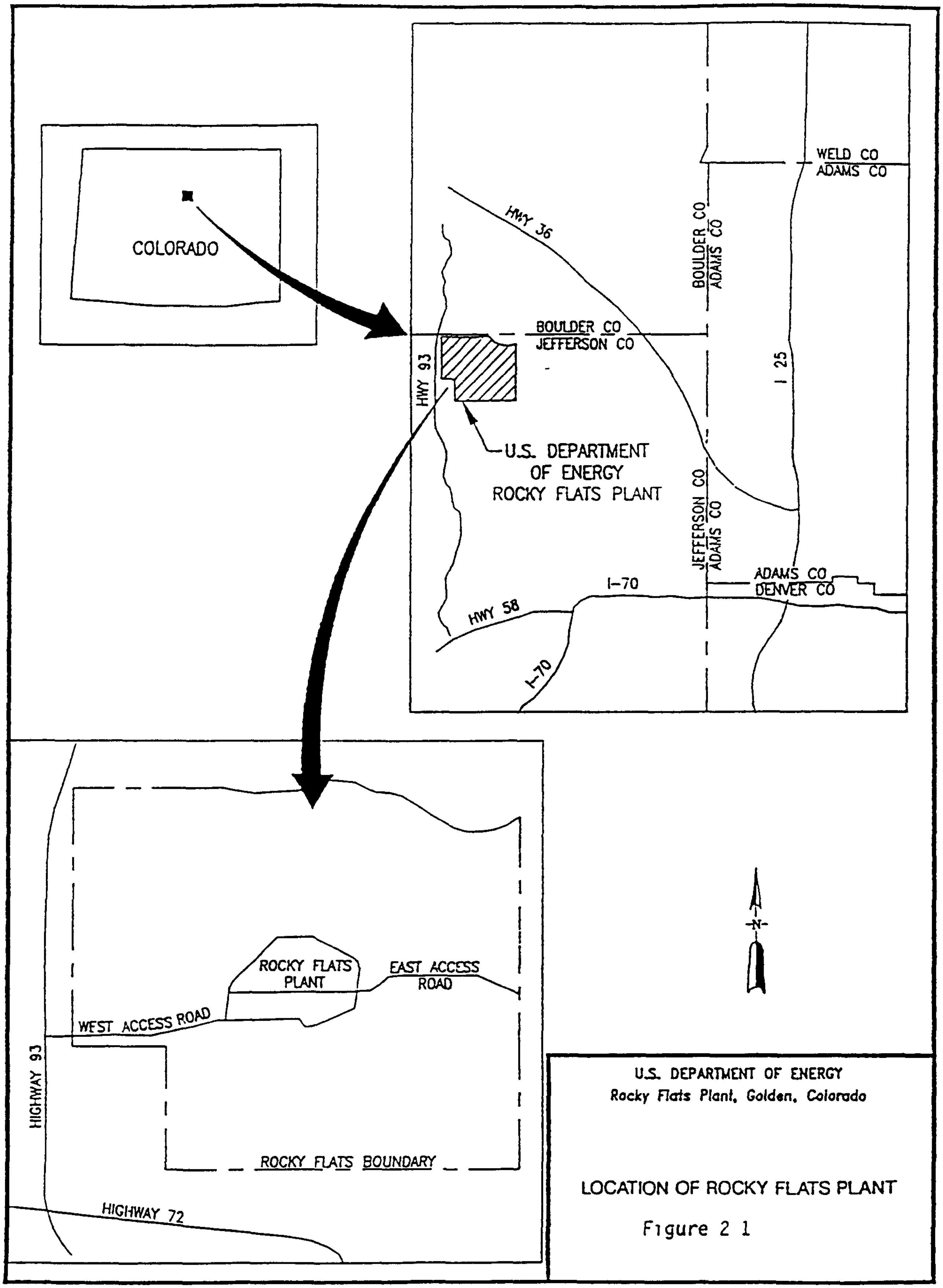
2.0 RFP Background Information

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 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



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Rocky Flats Plant, Golden, Colorado

LOCATION OF ROCKY FLATS PLANT

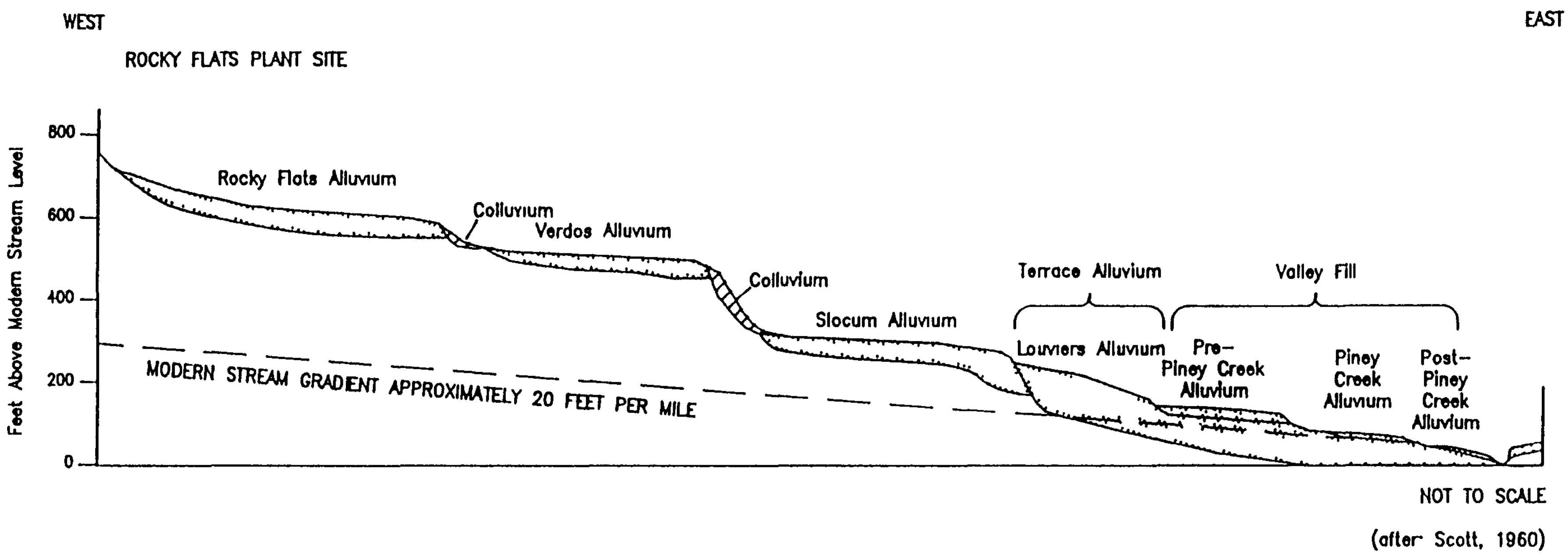
Figure 2 1

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 Rocky Flats Plant is responsible 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

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,



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EROSIONAL SURFACES AND ALLUVIAL DEPOSITS EAST OF THE FRONT RANGE COLORADO

FIGURE 2 2

February, 1991

R33066 PJ-013091

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

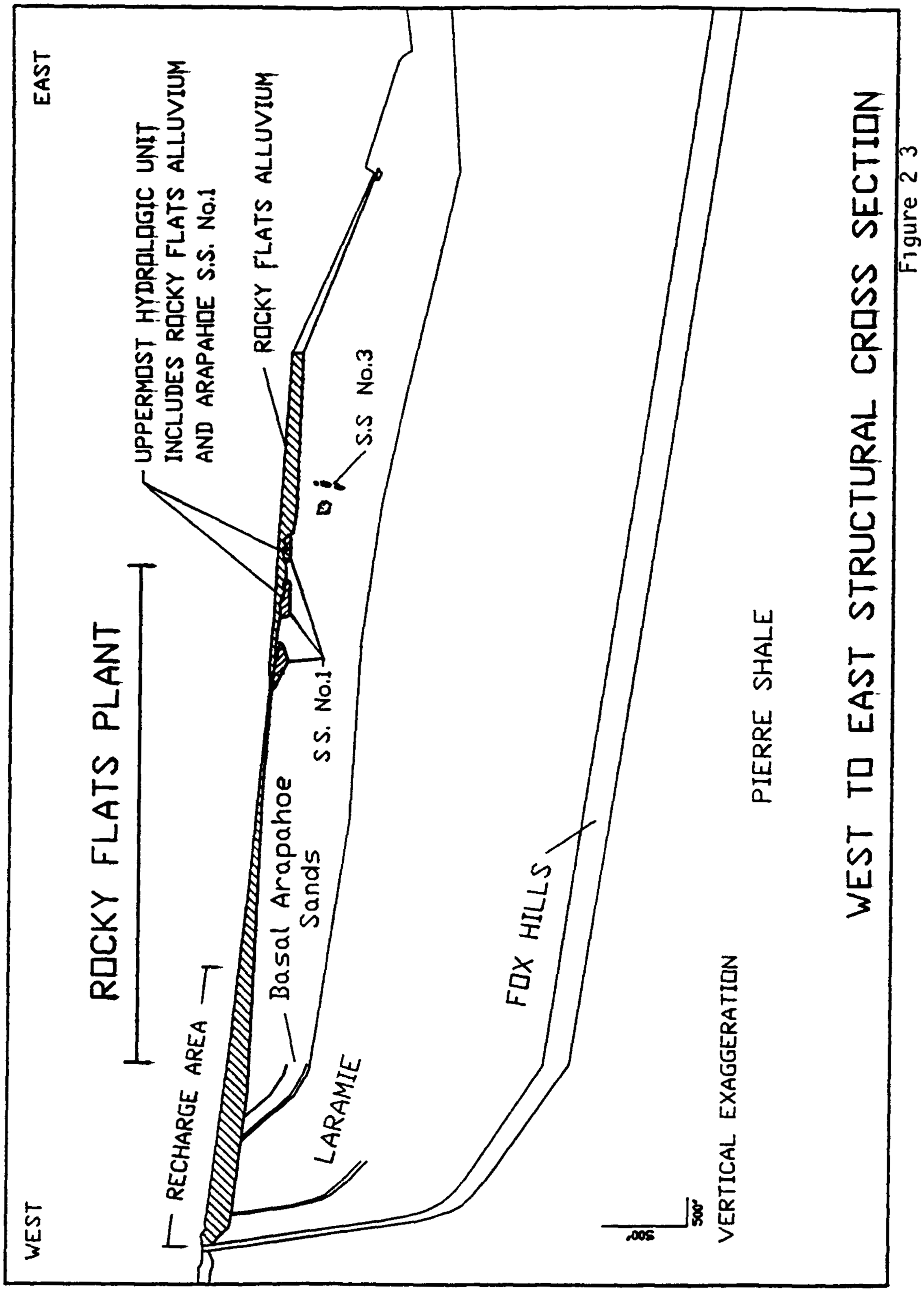
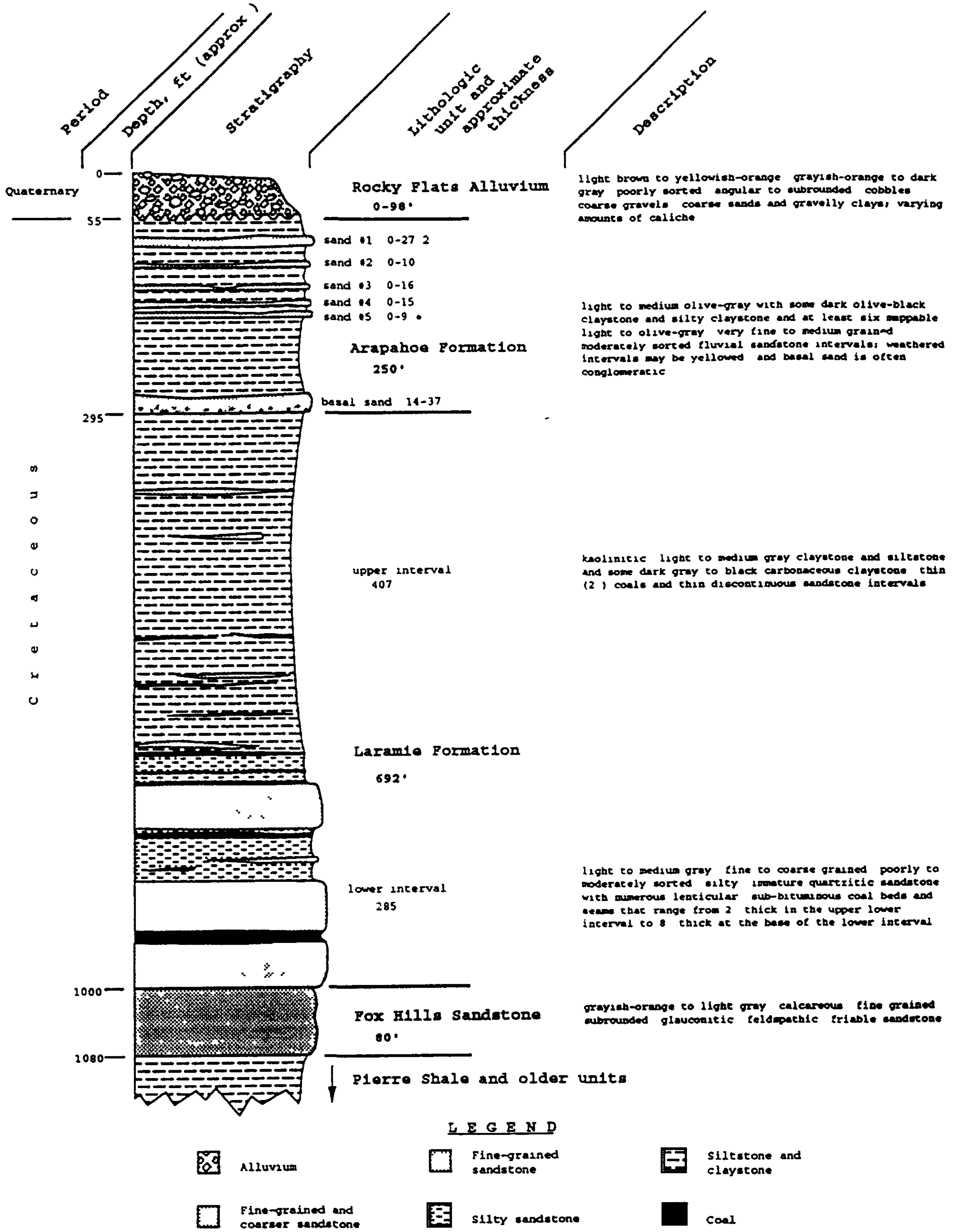


Figure 2.3 West to East Structural Cross Section



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 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 at Colorado Route 128

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) and bypass limitations set by EPA, to a diversion ditch that goes around 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 at Indiana Street

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 was 60 cfs in May 1973 (Hurr 1976)

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 until recently flowed east offsite to Great Western Reservoir, a water supply for a portion of the City of Broomfield and located approximately one mile east of this confluence The City of Broomfield has built and currently uses the Broomfield Diversion Ditch (BDD) to divert Walnut Creek around Great Western Reservoir 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 at Indiana Street 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 was 61 cfs in May 1973 (Hurr 1976)

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)

2 5 REGULATORY SETTING

2 5 1 Overview

This Workplan is a requirement set forth in the Section XII of the Statement of Work to 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

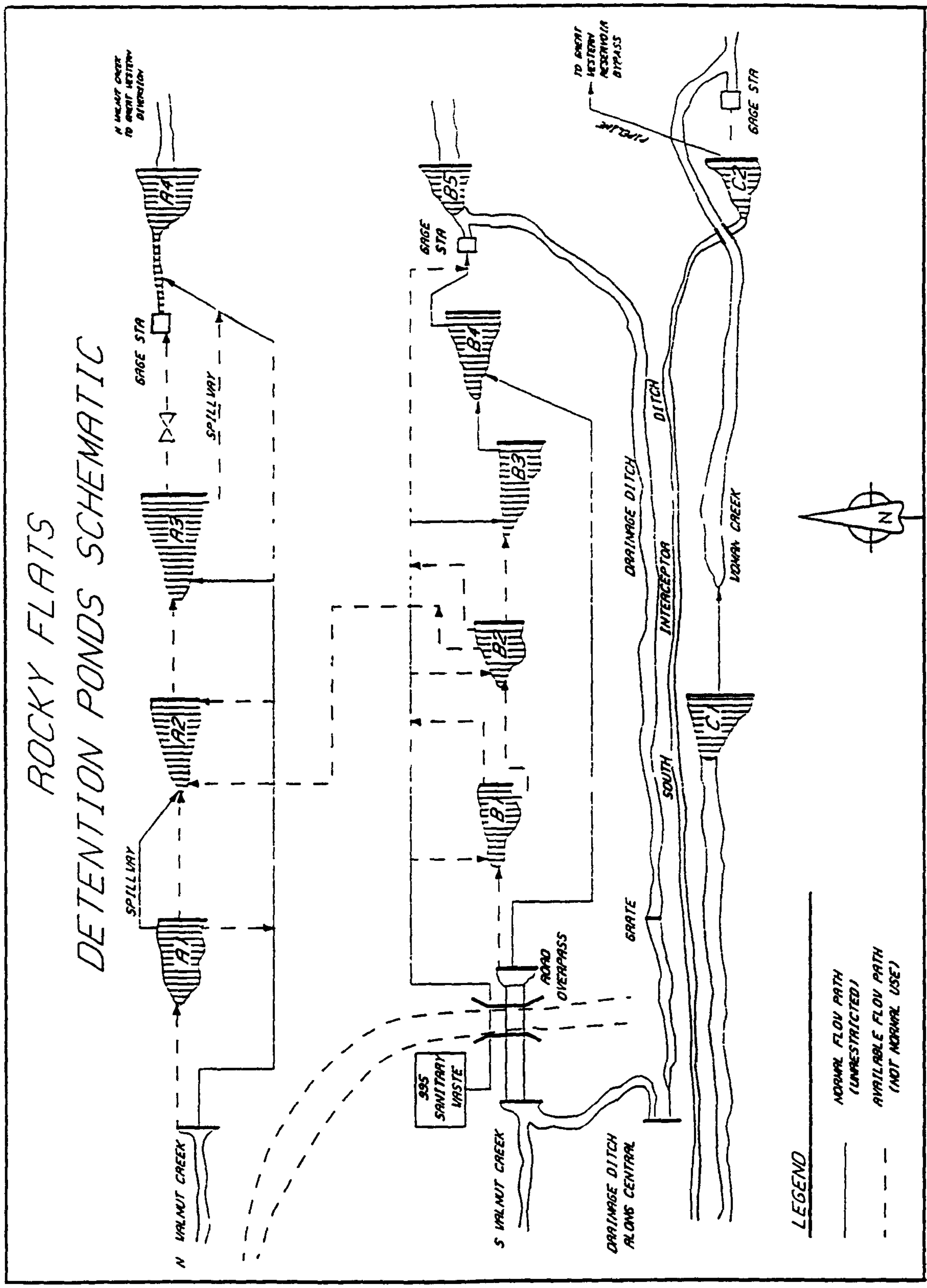


Figure 2.6 RFP Detention Ponds Schematic

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 (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)

Among secondary requirements is DOE Order 5400 1, which affects surface water management activities by requiring source reduction, environmental monitoring, and zero discharge evaluation programs DOE Order 5400 5 pertains to dose limits and presents Derived Concentration Guides (DCGs) that apply to surface-water programs Some environmental programs affecting surface-water management, notably radionuclide treatability in pond discharges, are not directly tied to this regulatory framework but have been undertaken in response to public and local concerns regarding possible impacts of RFP activities on water quality

2 5 2 <u>NPDES Permit Requirements</u>

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 1992 The NPDES permit currently requires monitoring of specific parameters at seven discharge points or outfalls (only five of which are currently in use) (Table 2.5-1) 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

Table 2 5-1
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

The NPDES permit authorizes seven point-source discharges, of which three (Ponds A-4, B-5, and C-2) discharge into drainages leading offsite For purposes of defining the scope of activities and plans for "controlling discharges of radionuclides" to be covered herein, this Workplan specifically focuses on releases of surface water from Outfalls 005, 006, and 007

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 as the primary enforceable document controlling water discharges from RFP

2 5 3 Colorado Water Quality Control Commission (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, respectively, Pond C-2 also considered part of Segment 5 Segment 5 feeds Segment 4, which includes the drainage below the RFP dams to the offsite 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

2 5 4 Radionuclide Discharge Standards

Radionuclide stream standards adopted by the CWQCC have become progressively more stringent over the last 20 years, primarily in response to nationwide tightening of water quality regulations However, in January 1990, the CWQCC adopted the newer strict water quality stream standards in Colorado for Segments 2, 3, 4, and 5 of Big Dry Creek Basin, which comprise Walnut Creek, Woman Creek, Standley Lake, and Great Western Reservoir (CWQCC 1990) The new standards were finalized March 30, 1990 Although the new standards are not reflected in the current RFP NPDES permit, DOE and the State of Colorado have been using them to evaluate and control the quality of water discharged from the terminal RFP detention ponds

In Table 2 5-2, statewide and Big Dry Creek Basin (i e , RFP) water quality standards for radionuclides are compared with those of the federal Safe Drinking Water Act In cases where comparisons are possible, current state standards for Big Dry Creek are equal to or more restrictive than federal drinking water standards

Table 2 5-2
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	0 05	-	-
Curium-244	60	-	-
Neptunium-237	30	-	-
Plutonium	0 05	15	-
Uranium*	5/10	40	(20)
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

3.0 Current Surface-Water Knowledge, Management Strategy and Practice

General site characteristics and water management issues were described in the previous sections of this Workplan This section provides more detail current surface water management practices and other topics related to development of the Workplan The information presented covers four general areas

- 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, review and approval, and management of upset conditions that require suspension and resumption of discharge
- Statistical evaluation of available information on radionuclide concentrations in pond water
- Identification, screening, development, and implementation of treatment

3 1 SURFACE WATER DETENTION

3 1 1 General Considerations

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 removal) 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 water rights of downstream users have not been explored in depth

The RFP pond system accumulates water flows of two basic types, treated sanitary 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 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 suspect flows or upsets 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 release of water due to unexpectedly heavy precipitation

Downgradient of Ponds A-1 and A-2, Pond A-3 collects surface water diverted around the upgradient ponds, and initially detains much of the runoff from the northern plant areas Pond A-3 is operated in the "detain, sample, analyze, release" mode at a frequency determined by inflow versus catchment volume Impoundment construction in the case of Ponds A-3 allows safe accumulation of routine pool levels in excess of 50 percent of capacity Releases from Pond A-3 is 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 operating 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 200,000 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 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 Federal Facilities Compliance Agreement (FFCA)

Ponds A-4, B-5, and C-2 were constructed and placed into service in the early to mid-1980s and are the final ponds in each pond series These three ponds provide the last practical 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 obviously provided when pool levels are kept low Treatment systems for removal of organic and some inorganic (and radionuclide) contaminants are available at the terminal ponds and can provide conditioning of water prior to discharge

3 1 3 Pond Management Strategy

RFP ponds serve three main purposes (1) monitoring and control of water quality, (2) spill control, and (3) 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
- Collecting water samples to evaluate and demonstrate water quality
- 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 potentially 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 *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 The Contingency Plan provides a detailed set of actions to be followed in providing controlled release of water from the affected pond(s)

3 2 SAMPLING AND ANALYSIS OF RADIONUCLIDES IN WATER

Evaluating the sensitivity and accuracy of radiometric measurements is a goal of this Workplan and approaches to achieving this objective are described in the following sections However, further discussion of this topic will be facilitated by initially examining background issues such as limitations of the current knowledge of the characteristics and quantitation of sub-pCi/L radionuclides in the RFP environs

3 2 1 Occurrence of Plutonium in the RFP Environs

3 2 1 1 Contaminant Source Terms

Knowledge of contaminant source term(s) is advantageous in designing and implementing a sampling and analysis program for targeted analytical parameters (or analytes*) Since actual measurement of radionuclides in water is a designated goal, sources contributing to contamination of the watercourses is desirable These source terms can be used to estimate the chemical and physical properties of contaminants and their probable mode of dispersion

Waterborne plutonium in the RFP area and environment originates from background sources (chiefly radioactive fallout from atmospheric tests of nuclear weapons) and from RFP-specific sources Radioactive contamination in the environs about RFP occurs in air, water, and soil compartments, and its transport to water discharge points occurs via the fluid phases—air and water

Contributions resulting from unplanned events (1957 and 1969 fires at RFP), resuspension from past releases (OU-2/903 Pad), inefficiencies in filter media or seals, or leaks/failures of the multi-stage filtration system are possible Studies have

* The term, "analyte," is used in the following sections of this Workplan to refer to analytical parameters

indicated that the largest single contributor to plutonium in the environs about RFP is resuspension of contaminants originating at the OU2/903 Pad (DOE 1991a)

Waterborne contaminants can arise as a result of re-suspension or introduction of fresh radionuclides into watercourses which are eventually directed offsite Since RFP plutonium process operations are separate from sanitary wastewater treatment systems and process operations do not discharge directly to the environment, the water source term contains contributions from ancillary industrial processes, fortuitous release pathways (i e., undocumented leaks or pathways to sanitary), physical transport of contaminated soils/sediments tributary to the holding ponds, and possible re-suspension of existing pond sediments

3 2 1 2 Occurrence of Plutonium in Water

Numerous references describe the occurrence of radionuclides in the environment (Hanson 1980, IAEA 1978, White 1977) Importantly, these sources typically characterize the nature of Pu, Am, and other radionuclides at activities above 0 1 pCi Recent studies (Orlandini 1990, Penrose 1990) have evaluated the particle sizes and chemistry of sub-pCi plutonium in natural watercourses Results indicate considerable variability in particle sizes—some as small as 0 02 micron—depending on the environmental conditions present Environmental conditions which influence the size and chemical characteristics of radiochemical particulates include pH, organic content, dissolved oxygen, and presence of nonvolatile suspended solids It is unclear to the extent to which these individual factors influence aggregation, or cause complexation or solubilization

A second related area of interest is that of the re-suspension or solubilization of radionuclides deposited in pond and lake sediments Rees et al (Rees 1981) evaluated re-dispersion of sediments from RFP Pond B-1 (average Pu loading of 1 6 nCi/g) by a combination of intense physical agitation, pH adjustment, and subsequent separation by centrifugation or filtration to assess (1) activity vs particle size, and (2) particle re-suspension and solubilization of radionuclides Results of this study indicated 74% of the plutonium activity occurred in the sediment fraction 4 6-9 µm in size, while less than 5% of the activity resided in the less than 2 3 µm fraction They concluded that temporary re-dispersal of up to 5% of sediment activity was possible at pH 9 and above They surmised that the re-dispersed phase probably occurred as discrete colloids, or adsorbates on sediment particles, whose average size decreased with increasing pH The re-dispersed phase readsorbed onto the source sediments with time The authors suggested that downstream migration of plutonium in sediments would be "slow," since its solubilization even at elevated pH was difficult

Such studies of plutonium in water and sediments of fresh water systems combine to provide a working model for the occurrence and characteristics of plutonium in the RFP pond system For purposes of the Workplan the following characteristics will be assumed

1 plutonium forms a strong association pond sediments

2 particulates larger than 2 μm accumulate in sediments

3 substantial portions of total activity (perhaps 95%) deposits in the sediments

4 re-suspension or solubilization of sediment activity (and therefore, migration) is difficult even at elevated pH

5 the roughly 5% activity remaining in the water phase occurs as a combination of soluble, colloidal or other dispersed micron and sub-micron phases

This collective assessment holds implications for both the practice of using holding ponds to provide residence time for settling of contaminants, and the nature of the resulting waterborne contaminants If the 95/5 partitioning of radionuclides between the sediment and aqueous phases extends to the sub-pCi/L regime (i e , sedimentation is independent of plutonium activity), then particulates in the sub-2 μm regime are implicated as the chief conveyors of "mobile" radionuclides Analytical methods and treatment approaches should take these characteristics into account

3 2 1 3 Sampling and Analytical Limitations

There are two parts to determining the concentration of radionuclides in pond water sampling and analysis At contaminant levels in the sub-pCi/l regime, both sampling and analytical methods can contribute significant uncertainty or variability to measured values Radiometric measurements also contribute additional variability—random uncertainty—which is associated with the (stochastic) radioactive decay process and background from natural or accumulated (contaminant) activity From the practical standpoint, an additional source of analytical uncertainty arises inhomogeneous distributions of particles within the water source

From the perspective of sampling and contamination, variability of nearly 0 03 pCi is associated with a single (stray) 0 4 µm PuO_2 particle (see Table 3 2 -1)

Table 3 2-1
Mean PuO_2 Particle Diameter vs Activity

Mean Particle Diameter (µm)	Activity (pCi)/Particle*	Particles to Equal 0 05 pCi
0 1	0 00044	114
0 25	0 0069	7
0 4	0 028	2
0 5	0 055	1
1 0	0 44	< 1

* Calculation uses a density of 11 5 g/cm^3 and a specific activity of 0 073 Ci/g for RFP PuO_2

This 0 4 µm particle, if unassociated, could pass the standard 0 45 µm filter, and two such 0 4 µm particles in one sample would produce an exceedance of the 0 05 pCi/L standard In fact, the presence of only a single 0 4 µm particle could account for the sample-to-sample variability normally observed in routine RFP radiochemical data (see Appendix II) This is particularly striking result if mean plutonium concentrations are examined (See Appendix II) Mean concentrations vary from 0 005 to 0 025 pCi/L and place an upper limit on sizes of "single" particle contaminants of roughly 0 25 and 0 4 µm, respectively (see Appendix II) Clearly, precautions must be taken to protect against sample contamination both in the field and in the analytical laboratory

3 2 2 Water Sampling and Analysis

3 2 2 1 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) Standard radiochemical analyses utilize characteristics of the radioactive decay process, itself, in identifying and quantifying radionuclides As such, practical lower limits of 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 an number of factors including the half-life of the specific radio-isotope, analytical recovery, and detector efficiency Water samples are collected and analyzed according to established protocols/procedures (see Section 3 2 2 3) Analytical results are returned in the following form

Sample Result = Mean Analyte Concentration ± 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

RFP reports all valid data resulting from water and environmental sampling programs (Rockwell 1988b, EG&G 1990c) Readers should note both reported measurement uncertainties and relevant MDAs (see Section 3 2 2 2 for discussion of MDA) when interpreting reported analytical values RFP routinely reports results of radiochemical analyses without altering or otherwise censoring the data Reported values include values that are less than the corresponding calculated MDAs and in some cases, values less than zero Negative values result when the mean value of the population of appropriate blank values is subtracted from an analytical result that was measured as a smaller value than the mean population blank value These resulting negative values, as well as positive values below the MDA, are included in any arithmetic calculations on the data set This practice is in accordance with recommended standard practice (EPA 1980) 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

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 methods require that all valid data be considered in formulating conclusions (Gilbert 1987) Recognizing that analytical measurements are subject to imperfections, approximations, interferences, and errors, data from analytical procedures are carefully evaluated by a combination of statistical methods and routine QA/QC practices for their validation (See Appendix III for discussion of Analytical QC)

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 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 2-2

Table 3 2-2
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

* 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 Section 3 2 2 MDA values are due to rounding

3 2 2 2 Minimum Detectable Activity (MDA)

Another key factor for evaluating radiometric data is that of minimum detectable activity (MDA) or lower limit of detection (LLD), 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 At RFP the MDA is formally defined by the relationship

$$MDA = (4\ 65 S_B + 2\ 71/(T_S E_S Y))/aV$$

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

Table 3 2-3
MDA vs Sample Volume and Recovery

Analyte	1-liter Sample	5-liter Sample	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 use an average detector efficiency of 20% and a 12 hour sample count time

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 above)* The accuracy and reliability of routine plutonium and americium data below this value are questionable The current onsite RFP analytical scheme optimizes sample throughput and turnaround using a one liter sample volume and 720 minute counting time

3 2 2 3 Sampling Methods

Sampling is conducted to achieve three basic objectives (1) to assemble routine water quality database, (2) to assess pre-discharge water quality versus CWQCC radionuclide standards and determine the need for treatment, and (3) to demonstrate compliance of water discharges with CWQCC standards Standard Operating Procedures (SOPs) are available to assure uniformity and quality of sampling Sampling of the ponds is conducted in several ways depending upon particular data needs and elaborated procedures are contained in SOPs For sampling radionuclides in a water matrix, relevant SOPs are

- Surface Water Sampling [SW 03]
- Pond Sampling [SW 08]
- Industrial Effluent and Pond Discharge Sampling [SW 09]

These are maintained as controlled documents and latest updates are available for current use Additional references to available water sampling-related SOPs are provided in the Quality Assurance Addendum to this Workplan

Sampling is conducted both prior to, and during discharge in order to support decisions on initiation, suspension, and resumption of discharge, and to monitor compliance Key objectives are (1) conducting sampling safely in unimproved RFP areas, (2) assuring sample representativity, and (3) avoiding contamination of the sample

Samples are of three types (1) single grab, (2) depth-composited, or (3) time-composited Sampling may be done from a boat, from shore, within the treatment train by sample tap, or at discharge by direct collection or mechanically actuated time-compositing Samples are preserved by standard methods according to

- Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples [FO-13]

for radionuclides to reduce adsorption onto sample container Relevant SOPs are referenced in the the Quality Assurance Addendum Further details of sampling procedures are kept as controlled documents by EG&G Rocky Flats Environmental Management Division

3 2 2 4 Current Analytical Methods

The following analytical methods are used for 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

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

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)* (EG&G 1991)

Accurate determinations of extremely low radionuclide concentrations require prolonged sample turnaround times, for many parameters, these time frames exceed two weeks for onsite laboratories and are frequently greater than 61 days for offsite laboratories Until analytical results are received, any water passing through any on-line treatment systems is recirculated (without discharge) to the source pond Ways to improve analytical performance are discussed in Section 4 3.

3 2 3 Statistical Evaluation of Radionuclides in RFP Pond Water

3 2 3 1 Basis and Scope of Study

RFP has conducted statistical assessments of available data for radiochemical contaminants (plutonium, uranium, and americium, gross alpha, and gross beta) in water to (1) assess water quality versus the CWQCC standards, (2) provide a general picture of RFP water quality and identify potential contaminants of concern, (3) compare various ponds/water sources, and (4) assess performance versus the "30-day moving average" (see Section 4 1 6 for definition of this term) (Bauer 1990)

The statistical analysis was based on a historical data set for which the analytical laboratory reported actual activities whether or not they were below the MDA Conclusions from this analysis are based on the assumption that the reported concentrations provide a true representation of the actual radiochemical concentrations in the water samples drawn from the various locations Detailed results of the statistical analysis are found in Appendix II

3 2 3 2 Assessment RFP Water vs CWQCC Stream Standards

CWQCC has set the stream standards listed in Table 3 2-4 for water at Walnut Creek at Indiana Street and at outfalls of Ponds A-4, B-5, and C-2

Table 3 2-4
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

Levels of radiochemical contaminants (Pu, Am, U, gross alpha, and gross beta) in samples collected from several surface-water sources in 1988, 1989, and 1990 were analyzed by statistical methods (see Appendix II for discussion of detailed results) 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)

Statistical comparisons were performed on historical data sets for Pu, Am, U, gross alpha, and gross beta Assessment was possible for uranium, gross alpha, and gross beta data sets, however, data quality limitations for Pu and Am, due mainly to MDAs for the analytical methods used to determine these analytes, prevent firm comparisons of performance against CWQCC standards for these two radionuclides

A comparison of mean uranium concentrations is presented in Table 3 2-5

Table 3 2-5
Average Uranium Concentration

LOCATION	Number of Samples	CWQCC Stream Standard (pCi/l)	MEAN U Concentration (pCi/l)	Standard Deviation	GROUPING*
Pond A-4	47	10	5 2	1 9	A
Walnut Creek	67	10	4 4	2 2	B
Pond C-2	21	5	3 5	1 4	C
Pond B-5	56	10	3 1	1 6	C
124 Raw	32	-	1 3	1 1	D
Pond C-1	105	-	1 2	0 8	D

* ANOVA p-value = 0 0001

Common practice is to use a "grouping" column to display statistically significant differences of mean concentrations between populations Means sharing a common letter in the grouping column are not statistically different from one another For example, in

Table 3 2-5 Pond A-4 (group A) has a statistically significant higher mean uranium concentration than the remaining 5 locations (groups B-D) As an aid in comparing mean concentrations the histograms in Appendix II should consulted These histograms help illustrate significant differences between the means

Mean uranium concentrations downstream of RFP appear higher than 124 Raw (Water) mean values Mean uranium concentrations in all locations are less than the CWQCC stream standards

Although there is not as much historical data available for both gross alpha and gross beta concentrations, a comparison can still be made for data collected from April 1990 through September 1990 The mean gross alpha results are shown in the Table 3 2-6 and mean gross beta total concentrations are shown in Table 3 2-7

Table 3 2-6
Average Gross Alpha Concentration

LOCATION	Number of Samples	CWQCC Stream Standard (pCi/l)	MEAN Gross Alpha Concentration (pCi/l)	Standard Deviation	GROUPING*
Pond C-2	38	7	3 5	1 4	A
Walnut Creek	85	11	3 0	1 5	B
Pond A-4	92	11	2 9	1 6	B
Pond B-5	65	11	1 9	1 6	C
Pond C-1	101	-	1 7	0 7	C
124 Raw	20	-	1 5	1 3	C

* ANOVA p-value = 0 0001

Table 3 2-7
Average Gross Beta Concentration

LOCATION	Number of Samples	CWQCC Stream Standard (pCi/l)	MEAN Gross Beta Concentration (pCi/l)	Standard Deviation	GROUPING*
Pond C-2	38	5	9 2	1 1	A
Pond B-5	65	19	8 8	1 2	A
Pond A-4	92	19	7 9	1 7	B
Walnut Creek	85	19	7 8	1 0	B
Pond C-1	99	-	3 7	1 0	C
124 Raw	20	-	1 9	1 1	D

* ANOVA p-value = 0 0001

Gross alpha and gross beta constituents appear elevated downstream of the RFP, but, with the exception of gross beta for Pond C-2, are below CWQCC stream standards Interestingly, the gross alpha and gross beta values among the terminal ponds (A-4, B-5, C-2) are roughly equivalent, but distinguishable by statistical methods

Generally, the testing for gross alpha and gross beta levels is performed as a screening tool for radiochemical contaminants When elevated results are obtained, follow-up tests for specific radionuclides are performed to determine whether the gross alpha or gross beta results indicate elevated specific radionuclides of concern Unfortunately, because the contributions of Pu and Am (at or below the CWQCC standard of 0 05 pCi/L) is roughly 1% of the total gross alpha, and well within the uncertainty in the measurement of this indicator parameter, it is unlikely that variations in Pu and Am levels would be detected through routine gross alpha measurements

Assessments of Pu and Am concentrations in RFP water are hindered by data quality and should be qualified by the data quality limitations mentioned above, however, the following general conclusions are possible

1 Concentrations of Pu and Am are consistently below the CWQCC stream standards for these analytes

2 Mean plutonium levels in Pond C-2 appear higher than the remaining five locations Mean plutonium concentrations at the five remaining locations are not statistically different from one another

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

3 2 3 3 Comparison of Local Water Sources

Available data for 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 radionuclide 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, occasional single-sample exceedences were found for plutonium and americium (but not for uranium) levels in offsite water This result is most likely an artifact of analytical uncertainty 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 of various RFP and non-RFP waters to the CWQCC radionuclide stream standards appear in Appendix II

3 2 3 4 Performance of the 30-Day Moving Average

Because of the high relative standard deviation of analytical results and extended turnaround times for Pu and Am analyses, a 30-day moving average has been proposed for evaluating compliance of offsite discharges from RFP with the CWQCC stream standards for these radionuclides To initiate exploration of the behavior of the 30-day moving average, a preliminary evaluation of this average for measured Pu levels in Pond A-4 discharges was made using available data from the most recent two year period Initial results are summarized (1) as expected, where an adequate number of data points exist within the averaging period, application of the 30-day moving average "smooths" data scatter resulting from high analytical uncertainty, and (2) it appears that the average Pu values are distributed evenly above and below zero suggesting that the true concentration approaches zero (A more complete presentation appears in Appendix II)

3 2.3 5 Conclusions of Statistical Studies

Assessment of available radionuclide analytical data indicate uncertainty in measured values for Pu and Am often exceeds the measured values themselves Because of limitations of analytical methods and data quality, conclusions for these analytes remain elusive at this time (See Appendix II)

Analysis of existing data indicates extremely low concentrations of radionuclides in water both influent to and effluent from RFP In all but a few cases—most notable for gross beta at Pond C-2—measured radionuclide levels were below CWQCC standards Some differences in mean levels of radionuclides at various sampling locations are indicated and most times downstream locations have statistically higher U, gross alpha, and gross beta (and possibly Pu and Am) levels than the RFP's raw water supply However, statistically significant differences in mean uranium, gross alpha, and gross beta concentrations do exist among locations With the possible 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 between onsite and offsite locations

The 30-day moving average of Pond A-4 plutonium levels from the most recent 2-year period shows the smoothing effect of the averaging approach and the importance of having adequate sampling upon which to calculate the average Examination of the data, though it is somewhat sparse, shows nearly equal populations of averages above and below the zero suggesting the average Pu level is near zero

3 3 POND DISCHARGE MANAGEMENT

3 3 1 Overview

Effective management of pond water discharges is a key component in controlling discharges of radionuclides Present pond discharge strategy and practice is to collect and isolate waters from the North Walnut Creek drainage (Pond A-3), the South Walnut Creek drainage (Pond B-5), and the Woman Creek drainage (Pond C-2), as needed, in Pond A-4 for possible treatment and offsite discharge Water from Pond A-3 is released (in accordance with RFP NPDES permit), and Ponds B-5 and C-2 (as required) transferred by overland pipeline to Pond A-4 where a central treatment facility is provided. Treatment including filtration and GAC adsorption are available at Pond A-4 to perform any water treatment prior to discharge

Pond discharge management is separated into three distinct phases (1) evaluating pond levels or fills, (2) sampling and assessing water quality, (3) initiating, monitoring, and suspending or terminating offsite water discharges Pond level goals, and sampling and analysis protocols for pond waters were discussed previously

This section presents management strategies and operational steps for planning, initiating, maintaining, suspending, and terminating offsite water discharges from RFP terminal ponds.

3 3 2 Pre-Discharge Evaluation

The first step in the discharge process is assessing the need for, and deciding when, and from which ponds discharge(s) will be conducted Several factors determine the need and timing of discharge, namely (1) current levels in terminal ponds and Pond A-3, (2) current water inflow rate to these ponds, and (3) anticipated rainfall or runoff/recharge rates The third factor is a major complicating factor since it involves predicting the weather for weeks in advance, i e , anticipating rainfall/precipitation and the onset of sub-freezing temperatures Typically, prediction of discharge uses seasonal approximations and historical, average monthly precipitation values to determine an anticipated discharge date

Following the initial planning step, a second set of pre-discharge activities occur (1) optimizing pond levels, (2) isolating as practical, the pond(s) to be discharged, (3) starting and operating any treatment system, (4) sampling and analyzing water, (5) preparing for discharge

Generally, the pre-discharge process is initiated for Pond B-5 when it approaches 30% of its effective capacity (7 Mgal) and for Pond A-3 when it approaches 50% of its effective capacity (7 Mgal) Prior to discharge (to Pond A-4), Pond A-3 is sampled for NPDES analytes (pH, nitrates) as well as parameters (gross alpha, gross beta, tritium) required for internal use Typical sample turnaround time for these analytes is one week For Pond B-5 the transfer to Pond A-4 requires only assuring pumping capability, and that the required NPDES-FFCA samples (Whole Effluent Toxicity, total chromium) are collected

By adjusting the discharge/transfer rates, Ponds A-3 and B-5 are scheduled to be reduced in volume (with goal of 10%) on approximately the same day RFP Engineering has set an upper volume limit on Pond A-4 at 65% of its effective capacity (20 Mgal) Thus accounting for the residual volume of 10% (3 Mgal) in Pond A-4, a maximum of 17 Mgal may be transferred to Pond A-4 for any one isolated discharge

Past practice has been to release water both with and without treatment based on analytical results of pre-discharge samples If the use of treatment is anticipated or planned, startup and operational testing is conducted prior to sampling (although no discharge of treated water is conducted prior to receipt of analytical results) Pre-discharge sampling (including splits) is conducted early enough to allow timely discharge and is discussed in Section 3 2 of this Workplan

Samples of pond water must be acquired as early as possible to provide the lead time necessary to initiate and conduct discharge before desired pond fill levels are exceeded Because the minimum time for processing *onsite* radiochemical samples (i e , analytical turnaround) is two to three weeks (longest for Pu and Am) and *offsite* turnaround is 61 days, adequate sampling lead time must be allowed prior to release Early sampling conflicts with the goal of acquiring representative measurements of contaminant levels, as the contents of the terminal ponds may vary with fresh inflow (e g , rain runoff) or possible windborne contamination following sampling Extended delays in receiving analytical results represent a key operational difficulty and present considerable challenge during high runoff periods

3 3 3 Availability of Treatment

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 roughly 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 Operating 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 (e.g., filters, GAC units) can quickly foul in sub-freezing conditions and may become inoperable before permission to discharge is obtained Heated enclosures that cover the treatment facilities are being installed to improve winter operability

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

3 3 4 Approvals to Discharge

According to provisions of the AIP, assessment of water quality is performed by CDH prior to offsite discharge This assessment includes radionuclides as well as other water quality parameters CDH concurrence is directed to the RFP 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 meets all requirements for release to Walnut Creek (or Woman Creek) CDH concurrence has typically required treatment prior to discharge The EPA is contacted for written approval for any diversion of water from Woman Creek to Walnut Creek or the Broomfield Diversion Ditch (BDD)

3 3 5 Current Discharge Mode

Water from Pond B-5 is transferred to Pond A-4 for treatment, and discharges from Pond A-4 are treated, as required, and discharged into Walnut Creek The Walnut Creek flows are diverted to the BDD, beginning on the east side of Indiana Street Water from Pond C-2 is conveyed overland and northeast by pipeline to the BDD or to Ponds B-5/A-4 The BDD outfalls into Big Dry Creek below Great Western Reservoir, therefore, the Reservoir is not impacted by discharges of Ponds A-4, B-5, or C-2

3 3 6 Interruption or Suspension of Discharge

RFP 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

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 portion of the original sample Analytical procedures are checked and additional sample portions are analyzed to determine if laboratory error or sample contamination occurred Additionally, comparisons with results from sample splits with one or more of the independent laboratories may also be available Multiple samples and analyses of water samples are desirable to ensure confidence in parameter measurements

Ideally, potential contaminant levels above CWQCC standards following treatment would require re-evaluation and refinement of treatment measures before discharge is resumed However, continuous inflow to the ponds together with the unavailability of dispersal or reuse options (e g , spray irrigation) does not permit indefinite suspension of discharge, and the decision to release water may be necessary to protect the structural integrity of the dams

3 3 7 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 discharges and (2) the frequent interruptions of discharges, 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 levels directed by dam safety considerations. Streamlining the discharge approval process control is necessary if RFP waters are to be controlled in an effective manner

3.3.8 Termination of Successful Discharge

Successful treatment operations are normally terminated when the residual pond water volume is at 10 to 20 percent of capacity Cessation of flow when pond levels are low is one measure taken to minimize sediment scouring, resuspension, and transport

3.4 CURRENT TREATMENT APPROACH

3 4 1 Evolution of Current Treatment

In March 1990, RFP began treating collected surface water prior to downstream release 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 since incorporated into the IAG

To meet the new radiochemical standards, RFP assessed available data for contaminants of concern and evaluated treatment technologies potentially applicable to the removal of radiochemical contaminants from pond water Initial evaluations, which included both literature reviews and vendor contacts, concluded that the primary radionuclides of concern (plutonium and americium) were 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 filtration to remove suspended solids (particulate matter greater than 0 45 micron) This would theoretically result in a corresponding reduction in radionuclide levels

3 4 2 Current Treatment Method Development

3.4 2.1 Filter Bag Evaluations

Preliminary field evaluations of Strainrite® nominally listed 0 5 micron polyester filter bags, using actual pond water at flow rates 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 because of impending dam safety considerations, a full-scale treatment operation utilizing staged series filtration with Strainrite® nominally listed 10 micron, 5 micron, and 0 5 micron filter bags was implemented as the current treatment system

Further field evaluations using alternative filter bags and filter housings manufactured by other suppliers were conducted Due to the analytical detection capability which used gross alpha and gross beta radiochemical measurements, comparisons were limited and difficult However, substantial reductions in total suspended solids and visual observation of dirt holding capacity indicated that the effectiveness of the filtration system can be measurably increased by upgrading both the filter bags and the filter bag holding vessels However, because of limitations of the available analytical methods, 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

3 4 2 2 Bench-Scale Flocculation Tests

As a credible pre-treatment step for removing radiochemistry, bench-scale tests in the form of jar tests of flocculants were performed in late July 1990 by Nalco Chemical Company Basic, one-time tests on Pond B-5 water samples were performed to determine effective doses of coagulant and flocculant needed to cause sedimentation of suspended solids Pond B-5 water was used because available data indicated that this water source had the highest concentration of suspended solids among the terminal ponds These initial jar test results indicated that a 60 parts per million (ppm) dose of cationic coagulant 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 Preliminary results are shown in Table 3 4-1

Table 3 4-1
Results of Preliminary Flocculation Tests

Coagulant Added	Dose (ppm)	Results
N-8157 (cationic)	60	Well-formed after 40 sec
N-8157 (cationic) + Clay	60	Well-formed after 40 sec, settled upon addition of clay
N-7763	1 0	Initiated formation of large floc
N-7768 (anionic)	1 0	Initiated formation of large floc
Alum	NA	No flocculation

These results are preliminary and should not be used as an indicator of future process performance Interestingly, dose levels are apparently rather high and could impact performance of downstream GAC units Further tests are required

3 4 2 3 Radionuclide Characterization and Low-Detection Limit Studies

Water collected from Pond B-5 in August 1990 was supplied to Los Alamos National Laboratory (LANL) for special isotope-specific radiochemical analyses to quantify accurately Pu and Am contaminant levels LANL also performed bench-scale evaluations of radionuclide removal by particulate filtration, both alone and in combination with clay/flocculant addition (Triay 1991) Preliminary results are shown in Tables 3 4-2 and 3 4-3

Table 3 4-2
Plutonium in Pond B-5 Water by ID/MS*

Treatment Method	Influent Level by ID/MS (pCi/L)	Influent Level by α-Spec (pCi/L)	Effluent level by ID/MS (pCi/L)	Removal (%)
None (Raw Water)	0 003 ± 10%	0 005 ± 0 006	-	-
Filtration	0 003 ± 10%	0 005 ± 0 006	0 0009 +0/-0 0009	70
Clay/Flocculation/ Filter	0 003 ± 10%	0 005 ± 0 006	0 0003 +0/-0 0003	90

* ID/MS = Isotope Dilution/Mass Spectrometry

Table 3.4-3
Americium in Pond B-5 Water by ID/MS

Treatment Method	Influent Level by ID/MS (pCi/L)	Influent Level by α-Spec (pCi/L)	Effluent level by ID/MS (pCi/L)	Removal (%)
None (Raw Water)	0 005 ± 50%	0 007 ± 0 009	-	-
Filtration	0 005 ± 50%	0 007 ± 0 009	0 0009 +0/-0 0009	80
Clay/Flocculation/ Filter	0 005 ± 50%	0 007 ± 0 009	0 0003 +0/-0 0003	90

* ID/MS = Isotope Dilution/Mass Spectrometry

Although preliminary, the empirical results suggest the following

1 ID/MS provides a more accurate measure of radionuclide levels than conventional α spectroscopy and may be the appropriate tool to assess treatability options

2. 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 can be used to confirm the accuracy of routine alpha spectrometry

3. Plutonium and americium levels in raw water samples were reduced significantly by filtration with 0 45 micron Millipore® filters

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

Although these results are preliminary (resulting from a single series of test samples) and should not be used to assess viability of methodology, or predict process performance, they suggest that both filtration and clay addition/flocculation/filtration are good candidates for removing radiochemistry from RFP pond water

3 4 3 <u>Current Treatment</u>

The current system configuration is shown in Figure 3 4-1 This figure is divided into sections and each section is describe below The basic configuration was modified slightly over time to match flow requirements Additional filter vessels, GAC tanks, and pumps were installed in parallel to accommodate higher discharge rates but the system was limited to the 8-inch discharge pipe capacity

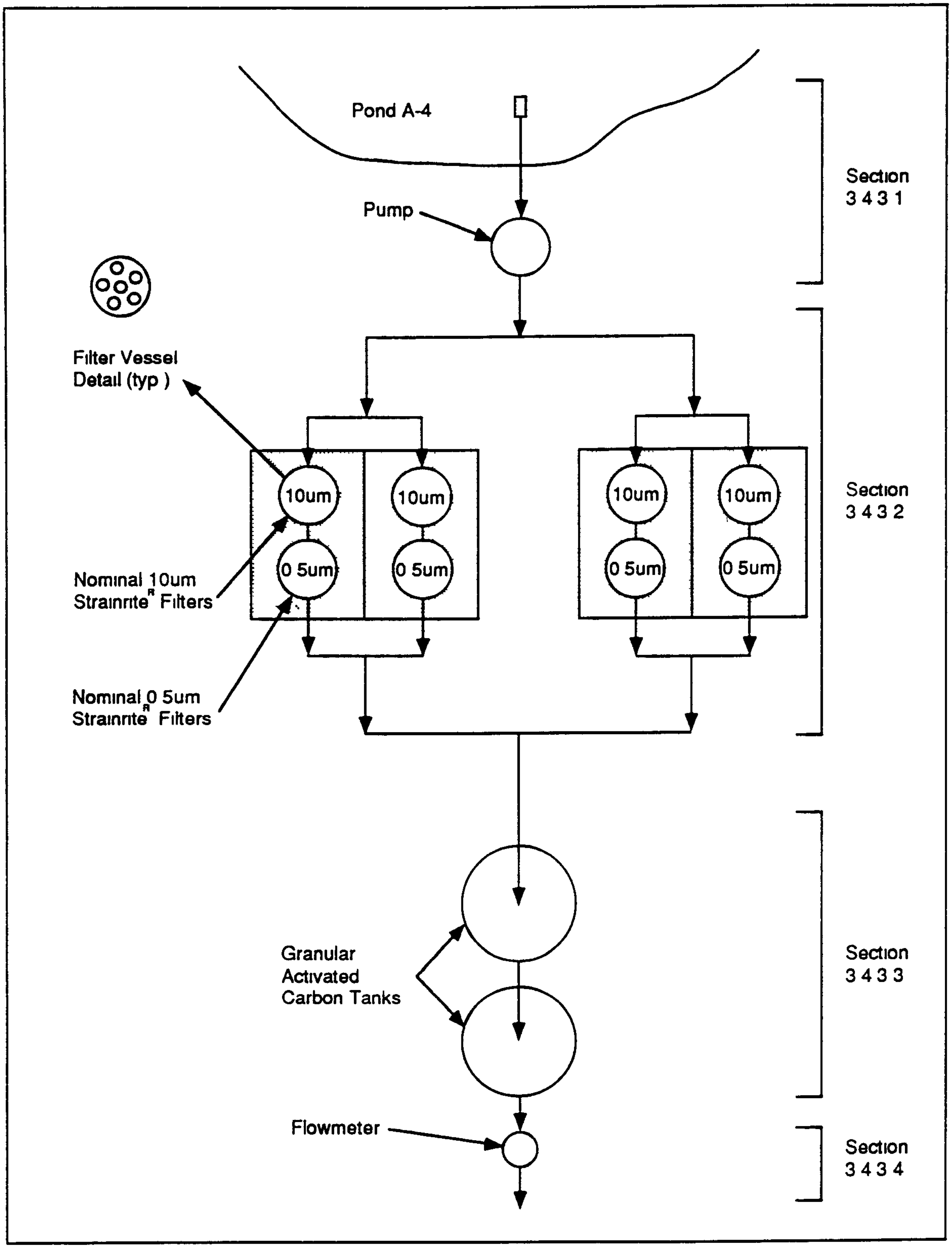


Figure 3.4-1 Pond A-4 Current Treatment System Configuration

3 4 3 1 The pumps are Gorman-Rupp or like and run on diesel fuel The pumps are portable to allow relocation with varying pond levels and connected with flexible piping The pump suction line is a floating influent with a roughing screen on the inlet

3.4 3 2 The filter vessels are the Super Clean W/C four vessel units, trailer mounted, and manufactured by Fluids Control Incorporated Each tank contains six filter baskets and filter bags sealed with rubber gasketing Pressure gauges mounted on vessels and piping provide differential pressure readings, which along with flow rate decreases, are used to determine filter change frequency Additional filter trailer arrangements may be put in parallel to increase the required discharge flow rate

3 4 3 3 The GAC tanks are manufactured by Calgon Carbon Corporation and contain approximately 20,000 pounds of granular activated carbon in each tank A variety of models have been used but they all have approximately the same amount of carbon and capacity Pressure gauges on the tanks indicate fouling of the GAC and the need for back flushing the carbon

3 4 3 4 The turbine flow meter provides a final discharge flow rate for the water treatment system A decrease in flow, indicating loading of the filter bags and/or GAC during operations, is an important factor for optimizing performance by determining filter bag change and GAC back flushing frequencies

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 was also apparent that the total suspended solids were not being reduced to the levels suggested by the 0 5 micron bag rating Although a reduction in radionuclides was anticipated with the suggested nominal 0 5 micron rating, the filter bags primary function is to protect the GAC from premature fouling and thereby preserve its capacity for the removal of organic contaminants

3 4 4 <u>Preliminary Radionuclide Removal Study</u>

A preliminary study was performed by RFP contractor tasked to evaluate all technologies, and combinations of technologies, that might effect the required radionuclide removals (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

A treatment train was assumed to consist of water conditioning followed by a final treatment step 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

Twelve alternatives were evaluated with regard to performance, costs, and waste generation Of these, designed to remove particles as small as 0 01-0 001 µm, six alternatives utilized ultrafiltration (UF) as a final polishing step for removal of uranium; the other six considered ion exchange (IX) The six UF alternatives were evaluated and 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 IX based on the presence of dissolved uranium Ion exchange was recommended for further work

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 Further discussion of proposed treatment evaluations is presented in Section 4 4 of this Workplan

4.0 Workplan to Control Radionuclides in RFP Discharges

Significant technical issues, deficiencies in data quality, and operational limitations were identified in previous sections (particularly, in Section 3) as requiring further evaluation, development, and resolution Section 4 of the Workplan document contains the "plan of work" separated into four major sections or Workplan "elements" Together these sections address these identified deficiencies and problem areas and offer recommendations/proposals/plans to improve performance in these areas

It will become clear in evaluating the following four sections that significant issues within these main workplan elements remain unclear, unresolved, or problematic These issues (e g , timely radiometric methodology) will receive further evaluation and development as early phases of work plans unfold As early Workplan elements described are implemented, improved understanding of technical issues will result in a refined technical approach

The following section form the core of the Workplan and describe the actual plans and work proposals designed to accomplish and improve the control of radionuclide levels in discharges of water from RFP Section 4 is organized accordingly to cover the four elements specified in IAG Statement of Work, 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 " [IAG 1991]

Control of radionuclides can be accomplished by two general approaches (1) control of the release of waters containing them from the RFP site, and (2) reducing their concentrations using treatment methods As noted in Section 3 4, available treatment methods do not provide an demonstrably effective means of reducing radionuclide levels in water Until such time as treatment is proven effective for removing radionuclides from water, the available means to control their release is by controlling the water that contains them Collection and detention (thereby taking advantage of natural in-pond sedimentation) allow time for analysis and planning its eventually reuse or discharge The following section describes continuing and proposed means of controlling and sampling pond water to regulate radionuclide discharges from RFP Proposals to refine/develop treatment methods will be presented in Section 4 4

4 1 1 Improving In-Pond Water Management

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

4 1 2 Improving Dam Integrity

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:

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 in the fourth quarter of 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 Other recommendations considered "important" or "routine" for good dam safety practice are scheduled for implementation or further study contingent upon fiscal constraints

4 1 3 Refining Runoff vs. Pond Level Models

Complexity of rainfall patterns, high variability in meteorological patterns at RFP, and continuing facility upgrades (and resulting changes in runoff) make hydrologic modeling of the site difficult 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 the second quarter of 1992

4 1 4 Weather-Proofing Treatment Facility

The current treatment operation occurs in the unimproved areas of RFP and utilizes a temporary treatment facility installed at Pond A-4 Because the major winter water flows accumulate in Pond B-5 from persistent releases from the STP through Ponds B-3 and B-4, problems arise from icing of the current uncovered operation A heated enclosure is being constructed to shelter treatment operations and provide weather protection at the centralized Pond A-4 Facility Water from both Ponds B-5 and C-2 will be piped, as required, to this facility for treatment prior to discharge (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, and water from Pond B-5 will be piped overland to Pond A-4 via a transfer line) Conveyance and enclosure improvements will be completed by the fourth quarter of 1991

4 1 5 Reusing/Recycling Pond C-2 Water

Proposals to reuse or recycle wastewater and return flows have been considered for nearly two decades A project to reuse Pond C-2 water in the raw water loop at RFP is currently under serious consideration with preliminary engineering designs already developed.

4 1 6 Sampling and Reporting Requirements

4 1 6 1 Sampling Program

General information on water sampling methods and procedures was presented in Section 3 2 3 (reference SOPs Surface Water Sampling [SW 03], Pond Sampling [SW 08], Industrial Effluent and Pond Discharge Sampling [SW 09]) RFP will continue to maintain its program for sampling and analysis for radionuclides in its terminal ponds (i e , Ponds A-4, B-5, and C-2)

Two types of samples are generally collected (1) pre-release samples to assess water quality prior to discharge, and (2) monitoring samples acquired during discharge Sampling conducted prior to discharge is designed to provide decision-making information and determine the need for treatment Discharge sampling is designed to provide compliance monitoring information

The discharge sampling program will be used to demonstrate the quality of discharge water with respect to the CWQCC stream standards for radionuclides RFP will improve the sampling program to provide maximum parametric and temporal coverage within the constraints of available laboratory capacity and fiscal limitations (See Proposed New Sampling Protocol, Section 4 1 7) RFP will continue to 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 continue to conduct regular monitoring of terminal pond water quality for the following radiochemical parameters gross alpha, gross beta, plutonium, americium, tritium, and uranium RFP will continue to collect in-pond, composite samples, made up of weekly grab samples, in addition to daily composited discharge samples in order to establish a database and evaluate temporal variations in radionuclide levels in the ponds.

Samples will be collected in sufficient volume to allow at least one re-analysis for each parameter, the total volume being dependent on the 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

4 1 6 2 Split Sampling

RFP will coordinate onsite sampling efforts with CDH and other regulatory agencies, through appointed representatives, to assure that representative predischarge and compliance samples are available to the various parties Although RFP is not required to analyze these split samples on a regular basis, RFP will archive them for the purpose of providing confirmatory analyses for regulatory agencies as needed 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

4 1 6 3 Representative Sampling

Representative samples will be collected by RFP from waters to be discharged from the terminal ponds These will include samples of water that have passed through any operating 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, RFP and CDH will negotiate continuing pond treatment on a recirculating basis for the purpose of data collection

4 1 6.4 Sample Analyses

Waters from the terminal ponds will be analyzed by RFP and any other entities collecting terminal pond waters, using methods capable of detecting radiochemical 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 approval or will be developed per Section 4 3 of this Workplan Until such time as approval for these or other radiochemical methods is received, current analytical methods will be used Analytical methods are discussed further in Section 3 2 and Section 4 3

4 1 7 Proposed New Sampling Protocol

Initiating offsite discharge has typically depended on analytical results from a single, predischarge samples for Pu and Am, these predischarge samples are split with CDH Continuing an ongoing discharge has hinged on two- and five-day composite samples collected during discharge and analyzed by RFP These values have been used to complete a 30-day average (see Section 3 2), which is compared to the CWQCC stream standards to determine whether discharge should continue However, for all these samples a one-liter sample volume is analyzed, resulting in corresponding minimum detectable activities (MDAs) of approximately 0 08 pCi/L for both americium and plutonium Both of these MDAs exceed the 0 05 pCi/L standard promulgated for Segment 4

Historically, offsite pond discharges have occurred at roughly six-week intervals Given this frequency, two key sampling/analysis goals providing increased temporal coverage between discharges, and lowering MDAs would be achieved by altering the sampling protocol for both predischarge and continuance sampling events at Pond A-4 The proposed sampling plan is indicated in Table 4 1-1 and described more fully below

Table 4 1-1
Proposed New Sampling Schedule for Pond A-4

Week Number	Sampling Scheme	Analytical Volume	Approximate MDA
Week 1	Seven Daily In-Pond Samples	7 liter	0 01 pCi/L
Week 2	Seven Daily In-Pond Samples	7 liter	0 01 pCi/L
Week 3	Seven Daily In-Pond Samples	7 liter	0 01 pCi/L
Week 4	Seven Daily In-Pond Samples	7 liter	0 01 pCi/L
	Two Depth Composited Samples	1 liter	0 08 pCi/L
Week 5	Seven Daily Discharge Samples	7 liter	0 01 pCi/L
Week 6	Seven Daily Discharge Samples	7 liter	0 01 pCi/L

RFP will extend the 30-day averaging regimen to both in-pond and discharge samples During no-discharge periods, RFP will collect daily in-pond samples One liter of each sample will be composited to provide a weekly, seven-liter sample for analysis This will reduce the MDAs for plutonium and americium to approximately 0 01 pCi/L

Predischarge sampling, with split samples being provided to CDH, would still be conducted prior to the initiating discharge Duplicate one-liter sample volumes would be collected and analyzed by RFP (MDA equal to 0 08 pCi/L), however, the results of the sampling event would be included in the 30-day running average to evaluate the need for treatment during the discharge

Compositing of the discharge flow will continue on a daily basis, however, the new compositing scheme will result in a seven-day, seven-liter sample with MDAs for plutonium and americium of approximately 0 01 pCi/L These results will also be included in the 30-day moving average The 30-day average will then be used to evaluate the current discharge operation

The intent of the new sampling and compositing approach is (1) to provide analytical data with MDAs less than the CWQCC stream standard, (2) to provide a sufficient number of sampling events during each 30-day period for a more consistent evaluation of Pond A-4 water quality both prior to, and during discharge, and (3) to provide an administrative tool which allows more consistent and regular offsite pond discharges by reducing the importance of a single elevated plutonium or americium value

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 " [IAG 1991]

Thorough assessment of water quality with respect to CWQCC standards involves a number of issues, some of which are addressed by established and ongoing programs, and others are not yet considered Relevant to the scope of this workplan element are (1) assessing available historical information for deficiencies, (2) placing the assessment in perspective relative to MDAs and data limitations, (3) determining data needs and objectives, (4) establishing plan to correct deficiencies and improve future water quality assessments, (5) recommending additional work

4 2.1 Deficiencies in Available Analytical Data

Routine analytical data are available for plutonium, americium, uranium, tritium, gross alpha, and gross beta Available radioanalytical water quality data were summarized in Section 3 2 and more extensive discussion appears in Appendix II A preliminary assessment of RFP water quality against CWQCC radionuclide standards is also provided in Section 3 2 and Appendix II of this Workplan As evidenced in this assessment, current data quality for Pu and Am limit comparisons of these parameters to the CWQCC standards Ways to improve data quality and thereby allow comparisons of performance against standards are presented in Section 4 3 Once more accurate analytical data are available, comparisons of Pu and Am data versus CWQCC standards will be conducted

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

- Variability of grab and composite sampling, and representativity of pond concentrations by various collection schedules and methods

- Comparability of results from alternative analytical methods, and the impact of initiating regular use of different methods (such as co-precipitation or gamma spectroscopy) on accuracy of laboratory results

- Variation of radionuclide levels with season of the year

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 fourth 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

- Evaluation of the proposed 30-day moving average versus other method(s) for determining compliance with 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 2 2 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 3 Application of CWQCC Stream Standards

4 2 3 1 30-Day Moving Average

Because of the extended delay in acquiring best available analytical determinations of Pu and Am, a 30-day moving average of all discharge composited samples, weekly and monthly grab samples will be used to monitor these radiochemical concentration levels in water to be discharged from RFP These 30-day moving averages will be used to determine the water's acceptability for release and its compliance with (and the need for treatment to meet) CWQCC stream standards For each of the various locations, average concentration levels will be calculated as the arithmetic mean of all the samples drawn within a given 30-day period These averaged values will be calculated on a weekly basis as the analytical results become available and will be used as a monitoring tool

In addition, the 30-day moving average will be used to show compliance with the CWQCC standards To obtain approval to discharge, a grab sample will be drawn and analyzed along with the other weekly grab samples which were drawn within the previous 30 days Results of these samples will be averaged along with other available results which may fall within the previous 30 days (i e , discharge samples from a previous discharge) and compared to the CWQCC standards

4 2.3.2 Single-Sample Exceedences

In cases where individual samples of pond water contain levels of radionuclides exceeding the radionuclide standards set by the CWQCC, but the 30-day running average is not exceeded, RFP will notify CDH of the single-sample exceedence, but will not necessarily 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 might cause exceedence(s) of the CWQCC radionuclide standards in the ponds or downstream discharges, and consult with CDH regarding the advisability of continued discharge

4 2 3 3 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 changes in operational factors

4 2 3 4 Resuming Discharge

Prior to resumption of discharge in those cases where discharge was 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 RFP will request that CDH grant concurrence for RFP to resume discharge from its terminal ponds if the running 30-day average is within the CWQCC standards and then notify CDH, EPA, and local municipalities of the resumption of discharge

If discharge from the terminal ponds was halted as a result of potential water quality concerns, such as an exceedence of a 30-day moving average for one of the CWQCC standards, RFP will conduct an internal investigation of the causes of the exceedence and institute appropriate measures to remediate the exceedence and/or prevent its recurrence Prior to resuming 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 provide concurrence 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 radiochemical parameters returns to levels at or below those of the CWQCC standards.

4 2.3 5 Regulatory Concurrence

CDH will analyze pond water samples resulting from split sampling with RFP and will notify RFP 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 initiating or continuing discharge

In those cases where exceedences of the running 30-day average for one or more radionuclide 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 (EG&G 1990e) Decisions regarding continuation or cessation of discharge under such circumstances will be made in consultation with CDH and the State Engineers Office

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 " [IAG 1991]

Analytical methods should have sensitivity, accuracy, and precision sufficient to determine radionuclide concentrations at or below stream standards/regulatory limits, the standards adopted for radionuclides are listed in Table 4 3-1

Table 4 3-1

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	0 05	0 05
Americium	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

Radioanalytical data convey three key types of information within the scope of this Workplan, namely they (1) provide information on predischarge water quality, (2) demonstrate compliance with radionuclide limits in discharges from RFP ponds, and (3) guide development of treatment methods which remove low-level radionuclide contaminants (as required) to meet water quality standards There are three chief concerns which drive this activity in the Workplan The first is the need to establish database of valid radioanalytical measurements of sufficient accuracy to demonstrate compliance with radionuclide limits The second is the need to improve the availability (timeliness) radioanalytical data for decision-making The third need is to enable technical evaluations of treatment options which depend on these methods to establish effectiveness for removal of sub-pCi level radiochemistry

4 3 1 General Considerations

The following section examines limitations of current analytical methods, and then indicates approaches being used or planned to minimize or mitigate analytical uncertainty and maximize data utility First, the analytes and analytical parameters of concern are identified by reference to data compiled and assessed in Section 3 2 and Appendix II Available analytical data are then used to determine analytical method requirements and, subsequently, to identify the deficiencies in analytical methods which limit data utility In the second portion of this section sampling approaches to improve data quality and utility are proposed for evaluation And finally, various approaches for refining and improving current methods and recommended options for alternative analytical approaches are presented

4 3 2 Establishing Analytes of Concern

When available radioanalytical data (see Section 3 2 and Appendix II) and methods are assessed relative to the CWQCC standards for radionuclides, the high relative variabilities in Pu and Am data present the most significant challenges to demonstrating compliance with discharge limits This situation is due chiefly to uncertainty in current RFP data as reflected in the MDA or LLD for these analytes (see Section 3 2) While sensitivity of analytical methods, particularly alpha spectrometry, has improved significantly in past two decades, the lower limit of detection (LLD) or MDA for recent historical radiometric data from RFP are limited to 0 08 pCi/L for the typical one liter sample (see Section 3 2) The MDA and associated accuracy limit data utility and data assessments must take this into consideration Approaches to reducing analytical variability and increasing analytical accuracy will be evaluated

4 3 3 Proposed Sampling Strategy

Especially in the case of sub-pCi/L radionuclides, the size and distribution of the contaminant in the water source is important Whether samples and resulting analyses are representative of the actual analyte concentration in the water source also presents concern Factors such as recent precipitation, sampling depth, location of sampling point, time of the year among other factors can contribute to non-representativity of the sample Fundamentally then, sampling is the selection or collection of portions of the total to provide a representative portion of the whole Clearly, the choice of sampling method and sampling location, collection methodology, and sample preservation are important to assuring representativity

RFP sampling strategy minimizes sampling uncertainty by collecting depth-composited samples from the source pool, or time-composited samples during discharge. Given the locations and pool height variations of the RFP holding ponds, representative sampling is a continuing concern In-pond sampling is routinely conducted from a sampling boat and variability associated with locating sampling points is minimized through use of same sampling location Complications arise during winter months when ponds are iced over and samples must be drawn from a shoreside location One future option includes evaluating feasibility of sampling ramps

Several issues relating to analytical method variability also relate to improving analytical performance Variability in analytical performance arises from initial chemical separation of the radionuclides and their subsequent measurement or quantitation The importance of some sources of variability may be minimized by better controls, but variability results both prior to (e g , as a result of sample collection strategy and procedure, sample preservation, sample contamination) or during the analysis process (e g , cross-contamination, improper or contaminated reagents, uncertainty in standards, interferences) Major sources of variability can be reduced by assuring uniform sampling and analysis procedures Identification of major sources of variability can only be resolved through experiments specifically designed to control for recognized sources

4 3 4 Improving Analytical Methods/Performance

Efforts to improve analytical performance will evaluate the following approaches improving detection limits, improving sampling methods, increasing analytical sensitivity, improving chemical separations, increasing sampling size, or using alternative methods Accuracy of analytical methods depends on knowledge of analyte characteristics, often chemical form and approximate concentration are important In the case of radionuclides

Except for the final category (Alternative Methods) the following approaches apply to improving performance of alpha spectrometric methods for quantifying Pu and Am—the identified analytes of concern These approaches will be evaluated by RFP (or its contractors) for practicability and impact on analytical performance *(a) Improving Detection Limit*

Given the stochastic nature of the radioactive decay process, improved detection can be accomplished by simply counting longer Increasing the current 720 minute counting period to 1000 or 2000 minutes to achieve improvements in signal-to-noise (roughly proportional to $[\text{time}]^{0.5}$) will be evaluated A second approach, that of increasing sample size (volume) to five or seven liters, would give a proportional improvement in detection limit and will be evaluated for decreasing MDA (see below for more discussion)

(b) Increasing Analytical Sensitivity

Analytical sensitivity can be improved by decreasing background/interferences through improved shielding and/or by utilizing more efficient instrumentation/detector systems RFP currently utilizes detectors with 20% collection efficiency Upgrading to a detector system having a newer 30% collection efficiency would be expected to improve instrumental sensitivity Plans to upgrade some of the alpha particle counting equipment are in progress and implementation of specific detection system recommendations will be evaluated

(c) Improving Chemical Separations

An important limitation to radioanalytical methods is the extensive sample preparation time Performance improvements are currently underway to shift from electrodeposition to chemical precipitation Alternative actinide-selective ion exchange resins will be evaluated for improving recovery and simplifying analytical separations

(d) Increasing Sample Size

Of the two obvious approaches to improving analytical performance—increasing sensitivity and increasing sample volumes—adopting the larger sample volume approach is the most straightforward If sample volumes were increased from the normal one liter to 5-7 liters then a corresponding decrease in MDA would be anticipated No special development in sample preparation or chemical separations would be required, investments would be mainly in increased preparation time and increased requirements for sample storage space. This approach will be evaluated on a limited basis to determine impacts on laboratory operations and sample throughput

(e) Alternative Methods

The quantitation of radiochemistry can be accomplished by two general approaches—those which measure radioactivity and those which quantitate the element/isotopes directly While the most common approaches (e g., gamma and alpha spectroscopy) measure analyte activity directly, techniques such as mass spectrometry allow counting of atomic or molecular ions directly and with detection limits approaching 10^6 analyte ions Analyte activity is then calculated using specific activities for the individual isotopes. RFP will evaluate the practicality of using mass spectrometric measurements (e g , isotope dilution mass spectrometry) to improve analytical performance

Of the foregoing approaches to improve analytical performance, the simplest approaches which include increased sample volumes and counting times can be evaluated rapidly Other improvements will require some development and will be developed and evaluated according to the schedule in Figure 4 4-2

4 3 5 Goals and Targets for Analytical Improvements

Successful implementation of improvements in analytical performance and methodology will assure timely demonstration of compliance with water quality limits for radionuclides and offer the capability to evaluate/demonstrate treatment methods to remove radionuclide contaminants In addition to general expectations, the four definitized analytical targets are offered to guide further development

1 To determine compliance and acceptability of continuing discharges ⇨ analytical protocol develop having Pu/Am MDA of 20 fCi/L or better with turnaround time of 1 day or less

2 To demonstrate treatment methods to remove residual radionuclides ⇨ develop analytical protocol having Pu/Am MDA of 3 fCi/L with turnaround time of 10-14 days

3 To provide real-time radiometric measurements ⇨ develop detector with LLD of 7 5 pCi/L total alpha in effluent water

4 To establish better understanding of environmental Pu ⇨ define its occurrence and characteristics in RFP pond water

These targets are expected to be met within three to five years of implementing the Workplan

4 3.6 Developing Concurrence on Analytical Methods

Analytical methods and data interpretation are key to the successful development of Workplan elements, this is especially true since analytical measurements approach practical method detection limits for Pu and Am Significant differences in analytical methodology, radiometric instrumentation, determination of MDA/LLD, and data interpretation occur between RFP and CDH A series of formal technical discussions to resolve technical issues and arrive at concurrence on analytical methodology, radiometric measurements, and data interpretation are proposed for these (and other interested) parties The first of thse technical discussions is proposed for the first calendar quarter following finalization of this Workplan

4 3 7 Proposed Analytical Methods

The methods suggested below are repeated from Section 3 2 and are proposed for EPA/CDH approval

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

8 *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

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

10 *Plutonium* - Ibid

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

12 *Curium-244* - ibid

4 3 8 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 a 0 45 micron Millipore® filter 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 This on-line technology will directly measure filtration effectiveness and produce specific particle distributions for unit (treatment) operations which remove micron-sized particles Early evaluations of the particle counting methodology were initiated second quarter 1990 Development testing of the technology for monitoring filtration effectiveness and on-line use will be completed by first quarter 1992 Future correlations of particle distributions to radionuclide concentrations may be possible provided the analytical measuring capability of sub-picocurie concentrations are reproducible and not below the detection limits of the radiometric instrumentation (See Section 3 2)

4 3 9 Analytical Quality Control

Quality control checks of analytical methodology will continue on a routine basis and are described more fully in Appendix III Analytical protocol requires routine checks of methods to assure data quality Routine sample batches include control standards and blanks in addition to field samples The minimum detectable activity (MDA) for each radiochemical analyte 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 At RFP the reported MDA (or LLD) is a measure of the variability of the entire analytical method and includes contributions from the analytical workup as well as the average variability from all radiometric detectors used in its estimation (See Appendix III for discussion of Analytical QA/QC)

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" [IAG 1991]

CWQCC stream standards for RFP are unique in their requirement for routine attainment of sub-picocurie plutonium and americium levels Virtually no information on characterization and treatment of sub-picocurie levels of these waterborne radionuclides exists in literature references (Hanson 1980, IAEA 1978, White 1977) Since stream standards of this nature have not been applied previously, no database of water treatment methodologies exists for reference This Section of the Workplan assumes that treatment to remove radionuclides will be required and, therefore, methodology to identify, develop, and implement treatment technology is presented Plans consider improvements in current methods, the work of others in developing treatment methods in like scenarios, and new treatability studies

The following Workplan sections include proposals in four areas which are (1) improving present treatment, (2) characterizing the physicochemical nature of radiochemical contaminants, (3) tracking potentially applicable treatment methods developed by others and, (4) considering conduct of additional bench scale treatability tests

4 4 1 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 pursued.

General facility improvements are being implemented as noted These include

- 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

In addition, treatment process enhancements are planned as follows

- Evaluating improved bag/cartridge filters and filter vessels
- Evaluating multi-media/sand filters

These improvements are currently underway with completion expected by the end of fourth quarter 1991 Particle counting and efficiency testing of filters and cartridges will provide evaluation criteria for the micron levels of filtration Pilot testing of multi-media/sand filtration units will provide evaluation criteria for this type of filtration Presently specific efficiency testing of multi-media/sand filtration may not be available except for actual installations at other facilities Analytical methods to verify treatment effectiveness for removal of radionuclides 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 1 1 Near-Term Treatment Improvement

This program will consist of bench- and pilot-scale process evaluation as well as consider specific full-scale equipment investigations Criteria will include capability for removing sub-picocurie levels of radionuclides and other contaminants This presents a significant challenge for the testing, design, and implementation of such a process *(a) Bench-Scale Tests of Strainers, Filters, and Cartridges*

The ability to strain the algae from the pond water, a consideration for the first unit operation, will be evaluated with a Filtester™ The Filtester™ is an instrument, for field or laboratory use, which simulates the microstraining process It is used to determine microstrainer unit capacity and the plant size required for a potential application. Removal efficiency and the optimum grade of microfabric can be established by analysis of filtrate samples from the instrument

This task will then 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 1992

A nominal rating for 0 5 micron filter bags was discovered to be inadequate based on current treatment results, (Section 3 4) thereby prompting further investigation Review of filter bags and cartridges used in the filtration of liquids, revealed that some bags on the present market are tested in-house and by independent laboratories to provide absolute efficiency ratings One such test is the AC Fine Test Dust challenge for a specific filter bag at a specific flow rate and pressure This test provides particle removal efficiencies for specific micron sized particles Recommendations on efficiency ratings, materials of construction, dirt holding capacity, sealing arrangements are expected from this work

(b) Pilot-Scale Testing of Sand Filters

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. Multi-media/sand filtration, a consideration for the first or second unit operation in the process, is best suited for pilot-scale testing for two reasons (1) limited information is available for micron efficiency removal of particles, and, (2) this is a difficult unit operation to scale up to the production size process *(c) Equipment Evaluations*

Depending upon the results of bench-scale and pilot-scale work, vendor evaluation of processing equipment will be performed Approaches will include unit operations of a staged filtration systems including algae and particulate removal, with and without chemical treatment, and final carbon adsorption as incorporated in the current system

Unit operations vary in effectiveness for decreasing particle size removal Figure 4 4-1 shows technologies appropriate to removal of various particle sizes Depending on characterization of Pu and Am, amenity to coagulation/agglomeration, emphasis may shift to membrane or IX processes

4 4 2 Characterizing Radionuclides

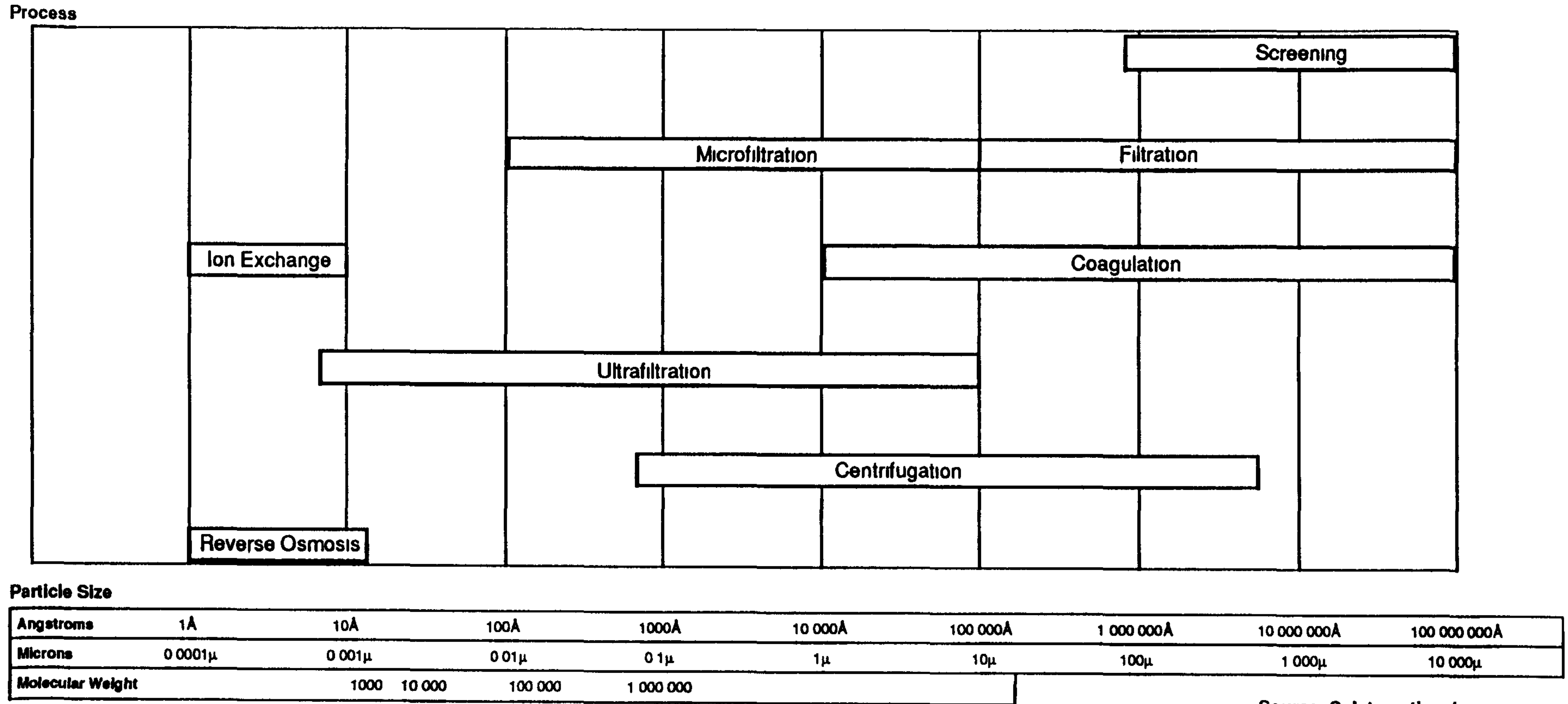
Further information is expected from study of upstream sources of contamination These source studies will assess possible in-stream re-suspension and removal mechanisms and downstream fates of radionuclides prior to the terminal ponds Studies first initiated through Los Alamos National Laboratory will be continued 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

4 4 2 1 Speciation and Quantitation of Radiochemical Species

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

Generalized Water Treatment Technologies
Particle Removal Capabilities of Various Separation Processes



Source C3 International

Figure 4 4-1

4 4 2.2 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 2.3 Radiochemical Source Control

This task will identify appropriate control measures to eliminate exceedences of CWQCC standards Based on fate and transport data developed in the previous two tasks, recommendations will be made as to possible control measures for both up-stream and in-pond sources

4 4 3 <u>Evaluating of Potentially Applicable Technologies</u>

Numerous potentially applicable projects are being developed which relate to the treatment of radionuclides Foremost is the preparation of Best Available Technology (BAT) by EPA which has been issued as a proposed rulemaking under the Safe Water Drinking Act (SWDA) Programs underway at RFP include the Sitewide Treatability Study Plan (TSP) (DOE 1991b) which describes technologies that are potentially applicable to the removal of radionuclides from water and recommends those for testing where additional process information is needed The Site-Wide Program may include nascent processes such as TRU/Clear™ Interim Measures/Interim Remedial Actions

(IM/IRAs) being implemented at RFP incorporate technologies for treatment of radionuclides in water that include for Operable Unit No 2 (OU2) the Memtek (MT) Process. In addition, DOE in possible collaboration with EPA has tentatively planned to assist in demonstrating the TechTran (TT) Process under the Superfund Innovative Technology Evaluation (SITE), Emerging Technologies Evaluation (ETEP) Program The Memtek, TRU/Clear™ and TechTran technologies all involve some form of precipitation and phase separation BAT also does but includes in addition ion exchange (IX) and reverse osmosis (RO) for some target species The OU1 IRA uses IX for radionuclide removal. A program being conducted at Los Alamos National Laboratory (LANL) includes a sorption process followed by a phase separation to effect removal of radionuclides.

This Workplan proposes annual review of these potentially applicable technologies be conducted according to evaluation criteria and site specific requirements discussed below

4 4 4 Evaluation of Potentially Applicable Technologies

4 4 4 1 Criteria for Evaluation of Treatment Technologies

Evaluation of process performance will include consideration of general design parameters as well as aspects related to site-specific characteristics that apply to RFP

Consideration of general process performance attributes will first identify the chemistry and concentration of contaminants to be removed and process performance in removing them Closely associated performance will be noted concerning other contamination such as heavy metals and water quality parameters, and determining if these parameters are improved by treatment to remove radionuclides Consideration of analytes which are "also present" will lead to evaluation of possible interferences, sensitivity of the process to control parameters, and ease of integration and control in association with other water treatment processes Capital and maintenance cost aspects will be considered in appraising process attractiveness System reliability and ruggedness will also be addressed in assessing process attributes Finally, the rigor of analytical methodology in demonstrating process performance and repeatability of results will be addressed in assessing process utility

Site specific concerns have separately been addressed concerning the extremely low concentrations of radionuclides that must be removed and also concern for the presence of colloids has been discussed in detail Additional site specific attributes include space limitations, necessary system size due to required flow rates and the strong incentive to accomplish treatment via means other than chemical addition so as to minimize water quality degradation and minimize cost and complexity Site remoteness makes power consumption and other utility support consideration important

4 4 4 2 EPA Best Available Technologies (BAT)

The EPA's Notice of Proposed Rulemaking (NPDWR 1991), proposed BATs under Section 1412 of the Safe Water Drinking Act (SWDA) for treatment of radionuclides By analyte, technologies proposed are as follows:

Table 4 4-1
EPA BAT for Radionuclide Removal Under SWDA

Analyte	Treatment
Radium 226/228	Ion exchange (IX), Lime Softening (LS) and Reverse Osmosis (RO)
Uranium	Coagulation/Filtration (CF), LS, IX and RO
Beta emitters	IX and RO
Alpha emitters	RO

The selection of BAT is based on factors relevant to RFP These process attributes include high treatment efficiency for effecting removals, general widespread applicability, acceptable cost, reasonable service life, compatability with other water treatment processes and ability to bring all the water in a system into compliance

In developing this list, EPA noted additional process characteristics which may govern specific application For lime softening (LS), EPA noted good performance for radionuclide removal and also for turbidity, heavy metals (HMs) and total hardness (TH) For ion exchange (IX), EPA noted that the corrosivity associated with high purity water obtained by this process could be avoided by blending back waters with high total dissolved solids (TDS) For reverse osmosis (RO), EPA noted good removals for radionuclides and TDS while the process can be upset by turbidity, iron, manganese, silicates and scale-producing constituents and also that brine concentrates produced by the process require disposal

It should be noted that BAT was developed with a paucity of data in some cases and with radionuclide concentrations far higher than those anticipated at RFP discharges points Nevertheless, BAT appears to be an excellent starting point with two exceptions First, coagulation/filtration (CF) was deleted from the BAT list for treatment of beta emitters because of variability of results obtained nationwide This does not rule out that LS could be effective on a site specific basis at RFP Second, recent data obtained on IX suggests that biological fouling under conditions expected periodically at RFP could present problems. There is further concern that leaching of trace organics from organic ion exchange resins could have an adverse impact on biomonitoring LS, CF and RO thus appear to be promising for potential application at RFP based on development of BAT by EPA The Handbook of Chemical Engineering describes these processes in detail (Perry 1984)

4 4 4 3 Sitewide Treatability Study Plan (TSP)

The TSP examined hundreds of treatment processes for inclusion in the RFP program (DOE 1991b) Screening criteria were developed which resulted in a short list, one that could be managed in a practical manner Processes were examined and selected by matrix Detailed workplans are now in preparation

For the water matrix, adsorption and IX were selected for bench scale study for removal of HMs and radionuclides Oxidation/reduction study was also selected while it seems more appropriately designated as a pretreatment method For radionuclides removal, ultrafiltration/microfiltration (UF/MF) was selected as well as a proprietary process, "TRU/Clear™ " TRU/Clear™ is a chemical precipitation process using ferrate ion, followed by microfiltration It is under development by Analytical Development Corporation, (Colorado Springs, CO) The selection of particular UF/MF technology is currently being considered in Workplan preparation for site-wide work

The criteria for selection of technologies to be considered under the TSP are discussed in detail in the Plan (DOE 1991b) Here it should be noted that potential application to two or more OUs was a requirement for inclusion of a process This did not eliminate a process for consideration from the work proposed herein

4 4 4 4 High Priority Operable Units

An Interim Measure/Interim Response Action (IM/IRA) is being implemented in OU1 which will use an IX treatment system for removal of radionuclides (DOE 1990) The treatment unit is scheduled for startup in fourth quarter of 1991

An IM/IRA is being implemented in OU2 which may include treatment capability for removal of radionuclides using a Memtek™ proprietary process The process typically uses lime precipitation followed by crossflow membrane filtration The precipitation may be assisted by iron or barium chloride addition The process is described in the IRAP (DOE 1991a)

4 4 4 5 Superfund Innovative Technology Evaluation (SITE) Program

Through a possible cooperative arrangement with DOE, RFP may serve as the host site for the demonstration of the TechTran, Inc process under the EPA's SITE program for Emerging Technology Evaluation Program (ETEP) using the Solar Pond OU4 The TechTran process is a developing one which precipitates metals and radionuclides and removes precipitates in a freshly prepared filtering matrix formed from proprietary chemicals The matrix is formed from silicates, calcium and magnesium and other salts

4 4 4 6 Adsorption of Radionuclides on Clays

As indicated in Section 3 4 work conducted by Los Alamos National Laboratory (LANL) for RFP indicates that certain clays preferentially adsorb colloidal radionuclide particles Further work to take advantage of this phenomenon may prove fruitful and is proposed for evaluation in conjunction with analytical development and colloid characterization by LANL (Triay 1991)

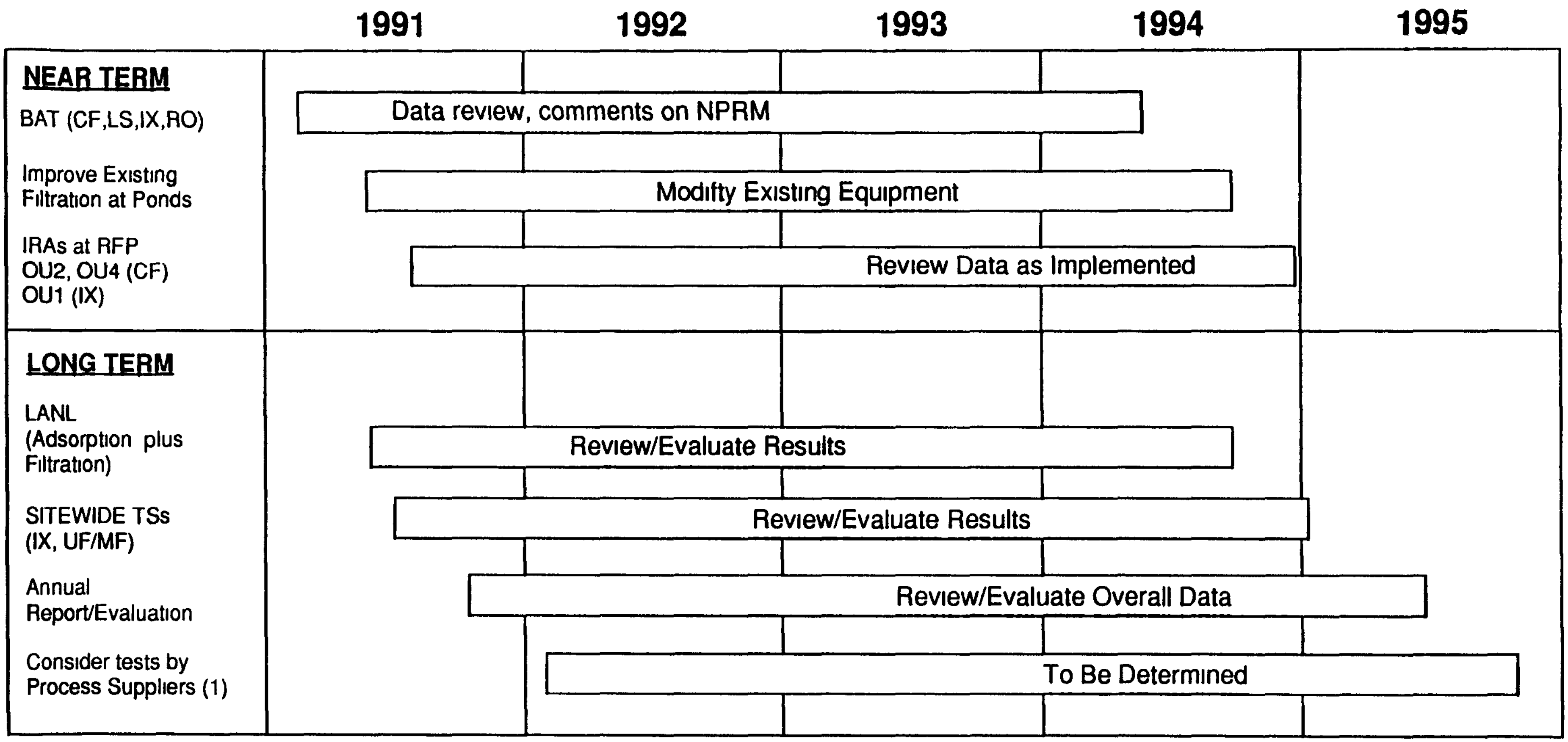
4 4 4 7 Annual Report and Recommendations for Further Work

This Workplan proposes conducting annual reviews of these potentially applicable technologies according to evaluation criteria and site specific requirements discussed in Section 4 4 4 1

The approximate schedule for conducting near-term and short-term treatment application development programs in shown in Figure 4 4-2 Ungoing interactive technical exchange is planned to assure consideration of latest technology for control of radionuclide discharges As noted in Figure 4 4-1, there is a commonality among the various sources of development as to the technology being utilized All technologies include variations of adsorption, coagulation, filtration, membrane separation and ion exchange, and all are similar to EPA proposed BAT Most are proven technologies and require adaptation to accommodate site-specific conditions Some however, are at bench-scale development stage

A proposed deliverable under this Workplan will be an followup report that summarizes advances in technology, and evaluates them for potential applicability to RFP based on the need to control radionuclide discharges by application of treatment technology This followup report will be delivered one year from finalization of this Workplan

Approximate Schedule for Evaluation of Promulgated Technologies for Treatment of Radionuclides in Water



(1) Potential Technologies Include
Coagulation (LS,CF)
Filtration (Alternative Media)
Membranes (RO UF) and
Ion Exchange

Figure 4 4-2

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6.0 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

Surficial Deposits (Rocky Flats Alluvium, Quaternary)

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

Bedrock Geology

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

Aquifer Definition and Ground-Water Flow Rates

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

7.0 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

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)

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

* ANOVA p-value = 0 0131

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

* ANOVA p-value = 0 5571

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

* ANOVA p-value = 0 0001

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

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

* ANOVA p-value = 0 0001

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

Table II-5
Average Gross Beta Concentration

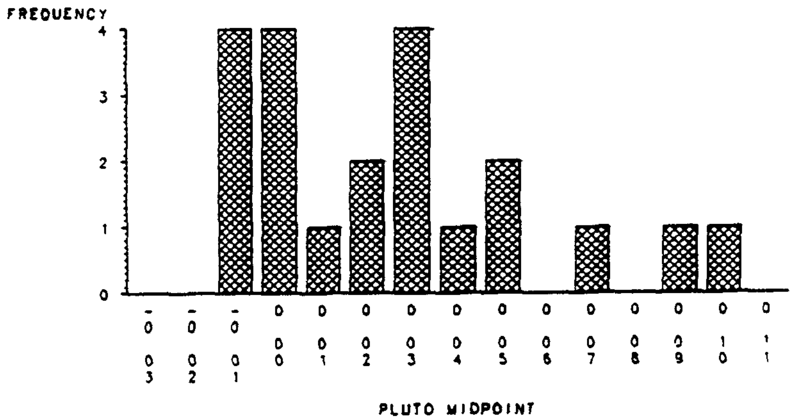
LOCATION	Number of Samples	MEAN Gross Beta Concentration (pCi/l)	GROUPING*	Standard Deviation
Pond C-2	38	9.21	A	1 09
Pond B-5	65	8.85	A	1 19
Pond A-4	92	7 87	B	1 72
Walnut Creek	85	7 76	B	0.98
Pond C-1	99	3.73	C	1 01
124 Raw	20	1 89	D	1 08

* ANOVA p-value = 0 0001

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

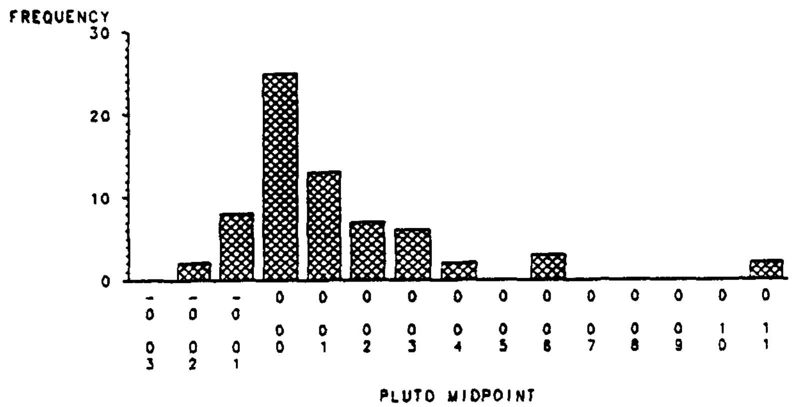
PLUTONIUM CONCENTRATION FOR POND C2

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

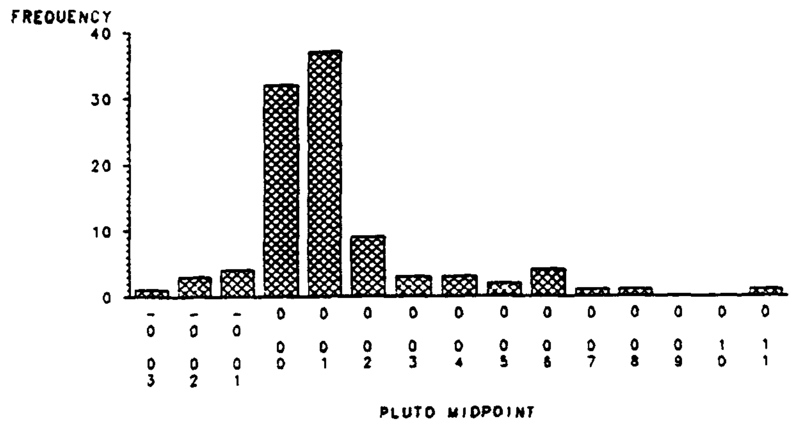
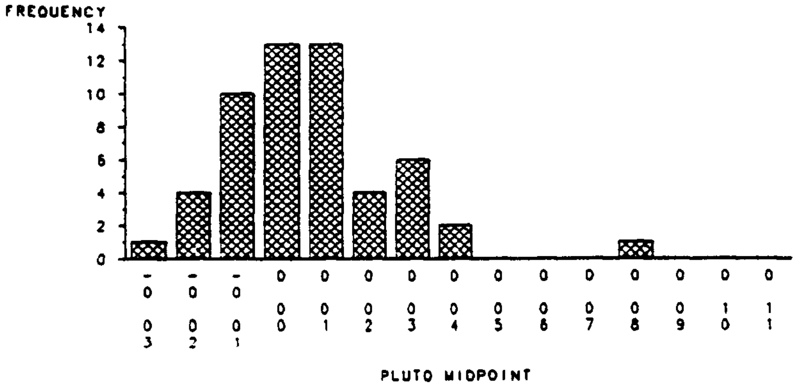


Figure II-1a Average Plutonium Concentration

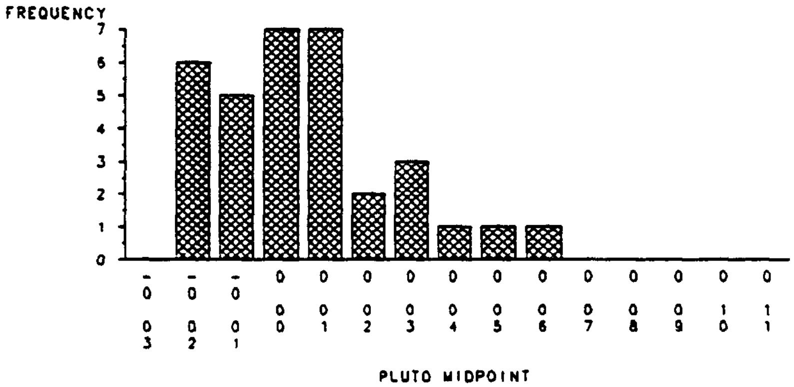
PLUTONIUM CONCENTRATION FOR POND B5

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

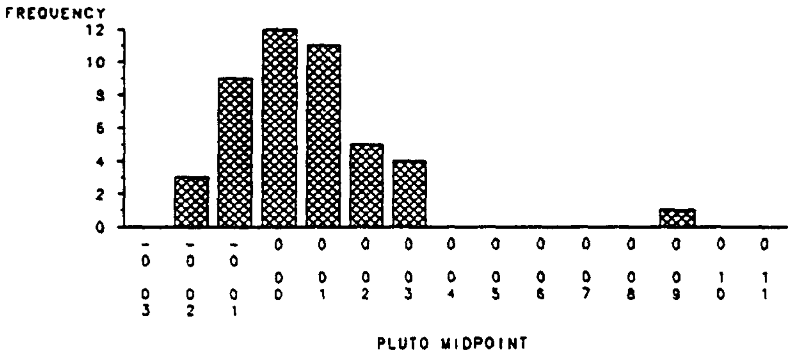
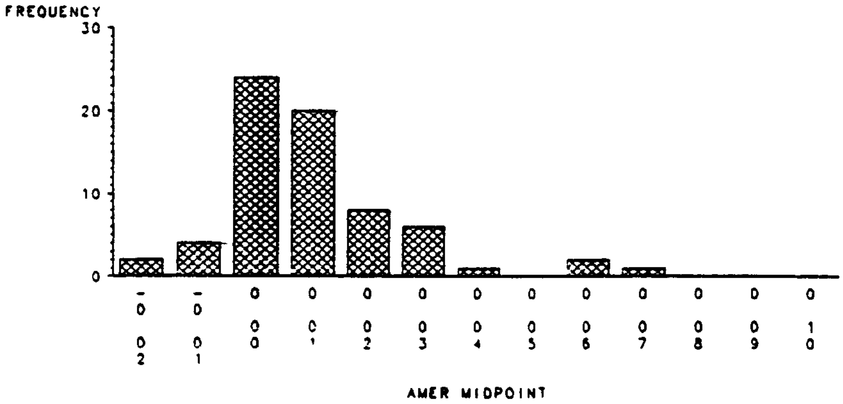


Figure II-1b Average Plutonium Concentration

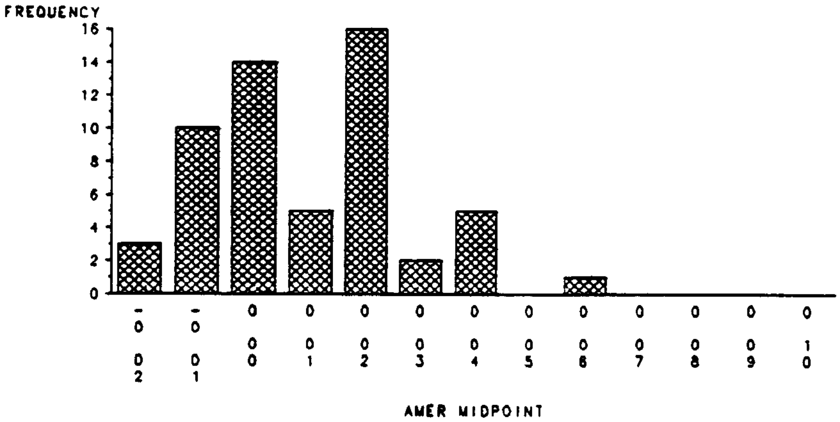
AMERICIUM CONCENTRATION FOR WALNUT CREEK

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

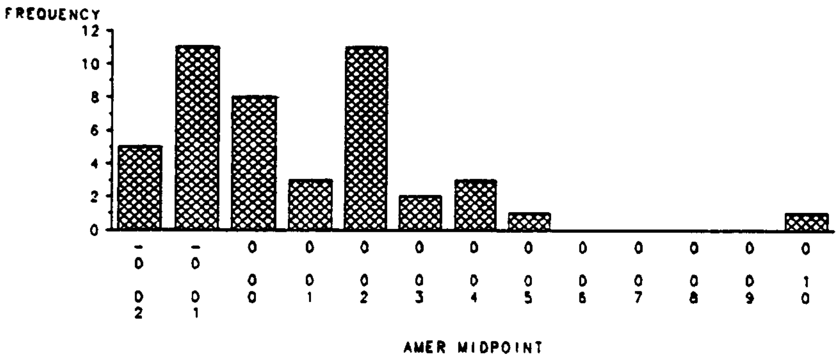


Figure II-2a Average Americium Concentration

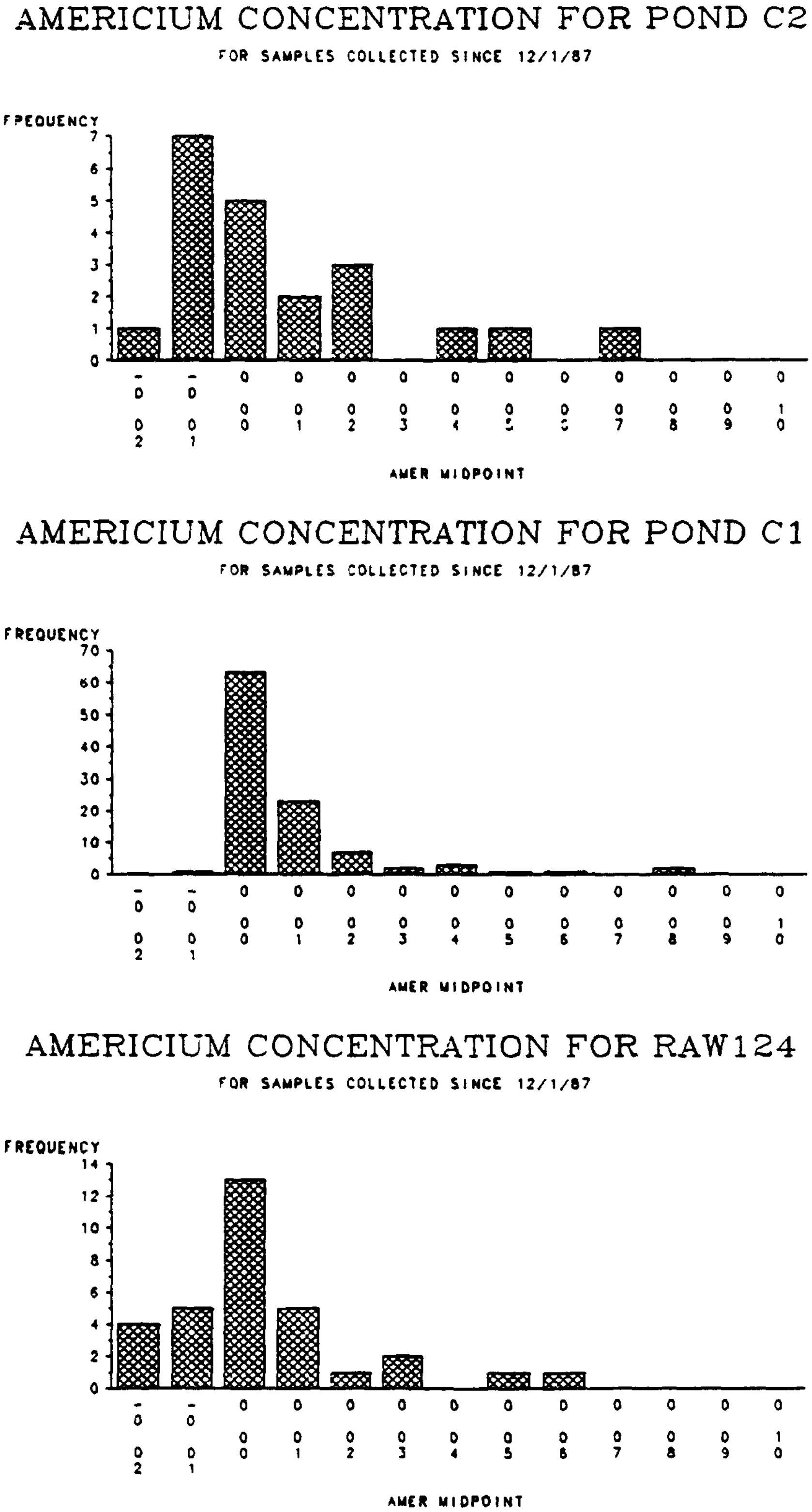
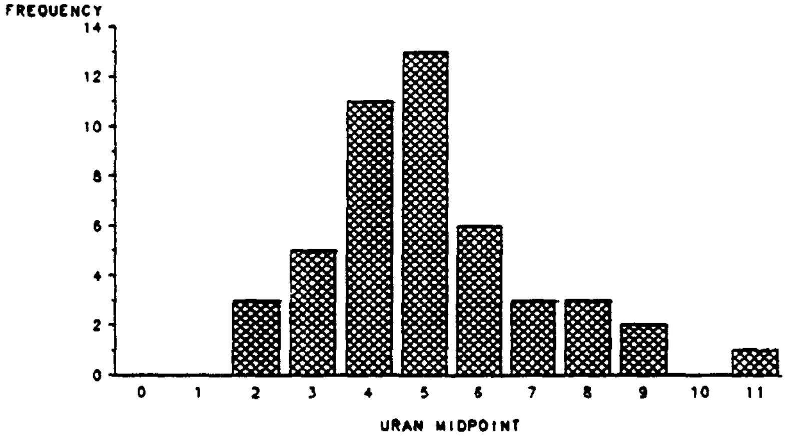


Figure II-2b Average Americium Concentration

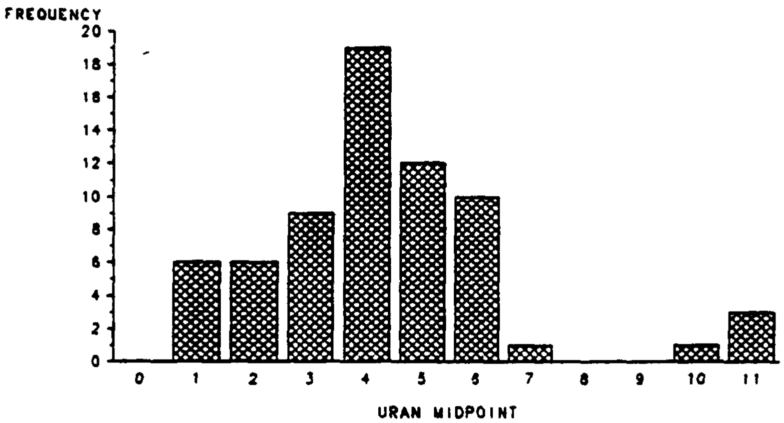
URANIUM CONCENTRATION FOR POND A4

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

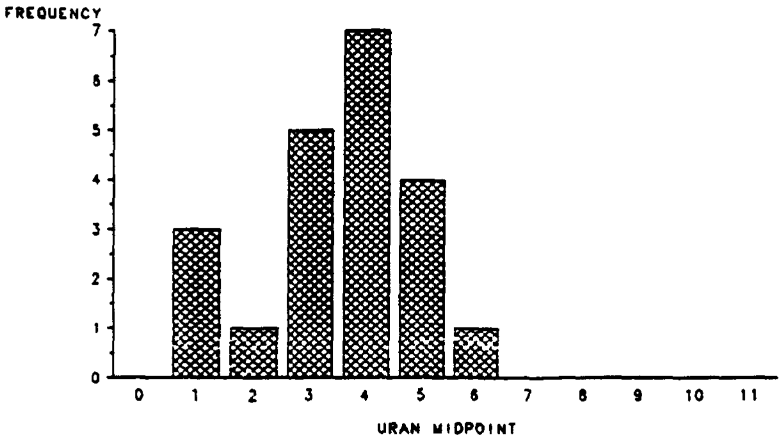
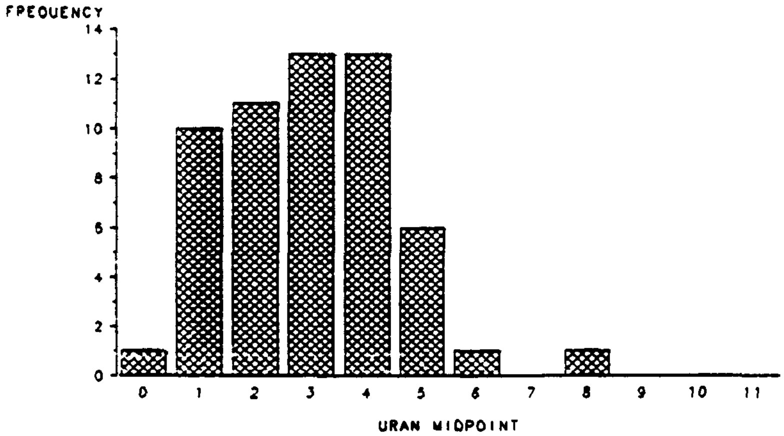


Figure II-3a Average Uranium Concentration

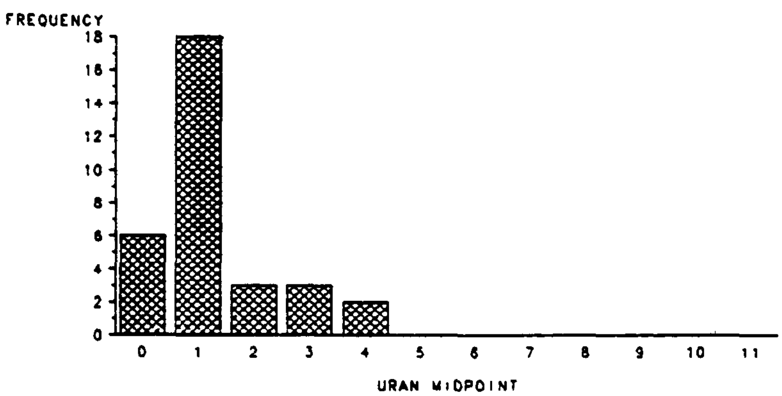
URANIUM CONCENTRATION FOR POND B5

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

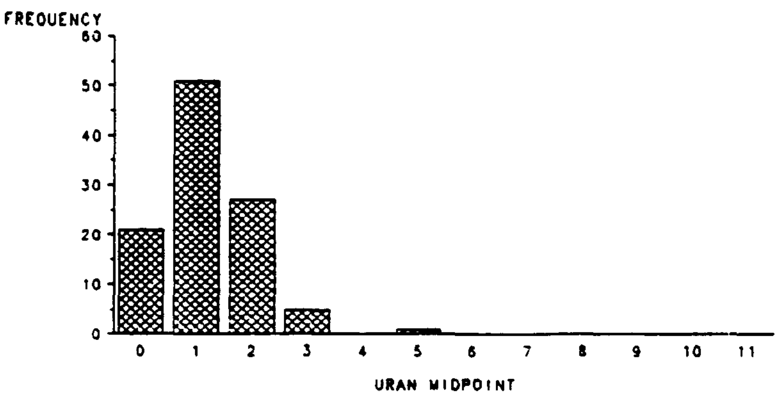


Figure II-3b Average Uranium Concentration

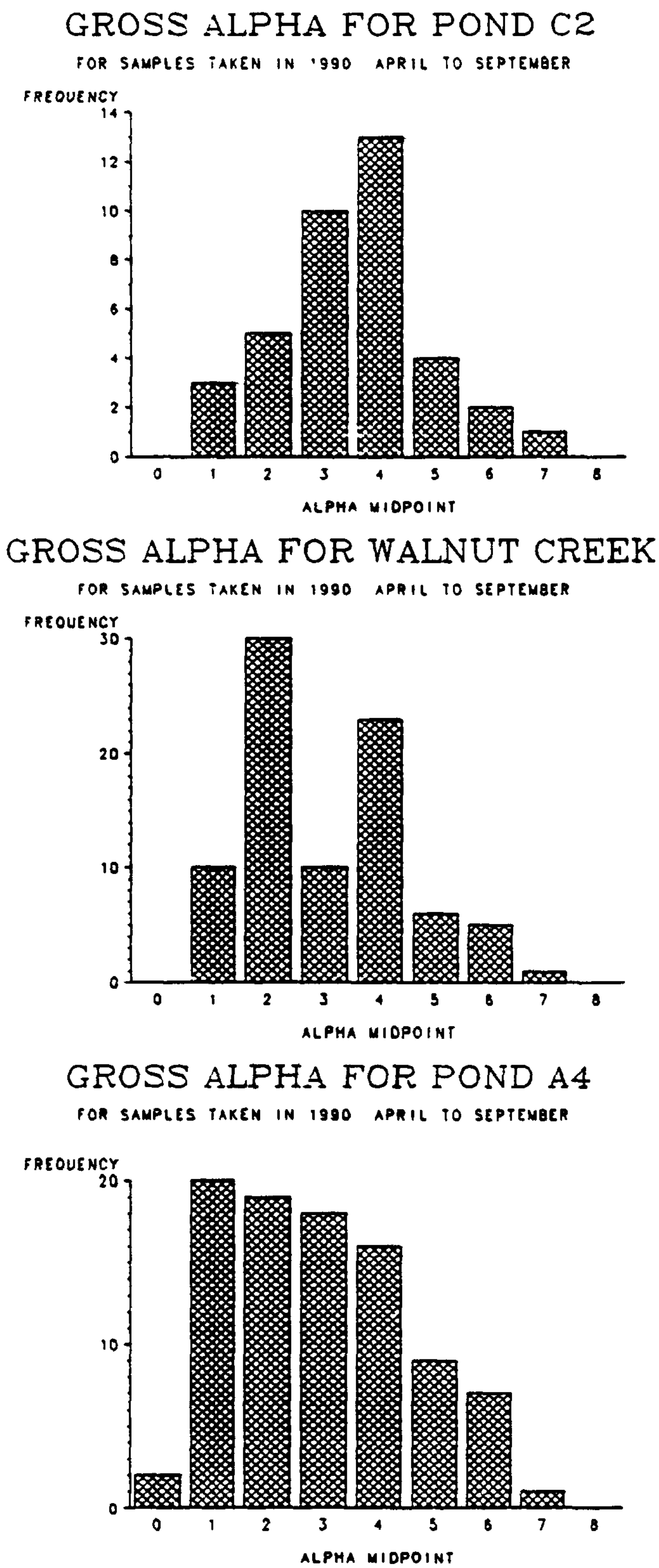


Figure II-4a Average Gross Alpha Concentration

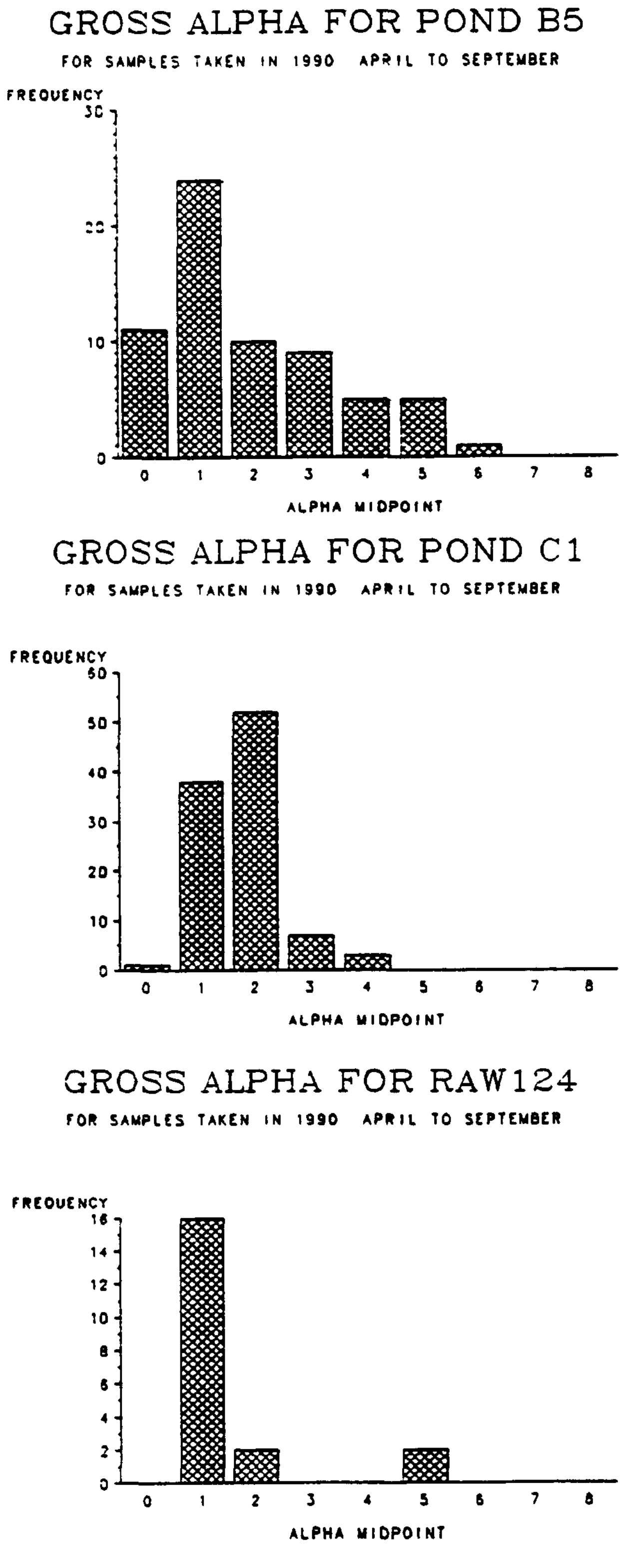


Figure II-4b Average Gross Alpha Concentration

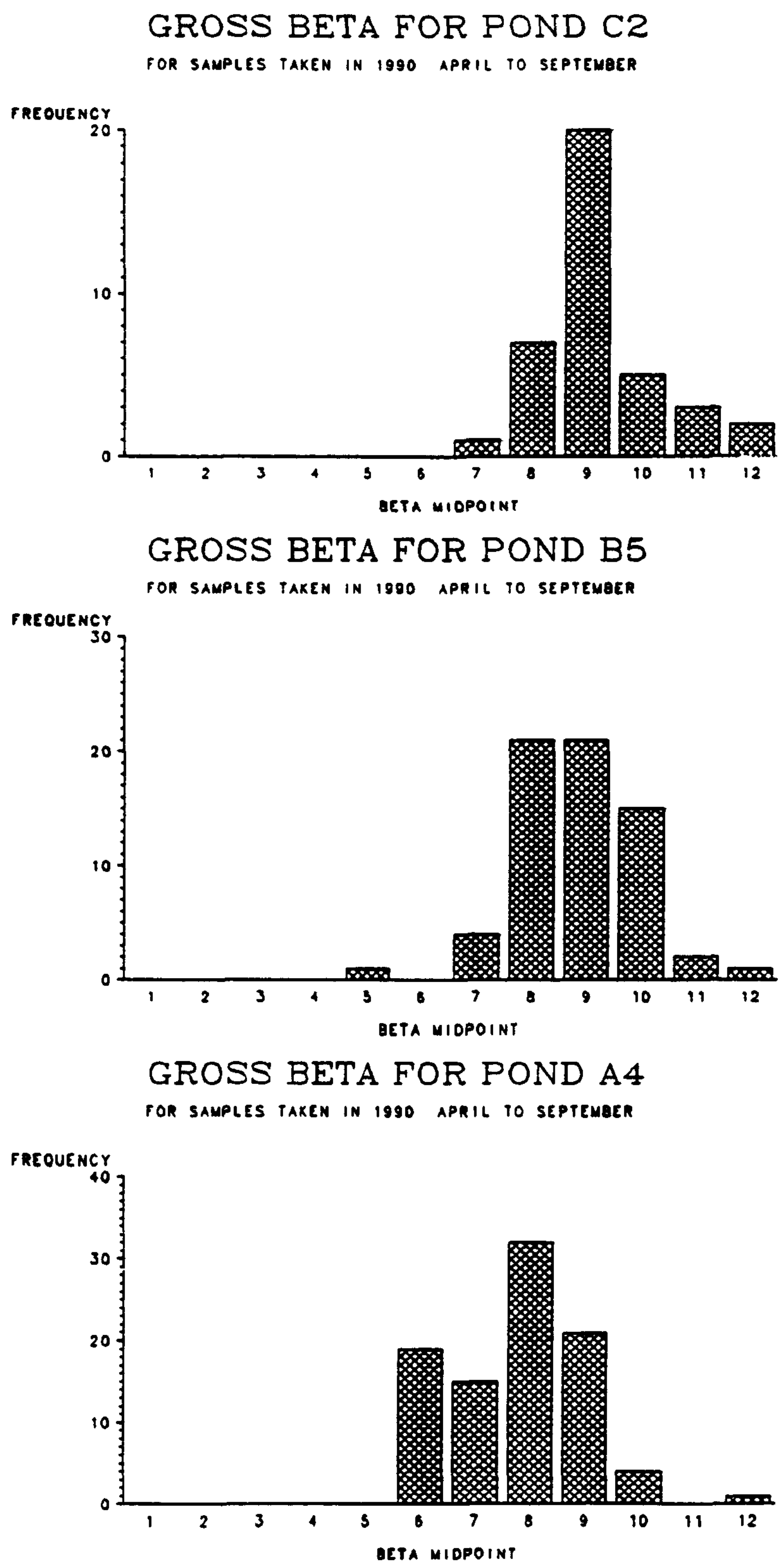
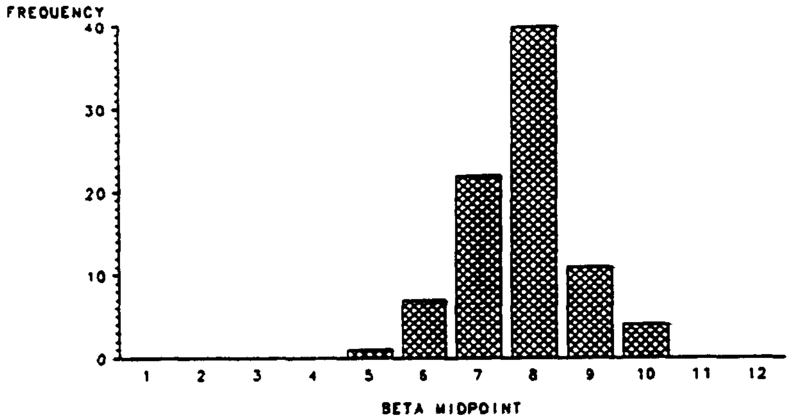


Figure II-5a Average Gross Beta Concentration

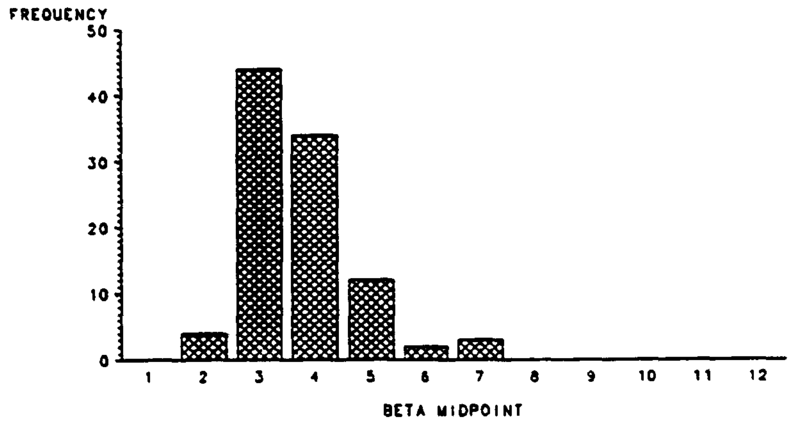
GROSS BETA FOR WALNUT CREEK

FOR SAMPLES TAKEN IN 1990 APRIL TO SEPTEMBER



GROSS BETA FOR POND C1

FOR SAMPLES TAKEN IN 1990 APRIL TO SEPTEMBER



GROSS BETA FOR RAW124

FOR SAMPLES TAKEN IN 1990 APRIL TO SEPTEMBER

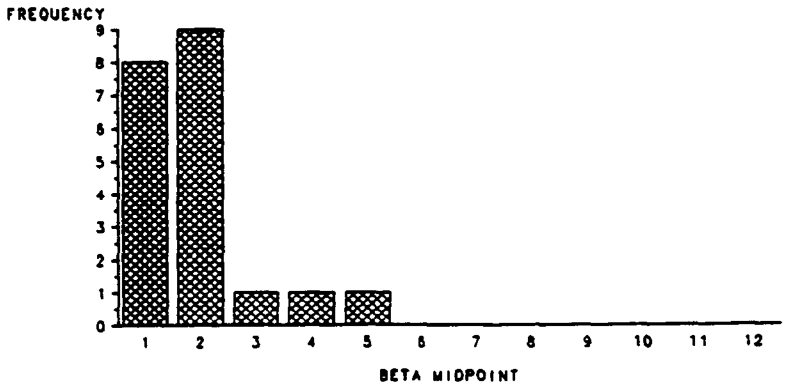


Figure II-5b Average Gross Beta Concentration

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

---

* 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%

certainty. Thus exceedence of a 93rd percentile stream standard should be expected as a common event, and treated with guarded concern when uncovered.

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.

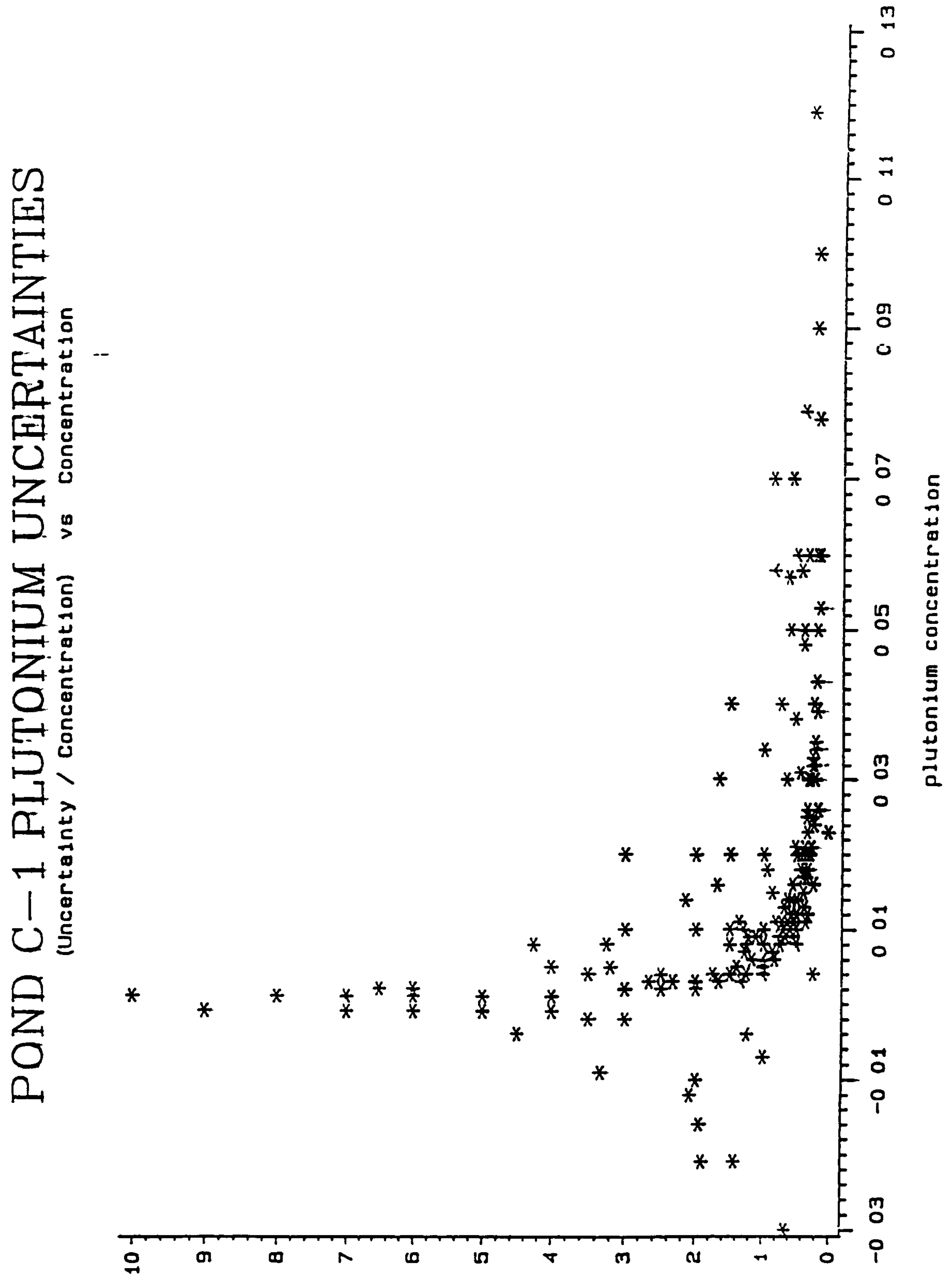


Figure II-6b Analytical Uncertainty Variance

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, occasional 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

Behavior of the 30-Day Moving Average

A 30-day moving average (or "30-day average") has been proposed for evaluating compliance of offsite discharges from RFP with the CWQCC stream standards for radionuclides To initially explore the behavior of the 30-day average, a preliminary evaluation of this average for measured Pu levels in Pond A-4 discharges was made using available data from the most recent two year period

The 30-day average was calculated for the 30th day (in any period where data were available) as the arithmetic mean of discharge values recorded in the 30 days prior to and including the final date of the average The results of these averages were tabulated and listed for the final day in the period The results of applying a 30-day moving average to plutonium concentrations in water discharged from Pond A-4 is shown in Figure II-7 Actual measured values appear as asterisks and 30-day averages are indicated by boxes, the number of boxes indicating the number of data values used in the average The data are plotted for the period July 1989 through July 1991, the CWQCC stream standard of 0 05 pCi/L is also indicated for comparison

The plot indicates routine compliance 30-day moving average with the CWQCC stream standard As expected, the "smoothing" effect of the 30-day averaging also diminishes the effect of individual values Additionally, the approximate equal numbers of average values above and below zero suggests that the average Pu level is near zero

Conclusions to Statistical Study of Radionuclides in Water

Analyses of existing data indicate low concentrations of radionuclides in water both influent to and effluent from RFP In all but a few cases—most notable for gross beta at Pond C-2—measured radionuclide levels were below CWQCC standards Some differences in mean levels of radionuclides at various sampling locations are indicated, most times downstream locations have statistically higher U, gross alpha, and gross beta (and possibly Pu and Am) levels than the RFP'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 locations

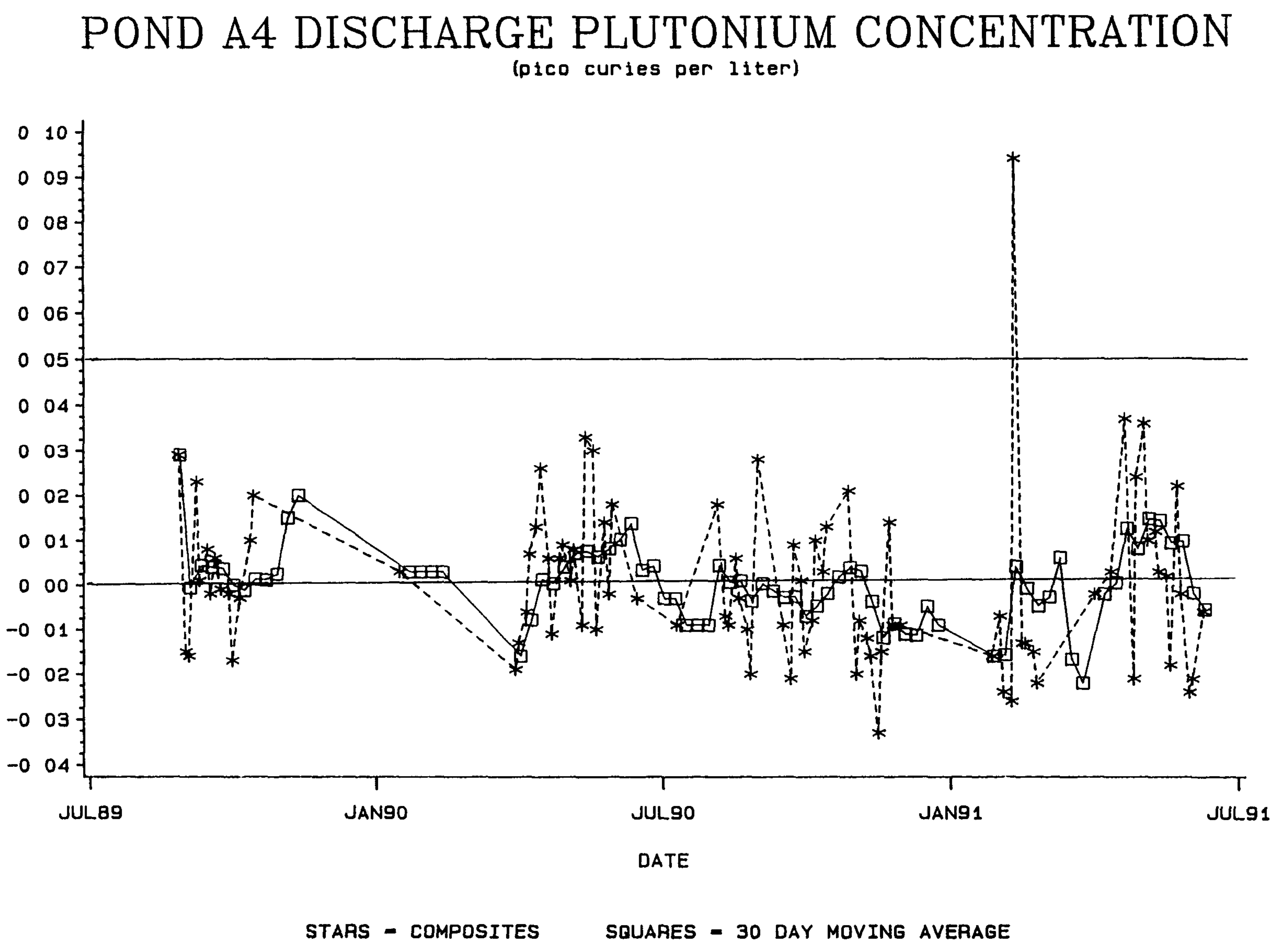

POND A4 DISCHARGE PLUTONIUM CONCENTRATION
(pico curies per liter)
0 10
0 09
0 08
0 07
0 06
0 05
0 04
0 03
0 02
0 01
0 00
-0 01
-0 02
-0 03
-0 04
JUL89
JAN90
JUL90
JAN91
JUL91
DATE
STARS - COMPOSITES
SQUARES - 30 DAY MOVING AVERAGE

Figure II-7

Available radionuclide data do not approximate the 95% confidence interval around the CWQCC standards for Pu, Am, and U because the data are not normally distributed Distribution-free statistics show the plutonium, americium, and uranium populations approximate the 93rd percentile range relative to the CWQCC standards for these radionuclides 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

Occasional exceedences of CWQCC stream standards (for Segment 4 of Big Dry Creek Basin) occur when these standards are applied to waters removed from 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 30-day moving average of Pond A-4 plutonium levels from the most recent 2-year period shows the smoothing effect of the averaging approach and the importance of having adequate sampling upon which to calculate the average Examination of the data, though it is somewhat sparse, shows nearly equal populations of averages above and below the zero suggesting the average Pu level is near zero.

8.0 Appendix III
ANALYTICAL QUALITY CONTROL

The minimum detectable activity (MDA) for each analyte isotope is dependent on detector background, analytical recovery, detector efficiency, and sample counting time as well as the volume of water sampled. These required parameters are calculated using historical data, which are routinely updated from 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 QC Batch *The reported MDA should be interpreted as that of the process and not that of a single measurement as data from all detectors is used for estimation*

(Note All control standards will contain analyte activity concentrations at least 10 times the (MDA) in order for the following criteria to be operable)

A "Quality Control Sample Batch" consists of a group of 12 or fewer samples that will include duplicate internal matrix control standards, a matrix blank, and possible IMECS control standard(s), in addition to field samples Each set of samples, blanks, and controls make up a "QC batch" and is assigned a QC Batch Number Each sample can be correlated with, and traced to, its corresponding QC Batch The statistical evaluation of the defined control sample parameters will determine the acceptability of the sample batch data relative to the agreed data quality specifications If any samples from the original QC Batch require re-analysis, the re-analyzed sample(s) will be included within a new QC Batch

Internal reference controls are prepared by the Health & Safety Labs Control Group and are traceable to National Institute of Standards and Technology (NIST) or NBL The population median blank (B_m) will be used for correction of the QC Batch and analytical values The results are reported to three significant figures Measurement uncertainties are reported as twice the standard deviation of their propagated counting errors

Acceptance Criteria

If the means of the measured values (OV) for the QC Batch matrix controls, plus or minus the 99 percent Poisson counting uncertainty, do not include the matrix control "true" value (SV), the batch results will be rejected If possible, re-analyses will be conducted

If a matrix control "true value" (SV) lies between the 99 percent and 99 percent Poisson confidence intervals of the mean measured value (OV), the QC batch values will be designated as "conditionally accepted "

If the matrix control "true value" (SV) lies within the mean measured value (OV) plus or minus the 95 percent Poisson counting uncertainty, the QC batch values are acceptable

If $OV + 2\ 58\sigma < SV$, or if $OV - 2\ 58\sigma\ SV$	Reject Batch
If $OV + 1\ 96\sigma < SV < OV + 2\ 58\sigma$	Conditional
If $OV - 1\ 96\sigma > SV > OV - 2\ 58\sigma$	Conditional
If $OV + 1\ 96\sigma > SV > OV - 1\ 96\sigma$	Acceptable

If the measured analytical recovery of a sample (R_S) or a reference control (R_C) minus its 99 percent Poisson counting uncertainty exceeds 100 percent, the Laboratory Data Base software rejects that result If the point value for the measured analytical recovery of a sample (R_S) or a reference control (R_C) is less than 10 percent, then the Laboratory Data Base software rejects that result also If possible, re-analyses will be conducted

If a batch blank (B_b) point value is greater than the population median blank (B_m) plus its 99 percent Poisson counting uncertainty, then (B_m) will be used for analytical batch measurements correction and the batch data shall be designated as "conditional" by the laboratory The data user, upon investigation, including historical comparisons, may choose to designate the data as rejected if there are indications that the data are suspect because of such conditions as suspected cross-contamination If possible, re-analyses will be conducted

If $B_b > B_m + 2\ 58\sigma$ Conditional

An interim approach, utilizing a precision index will be used. The precision index is derived from the range of the measured point values for QC Batch control duplicates relative to their standard value (SV) If the precision index is less than 25 percent, then the QC Batch is acceptable If the precision index falls between 25 percent and 40 percent, the QC Batch data will be accepted as conditional If the precision index exceeds 40 percent, the QC Batch data will be rejected

If (OV Range) 100/SV < 25%	Acceptable
If 25% < (OV Range) 100/SV < 40%	Conditional
If (OV Range) 100/SV > 40%	Reject Batch

The present Acceptable Minimum Detectable Activities (AMDA) values agreed upon by EG&G Rocky Flats Environmental Management Division are at 1 percent of the most restrictive values for DCGs from DOE Order 5400 5, "Radiation Protection of the Public and the Environment "

Isotope	AMDA (dis/min/liter)
U-234	5 0
U-235	6 0
U-238	6 0
Pu-239	0 3
Pu-238	0 4
Am-241	0 3
Th-228	4 0
Th-232	0 5

QUALITY ASSURANCE ADDENDUM

for the

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

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN, COLORADO

SECTION 9.0
APPENDIX IV

TITLE
Quality Assurance Addendum for the Control of Radionuclide Levels in Water Discharges from the Rocky Flats Plant

Approved By

__________________ ___/___/___
Manager, Remediation Programs

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INTRODUCTION AND SCOPE

This Quality Assurance Addendum (QAA) supplements the "Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigation/Corrective Measures Studies Activities" (QAPjP) This QAA establishes the specific quality assurance (QA) controls applicable to the activities described in the "Control of Radionuclide Levels In Water Discharges From the Rocky Flats Plant, as Required by Section XII of the Interagency Agreement" Work Plan (referred to herein as the Section XII WP)

Section 3 0 of the Section XII WP describes the current surface water management strategies and practices being employed at the Department of Energy (DOE) Rocky Flats Plant (RFP) Current surface water management practices concerning detention pond operations and discharges are managed in accordance with the DOE's National Pollution Discharge Elimination System (NPDES) permit for RFP Since these current surface water management practices are regulated by the conditions of the NPDES permit, they are beyond the scope of the RFP Interagency Agreement (IAG) requirements Current practices are presented in the Section XII WP as background information

Section 4 0 of the Section XII WP describes the planned actions and proposals for controlling radionuclide levels in water discharges from RFP that are required to be addressed by Section XII of the Statement of Work (Attachment 2) of the IAG Section 4 0 of the Section XII WP describes the methodologies to be employed to control the levels of radionuclides in discharged waters, methods of assessing radionuclide levels in RFP surface waters, methods of analysis, and potential treatment technologies to be evaluated for removal of radionuclides from RFP surface waters

1 0 ORGANIZATION AND RESPONSIBILITIES

The overall organization of EG&G Rocky Flats and the Environmental Management (EM) Department divisions involved in environmental restoration activities is illustrated and discussed in Section 1 0 of the QAPjP The organization and responsibilities for the activities described in the Section XII WP differs from the organizational structure presented in the QAPjP The EG&G Clean Water Act

Division (CWAD) (a division within the EM Department) provides surveillance of surface water conditions on and around RFP, maintains water discharge permits (e g , the NPDES permit), coordinates detention pond discharge with the DOE and various regulatory agencies and municipalities, supports upgrades to plan operations pertaining to surface water, and performs or supports developmental activities for improved control, monitoring, and/or treatment to meet existing regulatory requirements As such, the CWAD is responsible for the current surface water management practices at RFP, which are described in Section 3 of the Section XII WP, and provides support for the planned actions described in Section 4 0 of the WP While the EG&G Remediation Programs Division (RPD) is primarily responsible for remedial investigations and actions, the recently created Environmental Research and Technology Division (ERTD) is responsible for evaluating potential remedial treatment technologies for RFP remediation Also, the Liquid Waste Operations (a division within the EG&G Waste Operations Department) manages the actual operations of the detention ponds, including discharges from and routing of flows between ponds This organization and management structure, including inter-departmental and -divisional interfaces is illustrated in Figure 1

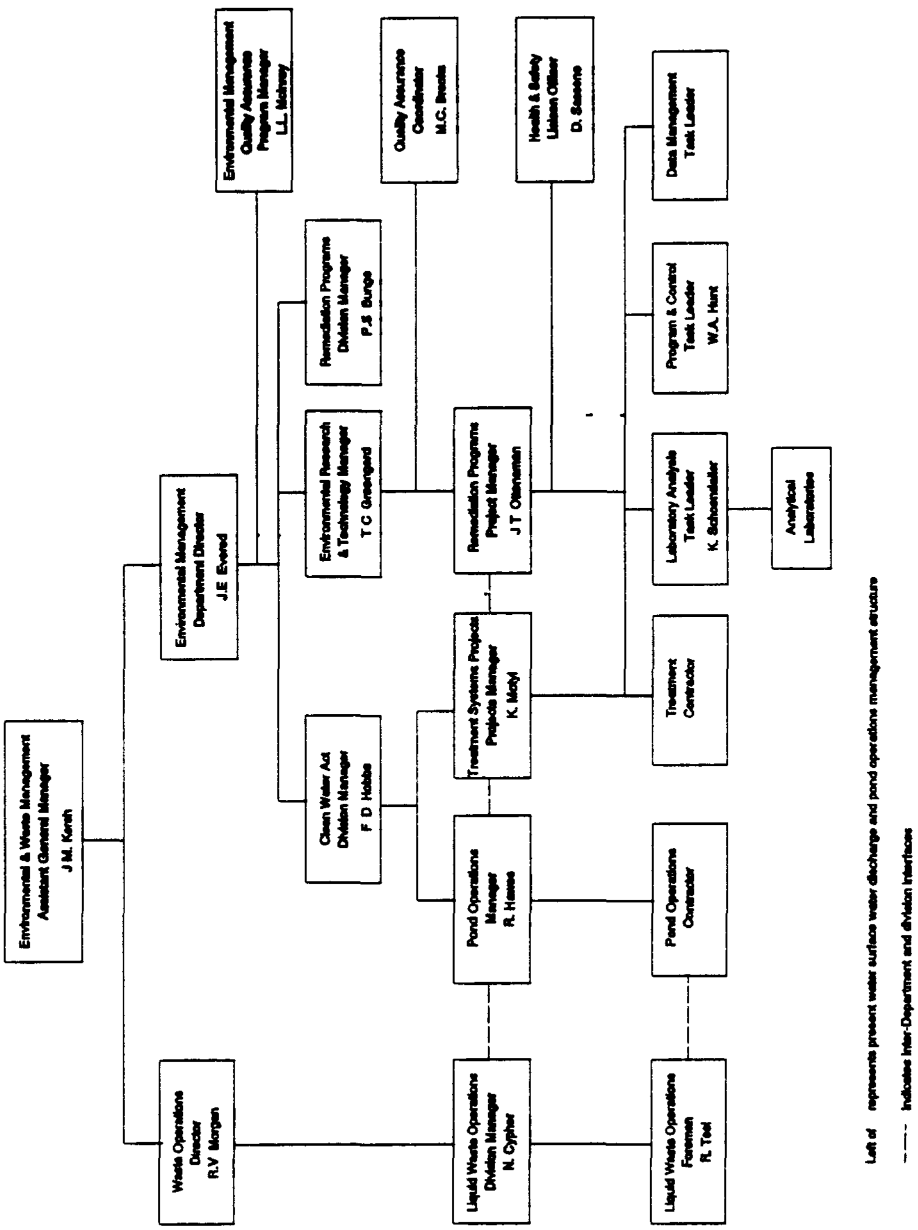
The Remediation Program Project Manager is responsible for the planned activities described in Section 4 0 of the Section XII WP The CWAD's Treatment Systems Project Manager is responsible for the current treatment systems operation and is the interface with the DOE concerning discharge of water from the RFP The decision to discharge water from RFP is made by the DOE with concurrence from the Colorado Department of Health (CDH) based on results of water sample analyses The CWAD Pond Operations Manager is responsible for pond surveillance and sampling Sampling is conducted by the pond operations contractor The Pond Operations Manager interfaces with the Liquid Waste Operations Manager concerning discharges between ponds The Liquid Operations Foreman is responsible for pond discharges (through direction from the CWAD) and routing of water between ponds and the current treatment facility

2 0 QUALITY ASSURANCE PROGRAM

The QAPjP was written to address QA controls and requirements for implementing IAG-related activities The content of the QAPjP was driven by DOE RFP Standard Operating Procedure (SOP)

Figure 1

Project Management for Control of Radionuclide Levels in Water Discharges at Rocky Flats Plant



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5700 6B, which requires that a QA program be implemented for all RFP activities based on American Society of Mechanical Engineers NQA-1, "Quality Assurance Requirements for Nuclear Facilities," as well as the IAG, which specifies that a QAPjP for IAG-related activities be developed in accordance with Environmental Protection Agency (EPA) QAMS-005/80, "Interim Guidelines and Specifications for Preparing QAPjPs " The 18-element format of NQA-1 was selected as the basis for both the plan and subsequent QAAs with the applicable elements of EPA QAMS-005/80 incorporated where appropriate Table 2-1 in Section 2 0 of the QAPjP illustrates where the 16 elements of QAMS-005/80 have been incorporated into the QAPjP format

Since the control of radionuclide levels in water discharges from the RFP is required to be addressed by the IAG, the QA controls and requirements addressed in the QAPjP are applicable to the activities described in sampling and analysis activities described in Section 4 0 of the Section XII WP As a supplement to the QAPjP, this QAA addresses additional and site-specific QA controls and requirements that are applicable to the activities described in the Section XII WP Any of the requirements or controls addressed in the QAPjP that are deemed not to be applicable to the activities addressed by the Section XII WP will be so noted in this QAA with justification as to why they are not applicable

2 1 Training

All personnel (including contractor personnel) shall complete the orientation and personnel training specified in Section 2 0 of the QAPjP This training shall be documented as specified in Section 2 0 of the QAPjP

2 2 Quality Assurance Reports to Management

A QA summary report will be prepared annually or at the conclusion of the activities (whichever is more frequent) addressed by this QAA by the EM Department QA Program Manager (QAPM) The QA report will include a summary of field and laboratory operation inspections, surveillance, and audits and a report of data verification/validation results

3 0 DESIGN CONTROL AND CONTROL OF SCIENTIFIC INVESTIGATIONS

3 1 Design Control

The Section XII WP is the design control plan for managing discharges of surface water from RFP and limiting/controlling the concentration of radionuclides in these waters The work plan describes the methods to control the release of waters from the RFP site, sampling and analysis of predischarge water to determine the concentration of radionuclides in the water, application of Colorado Water Quality Control Commission (CWQCC) stream standards to water discharges, analytical methods, and potential treatment technologies The Section XII WP will be reviewed and approved by the EG&G Rocky Flats Remediation Programs Manager or designee, the DOE Rocky Flats Office, the EPA Regional Administrator, and the Director of the CDH Once the Section XII WP has been reviewed and approved, any changes to or revisions of the workplan will also be reviewed and approved by the previously specified organizations

3 2 Data Quality Objectives

Data quality objectives (DQOs) quantitatively describe the uncertainty that decision makers are willing to accept in results derived from environmental measurement data This uncertainty is used to specify the quality of the data required to meet the objectives of the investigations The process of developing DQOs for measurement data is summarized in Appendix A of the QAPjP

Parameters that are used as indicators of data quality are precision, accuracy, representativeness, comparability, and completeness (PARCC parameters) The definitions and methods of calculating these parameters are presented in Appendix A of the QAPjP The objectives of the data collection activities associated with the control of radionuclides in water discharges are summarized below The objectives for the PARCC parameters for the measurement data are also established

3 2 1 Objectives

The data collection activities associated with controlling radionuclides in water discharges include estimating pond water level elevations, measuring water levels in piezometers installed in pond dams, and characterizing predischarge and discharged water Identifying potential sources and transport mechanisms that result in radiological contaminants in RFP pond water will also be conducted as part of the Section XII WP activities through evaluating existing pond water data and topographic, soils, and vegetation data obtained from other investigations Assessment of potential treatment alternatives will be conducted in conjuction with sitewide treatability studies Identification of upstream sources of potential contamination and assessment of potential treatment alternatives are not considered Section XII WP data collection activities requiring development of data quality objectives

Pond water elevation estimates are made to determine when water should be discharged to the RFP water collection system ponds This data consists of estimated levels where data quality is obtained by following established procedures Measurements of depth to water in piezometers is considered a screening activity to determine the saturated level of the dams, which also contributes information needed to determine when water should be discharged Data quality for these measurements consists of measuring depths to the nearest 0 1 foot by following established procedures for measuring depths to the water level in piezometers

Predischarge and discharge characterization data consists of analytical data to determine the concentration of radionuclides in water This characterization data should be of a known quality in order to adequately determine compliance with approved CWQCC stream standards for water discharged from the RFP site

In order to assist investigators in determining the types of analytical and sampling protocols to be used to obtain the appropriate quality of data necessary to meet the objectives of the study, the EPA has established five analytical levels, with increasingly rigorous QA/QC applicable at each successively higher level These analytical levels (Levels I - V), which are incorporated into the DQO development process, are defined and discussed in Appendix A of the QAPjP Analytical level V data, which require rigorous method-specific QA/QC controls, is appropriate for producing radionuclide characterization data of a known quality and at detection limits at or below the promulgated stream standards

3 2 2 Precision and Accuracy

The objectives of precision and accuracy are dependent on the analyte of interest, the sample matrix, the analytical method, and the quality controls applicable to that method The pre-discharge and discharge water samples will be analyzed for the radionuclides specified in the Section XII WP according to the analytical methods specified in the work plan The objective for accuracy for this analytical data is ± 30 percent recovery of the laboratory control sample The objective for precision is 30 percent relative percent difference as specified in Appendix A of the QAPjP

3 2 3 Completeness

The target objective for completeness for this analytical data is 100%, with a minimum acceptability of 90%

3 2 4 Comparability and Representativeness

These are qualitative parameters that are ensured through careful development and review of the sampling and analysis strategy outlined in the Section XII WP, and adherence to the established sampling procedures and analytical protocols

3 3 Field Sampling Program and Sampling Procedures

The field sampling program associated with the control of radionuclide levels in water discharges includes the water management practices and pond and discharge sampling currently being employed at the RFP site, as described in Section 3 of the Section XII WP The EG&G Environmental Monitoring and Assessment Division (EMAD) Operating Procedures (OPs) that are applicable to the Section XII WP field activities are listed in Table 1 These OPs are also referred to as SOPs in the QAPjP and this QAA The following activities comprise the field sampling program associated with the Section XII WP

- The elevation of water in the detention ponds is estimated a minimum of three times per week (during periods of significant runoff due to precipitation, this frequency is increased)

- The water level in piezometers installed in dams is measured at the same time as pond water elevations are estimated These measurements are made according to the OP-GW 01, Water Level Measurements in Wells and Piezometers

- Each detention pond dam is inspected on a routine basis by EM Department personnel according to CWAD Operating Procedure OPS-SW 06, Dam Inspection and Monitoring (this is an internal EG&G Rocky Flats procedure that has not been submitted to EPA and the Colorado Department of Health for review because it does not have an impact on ER Program data) These inspections are intended as a supplement to the annual, in-depth dam inspection work currently done by the U S Army Corps of Engineers and others

- Pre-discharge sampling of pond water is completed according to OP-SW 08, Pond Sampling Surface water field measurements are made at the time of sampling according to OP-SW 02, Field Measurements of Surface Water Field Parameters The sampling strategy for this pre-discharge sampling program is described in Section 4 of the Section XII WP

- Pond discharge sampling is completed according to OP-SW 09, Industrial Effluent and Pond Discharge Sampling Field parameters of discharge water will be measured at the time of sample collection according to OP-SW 02 The strategy for collection of discharge samples is also described in Section 4 1 5 of the Section XII WP

TABLE 1

Operating Procedures Applicable to Field Activities Associated with the Control of Radionuclide Levels in Water Discharges from the RFP Site

Former SOP Reference Number	New EMAD OP Reference Number	Operating Procedure Title
1 2	FO 02	Field Document Control
1 3	FO 03	General Equipment Decontamination
1 6	FO 06	Handling of Personal Protective Equipment
1 7	FO 07	Handling of Decontamination Water and Wash Water
1 11	FO 11	Field Communications
1 12	FO 12	Decontamination Facility Operations
1 13	FO 13	Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples
1 14	FO 14	Data Base Management
2 1	GW 01	Water Level Measurements in Wells and Piezometers
4 1	SW 01	Surface Water Data Collection Activities
4 2	SW 02	Field Measurements of Surface Water Field Parameters
4 3	SW 03	Surface Water Sampling
4 8	SW 08	Pond Sampling
4 9	SW 09	Industrial Effluent and Pond Discharge Sampling
CWAD-OPS-SW 06		Dam Inspection and Monitoring

3.4 Analytical Procedures

The radionuclide analytical program for discharged water at the RFP site is described in Section 4 3 of the Section XII WP The radiochemical parameters of interest and required detection limits are based on the parameters and stream standards promulgated by the CWQCC These parameters and standards are listed in Table 4 1 of the Section XII WP The detection limits selected by EG&G for the radionuclides of interest are listed in Table 3 2-3 of the Section XII WP, and were established based on the minimum detectable activity (MDA) Method variability and other method-specific parameters are used to determine an MDA MDA is formally defined and discussed in Section 3 of the Section XII WP

The analytical protocols that will be adhered to for analyses of pre-discharge and discharge water samples are referenced in Section 4 0 of the Section XII WP

3 5 Equipment Decontamination

Non-dedicated sampling equipment shall be decontaminated between sampling locations in accordance with OP-FO 03, General Equipment Decontamination

3 6 Quality Control Samples

To assure the quality of the field sampling techniques, collection and/or preparation of field quality control (QC) samples are incorporated into the sampling scheme Field QC samples and collection frequencies are shown in Table 2 In addition to those QC samples, EG&G will split samples with the CDH and EPA, as requested, for independent analyses

3 6 1 Laboratory Quality Control

Laboratory QC procedures are used to provide measures of internal consistency of analytical and storage procedures As required by the QAPjP and the EG&G Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP), the analytical laboratories will submit written

TABLE 2

Field QC Sample Collection Frequency

Activity	Frequency
Field Duplicate	1 in 10[1] or 1 per sampling event
Field Blank[2]	1 per 20 or 1 per shipping container
Trip Blank[3]	1 in 20
Equipment Rinsate Blank	1 in 20 or 1 per day[4]

1 One duplicate sample per sampling event or a minimum of one in every 20 samples collected, whichever is more frequent
2 For sample to be analyzed for inorganics
3 For sample to be analyzed for volatile organics only Therefore, trip blanks are not applicable for sampling associated with controlling radionuclides in water discharges
4 One equipment rinsate blank in 20 samples or one per day, whichever is more frequent

SOPs to the EG&G Laboratory Analysis Task Leader (see Figure 1) for review and approval prior to conducting analyses The interlaboratory SOPs shall be consistent with or equivalent to EPA Contract Laboratory Program QC procedures The items to be addressed in these interlaboratory SOPs are specified in Section 3 0 of the QAPjP and Exhibit I of the GRRASP

3 7 Data Reduction, Validation, and Reporting

3 7 1 Analytical Reporting Turnaround Times

Analytical reporting turnaround times are specified in Table 3-1 of Section 3 0 of the QAPjP For pre-discharge sample radiochemical analyses, EG&G will request that the analytical laboratories expedite the analyses

3 7 2 Data Verification and Validation

Validation activities consist of reviewing and verifying field and laboratory data and evaluating the data against DQOs, where appropriate, to determine validity of analytical results The data will then be evaluated for validity and usability following the criteria established in Section 3 0, Subsection 3 7 of the QAPjP This process is illustrated graphically in Figure 3-1 of Section 3 0 of the QAPjP

3 7 3 Data Reduction

All field data shall be recorded on field sampling data sheets and/or logbooks as specified in the appropriate field sampling OP Field data shall be controlled according to OP-FO 02, Field Document Control The reduction of field and laboratory data is described in Section 3 0 of the QAPjP All field and laboratory raw data sets shall be verified and validated (as described above) and valid data shall then be input into the EG&G Rocky Flats Environmental Data System (RFEDS) using a remote data entry module (see OP-FO 14, Database Management)

3 7 4 Data Reporting

While all data will be evaluated for validity and usability as described above (Section 3 7 2), the results of data analyses for predischarge samples will be submitted to the EG&G Laboratory Analysis Task Leader by the analytical laboratories immediately upon completion of the analysis The data will then be reviewed by EG&G and will be provided to DOE and CDH as unvalidated data along with discharge requirements This is necessary because of the additional time required for the data validation process Authorization for offsite discharge will be granted by DOE with concurrence by CDH Since the discharges will be diverted around Great Western Reservoir by the City of Broomfield, DOE will provide written notification to the City prior to discharge

The results of the data validation shall be reported in EM Department Data Assessment Summary reports The validity of data shall be addressed by the Project Manager

4 0 PROCUREMENT DOCUMENT CONTROL

The appropriate requirements from the QAPjP, this QAA, and the GRRASP shall be passed on to laboratories performing analytical services for the pre-discharge and discharge samples via procurement documents, as specified in Section 4 0 of the QAPjP

5 0 INSTRUCTIONS, PROCEDURES, AND DRAWINGS

The Section XII WP and the OPs listed in Table 1 will be reviewed and approved in accordance with the requirements for instructions, procedures, and drawings specified in Section 5 0 of the QAPjP Any changes or revisions to the work plan and OPs will be reviewed and approved as specified in Section 5 0 of the QAPjP

6 0 DOCUMENT CONTROL

The following documents will be controlled in accordance with the requirements of Section 6 0 of the QAPjP

- "Control of Radionuclide Levels in Water Discharges From the Rocky Flats Plant as Required in Section XII of the Interagency Agreement" Work Plan,

- "RFP Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigations/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities,"

- "Quality Assurance Addendum for the Control of Radionuclide Levels in Water Discharges From the Rocky Flats Plant," and

- The operating procedures listed in Table 1

7 0 CONTROL OF PURCHASED ITEMS AND SERVICES

Laboratories that provide analytical services described in the Section XII WP will be selected and evaluated as outlined in Section 7 0 of the QAPjP

8 0 IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA

8 1 Sample Containers/Preservation

Appropriate volumes, containers, preservation requirements, and holding times for predischarge and discharge samples for radiochemical analyses are specified in Table A-3 of OP-FO 13, Containerizing, Preserving, Handling and Shipping of Soil and Water Samples

8 2 Sample Identification

Samples shall be labeled and identified in accordance with Section 8 0 of the QAPjP and OP-SW 09, Industrial Effluent and Pond Discharge Sampling

8 3 Chain-of Custody

Sample chain-of-custody will be maintained from the time the samples are collected until they are analyzed in the laboratory Sample chain-of-custody requirements that shall be adhered to are specified in Section 8 0 of the QAPjP and OP-FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples

8 4 Control of Field Data

All field descriptions, measurements, and observations shall be recorded in appropriate Data Collection Forms as required by OP-SW 01, Surface Water Data Collection Activities

9.0 CONTROL OF PROCESSES

The overall process of collecting pre-discharge and discharge samples, performing analyses, reporting, and inputting data into the RFEDS data base will be controlled through implementation of the Section XII WP and OPs listed in Table 1

10 0 INSPECTION

Routine inspections of detention pond dams will be conducted by EG&G according to CWAD-OPS-SW 06 Annual inspections of detention pond dams will be conducted by the U S Army Corps of Engineers jointly with the State Engineers Office and the Federal Energy Regulatory Commission Independent inspections of the pre-discharge and discharge sampling process will also be conducted by EG&G Inspection checklists will be developed for all inspections conducted by EG&G

11 0 TEST CONTROL

The control of radionuclide levels in water discharges from the RFP does not involve testing as addressed in Section 11 0 of the QAPjP Therefore, test control requirements are not applicable

12.0 CONTROL OF MEASURING AND TEST EQUIPMENT

Field instruments used to obtain field measurements of surface water field parameters will be controlled, calibrated, and maintained according to the requirements of Section 12 0 of the QAPjP and OP-SW 02, Field Measurements of Surface Water Field Parameters

13 0 HANDLING, STORAGE, AND SHIPPING

The requirements for handling, packaging, transporting, and storage of pre-discharge and discharge samples are as specified in OP-FO 13, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples

14 0 STATUS OF INSPECTIONS, TEST, AND OPERATIONS

The requirements for controlling the status of inspection, test and operations apply to items, products, materials, systems, or equipment used to implement work plan activities Other than the field instruments used for field measurements, which are controlled according to Section 12 0 of the QAPjP, no other items, products, materials, systems or operations are required for these activities Therefore, the requirements of Section 12 0 of the QAPjP are not applicable

15 0 CONTROL OF NONCONFORMANCES

The requirements for the identification, control, evaluation, and disposition of nonconforming samples and data will be implemented as specified in Section 15 0 of the QAPjP

16 0 CORRECTIVE ACTIONS

The requirements for identification, documentation, and verification of corrective actions for conditions adverse to quality will be implemented as outlined in Section 16 0 of the QAPjP

17 0 QUALITY ASSURANCE RECORDS

All field and laboratory records are considered QA records and shall be controlled in accordance with Section 17 0 of the QAPjP QA records to be generated as a result of implementation of the Section XII WP include, but are not limited to

- Field data records, including data sheets and logbooks
- Laboratory analyses data packages
- Calibration records
- Sample chain-of-custody records
- Audit/Surveillance/Inspection reports and checklists
- Nonconformance and Corrective Action Reports
- The Section XII WP
- The QAPjP and this QAA
- Data validation results
- Procurement documents for analytical services
- Training/Qualification records
- DOE authorizations to discharge and notifications of discharge

All QA records generated from implementation of the Section XII WP activities will be submitted to the EM Department Custodian for processing according to the EM Department QA records system described in Section 17 0 of the QAPjP

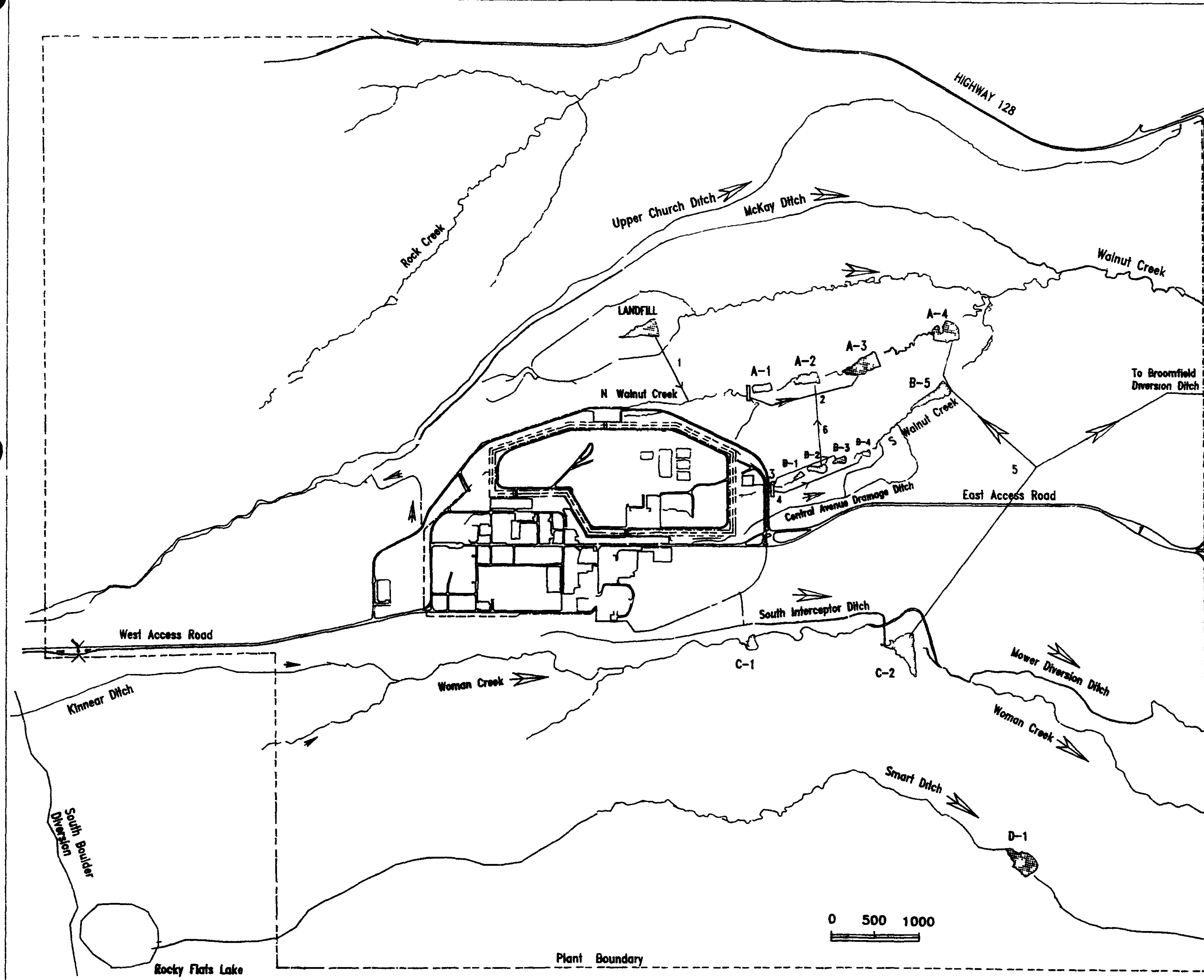
18 0 QUALITY VERIFICATION

The requirements for the verification of quality shall be implemented as specified in Section 18 0 of the QAPjP EG&G Site Quality Assurance will conduct independent audits and surveillance of sample collection and laboratory analysis The EM Department QAPM shall develop a surveillance and audit schedule with surveillance intervals based on the importance and complexity of each sampling/analytical activity

The pre-discharge and discharge sampling and analytical activities described in the Section XII WP are ongoing, therefore, a Readiness Review, as required in Section 2 0 of the QAPjP will not be conducted for these activities

19 0 SOFTWARE CONTROL

The requirements for software development and control shall be implemented as specified in Section 19 0 of the QAPjP Computer software utilized by the analytical laboratories will be furnished by EG&G Only data base and spreadsheet software will be used for Section XII WP activities



NOTES

1 Emergency Landfill Transfer to N Walnut Creek
2 A-1 Bypass Surface Runoff & Seepage To A-3
3 WWTP Discharge of Waste Water Treatment Plant Effluent To B-3
4 B-1 Bypass Surface Runoff & Seepage To B-4
5 C-2 Transfer To Broomfield Diversion Ditch Ponds B-5 or A-4
6 Pond B-2 Transfer to Pond A-2

Figure 2 5

Surface Water Features
United States Department of Energy Rocky Flats Plant

Surface Drainage West to East

8/28/91 CWAD