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Workplan for the Control of Radionuclide Levels in Water Discharges from the Rocky Flats Plant

ENVIRONMENTAL MANAGEMENT WORKPLAN

NOT RELATED TO PLANT SAFETY

Category 1
Effective Date: ______________

Approved By:
[signature] 10/14/92
Director, Remediation Programs *(Date)*

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List of Acronyms and Abbreviations

The following acronyms and abbreviations are used in the Workplan:

AIP	Agreement in Principle
α-spec	Alpha Spectrometry
Am	Americium
AMDA	Acceptable Minimum Detectable Activity
BAT	Best Available Technology
BDD	Broomfield Diversion Ditch
CDH	Colorado Department of Health
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CF	Coagulation/Filtration
CFR	Code of Federal Regulations
cfs	cubic feet per second
Ci/g	Curies per gram
cm/s	centimeter per second
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CHS	Colorado Health Standards
COE	U.S. Corps of Engineers
CRS	Colorado Revised Statutes
CUHP	Colorado Urban Hydrograph Procedure
CWA	Clean Water Act
CWQCC	Colorado Water Quality Control Commission
DAF	Dissolved Air Flotation
DCG	Derived Concentration Guide
d/m	Disintegrations per minute
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ETEP	Emerging Technologies Evaluation Program
FERC	Federal Energy Regulatory Commission
FFCA	Federal Facilities Compliance Agreement
fCi/L	fempto curies per liter
GAC	granular activated carbon

GC	gas chromatography
GOCO	Government-owned and contractor-operated facility
g/cm^3	grams per cubic centimeter
gpm	gallons per minute
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HM	Heavy Metals
H/S	Health and Safety
IAEA	International Atomic Energy Agency
IAG	Interagency Agreement
ID/MS	Isotope Dilution/Mass Spectrometry
IMECS	Interactive Measurement Evaluation and Control System
IM/IRA	Interim Measures/Interim Remedial Actions
IRAP	Interim Remedial Action Plan
IX	Ion Exchange
LANL	Los Alamos National Laboratory
LS	Lime Softening
m	Minute
MDA	Minimum Detectable Activity
MREM/YR	millirem Per Year
mph	miles per hour
Mgal	Million Gallons
nCi/g	Nanocuries per gram (10^{-9})
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NBL	New Brunswick Laboratory
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
O & M	Operating and Maintenance
OU	Operable Unit
pCi	Picocurie (10^{-12})
pCi/L	Picocurie per Liter (10^{-12})
ppm	parts per million
Pu	Plutonium
QA/QC	Quality Analysis/Quality Control
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
SID	South Interceptor Ditch
SITE	Superfund Innovative Technology Evaluation
SOP	Standard Operating Procedure
SOW	Scope of Work
STP	Sewage Treatment Plant
SWD	Surface Water Division
SWTSP	Sitewide Treatability Study Plan
SWMP	Surface Water Management Plan
SWMU	Solid Waste Management Unit
TDS	Total Dissolved Solids
TH	Total Hardness
U	Uranium
UF	ultrafiltration
UF/MF	Ultrafiltration/Microfiltration
mm	Micrometer (10^{-6})
WET	Whole Effluent Toxicity
WQCD	Water Quality Control Division

Record of Response to Comments

Document Reviewed: Final Workplan for Control of Radionuclide Levels in Water Discharges from the Rocky Flats Plant, September 1991

Document Reviewer: City of Broomfield **Date:** 10/19/92

City of Broomfield December 12, 1991 ltr Item (2) pg. 1, P3	<u>General comments</u>: The Workplan is generally very good and well organized. However, there is one recurring problem throughout the document. In several places an overland transfer of Pond C-2 water to Pond B-5 is stated as a <u>current practice.</u> This is <u>not</u> the case and will not be the case until after Great Western Reservoir is abandoned as a drinking water supply (When Option B is fully implemented, which may not be until 1995-96). This has been discussed at Water Group meetings with DOE/EG&G, and Broomfield commented on this transfer on the SWMP. It is Broomfield's understanding that the pipeline is in place but not connected to the ponds on either end. The actual current practice is to discharge Pond C-2 water, with treatment if it doesn't meet Colorado CWQCC standards for Walnut Creek, to Broomfield's diversion ditch. <u>This is the only arrangement that Broomfield has agreed to until such time that Great Western Reservoir is abandoned as a drinking water supply.</u> There are specific referrences to this particular pond to pond transfer on page 3-21, last paragraph; page 3-24, last paragraph; and page 4-4, first paragraph. These and all other references to the Pond C-2 to B-5 transfer should be corrected to indicate that it is <u>proposed</u> to be implemented after Option B is in place, not current practice (or fourth quarter 1991 as indicated on page 4-4).	The transfer of water from Pond C-2 to Pond B-5 or A-4 is intended as an emergency option, not a standard practice. It is preferable for overall public health protection to transfer the water from Pond C-2 to Pond B-5 or A-4, where it is split-sampled, analyzed, and approved by CDH before discharge, rather than have it overtop the Pond C-2 dam or spillway, or be released to the Broomfield Diversion Ditch directly. All water transferred from Pond C-2 to Pond B-5 or A-4 will be sampled during transfer to the Minimum Detectable Activity (MDA) achieved for normal routine pond discharges for the radionuclides as specified in the CWQCC stream standards.

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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 on 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, using radioactive materials, is not released; it is treated within the process areas and reused. 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 are regulated by, and discharges are performed in accordance with, the RFP NPDES permit.

Pond A-3, which collects the substantial portion of the North Walnut Creek and northern plant site runoff, is released periodically to Pond A-4. Sampling is conducted prior to release to ensure high-quality water. Timing of this release is dependent on anticipated inflow of storm-water runoff, current pool level of both Ponds A-3 and A-4, and the existence of operating treatment facilities at Pond A-4. The goal is to equalize the retained volumes in both ponds so 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 and the Federal Facilities Compliance Agreement (FFCA). Biomonitoring, including whole effluent toxicity (WET) testing, is being conducted using ceriodaphnia and fathead minnows per the requirements of the FFCA.

Ponds A-4, B-5, and C-2 were constructed and placed into service in the early to mid-1980s 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 event; therefore, 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.
- Controlling 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.
- Operating 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.
- Transferring water among ponds to equilibrate rainfall capacities, conduct spray evaporation, or facilitate water treatment operations.
- Collecting water samples to evaluate and demonstrate water quality.
- Operating 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 that water releases to downstream users meet CWQCC standards with CDH concurrence. 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 Radiological Sources

Identification of radiological source(s) is necessary 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, identification of the radiological sources is necessary. The chemical and physical properties of radiological sources can be used to determine the probable mode of dispersion.

Waterborne plutonium in the RFP area and environment originates from background sources (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 and its transport to water discharge points occurs via the fluid phases—air and water.

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

Contributions resulting from unplanned events (1957 and 1969 fires at RFP), resuspension from past releases (OU-2/903 Pad), deficiencies in filter media or seals, or leaks/failures of the multi-stage filtration system are possible. Studies have indicated that the largest single contributor to Pu in the environs about RFP is resuspension of contaminants originating at the OU2/903 Pad (DOE 1991a).

Waterborne radiological sources can arise as a result of re-suspension or introduction of fresh radionuclides into watercourses which are eventually directed offsite. Since RFP Pu process operations are separate from sanitary wastewater treatment systems and process operations do not discharge directly to the environment, the water source may contains contributions from inadvertent leakage, unplanned release pathways, physical transport of contaminated soils/sediments 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 including Pu in the environment (Katz 1986, 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/L. Recent studies (Orlandini 1990, Penrose 1990) have evaluated the particle sizes and chemistry of sub-pCi Pu 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 nano curies per gram (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 micrometer (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 Pu in sediments would be "slow," since its solubilization even at elevated pH was difficult.

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

1. Plutonium forms a strong association within pond sediments.
2. Particulates larger than 2 µm accumulate in sediments.
3. Substantial portions of total activity (perhaps 95%) deposits are 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 Pu 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

Two methods are used to determine the concentration of radionuclides in pond water: sampling and analysis. At radiological 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 (radiological) 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 Plutonium Oxide (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 grams per cubic centimeter (g/cm^3)and a specific activity of 0.073 curies per gram (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 exceed 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 result is particularly striking 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 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 a 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 for radionuclides are presented 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.

Surface water quality data collected by RFP are routinely provided to CDH, local cities, and the interested public at monthly data exchange meetings, and through monthly and annual reports. (Rockwell 1988b; EG&G 1990c). Readers should note both reported measurement uncertainties and relevant minimum detectable activities (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 limitations affect any conclusions drawn from these 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 Quality Assurance/Quality Control (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
Minimum Detectable Activity for
Radiochemical Parameters in Water Samples*

Parameter	Detection Limit (pCi/L)
Gross Alpha	2
Gross Beta	4
Tritium	400
Plutonium-239,240*	0.02
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

* MDAs are sensitive to sample volume; listed MDAs are characteristic of 5-liter sample volumes, whereas, the majority of current and historical data were acquired using 1-liter samples whose corresponding MDAs were *five* times higher. Apparent inconsistencies with Section 3.2.2 MDA values are due to rounding.

3.2.2.2 Minimum Detectable Activity

Another key factor for evaluating radiometric data is that of MDA. This factor is extremely important to quantitation of low-level analytes. Method variability and other method-specific parameters are used to determine a MDA, which depends on the radiochemical analyte and matrix being analyzed. The MDA is on a prior level at which a given method may be expected to provide adequate quantitation. At RFP the MDA is formally defined by the relationship:

$$MDA = (4.65S_B + 2.71/(T_S E_S Y))/aV$$

where:

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

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

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. *Historically, 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 site-wide 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. These SOPs are under final review and describe field sampling protocols and equipment required to collect samples and take flow measurements, and are designed to foster adequate documentation, preservation, packaging, shipping and decontamination. For sampling radionuclides in a water matrix, relevant SOPs are the following:

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

These SOPs 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. The sampling program is flexible and allows the incorporation of additional sites to meet specific needs or the elimination of sites no longer needed.

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 not as much historical data are 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 Table 3.2-6, and the 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. There is no operation cause for the gross beta exceedances since the major RFP contributors to water chemistry are alpha emitters. 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 Pu levels in Pond C-2 appear higher than the remaining five locations. Mean Pu concentrations at the five remaining locations are not statistically different from one another.

3. No statistically significant differences exist for the mean Am concentrations among the six locations.

3.2.3.3 Comparison of Local Water Sources

Available data for Pu, Am, and U 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 Pu and Am (but not for U) 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. In summary initial results indicate: (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 indicates uncertainty in measured values for Pu and Am, which often exceed 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.)

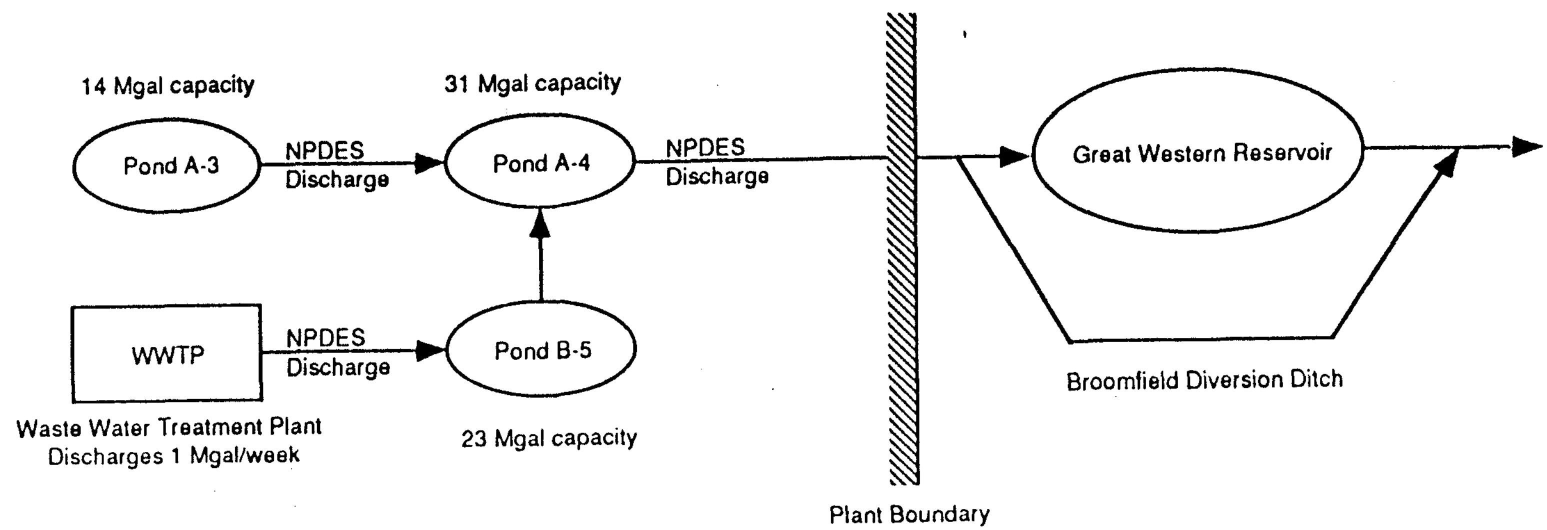
Analysis of existing data indicates extremely low concentrations of radionuclides in water both influent to and effluent from RFP. In all but a few cases—most notable for gross beta at Pond C-2—measured radionuclide levels were below CWQCC standards. Some differences in mean levels of radionuclides at 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 U, gross alpha, and gross beta concentrations do exist among locations. With the possible exception of the slightly elevated Pu levels in Pond C-2 water and U 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. See Figure 3.3-1. Present pond discharge strategy and practice is to collect waters from the North Walnut Creek drainage in Pond A-3, the South Walnut Creek drainage in Pond B-5, and the Woman Creek drainage in Pond C-2. Water in Pond B-5 is transferred to Pond A-4 for possible treatment and offsite



Optimal Operation:

(1) Initiate transfer/discharge of Pond A-3 and/or Pond B-5 to Pond A-4 when their volumes approaches 50%.
(2) Maintain Pond A-4 near 50%, but less than 65%.
(3) Discontinue (1) prior to pre-discharge sampling event with CDH and interested municipalities.
(4) Request discharge concurrence from CDH when analytical results are available.
(5) Initiate Pond A-4 discharge, with or without treatment, per CDH concurrence.
(6) Re-initiate (1). Optimal discharge cycle requires 6 weeks to complete.

Notes:

Pond A-3 collects surface water runoff from north plant site.
Pond B-5 collects surface water runoff from central plant site and treated WWTP effluent.
Pond A-4 collects transfers/discharges from Pond A-3 and Pond B-5 for sampling prior to release off-site.

Figure 3.3-1. RFP Pond Management Overview

discharge. Water from Pond A-3 is released (in accordance with RFP NPDES permit) and Pond B-5 transferred by overland pipeline to Pond A-4 where a central treatment facility is provided. Water from Pond C-2 is, with approval of the City of Broomfield, transferred to the BDD. Alternatively, the option to transfer Pond C-2 water to Pond B-5 exists via the overland pipeline. Treatment including filtration and granulated activities carbon (GAC) adsorption are available at Pond A-4 to perform 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, and (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 Remediation Activites Interface

Figures 3.3.2 and 3.3.3 represent the responsible parties within the Environmental Protection and Environmental Restoration (ER) Management Divisions of EG&G and Environmental Management of DOE, respectively, regarding OU operations and remediation activities which may potentially impact surface water quality. Two information pathways that exist within EG&G are administrative and technical. The administrative information pathways between divisions include: (1) periodic interdepartmental meetings; (2) surface water impact assessments and monthly project reports for each OU program manager; (3) review of Engineering Job Orders and OU workplans, OU project reports, and weekly highlights as reviewed by both ER and SWD. The technical information regularly exchanged between divisions includes: (1) sample collection and data evaluation; (2) real-time water monitoring; (3) periodic field surveillance; (4) statistical assessments; (5) contaminant fate and transport studies; and (6) hydrological modeling information. Abnormal conditions are reported through DOE to CDH by the offices of: Environmental Restoration Project Management for OU and remediation activities; Surface Water Division for pond status, transfers, and discharges; and Waste Programs for RCRA compliance (not shown on Figure 3.3.2 for simplicity).

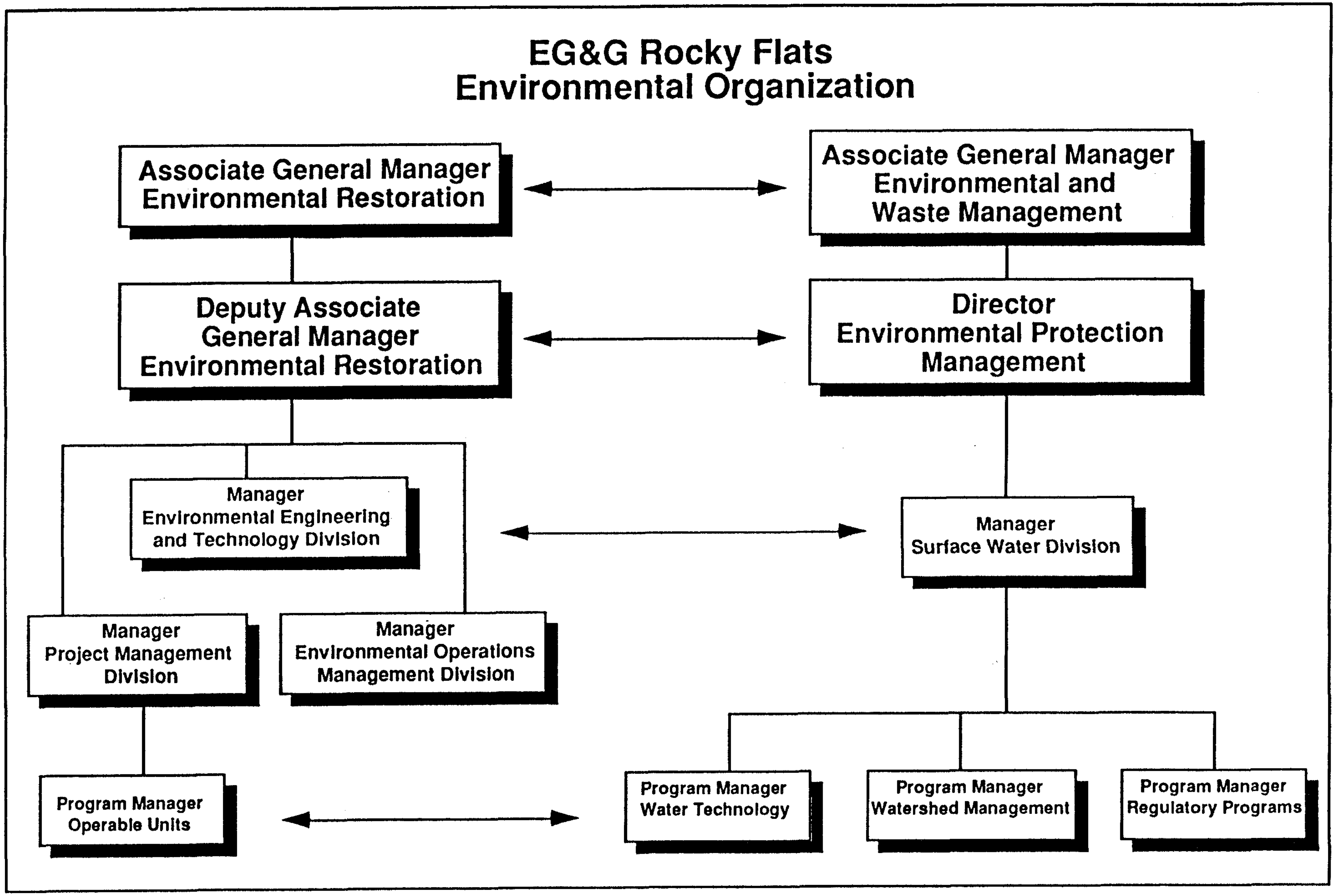


Figure 3.3.2 Surface Water and Remediation Programs Coordination

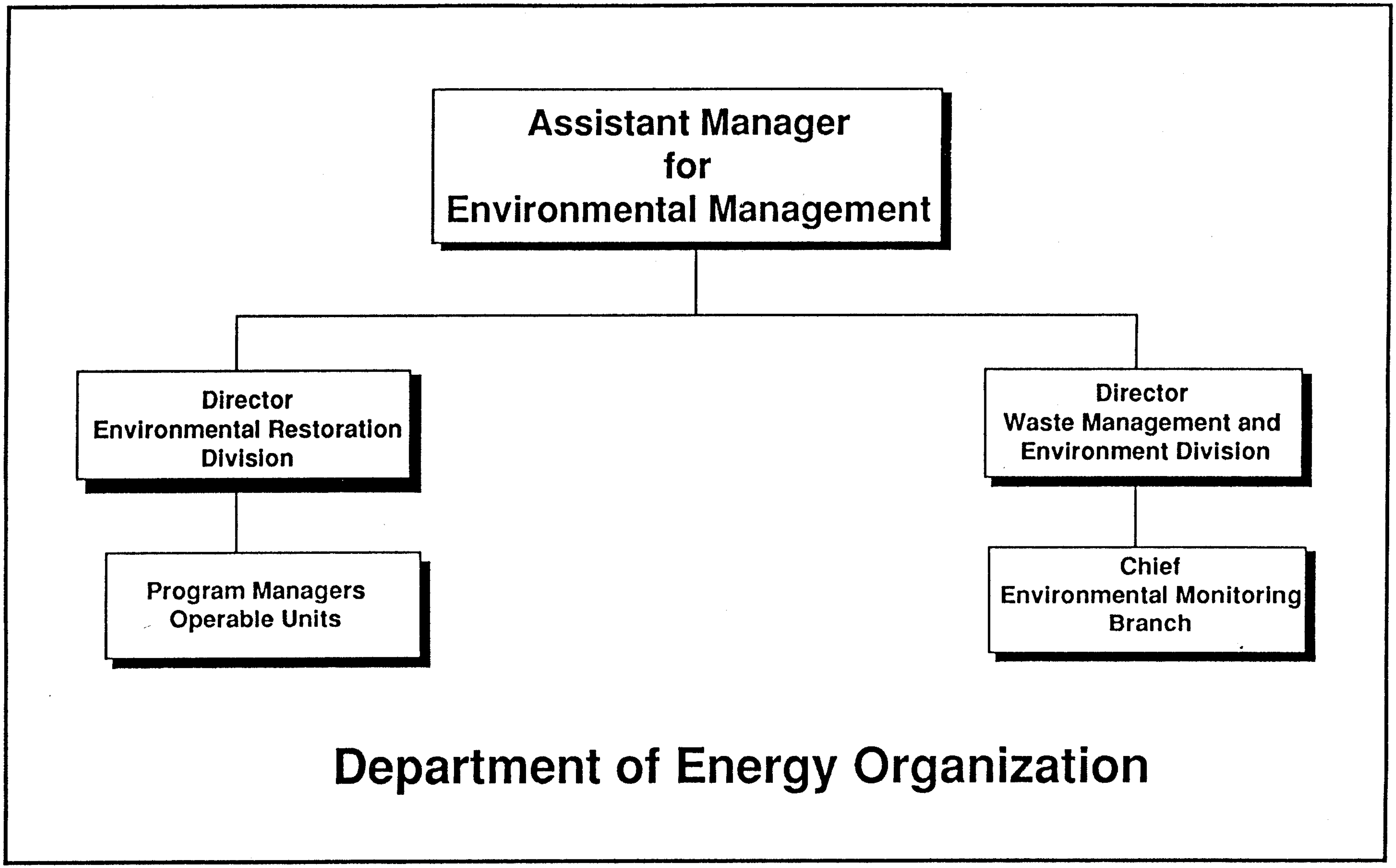


Figure 3.3.3 Environmental Restoration and Enviromental Monitoring Coordination

It is the goal for routine operations of Pond A-4 to maintain hydraulic isolation prior to and during offsite discharge of water. The ER and SWD interactions are most applicable to non-routine Pond A-4 water discharges during high precipitation periods and to routine Pond C-2 water discharges. This results from a concern that the ongoing remediation projects at OU1 and OU2 might result in elevated contaminant levels in the ponds downstream. Consultation with DOE and CDH regarding resampling of the ponds prior to discharge will occur when pond volumes increase more than 20% after the initial sampling event or when significant increases in pond turbidity occur or if a potential release into the pond occurs. Further confidence in the quality of the water discharges is provided as all pond water discharges are monitored during release by EG&G and CDH.

3.3.3 Pre-Discharge Evaluation

The first step in the discharge process is assessing the need for the process 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 occurs:
(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, and
(5) preparing for discharge.

Generally, the pre-discharge process is initiated for Pond B-5 when it approaches 30% of its effective capacity (7 million gallons (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 (WET, 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). 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. A goal is to operate pond discharges as batch operations, without continual inflow. However, this may not be possible during spring runoff or other high inflow events.

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.

3.3.4 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.

3.3.5 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 to initiate downstream release is directed to the RFP. 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 require treatment prior to discharge or may approve discharge without treatment. The EPA is contacted for written approval for any diversion of water from Pond C-2 to Walnut Creek or BDD.
Water is pumped from Pond C-2 to the BDD after sampling and analysis are completed and concurrence is received according to the same process as described above.

3.3.6 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 temporarily conveyed overland and northeast by pipeline to the BDD. Ana dditional overland pipeline connects Pond C-2 to Pond B-5/A-4. Although unused to date, Pond C-2 water may be conveyed 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.

3.3.7 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 exceedance 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 errors (laboratory error, sample contamination, reporting error) are possible. The results 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.

Resumption of any discharge by RFP would be expected to receive concurrence from CDH and occur when the running 30-day average radiochemical parameters return to levels at or below those of the CWQCC standards. 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.

3.3.8 Pond Level Operational Goal

Operational approach will vary slightly with seasonal runoff, with March to June as the most critical time period. The general approach is to reduce the risk of dam weakening by maximizing the time that pond levels are low (preferably at or below 10 percent of capacity). This appears simple in principle, but maintenance of pond volumes below 20 percent of capacity is difficult in practice because of (1) the time required to obtain discharge approval for 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.

3.3.9 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 Pu, Am, U, 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 (Pu and Am) 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 filtration treatment 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

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

α - spec = Alpha 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

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 Am 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 Am levels in raw water samples were reduced significantly by filtration with 0.45 micron Millipore® filters.

4. Plutonium and Am 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 radionuclides from RFP pond water.

3.4.3 Current Treatment

The current system configuration is shown in Figure 3.4-1. This figure is divided into sections and each section is described 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.

3.4.3.1 The pumps are Gorman-Rupp or the equivalent 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.

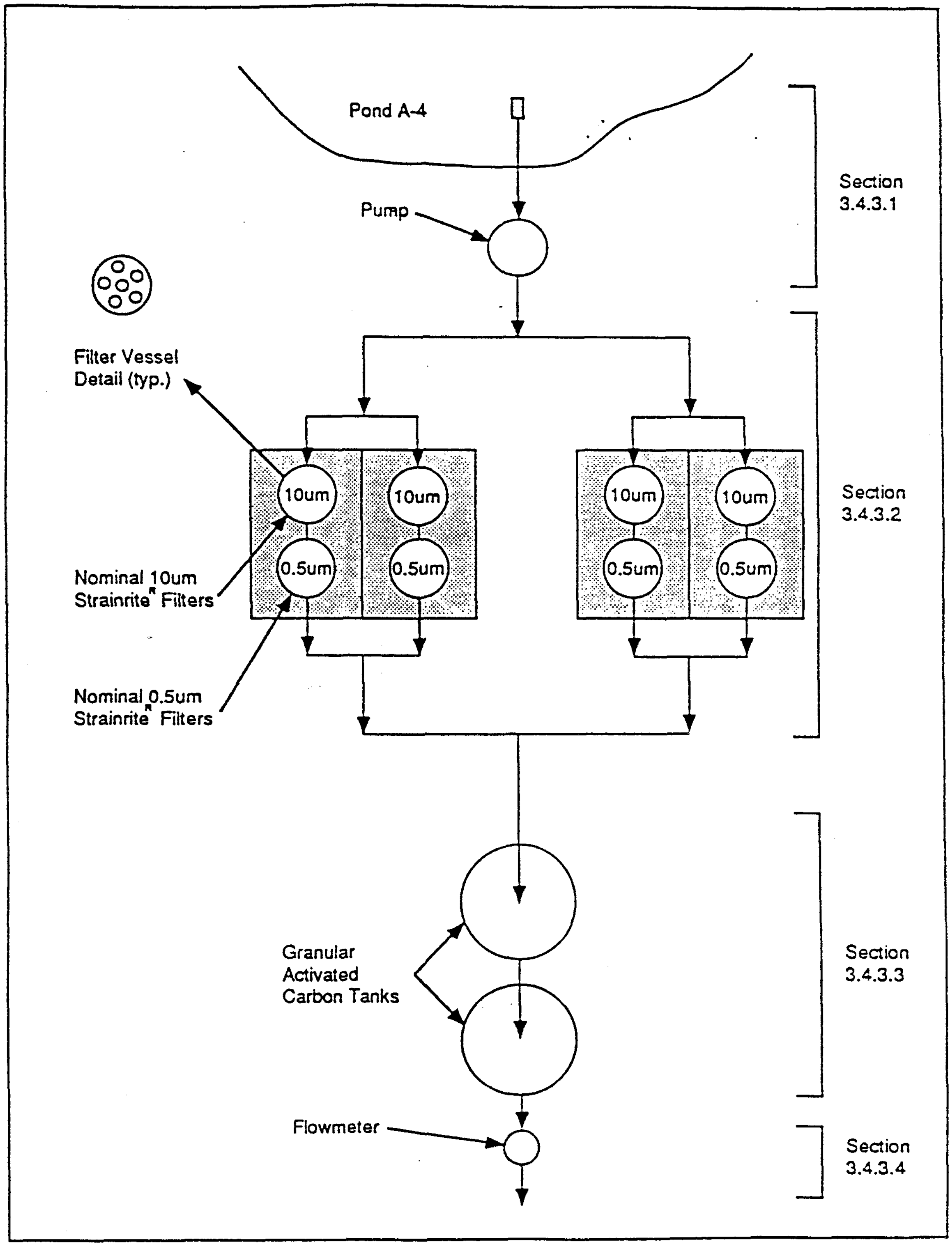


Figure 3.4-1 Pond A-4 Current Treatment System Configuration

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 Pu and Am) 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 primary function of the filter bags is to protect the GAC from premature fouling and thereby preserve its capacity for the removal of organic contaminants.

3.4.4 Preliminary Radionuclide Removal Study

A preliminary study was performed by an 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 Pu and Am contaminants between particulate, colloidal, and dissolved phases in RFP pond water is currently unknown. Evaluators utilized knowledge and experience of U 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 (IX) or ultrafiltration (UF) for uranium removal. A list of the favored methods follows:

- Parallel plate separator, followed by polishing with sand filtration.
- Parallel plate separator, 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.
- Dissolved air flotation, followed by polishing with cartridge filtration.
- Sand filtration, with the backwash of the sand filter being treated by a dissolved air flotation (DAF) 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 UF as a final polishing step for removal of U; the other six considered (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 U. 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-scale and pilot-scale testing. Further discussion of proposed treatment evaluations is presented in Section 4.4. of this Workplan.