

FINAL DRAFT

**TREATABILITY STUDY WORK PLAN
FOR ION EXCHANGE PROCESSES
AND
TREATABILITY STUDY WORK PLAN
FOR ADSORPTION PROCESSES**

ROCKY FLATS PLANT

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

ENVIRONMENTAL RESTORATION PROGRAM

February 1993

EXECUTIVE SUMMARY

Section 1
INTRODUCTION

Section 2
PROJECT DESCRIPTION
ION EXCHANGE TREATABILITY STUDY

Section 3
REMEDIAL TECHNOLOGY DESCRIPTION
ION EXCHANGE PROCESS

Section 4
DATA QUALITY OBJECTIVES
ION EXCHANGE TREATABILITY STUDY

Section 5
EQUIPMENT AND MATERIALS
ION EXCHANGE TREATABILITY STUDY

Section 6
EXPERIMENT DESIGN AND PROCEDURES
ION EXCHANGE TREATABILITY STUDY

Section 7
DATA MANAGEMENT
ION EXCHANGE TREATABILITY STUDY

Section 8
DATA ANALYSIS AND INTERPRETATION
ION EXCHANGE TREATABILITY STUDY

Section 9
RESIDUAL MANAGEMENT
ION EXCHANGE TREATABILITY STUDY

Section 10

ION EXCHANGE TREATABILITY STUDY REPORT

ION EXCHANGE TREATABILITY STUDY SCHEDULE

Section 11

Section 12
MANAGEMENT AND STAFFING
ION EXCHANGE TREATABILITY STUDY

Section 13
REGULATORY REQUIREMENTS FOR OFFSITE TESTING
ION EXCHANGE TREATABILITY STUDY

Section 14
INTRODUCTION
ADSORPTION TREATABILITY STUDY

Section 15
PROJECT DESCRIPTION
ADSORPTION TREATABILITY STUDY

Section 16
REMEDIAL TECHNOLOGY DESCRIPTION
ADSORPTION TREATABILITY PROCESS

Section 17
DATA QUALITY OBJECTIVE
ADSORPTION TREATABILITY STUDY

Section 19
EXPERIMENT DESIGN AND PROCEDURES
ADSORPTION TREATABILITY STUDY

Section 20
DATA MANAGEMENT
ADSORPTION TREATABILITY STUDY

Section 21
DATA ANALYSIS AND INTERPRETATION
ADSORPTION TREATABILITY STUDY

Section 22
RESIDUAL MANAGEMENT
ADSORPTION TREATABILITY STUDY

Section 23
ADSORPTION TREATABILITY STUDY REPORT

Section 24
ADSORPTION TREATABILITY STUDY SCHEDULE

Section 26
REGULATORY REQUIREMENTS FOR OFFSITE TESTING
ADSORPTION TREATABILITY STUDY

Section 27
REFERENCES

Appendix A
SAMPLING PLAN

Appendix B
HEALTH AND SAFETY PLAN

Appendix C
QUALITY ASSURANCE ADDENDUM FOR THE
ION EXCHANGE TREATABILITY STUDY WORK PLAN

Appendix D
QUALITY ASSURANCE ADDENDUM FOR THE
ADSORPTION TREATABILITY STUDY WORK PLAN

Appendix E
EXAMPLE CALCULATIONS FOR
ION EXCHANGE AND ADSORPTION
CAPABILITY AND CAPACITY TESTS

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

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Page: 1 of 2

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TITLE: Ion Exchange Treatability Study Schedule

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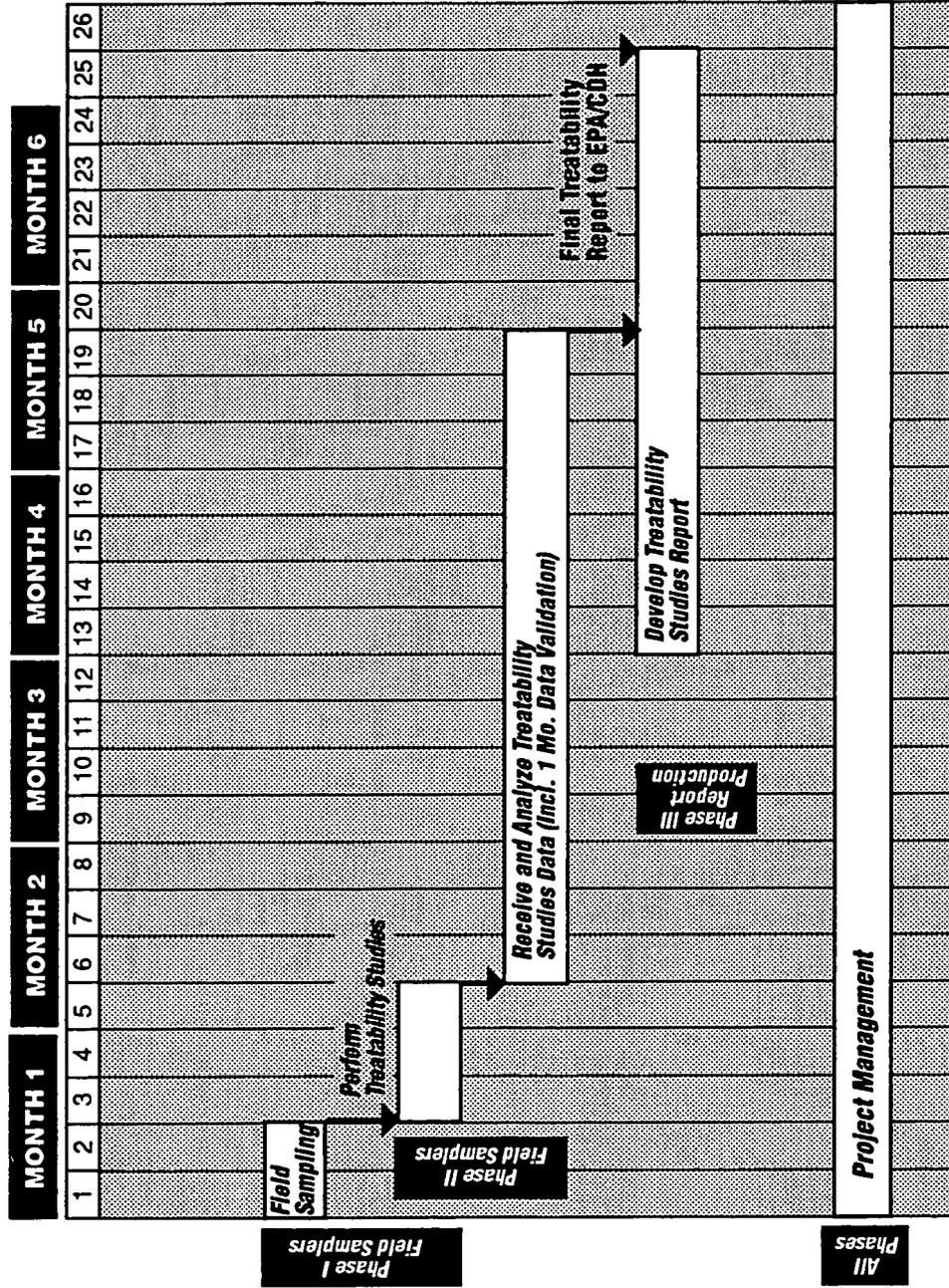
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11.0 ION EXCHANGE TREATABILITY STUDY SCHEDULE

The Ion Exchange Treatability Study shall consist of three phases during a 32-week period. Prior to Phase I, approximately 3 weeks will be used to finalize sampling logistics. Phase I will consist of 2 weeks to perform field sampling. Phase II shall consist of 3 weeks to perform the IX treatability study, followed by 14 weeks to receive and analyze the IX treatability study data.

The IX treatability study will be performed by running two treatability tests at a time, until all tests are complete, in order to achieve the 3-week schedule. Phase III shall consist of 13 weeks to develop, review and finalize the Treatability Study Report (TSR). An approximate project schedule to illustrate the timing, duration, and interrelationship between phases for the Ion Exchange Treatability Study is shown in Figure 11-1.

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▼ DELIVERABLES

Figure 11-1
PROGRAM SCHEDULE FOR
THE ION EXCHANGE TREATABILITY STUDY

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 12

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TITLE: Management and Staffing—
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12.0 MANAGEMENT AND STAFFING—ION EXCHANGE TREATABILITY STUDY

This section describes the management approach and staffing for the IX treatability study. The lines of authority and responsibilities of the IX treatability study team members are described.

12.1 INTRODUCTION

The objective of project management during the IX treatability study is to direct and document project activities so that data and evaluations generated meet the goals and objectives of this TSWP.

Specific project management activities that shall occur throughout the IX treatability study include the following:

- Meetings
- Cost and schedule control
- Data management
- Quality control
- Health and safety

These activities shall be conducted to identify potential problems quickly enough to make necessary corrections and keep the project focused on its objectives, on schedule, and within budget.

12.2 PROJECT TEAM

The project team for the IX treatability study at the Rocky Flats Plant is comprised of individuals from various technical disciplines. This section discusses the responsibilities of the respective key management and personnel. Each project team member should review this section with particular

interest as to each other's responsibilities. This understanding will help in overall project coordination and ensure understanding of the respective jobs to be done. Figure 12-1 depicts the IX treatability study project organization. The specific responsibilities of key management and personnel are described in the following subsection.

12.2.1 EG&G Program Manager

The EG&G program manager's role is to oversee and ensure the work progresses according to the priorities and objectives established during the IX treatability study project planning phase. This role requires planning project scopes and deriving cost estimates for the specific tasks and activities described in the work plan. The EG&G program manager shall also facilitate the interaction among EG&G staff and contractor personnel.

12.2.2 Senior Review Team

The senior review team's responsibilities include continued quality control (QC) review of project deliverables. In general, these include the IX Treatability Study Sampling Plan (TSSP) and the IX Treatability Study Report (TSR).

12.2.3 Project Manager

The project manager (PM) is responsible for the coordination of all activities and tasks and project administration. The PM's responsibility includes quality control and technical excellence of all project aspects, and also extends to meeting assigned project budgets and schedules. The project manager shall be kept aware of major deviations from the scope and procedures established in the TSWP prior to their implementation. The PM will ensure that deliverables clearly present the results of the IX treatability study.

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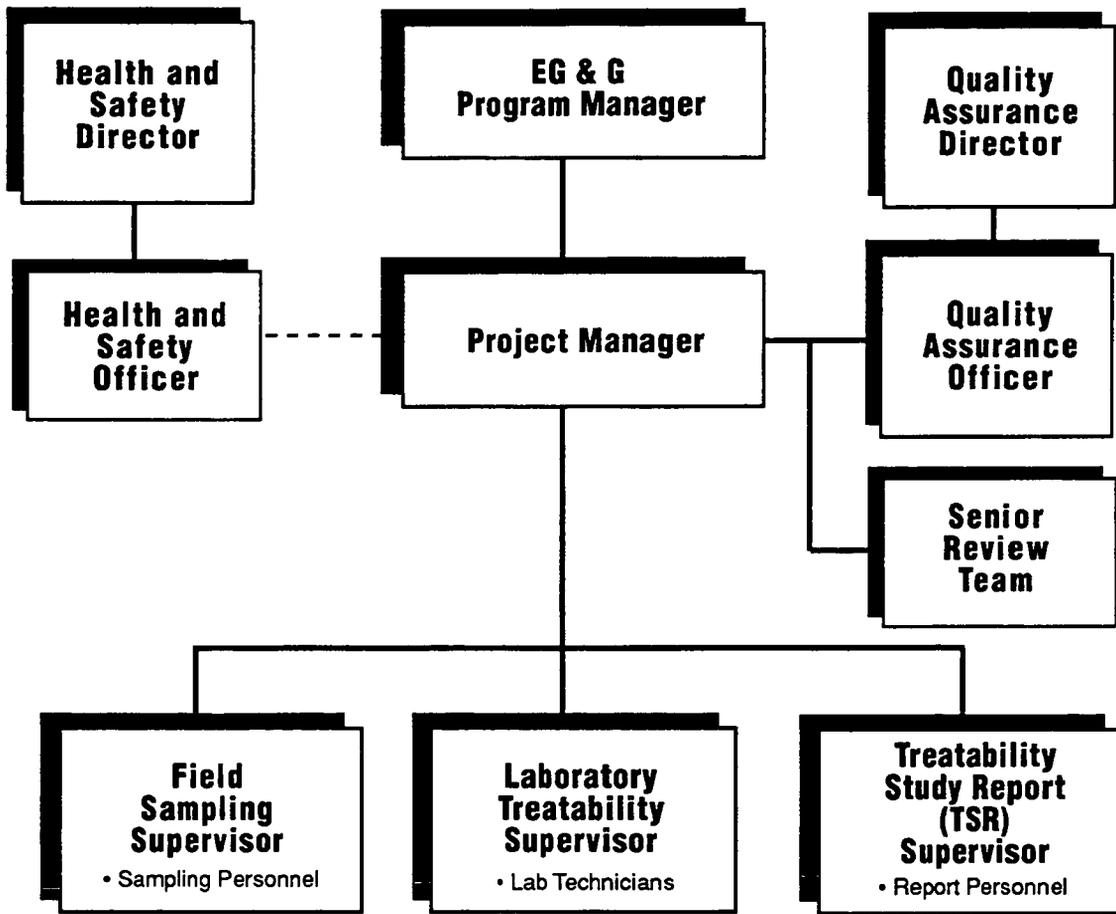


Figure 12-1
MANAGEMENT ORGANIZATION
ROCKY FLATS ION EXCHANGE TSWP

12.2.4 Health and Safety Officer (HSO)

The HSO is responsible for the establishment and implementation of health and safety requirements, and any monitoring programs. The maintenance of Health and Safety Records and monitoring equipment is also the responsibility of this person. The HSO will monitor compliance with health and safety requirements through audits.

12.2.5 Quality Assurance Officer (QAO)

The QAO is responsible for development and implementation of quality requirements, and monitors compliance through field and records audits. The QAO provides general oversight and guidance on quality issues, and sets procedures for equipment calibration and maintenance.

12.2.6 Sampling Field Supervisor

The sampling field supervisor shall be responsible for ensuring that the Sampling Plan for the IX treatability study (Appendix A of this document) is adhered to by sampling personnel, including proper identification of sampling locations, implementation of sample designation and sample handling procedures, use of proper sampling equipment, calibration and maintenance of equipment, and completion of required paperwork.

12.2.7 Laboratory Treatability Supervisor

The laboratory treatability supervisor's responsibilities include ensuring that treatability testing procedures are followed and documented, including proper sample designation and handling procedures, use of proper test equipment, and calibration and maintenance of test equipment.

12.2.8 Sampling Personnel

Sampling personnel responsibilities relate to both groundwater and surface water sampling. Their responsibilities include sample collection, sample documentation and chain of custody, initial packing of samples, shipment of samples, and decontamination of sampling equipment and vehicles.

12.2.9 Laboratory Technicians

The laboratory technicians shall be responsible for performing the IX treatability tests, maintaining equipment and materials, and following experimental procedures and analytical methods. Their responsibilities include the following:

- Daily documentation of IX treatability testing results and other pertinent information in log books.
- Proper sample collection, designation, documentation, and chain of custody of treatability samples for outside laboratory analysis.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange Adsorption Processes

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TITLE: Regulatory Requirements for Onsite
and Offsite Testing—
Ion Exchange Treatability Study

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13.0 REGULATORY REQUIREMENTS FOR ONSITE AND OFFSITE TESTING— ION EXCHANGE TREATABILITY STUDY

If the IX treatability study is conducted offsite, sample collection and shipping restrictions will be followed to comply with the Sample Exclusion Provision (40 CFR 261.4(d)) of RCRA. This provision includes environmental samples used in small-scale treatability studies and is referred to as the Federal Treatability Studies Exemption Rule. In accordance with this rule, samples that are collected, stored, or transported to an offsite laboratory or testing facility will be exempt from the RCRA generator and transporter requirements (40 CFR Parts 262 and 263) by following these guidelines:

- No more than 1,000 kilograms (kg) of the water to be used in the TS may be shipped to the offsite laboratory.
- Check the sample package—*before shipment*. It must not leak, spill, or vaporize from its packaging during shipment, and the transportation of each sample shipment must comply with U.S. Department of Transportation (DOT), U.S. Postal Service (USPS), or any other applicable regulations for shipping hazardous materials. All sample packages must be surveyed for radioactivity following Rocky Flats Plant and DOT requirements. Packages must be appropriately labelled after surveys, according to DOT regulations. (49 CFR 173)
- Check the permit status of the laboratory or testing facility. The water samples can only be shipped to a laboratory or testing facility that is exempt under 40 CFR 261.4(f) or that has an appropriate RCRA permit or interim status. Since the samples are anticipated to contain radionuclides, all laboratories (including analytical laboratories) handling the samples must be licensed by the Nuclear Regulatory Commission (NRC) or the applicable state agency if they have NRC licensing

authority for handling, analyzing, treating, or storing radioactive material. The license must be inclusive of the radionuclides expected and allow amounts of those radionuclides in excess of the quantities anticipated.

If the IX treatability study is conducted onsite, substantive compliance with federal, state, or local requirements will be demonstrated.

The following information must be maintained for each individual waste stream:

- The date the sample was collected.
- The date the sample was received at the treatability studies unit.
- The total quantity in kg of "as received" waste in storage per day at the treatability studies facility.
- If the "as received" waste sample was stored prior to initiating the treatability test, state where it was stored.
- The quantities and types of waste subjected to the treatability studies.
- The date treatment was initiated, and the amount of "as received" waste introduced to treatment each day. (For example, if the treatment process is conducted in a glovebox, *and* an individual sample is treated in multiple runs, *then* the day the entire sample enters the glovebox is the date initiation of treatment for the sample.)
- The dates of initiation and conclusion of each treatability test.

- The final disposition of residues and unused samples from the IX treatability study (such as which RCRA-permitted hazardous waste storage area the residues and unused samples were stored in).
- Records of any spills or releases.
- Records that show compliance with the treatment rate limits, and the storage time and quantity limits, must be kept for a minimum of 3 years after completion of the IX treatability study.

Monthly reporting will be required for the IX treatability study. These reports will include the following:

- The waste stream studied
- The treatability test number
- The date the sample was collected
- Where sample was stored prior to treatment
- The date treatment was initiated
- The initial sample weight
- The date treatment concluded
- The final residue and unused sample weight
- Where the residue was stored prior to its return to the permitted storage area
- The date the residue was returned to permitted storage area

The requirements described in this section are summarized from 40 CFR 261.4(d), the Sample Exclusion Provision of RCRA, and are also taken from the TSP, which references the Sample Exclusion Provision.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01
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Approved By:

TITLE: Introduction—
Adsorption Treatability Study

Name (Date)

14.0 INTRODUCTION—ADSORPTION TREATABILITY STUDY

Sections 14.0 through 26.0 present the work plan for conducting adsorption treatability tests at the U.S. Department of Energy (DOE) Rocky Flats Plant.

The final Inter-Agency Agreement (IAG) stated that DOE would develop a Treatability Studies Plan (TSP) to evaluate candidate remedial technologies for the general types of contamination encountered sitewide at the RFP. The TSP (DOE, 1991a) presented a number of treatment technologies applicable to remediation efforts at two or more operable units (OUs). The treatability studies are designed to provide information for the individual OU Feasibility Study/Corrective Measures Studies (FS/CMS) without having to perform individual OU-specific treatability studies.

The TSP identified adsorption as a technology to be tested. This technology was selected for removal of metals and radionuclides in groundwater and surface water. The purpose of this work plan is to describe the testing procedures for screening selected adsorption media for their capabilities to remove the selected metals and radionuclides from groundwater and surface water. Adsorption media that show significant capabilities to absorb metals and radionuclides will be further tested to determine their capacities. Experimental procedures have been designed that allow for variation in the concentration of targeted contaminants to perform an effective treatability study.

An additional purpose of this treatability study is to establish basic adsorption technology limitations for use in the technologies and alternatives evaluation phases of the FS/CMS to be conducted at each OU.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01
Section: 14
Revision: 2
Page: 2 of 2
Effective Date: _____
Organization: ERT

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14.1 OBJECTIVES

The overall objective of the adsorption treatability study is to evaluate the effectiveness of the adsorption media as a potential treatment alternative in reducing the volume, toxicity, or mobility of selected metals and radionuclides from Rocky Flats surface water and groundwater. The individual adsorbents will first be tested to determine their capability for reducing the concentration of beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium in the onsite waters at Rocky Flats ([TSP] DOE, 1991a). Media that show sufficient capabilities will be further tested to determine their capacities and breakthrough times, as well as their regeneration abilities. Measurements of performance are described in Subsection 21.1 of this document.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

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Adsorption Treatability Study

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15.0 PROJECT DESCRIPTION-ADSORPTION TREATABILITY STUDY

This section provides background information on the Rocky Flats Plant (RFP) site and summarizes the contaminants of concern for the adsorption treatability study. A discussion of the types of adsorption studies to be conducted is also included.

15.1 BACKGROUND INFORMATION

The RFP is a government-owned, contractor-operated facility that is part of the nationwide nuclear weapons production complex. The primary mission of the RFP is to fabricate nuclear weapon components from plutonium, uranium, and nonradioactive metals (the later primarily being beryllium and stainless steel). The nuclear weapon component parts made at the Plant are shipped elsewhere for final assembly. The RFP also formerly reprocessed components for recovery of plutonium after they were removed from obsolete weapons. Other activities at the RFP formerly included research and development in metallurgy, machining, nondestructive testing, chemistry, physics, engineering, and environmental management.

Both radioactive and nonradioactive wastes are generated in the production process. Current waste handling practices involve onsite storage of hazardous and radioactive mixed wastes and offsite disposal of solid radioactive materials at other DOE facilities. However, both storage and disposal of hazardous and radioactive wastes occurred onsite in the past. Preliminary assessments under the Environmental Restoration (ER) Program identified some of the past onsite storage and disposal locations as potential sources of environmental contamination.

Details concerning the site's location, climatology and meteorology, and geology and hydrogeology that can potentially affect the remediation methodology and implementation are included in the following subsections. Various studies have been conducted at the RFP to characterize

environmental media and to assess the extent of radiological and chemical contaminant releases to the environment. More information on these subjects may be found in the TSP.

15.1.1 Location

The RFP is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver (Figure 15-1). Other surrounding cities include Boulder, Westminster, and Arvada, which are located less than 10 miles to the northwest, east, and southeast, respectively. Major buildings are located within the approximate 400-acre security area of the RFP. The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 15-2).

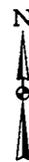
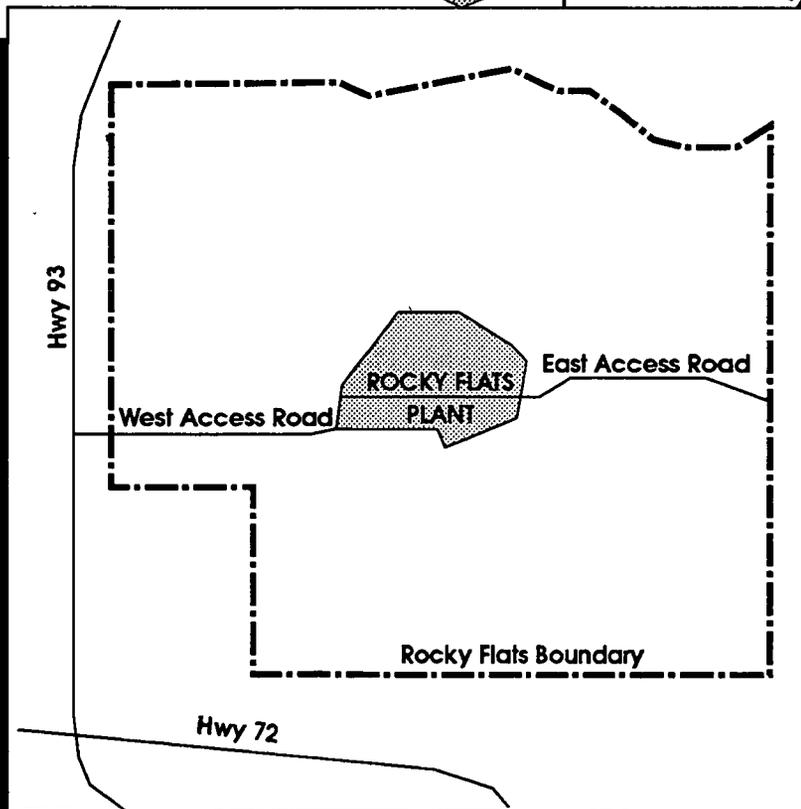
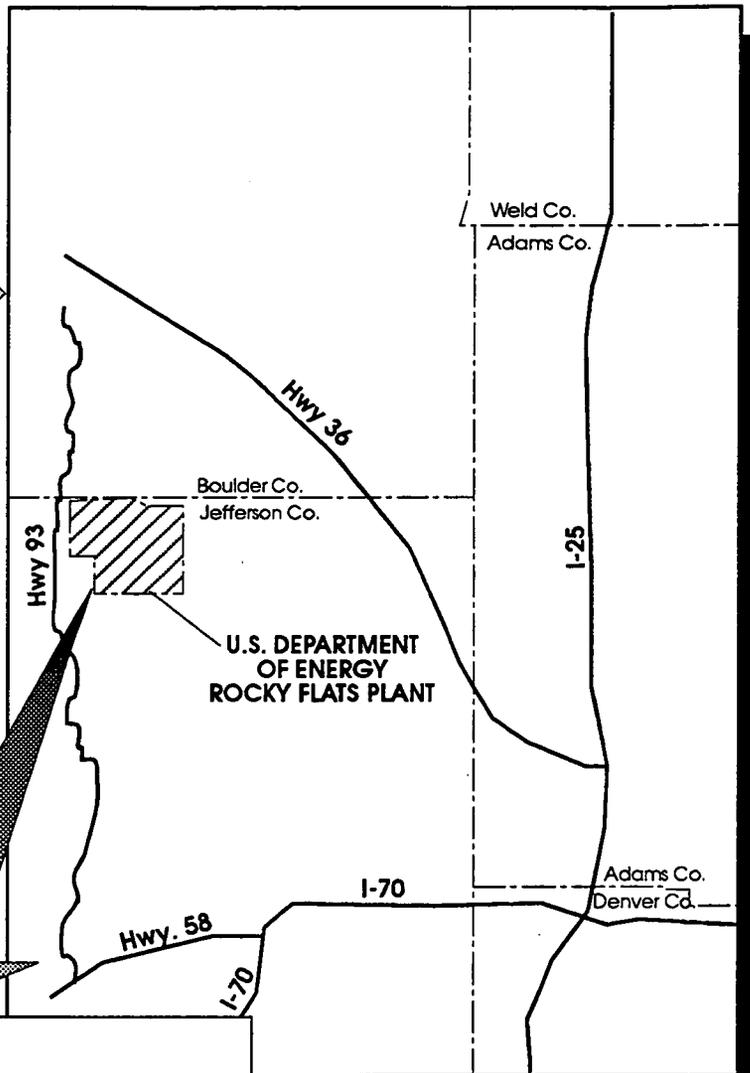
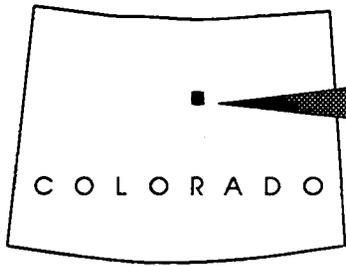
15.1.2 Climatology and Meteorology

The area surrounding the RFP has a semiarid climate characteristic of much of the central Rocky Mountain region. Approximately 40 percent of the 15-inch annual precipitation falls during the spring season—much of it as wet snow. Thunderstorms (occurring from June to August) account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, falling from October through May (DOE, 1980).

15.1.3 Geology and Hydrogeology

The stratigraphic section that pertains to the RFP includes, in descending order, unconsolidated surficial units (Rocky Flats Alluvium, various other alluvial deposits, valley fill alluvium, and colluvium), the Arapahoe Formation, the Laramie Formation, and Fox Hills Sandstone. Groundwater occurs under unconfined conditions in both the surficial and shallow bedrock units. In addition, confined groundwater flow occurs in deeper bedrock sandstones (such as the Fox Hills Sandstone formation). More information on these subjects may be found in the TSP.

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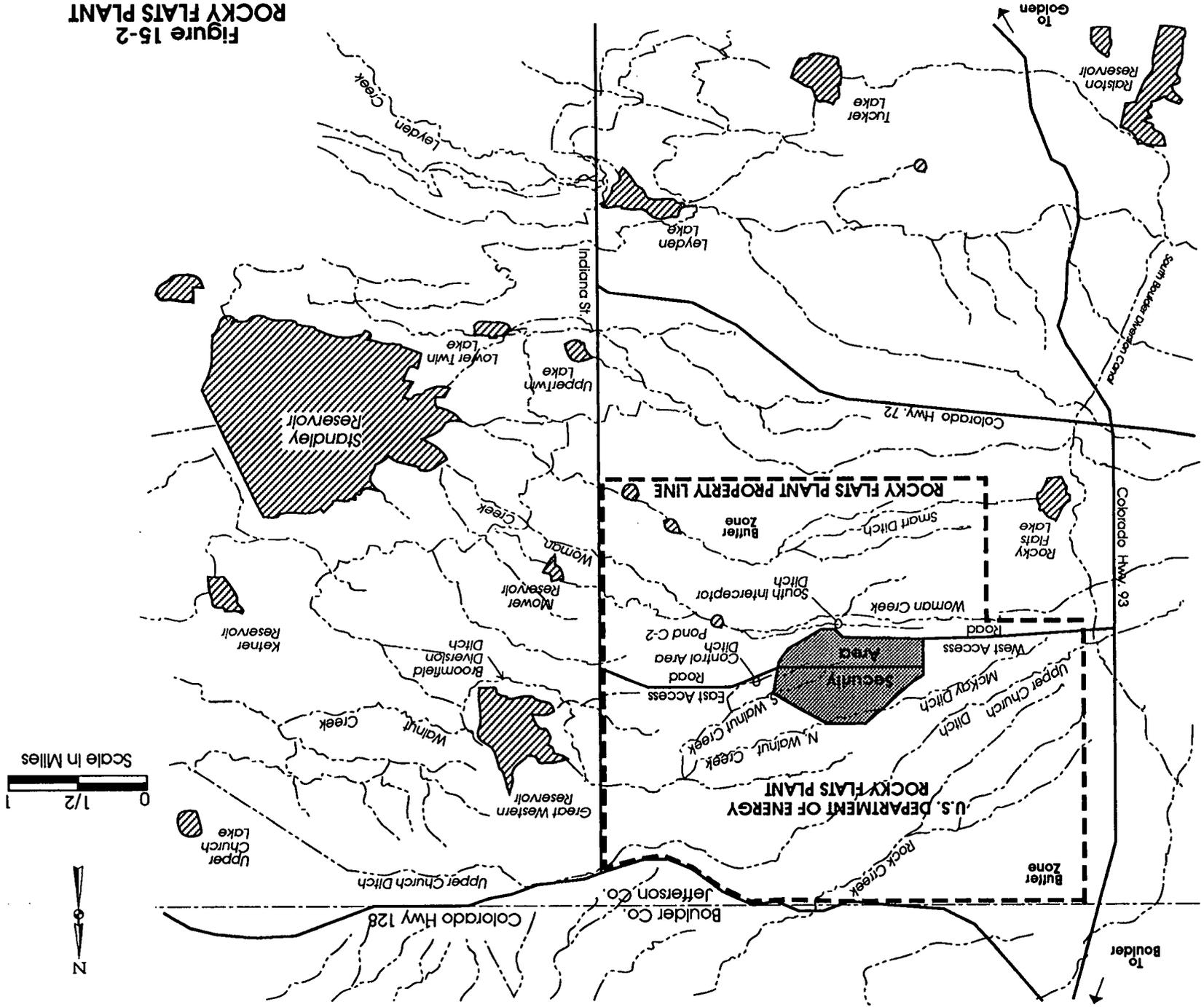
Source: DOE, 1991a

**Figure 15-1
LOCATION OF
ROCKY FLATS PLANT**

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			<i>2/23/93</i>		
			<i>2/24/93</i>		

Source: DOE, 1991a

Figure 15-2
ROCKY FLATS PLANT
BOUNDARIES AND BUFFER ZONE



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15.2 TREATMENT GOALS/ARARs

This section presents the treatment (or performance) goals for the adsorption TSWP, which are to meet the potential Applicable or Relevant and Appropriate Requirements (ARARs) and to-be-considered standards (TBC) for the RFP associated with the groundwater (GW) and surface water (SW). The TSP presented the potential ARARs and TBCs for the RFP. The potential ARARs/TBCs for groundwater and surface water are based on chemicals suspected to be present at RFP, in addition to the following current federal and state health and environmental statutes and regulations:

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) applied to both surface and groundwater.
- Clean Water Act (CWA) Water Quality Criteria (WQC) applied to surface water.
- RCRA Subpart F Groundwater Concentration Limits (40 CFR 264.94) applied to groundwater.
- Colorado Department of Health (CDH) surface water standards for Woman Creek and Walnut Creek (5 CCR 1002-8, Section 3.8.0, amended February 15, 1990) applied to surface water.
- CDH Water Quality Control Commission (WQCC) statewide and classified groundwater area standards (5 CCR 1002-8, Section 3.11) applied to groundwater.

In addition to the potential ARARs/TBCs, health effects assessment (HEA) criteria or "action levels" developed by Environmental Protection Agency (EPA) for carcinogens and systemic toxicants were considered as possible or potential cleanup goals in the TSP.

Where ARARs did not exist for a particular metal or radionuclide, or where existing ARARs are not protective of human health or the environment, TBC criteria, guidances, proposed standards, and

advisories were evaluated for use. In Table 15-1, the "Potential ARARs" column does not contain an entry whenever ARARs do not exist for a particular radionuclide.

The goal of the adsorption treatability study will be to evaluate various types of adsorption media for their effectiveness in removing specified metals and radionuclides from groundwater and surface water. The resulting conclusions will be used in support of the FS/CMS.

Sitewide potential ARARs/TBCs were selected for comparison to sitewide maximum and minimum analyte concentrations. This process is described in the following subsection.

15.3 DESCRIPTION OF CONTAMINANTS

Summaries of the potentially hazardous substances found within groundwater, surface water, soils, and wastes at the RFP were also presented in the TSP. The TSP identified metals and radionuclides as contaminants of concern in groundwater and surface water for several OUs. This section presents the contaminants to be addressed by the adsorption treatability study.

Potential standards were selected for comparison to maximum and minimum analyte levels. MCLs were selected as the principal standards for both surface water and groundwater. The appropriate state standard was used for groundwater where there was no MCL. The state agricultural value was not considered in determining the appropriate state standard. In cases where the state standard was below the current analytical detection limit, the detection limit was used as the default value. For surface water, the lowest federal Water Quality Criteria (WQC) was used where there was no MCL, unless the WQC was below detection limit, in which case the detection limit was used. The appropriate state standard was used for surface water where there was no MCL or Ambient Water Quality Criteria (AWQC), unless this value was below detection limit, in which case the detection limit was used. The lowest systemic or carcinogenic HEA criterion was used for surface water and groundwater for those chemicals which had no MCL, WQC, or state standard. Where HEA criteria were below the detection limit, the detection limit was used.

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TABLE 15-1*
 ANALYTE CONCENTRATIONS AND ARARS

Parameter	Groundwater (mg/l)			Surface Water (mg/l)		
	Maximum ^b	Minimum ^c	Potential ARAR	Maximum ^b	Minimum ^c	Potential ARAR
METALS (TOTAL AND DISSOLVED)						
Beryllium	0.029 (E)	0.005	0.1	0.09 (E)	0.005 ^d	0.005
Chromium	0.172 BR (F)	0.010	0.05	0.298 (A)	0.010	0.05
Iron	57.1 (F)	0.100	0.30	3220 (A)	0.100	0.30
Lead	0.21 J BR (B)	0.005	0.05	0.516 (A)	0.005	0.05
Manganese	6 (F)	0.015	0.05	27.7 (A)	0.015	0.05
Mercury	0.006 (E)	0.0002	0.002	3.97 (E)	0.0002	0.002
Selenium	3.2 (E)	0.005	0.010	0.55 (A)	0.005	0.010

*Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.

^bMaximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.

^cValue given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).

^dPresent in laboratory blank.

Notes: J = Analyzed below detection limit.
 BR = Bedrock (including some weathered bedrock).

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TABLE 15-1*
ANALYTE CONCENTRATIONS AND ARARS
(Continued)

Parameter	Groundwater (pCi/l)			Surface Water (pCi/l)		
	Maximum ^b	Minimum ^c	Potential ARAR	Maximum ^b	Minimum ^c	Potential ARAR
RADIONUCLIDES (TOTAL AND DISSOLVED)						
Americium 241	2.3 (E)	0.01		90 (A)	0.01	30
Plutonium 239 + 240	4.6 (G)	0.01	15(a)	120 (A)	0.01	15(a)
Uranium 233 + 234	723 (G)	0.6		861 (A)	0.6	
Uranium 235	9 (F)	0.6		65.5(A)	0.6	
Uranium 235 + 236	0.009 (G)	0.6		1.192 (G)	0.6	
Uranium 238	190 (F)	0.6		366 (A)	0.6	
Uranium (Total)	63.7 (B)	0.6		1023 (A)	0.6	5

*Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.

^bMaximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.

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Final Draft

TABLE 15-1*

ANALYTE CONCENTRATIONS AND ARARS
 (Concluded)

Parameter	Groundwater (pCi/l)			Surface Water (pCi/l)		
	Maximum ^b	Minimum ^c	Potential ARAR	Maximum ^b	Minimum ^c	Potential ARAR

References:

Note: Analytical data received prior to October 1988 not subjected to validation procedure. Some of the contaminant values reported in this table have not yet been validated, and the analyte list may be changed after the data are validated.

- (A) EG&G. February 22, 1991a, Surface Water and Sediment Geochemical Characterization Report, Draft Copy.
- (B) U.S. DOE. April 2, 1990c, Final Phase II Remedial Investigation/Feasibility Study Workplan (Alluvial), OU 2, Draft Copy.
- (C) U.S. DOE. January 11, 1991a, Proposed Surface Water Interim Measures, Interim Remedial Action Plan/Environmental Assessment and Decision Document South Walnut Creek Basin, OU 2, Final Draft.
- (D) U.S. DOE. January 24, 1991b, Phase II Remedial Investigation/Feasibility Study Workplan (Bedrock), OU 2, Draft Copy.
- (E) U.S. DOE. October 1990d, Phase III Remedial Investigation/Feasibility Study Workplan 881 Hillside Area, OU 1, Final Draft.
- (F) EG&G. March 1, 1991b, 1990 Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Plant, Draft Copy.
- (G) EG&G. May 1991, Unpublished data (see note to reference).

*Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.

^bMaximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.

^cValue given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).

^dPresent in laboratory blank.

Notes: J = Analyzed below detection limit.
 BR = Bedrock (including some weathered bedrock).

Table 15-1 presents the maximum and minimum concentrations of all metals and radionuclides analyzed for and the potential standard associated with each contaminant. Table 15-2 lists the OUs that contain these contaminants in levels above the potential standard.

The TSP identified the following metals and radionuclides for a sitewide evaluation of adsorption as a remediation technology: beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium.

15.4 ADSORPTION TREATABILITY STUDY OVERVIEW

General laboratory-scale testing will be conducted on all of the chosen adsorbents to determine the relative effectiveness of the adsorbents. The actual testing procedures for the adsorption process are detailed in Section 19.0 of this document.

The overall objective of the adsorption treatability study is to evaluate the effectiveness of the adsorption media as potential treatment alternatives in reducing the volume, toxicity, or mobility of selected metals and radionuclides from Rocky Flats surface water and groundwater. The individual adsorbents will first be tested to determine their capabilities for reducing the concentration of beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium in the onsite waters at Rocky Flats (TSP, DOE, 1991a). Media that show sufficient capability will be further tested to determine their capacity and breakthrough times.

Upon completion of the adsorption treatability study, the results will be reviewed in order to determine if there is sufficient information to evaluate this technology for the FS/CMSs without further testing for various OUs. If more information is necessary, the information needed will be described in the adsorption treatability study summary report. The review process is described in Section 21.0 of this document.

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TABLE 15-2

LIST OF CHEMICALS REPORTED ABOVE
 ARARs IN TWO OR MORE OPERABLE UNITS

Contaminant	Operable Units (Two or More)	
	Reported in Groundwater	Reported in Surface Water
METALS		
Beryllium		1,6, LSID
Chromium	1,2,4,7	1,2,4,7 USID, LSID
Iron	1,2,4	1,2,4,5,6,7, LSID, USID
Lead	2,4	1,2,4,5,6,7, LSID, USID
Manganese	1,2,4,7	1,2,4,5,6,7, LSID, USID
Mercury		1,4,6
Selenium	1,2,4,7	1,2,4,5,6,7, LSID
RADIONUCLIDES		
Americium 241		
Plutonium 239 + 240		2,4
Uranium (total)		1,2,4,5,6,7, USID

Notes: BACK = Sitewide Background Maximum
 USID = Upper South Interceptor Ditch
 LSID = Lower South Interceptor Ditch

Source: DOE, 1991a.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 16

Revision: 2

Page: 1 of 1

Effective Date: _____

Organization: ERT

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Final Draft

Approved By:

TITLE: Remedial Technology Description--
Adsorption Process

Name

_____/_____
(Date)

16.0 REMEDIAL TECHNOLOGY DESCRIPTION--ADSORPTION PROCESS

This section provides a general overview of the adsorption remedial technology. At the Rocky Flats Plant (RFP), this process can potentially provide an effective means of removing dissolved metals and radionuclides from surface water and groundwater.

The adsorption process utilizes natural or synthetic materials of a microcrystalline structure. The resulting porosity provides a very large surface area available for solute uptake. The "sponge-like" nature of the adsorbents may provide as much as 100 square meters of surface area per cubic centimeter of adsorbent. Physical attractive forces cause the solute molecules to adhere to the adsorbent particles, primarily in a single layer of molecules, although the material may still be selective for a height of up to four molecules. Because of this potential "stacking," the capacity of the adsorbent usually depends on the concentration of solute. Adsorbents that will be tested in this treatability study include activated carbon, activated alumina, bone char, natural zeolites, and specialty adsorbents.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 17
Revision: 2
Page: 1 of 18

Non-Safety Related

Final Draft

Effective Date: _____
Organization: ERT

TITLE: Data Quality Objectives-
Adsorption Treatability Study

Approved By:

Name

_____/_____/_____
(Date)

17.0 DATA QUALITY OBJECTIVES-ADSORPTION TREATABILITY STUDY

The overall objective of the adsorption treatability study is to evaluate the effectiveness of the various adsorption media as potential treatment alternatives in reducing the volume, toxicity, or mobility of selected metals and radionuclides from Rocky Flats surface water and groundwater. The adsorbents will first be tested to determine their capability for reducing the concentration of beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium in the onsite waters at Rocky Flats. Media that show sufficient capability will be further tested to determine their capacity and breakthrough times.

This treatability study is designed to screen and test different types of adsorbents to determine the effectiveness of the adsorption process. In order to select the most appropriate materials for removing each constituent, operational characteristics of the adsorbents, such as loading capacity, regeneration properties, and breakthrough characteristics will be investigated.

A primary objective of this TSWP is to investigate a broad range of adsorbents. Adsorbent manufacturers have been contacted and a literature search has been conducted for this TSWP. Based upon these efforts, and after having evaluated the broad range of materials, the most appropriate adsorbents have been selected for the treatability study testing. Both the range evaluation and the final selection process are described in Section 19.0.

Data quality objectives (DQOs) express qualitative and quantitative statements describing the quality and quantity of data required by the treatability studies. Developing DQOs relies on the following three stage process:

- **Stage 1-Identify decision types**

- **Stage 2**—Identify data uses/needs
- **Stage 3**—Design a data collection program

17.1 STAGE 1—IDENTIFYING DECISION TYPES

Of the three stages above, Stage 1 has already been completed as part of the TSP. The Final TSP Report identified the treatability study program goals and objectives and the technical approach. The overall objective of the treatability study program is to provide information to support the Feasibility Studies or Corrective Measure Studies (FS/CMS) to be conducted at each of the 16 Operable Units (OUs). As such, the TSP identified potentially applicable technologies for remediating the types of wastes and waste matrices that may be common to more than one OU in addition to generating data required to evaluate and screen technologies and/or alternatives. Ultimately, the information obtained from the sitewide and specific OU treatability studies will provide data to support the final remedy selection and design process.

The TSP followed a process of identifying potentially applicable technologies based on a literature/data base search and review of other available information. The potentially applicable technologies were evaluated in a two-step screening process. The preliminary screening identified those technologies suitable for application at Rocky Flats. The final screening identified the technologies appropriate for consideration in the sitewide treatability testing.

This TSWP fulfills the Stages 2 and 3 DQO process. The following discussion describes specific elements addressed in Stage 2, consistent with the Data Quality Objectives for Remedial Response Activities (EPA, 1987). These elements include:

- Data uses
- Data types
- Data quality needs
- Data quantity needs
- Sampling/analysis options

- Precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters

17.2 STAGE 2—IDENTIFYING DATA USES/NEEDS

Stage 2 of the DQO process defines data uses and specifies the data types needed to meet the project objectives. As noted above, the DQOs presented reflect the treatability studies screened in Stage 1. Table 17-1 describes the data needed to fulfill the specific objectives for the adsorption treatability study, the type of activity used to collect the data, the analytical level, and the intended data use.

17.2.1 Identifying Data Uses

Data uses for the Stage 2 Treatability Studies include determining the original concentrations of the CLP target analyte list (TAL), radionuclides, and water quality parameters for the treatability influent. The data will be useful for verifying suitable process selections, but will not fulfill all the needs for designing such a process.

17.2.2 Identifying Data Types

Data types include analytical results to assess treatment effectiveness. The adsorption study will generate analytical data measuring:

- pH
- Flow rates of influent sample water and regeneration solution
- Analytical data measuring concentrations of metals and radionuclides in the process effluents and regenerant wastes

TABLE 17-1

**DATA NEEDS TO FULFILL SPECIFIC OBJECTIVES
FOR ADSORPTION TREATABILITY STUDY**

Treatability Study Influent

Data Need:	Establish influent concentrations for a composite groundwater/surface water sample before initiating the treatability studies.
Activity:	Collect representative samples from the two selected groundwater and surface water locations. Composite the samples using flow-proportioned amounts. Analyze the unfiltered composite. Filter and analyze a sample of the composite.
DQO Levels: (Refer to Table 17-2 in this document)	pH—Level II Metals, and Radionuclides—Level III Cr (VI)—Level III Water Quality Parameters—Level III
Data Use:	Use the data in calculating the performance or removal efficiency for each treatability test

Adsorption Capability Tests

Data Need:	Evaluate the capability of six different adsorbents for removing metals and radionuclides from surface water and groundwater at the manufacturer's recommended water feed rate, regenerant concentration and feed rate, and the rinsewater feed rate.
Activity:	Conduct single-column bench scale tests. Evaluate Filtrasorb® 300 (granular-activated carbon), Brimac 216 (bone char), F1 Alumina (granular activated carbon), SORBPLUS® (oxide adsorbent), BIO-FIX® (immobilized biomass), and Clinoptilolite (natural zeolite) for removal of targeted metals and radionuclides. Tests will be run at three pH levels: (1) acidic pH (3 to 4); (2) neutral pH (8 to 2); and (3) alkaline pH (9 to 10).
DQO Levels: (Refer to Table 4-2 in this document)	pH and flow rate—Level II Metals and radionuclides—Level IV Cr (VI)—Level III Water Quality Parameters—Level III

TABLE 17-1

**DATA NEEDS TO FULFILL SPECIFIC OBJECTIVES
FOR ADSORPTION TREATABILITY STUDY
(Concluded)**

Data Use: Determine the relative capabilities of the six adsorbents to produce an effluent that meets the anticipated treatment targets for one or more of the constituents of concern. Use this data to select the optimum pH for the capacity tests.

Adsorption Capacity Tests

Data Need: Evaluate the adsorptive capacities, breakthrough characteristics, and quantities and characteristics of regenerant wastes produced for each of the adsorbents and using the optimum pH identified for each adsorbent tested in the capacity tests.

Activity: Conduct small two-column bench scale tests. Based on pH results of capability tests, evaluate adsorbents to determine breakthrough characteristics and the adsorptive capacities. In addition, samples of the regenerant wastes will be analyzed to provide estimates of the waste quantities and characteristics.

DQO Levels: pH and flow rate—Level II
(Refer to Table 17-2 Metals and radionuclides—Level III
in this document) Cr (VI)—Level III
Water Quality Parameters—Level III

Data Use: Determine the relative capacities of the selected adsorbents for loading the constituents of concern and for generating low quantities and favorable regenerant wastes characteristics.

- Physical measurements (volumetric, weight) will be made to establish the absorbent bed volumes
- Other characteristics and parameters may include electrical conductivity, temperature, and other (unspecified) measurements.

17.2.3 Identifying Data Quality and Quantity Needs

EPA defines five levels of analytical data (EPA, 1987 modified) associated with data quality for treatability studies. The analytical levels correspond with those noted in Table 17-1.

- **Level I**—Field screening or analysis with portable instruments. This level provides an indication of contamination presence and has few QA/QC requirements.
- **Level II**—Field analyses with more sophisticated portable instruments or mobile laboratory. The data quality associated with this level depends on the QA/QC steps used. Data concentrations are usually reported in concentration ranges.
- **Level III**—Analyses of organics and inorganics are performed in an offsite analytical laboratory that may or may not involve contract laboratory program (CLP) procedures. The detection limits will be similar to those specified by the CLP. Level III uses rigorous QA/QC.
- **Level IV**—Analyses encompass the hazardous substance list (HSL) organic and inorganic parameters by sophisticated laboratory instrumentation such as gas chromatography/mass spectroscopy (GC/MS), atomic absorption (AA), and inductively coupled plasma (ICP). Detection limits reach the low parts-per-billion levels. This analytical level also provides tentative identification of non-HSL parameters. Data require validation to evaluate compliance with rigorous QA/QC requirements. Level IV procedures are appropriate to develop data of known quality.

Note: The radionuclides analyses would generally be considered Level V because they are not "CLP" analyses; however, the level of QA/QC included in the EG&G Rocky Flats GRRASP Version 2.1 (DOE, 1991) is equivalent to that of "CLP" analyses. As such, the radionuclide analyses are considered to meet the Level IV data requirements.

- **Level V**—Analyses using nonstandard analytical methods. Method development or method modification may be required for specific constituents or detection limits.

Table 17-1 specifies the appropriate analytical levels for the data needs and data uses described in the table. Stage 2 treatability studies typically rely on Levels II through IV as reflected in Table 17-1.

Section 19.0 of this report describes the rationale for sampling frequencies and quantities for the adsorption treatability study.

17.2.4 Evaluating Sampling/Analysis Options

Data collection activities must be designed to obtain maximum use of the data. The sampling/analysis approach for this treatability study is based on guidelines provided in the TSP. If treatability results indicate that additional analyses or sampling are necessary, modifications will be made to the sampling analysis program. This will be done to avoid performing additional, redundant studies. Section 19.0 describes the sampling/analysis options in more detail.

17.2.5 Reviewing PARCC Parameter Information

PARCC (precision, accuracy, representativeness, completeness, comparability) parameters are indicators of data quality. Precision, accuracy, and completeness goals consider the analyses to be performed and the required analytical levels. Criteria established to meet PARCC requirements will be used to evaluate the data useability for data collected as part of the treatability study.

Table 19-6 of this document describes the analytical requirements for the adsorption treatability study. The analytical program specifies the use of analytical methods referenced in the EG&G Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP, Version 2.1) (DOE, 1991) for all analytes. These analytical methods are appropriate for meeting the data quality requirements for analytical levels II through V. The precision, accuracy, and completeness parameters for analytical levels II through V are discussed below along with the comparability and representativeness for all analytical levels. The DQOs specified for the precision, accuracy, and completeness will be used in evaluating the quality and useability of the laboratory data.

Precision and accuracy objectives for the treatability study data will be evaluated based on the control limits specified in the referenced analytical method and/or in data validation guidelines. For the radionuclide analyses, the accuracy objectives specified in the GRRASP will be followed. The specified criteria for precision and accuracy are summarized in subsection 17.4.

For each sample taken and analysis performed in the treatability study, the objective for achieving useable data points is 90 percent.

Comparability is a qualitative parameter that expresses the confidence with which one data set can be compared with another. In order to achieve comparability, work performed as part of the treatability studies will follow approved sampling and analysis plans, use standardized analytical protocols, collect data following Environmental Restoration Management Operating Procedures (ERM OPS), and report data in consistent units of measurement.

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. It is a qualitative parameter that is most concerned with the proper design of the sampling program. The Adsorption Treatability Study Sampling Plan described in Appendix A of this document and the referenced ERM OPS describe the rationale for the sample program to provide for representative samples. In designing the treatability study, statistical considerations were evaluated in selection of sample numbers.

17.3 STAGE 3--DESIGN DATA COLLECTION PROGRAM

The Stage 3 DQO process includes discussions of the following elements, consistent with Data Quality Objectives for Remedial Response Activities (EPA, 1987):

- Data collection components
- Sampling and analysis plan

To accomplish this, the elements identified in Stages 1 and 2 were assembled and the Adsorption Treatability Sampling Plan (Appendix A of this document) was prepared. Analytical methods are indicated in Subsection 19.4.3, Table 19-6. A brief summary of all samples to be collected are presented in Table 19-5, including sample type, number of samples, and analyses. QA/QC samples are shown in Table 17-2.

17.4 SUMMARY OF DATA QUALITY OBJECTIVES

Table 17-2 presents the QA/QC criteria for the Levels III and IV laboratory analyses proposed for the treatability studies. No specific criteria are set for electrical conductivity and pH measurements other than multiple readings and those procedures prescribed by the instrument manufacturer. Reagent dosages primarily involve physical measurements of the volume and/or weights. Standard laboratory scales and volumetric devices are used for this purpose. Other than "good laboratory practices," no specific criteria are set for physical measurements. The weights and volumes will be estimated using the correct stoichiometry and the calculations will be double-checked for accuracy. The water quality parameters are to be determined only for the treatability influent. These analyses will be performed consistent with the Level III goals.

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TABLE 17-2

SUMMARY OF LABORATORY QA/QC CRITERIA

Analyses	Frequency of QA/QC	QA/QC Criteria
TAL METALS:		
Initial Calibration	Daily (once every 24 hours).	ICP ¹ : A blank and a minimum of one standard in proper operating range GFAA ² : A blank and three standards in proper operating range. CVA ³ : A blank and four standards
Initial Calibration Verification (ICV)	Immediately after the initial calibration.	The measured value must be within 90 to 110 percent of the true value.
Continuing Calibration Verification (CCV)	Once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The measured value must be within 90 to 110 percent of the true value.
Contract Required Detection Limit (CRDL) Standard	A minimum of twice per 8 hours or at the beginning and the end of the sample run.	ICP ¹ : At two times the CRDL or Initial Detection Limit (IDL); whichever is greater. Report the data. GFAA ² : At CRDL or IDL; whichever is greater. Report the data.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

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TABLE 17-2
SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Initial Calibration Blank (ICB)	Immediately after ICV, and once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the 10 samples prior to the noncompliant blank.
Continuing Calibration Blank (CCB)	Immediately after ICB, and once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the 10 samples prior to the noncompliant blank.
Preparation Blank (PB)	Once per 20 samples, a group ⁶ of samples, or 14 days, whichever is most frequent.	The blank concentrations must be below CRDL or the lowest sample concentration must be at least 10 times the blank concentration. Otherwise, redigest and reanalyze all samples.
ICP ¹ Interference Check Sample (ICS)	At the beginning and the end of a sample run, or twice per 8 hours.	The ICS results must be within 80 to 120 percent of the true value.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

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TABLE 17-2
SUMMARY OF LABORATORY QA/QC CRITERIA
 (Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Matrix Spike	Once per 20 samples, group of samples, or 14 days—whichever is most frequent.	The spiked sample results (after subtracting the original sample result) must be within 75 to 125 percent of the spiked value for sample concentrations, not exceeding four times the spike concentration. A post-digestion spike is required for ICP analyses if the spike criteria are not met.
Post Digestion Spike	In the event the matrix spike criteria are not met, once per 20 samples, group of samples, or 14 days—whichever is most frequent.	Spike the digestate at two times the sample level or the CRDL, whichever is greater. Report the data.
Duplicate Analysis	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	The relative percent difference (RPD) for sample concentrations greater than five times the CRDL must be within 20 percent for the duplicate pair. For concentrations below five times the CRDL, the duplicate results must be within +/-CRDL of the original value.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

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TABLE 17-2

**SUMMARY OF LABORATORY QA/QC CRITERIA
 (Continued)**

Analyses	Frequency of QA/QC	QA/QC Criteria
Laboratory Control Sample (LCS)	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	The LCS results must be within 80 to 120 percent of the true value. Otherwise, the samples must be redigested and reanalyzed.
ICP ¹ Serial Dilution	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	For sample concentrations above 50 times the IDL, the serially diluted results must be within 90 to 110 percent of the original sample concentrations.
Instrument Detection Limit	Once every 3 calendar months.	IDL is calculated as three times the standard deviation of seven consecutive determinations per day for 3 nonconsecutive days (a total of 21 measurements). The IDLs must meet or exceed the CRDLs.
ICP ¹ Interelement Correction Factors	Once every year, or after major instrument adjustments.	Report the factors.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO_x, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

TABLE 17-2
SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
ICP ¹ Linear Range	Once every 3 months.	The linear range standard must measure between 95 to 105 percent of the true value. Sample results cannot be reported beyond this value.
Standard Addition (GFAA) ²	As required by the GFAA analytical scheme in the CLP Statement of Work (SOW).	The analytical spike recovery must be between 85 to 115 percent of the spiked amount. If not, samples with absorbance greater than 50 percent of the spiked sample absorbance must be analyzed by addition of three levels of standards. The coefficient of variance for the standard addition results must be 0.995 or better.
RADIONUCLIDES:⁴		
Instrument Background	Once every month.	Count for a minimum of 12 hours, and report.
Instrument Calibration	Once every week.	Report the data.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

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TABLE 17-2
SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Efficiency Check Standards	Once every week.	Counted until 2,000 counts ⁷ (units of measure) recorded.
Laboratory Control Sample	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	Prepare and count the same as the samples. The measured value must be within three standard deviations of the true value, and the relative percent error not to exceed 10 percent. For tritium, gross alpha, and gross beta activities, the relative percent error must not exceed 15 percent.
Duplicate Sample	Once per 10 samples, group of samples, or 14 days' group—whichever is most frequent.	Prepare and count the same as the samples. The measured value must be within three standard deviations of the weighted average and its associated standard error.
Preparation Blank	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	Prepare and count the same as the samples. Report the data.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

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TABLE 17-2
SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Minimum Detectable Activities (MDAs)	All samples.	The count duration should be optimized so that the required method detection limits are achieved.
Chemical Recovery	All samples.	Recovery for uranium isotopes must be within 30 to 105 percent. Recoveries for plutonium and americium isotopes must be within 20 to 105 percent.
WATER QUALITY PARAMETERS:⁵		
Instrument Calibration	Daily (once every 24 hours).	One blank and at least three standards in the proper operating range. The correlation coefficient must be 0.995 or greater.
ICV	Immediately after the initial calibration.	The ICV must be within 85 to 115 percent of the true value.
CCV	Immediately after the initial calibration.	The CCV must be within 85 to 115 percent of the true value.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

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⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

TABLE 17-2
SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
ICB	Immediately after ICV, and before the samples.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the samples prior to the noncompliant blank.
CCB	Immediately after ICB, and once every 20 samples; also at the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the samples prior to the noncompliant blank.
PB	If applicable to the method, once per 20 samples, group of samples, or 14 days—whichever is most frequent.	The blank concentrations must be below CRDL, or the lowest sample concentration must be at least five times the blank concentration. Otherwise, redigest and reanalyze all samples.
LCS	Once every 20 samples, group of samples, or 14 days—whichever is most frequent.	The LCS recoveries must be within 80 to 120 percent of the true value.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

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TABLE 17-2

SUMMARY OF LABORATORY QA/QC CRITERIA
 (Concluded)

Analyses	Frequency of QA/QC	QA/QC Criteria
Duplicate Sample	Once every 20 samples, a group of samples, or 14 days—whichever is most frequent.	The relative percent difference (RPD) between the duplicate pair must not exceed 20 percent.
Matrix Spike	Once every 20 samples, group of samples, or 14 days—whichever is most frequent.	Matrix spike recoveries must be within 75 to 125 percent for the samples with concentrations not exceeding four times the spike concentration

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

Section 18
EQUIPMENT AND MATERIALS
ADSORPTION TREATABILITY STUDY

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 18
Revision: 0
Page: 1 of 3

Non-Safety Related

Final Draft

Effective Date: _____
Organization: ERT

TITLE: Equipment and Materials-
Adsorption Treatability Study

Approved By:

_____/_____/_____
Name (Date)

18.0 EQUIPMENT AND MATERIALS-ADSORPTION TREATABILITY STUDY

The equipment and materials necessary for performing the treatability tests are listed in Tables 18-1 and 18-2. The equipment listed in Table 18-2 is sufficient to run two capability or two capacity tests simultaneously.

18.1 EQUIPMENT CALIBRATION, CALIBRATION RECORDS, AND CONTROL

Laboratory equipment used in the treatability studies (such as a pH meter and a peristaltic pump) will be identified in the log book(s) by manufacturer's serial number or another suitable unique number. This equipment will be used and calibrated in strict accordance with the manufacturer's instructions. Records of calibration techniques/procedures, source of calibration standard solutions, and date/time of calibration will be maintained in the laboratory log books. The date/time of the last calibration of each instrument will be entered on a label which is attached to the instrument.

Manufacturer's operation, calibration, and maintenance instructions will be kept in close proximity to the equipment during the entire duration of the treatability studies. Equipment/instruments will be maintained in accordance with the manufacturer's instructions.

Table 18-1

EQUIPMENT AND MATERIALS—ADSORPTION TREATABILITY STUDY

Item	Quantity¹
Feed tanks, 7.5 gallon min.	2
Solution tanks, 2.0 gallon min., teflon (two feed, one regen., one conversion, one rinse, one extra)	6
Metering pump, 0-75 mL/min, reversible flow ¹ (minimum flow = 2.9 mL/min; regen./conversion pumps, rinse pumps—low capacity)	4
Metering pump, 25-500 mL/min, reversible flow ¹ (regeneration/conversion pumps, rinse/backwash pumps—high capacity)	4
Metering pump, 10-250 mL/min, reversible flow ¹ (feed pumps)	2
Laboratory columns, 1.25-in I.D. x 36-in long, glass (two adsorbent capability tests)	4
Laboratory columns, 2.00-in I.D. x 36-in long, glass (two adsorbent capability/capacity tests)	2
Laboratory columns, 0.75-in I.D. x 48-in long, glass (two adsorbent capacity tests)	4
Assorted teflon tubing, valves, and fittings	
Assorted laboratory glassware, equipment, accessories, and supplies	

¹All wetted parts to be teflon unless otherwise noted.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 18

Revision: 0

Page: 3 of 3

Effective Date: _____

Non-Safety Related

Final Draft

Organization: ERT

Table 18-2

CHEMICAL SUPPLIES-ADSORPTION TREATABILITY STUDY

Compound	Quantity
Hydrochloric acid, 37 percent (technical or reagent grade)	2,000 mL
Sulfuric acid, 95 to 98 percent (technical or reagent grade)	100 mL
Sodium hydroxide, beads or pellets (technical or reagent grade)	500 g
Ammonium hydroxide (technical or reagent grade)	100 mL
Sodium chloride (technical grade)	1,000 g

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 19

Revision: 1

Page: 1 of 42

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

Approved By:

TITLE: Experiment Design and Procedures–
Adsorption Treatability Study Work Plan

_____/_____/_____
Name (Date)

19.0 EXPERIMENT DESIGN AND PROCEDURES–ADSORPTION TREATABILITY STUDY

This section describes the general approach and the detailed procedures to be followed in performing the treatability study for the adsorption process.

19.1 TEST OBJECTIVES

The overall objective of the adsorption treatability study is to evaluate the effectiveness of the various adsorption media as a potential treatment alternative in reducing the volume, toxicity, or mobility of selected metals and radionuclides from Rocky Flats surface water and groundwater. The individual adsorbents will first be tested in small columns to determine their capabilities for reducing the concentrations of beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium in the composite raw waters at Rocky Flats. Media that show sufficient capabilities will be further tested in columns to determine their capacities and breakthrough times, as well as the adsorbents' regeneration abilities.

The effectiveness of the adsorbents in removing the contaminants of concern will be evaluated in bench-scale column tests. The specific objectives of bench-scale treatability testing are as follows:

- Conduct bench-scale tests to determine the capability of each of the selected adsorbents to remove the contaminants of concern.
- Conduct bench-scale column tests to determine the capacities, breakthrough characteristics, and quantities and characteristics of regenerant wastes expected for each of the adsorbents.

19.2 SCREENING AND SELECTION OF ADSORBENTS

This section contains descriptions of the adsorbents that were considered for use during treatability testing. The process to select adsorbents for initial screenings was based on the requirements listed in Attachment No. 2 of EG&G's Statement of Work and past experience. The following screening criteria were used:

- Capable of removing one or more of the contaminants of concern present in the Rocky Flats water
- Able to be tested in bench-scale columns
- Commercially available for testing at the Rocky Flats facility

Descriptions of all of the adsorbents selected for testing are presented in subsection 19.2.1. Descriptions of the adsorbents screened, but not selected for testing, along with the reason(s) they were not selected, are presented in subsection 19.2.2. It was assumed during the screening and selection process that only one adsorbent from each class of adsorbents would be tested if there were no data suggesting that any significant performance difference would be expected. For example, there are a number of natural zeolites commercially available from different sources that are similar in physical characteristics and functionality. For these cases, an educated choice was made based on available literature and past experience.

19.2.1 Adsorbents to be Tested

In addition to the general resin screening criteria discussed earlier, other considerations include:

- The ability to meet the total dissolved solids (TDS) anticipated effluent limit of 500 mg/L

- The impact of the raw water TDS concentration on removal efficiencies of the contaminants of concern
- Minimization of generated secondary wastes
- The ability to remove colloidal materials (some radionuclides adsorb preferentially to colloids)
- Minimization of water required for testing

The adsorbents that were screened for inclusion in this TSWP can be broadly classified into four groups:

- Biosorbents
- Carbon-based adsorbents
- Silica-based adsorbents
- Metal-based adsorbents

In general, the biological or physicochemical process by which adsorption occurs is similar for adsorbents within each group. However, the selectivities for specific constituents will vary among adsorbents within a group depending on the physical, chemical, and biological characteristics of the adsorbent.

The remainder of this section contains detailed descriptions of the typical uses and performance characteristics of the adsorbents chosen for testing as part of this TSWP. Unless otherwise noted, the information presented in this section was taken from the manufacturer's product bulletins and data sheets and not specifically referenced in Section 27.0. However, where published literature data were used to support the performance claims of the manufacturers, specific references to the literature are included in the text and referenced in Section 27.0. The addresses and telephone numbers of each of the adsorbent manufacturers and distributors are given below.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 19
Revision: 1
Page: 4 of 42

Non-Safety Related

Final Draft

Effective Date: _____
Organization: ERT

Adsorbents Manufacturers List

Mr. Dennis Green, BIO-FIX Bead Distributor
Harrison Western Environmental Services, Inc.
1208 Quail Street
Lakewood, CO 80215
(303) 234-0273

Mr. Tim Barder, Ionsiv Representative
UOP
25 East Algonquin Road
Des Plaines, IL 60017
(708) 391-2000

Dr. Godfrey Crane, AlgaSORB Representative
Bio-Recovery Systems, Inc.
2001 Copper Avenue
Las Cruces, NM 88005
(800) 697-2001

Mr. Kevin Hengst
Technical Sales Representative
Calgon Carbon Corporation
4343 Commerce Court, Suite 400
Lisle, IL 60532
(708) 505-1919

Mr. Frank J. Caliguin, Ferrosand Representative
Hungerford and Terry, Inc.
P.O. Box 650
Clayton, NJ 08312-0650

Mr. Louis C. Fancher III
Sales Representative, SORBPLUS
ALCOA
100 Westlakes Drive, Suite 250
Berwyn, PA 19312
(215) 889-3736

Mr. E. Lee Johnson, Chilosan Representative
Vanson
8840 152nd Avenue Northeast
Redmond, WA 98052-3535
(206) 881-6464

ALCOA Industrial Chemicals Division (F-1
Alumina)
P.O. Box 2128
Vidalia, LA 71373
(800) 533-4511

East-West Minerals, Inc. (Clinoptilolite)
100 Shoreline Highway, Suite 175A
Mill Valley, CA 94941
(415) 331-8880

19.2.1.1 Biosorbents

The mechanisms associated with metal and radionuclide adsorption by biological materials are complex and involve both intracellular and extracellular binding (Jeffers *et al.*, 1991). The difficulty with growing and maintaining a healthy, living population of microorganisms in many treatment applications has led to the development of technologies wherein non-living microorganisms are immobilized in a rigid, porous matrix that is amenable for use in flow-through columns. In fact, the literature reports that many microorganisms sorb metals more effectively in a non-living state (Jeffers *et al.*, 1991).

Three types of biosorbents that have proven effective in removing metals or radionuclides in a non-living, immobilized state include BIO-FIX beads (immobilized sphagnum peat moss), AlgaSORB® (primarily algae), and *Pseudomonas aeruginosa*. A fourth biosorbent considered—Chitosan—is different in that the base material used is chitin, a material obtained from the structural material of shellfish. Each of these sorbents can adsorb selected heavy metals and radionuclides but are ineffective at removing the common cations such as sodium and calcium. Therefore, other processes would have to be considered for the removal of TDS.

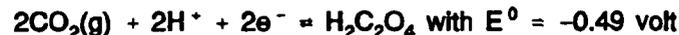
19.2.1.1.1 BIO-FIX. BIO-FIX beads are a porous adsorbent containing immobilized biological materials such as algae, biological polymers, and moss. The technology was recently developed by the U.S. Bureau of Mines and has been licensed for commercial distribution. The BIO-FIX beads are particularly selective for heavy metals, displacing the more common alkaline earth metals such as calcium and magnesium (Jeffers *et al.*, 1991). No data were available on the effectiveness of BIO-FIX to remove radionuclides although the affinity of the sorbent for higher valence cations suggests that its potential effectiveness for the radionuclides of concern at Rocky Flats is good.

BIO-FIX beads have an approximate operating adsorptive capacity of 10,000 mg CaCO₃/L beads containing immobilized sphagnum peat moss as the biological sorbent. The beads can be regenerated using a 1 percent solution of sulfuric acid and subsequently neutralized using 1 percent sodium carbonate. In laboratory tests, no decrease in sorption or elution efficiencies were measured after 100 cycles and no physical deterioration of the beads was observed (Ferguson and Jeffers, 1991). The beads also

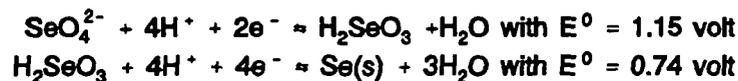
exhibited no deterioration in performance or physical characteristics following repeated freeze-thaw and wet-dry cycles. The recommended pH range for metal sorption was 3 to 8, although significant mercury and anion removals were observed in one test at a pH > 13 (Ferguson and Jeffers, 1991). The recommended loading rate ranges from 20 to 30 bed volumes per hour.

19.2.1.2 Carbon-Based Adsorbents

The process by which metals and radionuclides are removed by carbon-based adsorbents is not precisely known. It is theorized that the principal removal mechanism is via an oxidation-reduction reaction rather than by chemisorption or by physical adsorption. For example, researchers at the Calgon Carbon Corporation have proposed that the following oxidation reaction takes place at the carbon surface:



Subsequently, ions whose reduction reaction potential lies above -0.49 volts by more than 0.2 to 0.3 volt can be reduced to a form that in some cases is insoluble and can be removed from the system by filtration within the carbon bed or in a downstream filter unit. For example, the following two reactions show how selenium is reduced to an insoluble form:



Target analyte metals (TAL) metals for which fair to good removal efficiencies may be expected include mercury, selenium, lead, and chromium at neutral to alkaline pHs. No literature information on the removal of the target radionuclides at Rocky Flats by carbon-based adsorbents has been found.

Two types of carbon-based adsorbents that have been considered for inclusion in this TSWP include granular activated carbon (GAC) and bone charcoal. GAC and bone charcoal are also effective in

removing common cations. Bone charcoal contains calcium phosphate, which may remove selected substances, such as fluoride, via an oxidation-reduction reaction similar to that described for carbon. Additional details regarding the two adsorbents are presented in the subsections below.

19.2.1.2.1 Filtrasorb 300. Filtrasorb 300 is a grade of granular activated carbon manufactured by Calgon that is commonly used to remove organic pollutants from water. Activated carbon also has the capability to remove trace amounts of heavy metals from water. Although the exact removal mechanism is not known, it is believed that activated carbon removes metals via an oxidation-reduction reaction rather than by chemisorption or physical adsorption. Past experience indicates that manganese, mercury, selenium, and, to a lesser extent, hexavalent chromium and lead can be efficiently removed by activated carbon. No data were available on the effectiveness of activated carbon to remove radionuclides.

The adsorption capacity of Filtrasorb 300 is dependent on a number of factors, including the target metal, pH, and chemical interferences (e.g., from cyanide or ammonia). Batch tests have indicated that metals removal capacities typically lie in the range of 5 to 50 micromoles (μmol) M^{2+}/g carbon (500 to 5,000 mg CaCO_3/L resin). Recommended loading rates are from 1 to 3 gpm/ ft^2 with empty bed contact times of 15 to 30 minutes. Metals removal efficiencies are dependent on pH; generally, acidic pHs (i.e., 3 to 5) are optimum for many heavy metals (Bhattacharyya and Cheng, 1987; Ku and Peters, 1987).

19.2.1.2.2 Brimac 216 (Bone Charcoal). Brimac 216 is a grade of bone charcoal (a.k.a. bone char) that contains both carbon and calcium phosphate, and is available from the Tate and Lyle Process Technology, located in Green Ox, Scotland. Its use in the United States has been limited to a few specialized applications; in contrast, it has been used frequently in Europe as an adsorbent for organic compounds, and for taste and odor removal from potable water supplies. Some studies conducted in Europe have shown that bone charcoal also has the capacity to remove various metals from aqueous streams, including the Rocky Flats TAL metals chromium, iron, lead, manganese, and mercury (Smith, C., 1993). Of these metals, the literature data suggest that Brimac 216 may be effective in consistently producing an effluent that meets the potential ARAs for iron and lead. One study showed that bone

charcoal had "far greater" adsorption capacity for lead and cadmium than did activated carbon. No data were available on the effectiveness of bone charcoal to remove radionuclides.

The adsorption capacity of Brimac 216 is dependent upon a number of factors including the target metal, pH, and matrix constituent concentrations. Column tests have indicated that operating capacities for lead lie in the range of 1,000 to 6,000 mg/L as CaCO₃ at a loading rate of 0.5 gpm/ft², and an empty bed contact time of 0.5 to 1.0 minute (Smith, C., 1993). Removal efficiencies as a function of pH vary with lead removals exhibiting little or no dependence on pH, while cadmium is removed more efficiently at high pHs.

There are currently no data to show that bone charcoal may be capable of producing an effluent that meets the potential ARARs for select Rocky Flats TAL metals, however, it may be effective for the following reasons:

- It is similar in physical characteristics, functionality, and operating capacity for metals to activated carbon, which is one of the adsorbents to be tested
- The operating capacities of other adsorbents to be tested that are selective for cations are equal or significantly greater than that of bone charcoal

19.2.1.3 Silica-Based Adsorbents

Silica-based adsorbents include clay minerals and zeolites. The physical structure of these adsorbents results in their possessing negative charge sites to which cations are drawn by electrostatic attraction. The selectivity of silica-based adsorbents is a function of many factors including ion charge, ion type, ion concentration, solute composition, temperature, and others (Breck, 1974). Furthermore, ions of higher selectivity can displace ions of lower selectivity, a property that is more typical of ion exchangers rather than adsorbents. The silica-based adsorbents are being considered as adsorbents rather than as ion exchangers for the purpose of this TSWP.

The two types of silica-based adsorbents being considered for this TSWP include natural clay soils and natural zeolites. Synthetic zeolites were eliminated during the screening process based on the recommendation¹ of a sales representative from UOP (a natural and synthetic zeolite supplier; Mahuta 1992). Because of their ion exchange properties, silica-based adsorbents have the potential for removing a substantial portion of the TDS present in solution.

19.2.1.3.1 Clinoptilolite. Clinoptilolite is a natural zeolite that possesses both adsorptive and ion exchange properties. It is commonly used to remove cations from water and water, including the target constituents iron, lead, mercury, and chromium. The selectivity of clinoptilolite is a function of the hydrated molecular size of the cation, the relative concentration of the cations in solution, and the average pore diameter of the material. The second factor suggests that the overall removal efficiency for various constituents may be limited by the concentrations of the alkali and alkaline earth metals present in the water. Clinoptilolite has also been shown to remove selected radionuclides from water (e.g., Sr-90 and Cs-137) (Breck, 1974). No data were available on the effectiveness of clinoptilolite to remove the target radionuclides from the Rocky Flats water.

Clinoptilolite has an approximate operating exchange capacity of 60,000 mg CaCO₃/L zeolite. It can be regenerated using a concentrated (20 percent) brine solution. The recommended loading rate for natural zeolites ranges from 5 to 15 minutes of empty bed contact time. A pH range of 7 to 9 was found to yield good Sr-90 and Cs-137 removals in one study (Breck, 1974).

19.2.1.4 Metal-Based Adsorbents

The process by which metal-based adsorbents remove metals and radionuclides depends on the adsorbent. Adsorbents considered during the screening process included activated alumina, a mixed-metal oxide adsorbent (SORBPLUS) highly selective for selenium, and ferrosand (a manganese greensand). The adsorption chemistry of aluminas (oxides and hydroxides of aluminum) and mixed-metal oxides is highly complex; however, adsorption can be generally characterized by three mechanisms (Fleming

¹The UOP representative did not believe that the zeolites were effective in reducing contaminant concentrations to achieve ARARs levels.

1986): (1) chemisorption via covalent attachment to the sorbent structure; (2) electrostatic attraction arising from surface protonation; and (3) ion exchange reactions. Typically, aluminas and SORBPLUS are used for anion removals. Although SORBPLUS cannot be regenerated, its relatively high selectivity for selenium often makes it a more cost-effective adsorbent to use versus activated alumina in applications where selenium removals are of concern. Ferrosand uses manganese oxide coated sand to catalyze an oxidation-reduction reaction, oxidizing soluble iron and manganese ions to highly insoluble forms that can be removed by filtration in the ferrosand.

No literature data was found to document the removal effectiveness of the target radionuclides at Rocky Flats by any of these metal-based adsorbents. Furthermore, it is unlikely that any significant quantities of TDS will be removed, requiring other processes for TDS removal.

19.2.1.4.1 SORBPLUS. SORBPLUS is a mixed-metal oxide adsorbent (principally thermally activated alumina and magnesium oxide) manufactured by Alcoa. It is an anion adsorbent that differs from activated alumina in that (1) it cannot be commercially regenerated, and (2) it has a significantly higher adsorption capacity than does activated alumina. SORBPLUS has a much higher selectivity for polyvalent anions than for monovalent anions and has been shown to be highly effective at removing "problem" anions from waters, including selenium (IV), arsenic, chromium (VI), and complexed cyanides. SORBPLUS is available in both powder and granular form; the granular form is typically used in column applications and is useful for this TSWP.

SORBPLUS has an operating capacity of approximately 3.5 meq/g sorbent (70,000 mg CaCO₃/L sorbent). However, competition from common divalent anions (such as carbonates and sulfates) can significantly lower the adsorption capacity of SORBPLUS for the Rocky Flats target anions. Carbonates can typically be removed by adjusting pH; sulfates can be removed by precipitation as the relatively insoluble barium sulfate. Recommended empty bed contact times range from 5 to 10 minutes.

19.2.1.4.2 F-1 Alumina. F-1 Alumina is a granular activated alumina manufactured by ALCOA. Activated alumina is commonly used to remove various anions (such as fluoride, arsenic, and selenium) from water and wastewater at pH levels in the neutral to acidic range, although removal of cations can

also be affected by aluminas in the neutral to alkaline pH range. Cation and anion exchange series for some ions on transition aluminas are shown below (Fleming, 1986):

Cations: U(IV) > Fe(III) > Hg(II) > UO₂(II) > Pb(II) > Fe(II) > Mn(II)

Anions: OH⁻ > CrO₄²⁻ > SO₄²⁻ > Cr₂O₇²⁻ > NO₂⁻ > Cl⁻ > NO₃⁻ > MnO₄⁻

F-1 Alumina has an operating capacity of approximately 4,500 mg/L as CaCO₃, based on operating data for fluoride removal from three water treatment plants (Rubel and Woosley, 1978). The actual operating capacity for F-1 Alumina treating Rocky Flats composite raw water will likely be different for a number of reasons, such as different water chemistry and different constituents targeted for removal. The uncertainty regarding the operating capacity has been taken into account in the experiment design.

F-1 Alumina's recommended loading rate is approximately 1.5 gpm/ft³

19.2.2 Adsorbents Not Selected for Testing

A number of other adsorbents were evaluated but not chosen for use in this treatability study. A brief description of each of these adsorbents along with the reason(s) for their exclusion follow.

19.2.2.1 Ionsiv IE-96

Ionsiv IE-96 is a natural zeolite (chabazite) supplied by UOP (formerly supplied by Union Carbide). This material was successfully tested at Oak Ridge National Laboratory for removing Sr-90 and Cs-137 from a water (Robinson, et al., no date). Its physical properties and performance characteristics are very similar to clinoptilolite, so additional tests with chabazite were not expected to yield any significant additional data beyond what will be collected during the tests with clinoptilolite.

19.2.2.2 Chitosan

Chitosan is an adsorbent that uses glucosamine as a metals-chelating agent. The raw material for chitosan comes from the structural material of shrimp and crabs (chitin). It is highly selective for heavy metals over alkaline earth metals. Typical operating capacities for Period 4 and 5 heavy metals (e.g., Ni, Cd) range from 100 to 150 mg/g with capacities increasing to greater than 1,000 mg/g for some Period 6 elements (e.g., Au). However, chitosan is more typically used as a fine powder and added to a stirred reactor where the metals chelation takes place in liquid suspension. When used in columns, the chitosan tends to blind rapidly, requiring more frequent backwashings to clean the media. Therefore, its use in column testing is not recommended at this time.

19.2.2.3 AlgaSORB®

AlgaSORB® is an adsorbent manufactured by Bio-Recovery Systems that contains biological materials, primarily algae, immobilized in a polymer. It has a high affinity for heavy metals that can be stripped and disposed of or recovered as needed. The AlgaSORB® media is not available for outside testing; the manufacturer requires that water samples be shipped to their Las Cruces, New Mexico laboratories for testing in-house. Because of this restriction and because the physical characteristics and performance of the medium are similar to the BIO-FIX beads already being tested, further testing of AlgaSORB® did not appear warranted.

19.2.2.4 Ferrosand

Ferrosand is the trade name for a manganese greensand supplied by Hungerford and Terry. It is primarily used to remove soluble metal cations from a waste stream that are susceptible to oxidation and precipitation by the permanganate-treated greensand. Iron and manganese are the two target constituents in the Rocky Flats composite raw water amenable to removal by Ferrosand. However, Ferrosand will foul rapidly because of the buildup of ferric hydroxide precipitate if the influent iron concentration appreciably exceeds 5 mg/L. This would likely necessitate the use of a pretreatment process to remove iron upstream of a Ferrosand unit treating Rocky Flats water. Also, the manufacturer recommends that

the Ferrosand unit be operated in a continuous regeneration mode when removal of iron as well as manganese is required. In this mode, potassium permanganate is continuously added to the feed stream in an amount proportional to the concentrations of iron and manganese present. The requirements for pretreatment and chemical addition to effectively test the performance of Ferrosand at Rocky Flats eliminates it from further consideration at this time.

19.2.2.5 *Pseudomonas Aeruginosa*

Pseudomonas aeruginosa is a bacterium possessing physicochemical and biological characteristics that enable it to remove appreciable quantities of uranium from aqueous solutions. In a study conducted by Oak Ridge National Laboratory, a number of different biosorbents were evaluated for their effectiveness in removing uranium (Connelly, et al., no date) including yeasts, fungi, and bacteria. The microorganisms were immobilized within a polymeric matrix that could be used in flow-through columns. Of the organisms tested, *pseudomonas aeruginosa* exhibited the best uranium removal efficiencies, varying from 82.7 percent at a feed concentration of 10 mg U/L to 39.3 percent at feed concentrations of 200 mg/L.

However, this biosorbent is not available commercially as tested. Therefore, it was not considered for inclusion in this TSWP.

19.2.2.6 Clay Soils

Clay soils are colloidal and possess a net negative charge at neutral to alkaline pHs. This enables clays to adsorb cations from aqueous solutions. Typical cation exchange capacities for natural clay and soils can be as high as 600 mmol/kg soil (Bohn, et al., 1985). In general, the smaller the ionic radius and the greater the valence, the more clearly and strongly the ion is adsorbed (Hillel, 1980). Furthermore, it was found that PuO_4^{4+} was held very tightly by a clayey soil in the southwestern U.S. (Smith, 1993), suggesting that the attractive force from the high valence of the PuO_4^{4+} molecule was more significant than was the effect of the molecule's larger ionic radius. Note that this data on plutonium

adsorption was gathered during a remedial action effort to clean up contaminated soils. The soils were not used as an adsorptive medium to retain cations.

The major drawback with the use of natural clay soils in a column adsorption test is their very low hydraulic conductivity. The conductivity of typical clay soils is approximately 10^{-6} cm/sec (Hillel, 1980), which corresponds to a hydraulic loading rate of 10^{-5} gpm/ft², five orders of magnitude lower than natural zeolites and other adsorption media. Furthermore, the two-dimensional structure of clay minerals undergo significant swelling and shrinking that can pose practical problems with their use in columns (for example, cracking can cause a short-circuiting flow). For these reasons, clays will not be tested as part of this TSWP.

19.3 KEY ASSUMPTIONS

Several assumptions were made in specifying the test conditions under which the adsorption treatability study will be performed:

- The constituents that are expected to be removed by each of the adsorbents being tested are presented in Figure 19-1. Evaluation of potential effectiveness was based on manufacturers' literature data and similarities between ionic species.
- The raw water to be tested will be a composite of water samples collected from several locations. Table 19-1 presents the water characteristics at the three sampling locations proposed for use in testing—09091-GW, B206789-GW, and GS10-SW—and the calculated composite concentrations based on the volume ratios indicated. Historical records were used to estimate the parameter concentrations at each location where available. In the case of the carbon dioxide system, the concentrations of the different inorganic carbon species were estimated based on the measured bicarbonate concentrations and equilibrium considerations assuming that the total inorganic carbon content remains constant. Where measured concentrations of significant ions were missing (e.g.,

FIGURE 19-1

REMOVAL EFFECTIVENESS OF THE ADSORBENTS TO BE TESTED FOR THE CONSTITUENTS OF CONCERN

Adsorbents	Type	Heavy Metals						Radionuclides			
		Be	Cr	Fe	Pb	Mn	Hg	Se	Am	Pu	U
Filtrisorb 300	Granular activated carbon	NI	○	○	■	○	●	●	NI	NI	NI
SORBPLUS	Mixed-metal oxide adsorbent	○	NI	○	○	○	○	●	○	○	NI
Clinoptilolite	Natural zeolite	NI	○	●	●	■	●	○	NI	NI	○
BIO-FIX	Immobilized biological adsorbent	NI	NI	●	●	●	●	○	NI	NI	■
F-1 Alumina	Granular activated alumina	NI	●	●	●	■	●	●	NI	NI	●
Brimac 216	Bone charcoal	NI	○	●	●	●	●	○	NI	NI	NI

Notes: ● = Target constituent.
 ■ = Potentially effective.
 ○ = Not effective.
 NI = No information available to evaluate potential effectiveness.

The anticipated removal effectiveness of these adsorbents is based on the assumed adsorbent species in Table 19-2.

Non-Safety Related

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Table 19-1

ROCKY FLATS COMPOSITE SAMPLE GENERATION					
Parameter	Unit	Constituent Concentrations at Location*:			Composite Concentrations
		09091-GW	B206789-GW	GS10-SW	
Cations					
Americium	pCi/L	47.0	0.0	0.0	18.8
Beryllium	ug/L	0.0	0.0	0.0	0.0
Calcium	ug/L	110,000.0	165,000.0	37,300.0	104,690.0
Iron	ug/L	14.0	23.0	35,500.0	10,662.5
Lead	ug/L	0.0	0.0	0.0	0.0
Magnesium	ug/L	10,100.0	42,500.0	7,840.0	19,142.0
Manganese	ug/L	0.0	0.0	946.0	283.8
Mercury**	ug/L	0.1	0.1	0.1	0.1
Plutonium	pCi/L	355.0	0.0	0.0	142.0
Potassium	ug/L	1,860.0	3,600.0	3,150.0	2,769.0
Sodium	ug/L	7,960.0	150,000.0	15,100.0	52,714.0
Anions					
Bicarbonate	ug/L	293,000.0	165,000.0	230,000.0	235,700.0
Carbonate	ug/L	0.0	0.0	0.0	0.0
Chloride	ug/L	45,000.0	89,200.0	100,000.0	74,760.0
Chromium	ug/L	0.0	8.0	34.5	12.8
Nitrate/Nitrite	ug/L	7,500.0	8,300.0	9,000.0	8,190.0
Selenium	ug/L	0.0	680.0	0.0	204.0
Silicon	ug/L	7,860.0	5,470.0	21,400.0	11,205.0
Sulfate	ug/L	100,000.0	100,000.0	100,000.0	100,000.0
Uranium	pCi/L	1.0	0.0	0.0	0.4
Miscellaneous					
TSS	ug/L	9,700,000.0	42,000.0	100,000.0	3,922,600.0
TDS (meas.)	ug/L	270,000.0	1,140,000.0	560,000.0	618,000.0
TDS (calc.)	ug/L	583,000.0	730,000.0	560,000.0	620,000.0
Ctotal	umol/L	6,000	3,300	4,100	4,600.0
pH	-	7.0	7.0	7.5	
Carbon Dioxide System					
[CO ₂]aq	umol/L	1,200	600	300	
[HCO ₃ ⁻]	umol/L	4,800	2,700	3,800	
[CO ₃ ⁼]	umol/L	0	0	0	
Volume Ratio		0.4	0.3	0.3	

*Note: Figures in italics are assumed values

**No mercury detected in any of the samples

Equilibrium Constants (at 20 deg. C)	
pK1	6.381 mol/L
pK2	10.377 mol/L

Molecular Weights (g/mol)	
CO ₂	44.0
HCO ₃ ⁻	61.0
CO ₃ ⁼	60.0

sulfate), assumed values were used that resulted in an approximate ionic balance in the composite water.

- Table 19-2 presents the raw water chemistry of the composite sample. The pH of the water was varied until the dissolved CO_2 concentration based on the equilibrium between the calculated aqueous inorganic carbon species approximately equaled the dissolved CO_2 concentration based on the equilibrium between atmospheric CO_2 and dissolved CO_2 (equil.).
- The physicochemical forms of the ionic species listed in Tables 19-1 and 19-2 were determined based on the following conventions: (1) cations exist in solution as individual atoms with a charge number equal to each atom's most stable oxidation state;² (2) of the common anions listed, bicarbonate, chloride, hydroxide, and nitrate/nitrite exist as monovalent ions in solution while carbonate and sulfate exist as divalent ions; (3) the assumed ionic forms of chromium (CrO_4^{2-}), selenium (SeO_4^{2-}), and silicon (HSiO_3^-) are common forms when the pH is in the neutral to alkaline range and the redox potential (E_h) is positive (e.g., oxidizing) (Dragun 1988), typical for many ground and surface waters.
- The physicochemical forms of the radionuclides in solution are unknown. Identification of each radionuclide as either a cationic or an anionic species was based on past experience of Rocky Flats staff and scientific judgement. It is known that some radionuclides exist as negatively charged colloids in solution despite the fact that electrochemical considerations suggest the more likely form would be cationic have a positive charge (such as the uranyl ion UO_2^{2+} that predominates at a pH greater than 10, and a positive redox potential [Dragun 1988]). One explanation for this effect is that

²The only exception is iron, which is most stable at an oxidation state of 3. However, Fe^{3+} forms the highly insoluble $\text{Fe}(\text{OH})_3$ under conditions typically found in many ground and most surface waters. Since the samples listed in Figure 19-1 will not be filtered prior to analysis, both the Fe^{2+} and Fe^{3+} oxidation states could be present. However, in commercial applications, filtering is a common practice to prevent the fouling of adsorbents, and therefore, the Fe^{2+} state is the one most likely to be present.

Table 19-2

ROCKY FLATS RAW COMPOSITE WATER CHEMISTRY					
Parameter	Molecular Weight	Equiv. per Mole	Concentration		
			Mass Basis (ug/L)*	Molar Basis (umol/L)	As CaCO3 (ug/L)
Cations					
Americium*	243.0	Unknown	18.8	Not defined	
Beryllium	9.0	2	0.0	0.0	0
Calcium	40.1	2	104,690.0	2,610.7	261,072
Hydrogen	1.0	1	0.0	0.0	0
Iron	55.8	2	10,662.5	191.1	19,108
Lead	207.2	2	0.0	0.0	0
Magnesium	24.3	2	19,142.0	787.7	78,774
Manganese	54.9	2	283.8	5.2	517
Mercury	200.6	2	0.1	0.0	0
Plutonium*	244.0	Unknown	142.0	Not defined	
Potassium	39.1	1	2,769.0	70.8	3,541
Sodium	23.0	1	52,714.0	2,291.9	114,596
Total Heavy Metals**					19,600
Total Cations			190,000	5,960	478,000
Anions					
Bicarbonate	60.0	1	264,272.0	4,404.5	220,226
Carbonate	61.0	2	11,278.0	184.9	18,488
Chloride	35.5	1	74,760.0	2,105.9	105,296
Chromium (as CrO4)	52.0	6	12.8	0.3	75
Hydroxide	17.0	1	117.0	6.9	345
Nitrate/Nitrite***	62.0	1	8,190.0	132.1	6,605
Selenium (as SeO4)	79.0	2	204.0	2.6	258
Silicon (as HSiO3)	28.1	1	11,205.0	398.8	19,938
Sulfate	96.1	2	100,000.0	1,040.6	104,058
Uranium*	238.0	Unknown	0.4	Not defined	
Total Anions			470,000	8,280	475,000

*Concentrations (mass basis) of radionuclides in units of pCi/L; ionic species unknown

**Excludes chromium

***Concentrations (mass basis) calculated on nitrate basis

Miscellaneous Parameters	
pH	9.0
Ctotal	4,600 umol C/L (fixed)
Dissolved CO2	10.6 umol C/L (calc.)
Dissolved CO2	12.3 umol C/L (equil.)
TSS	3,923 mg/L
TDS	620 mg/L
Alkalinity	239 mg/L as CaCO3
Hardness	359 mg/L as CaCO3

Equilibrium Constants (at 20 deg. C)	
Water:	
pKw	14.161 (mol/L) ²
CO2 System:	
pPCO2	3.5 atm
pKH	1.41 mol/L/atm
pK1	6.381 mol/L
pK2	10.377 mol/L

particulates found in natural waters—typically negatively charged at neutral to alkaline pHs—attract and hold the uranyl ions through electrostatic attraction. Since these particulates (such as clays and organic materials) can become positively charged at acidic pHs, removal of uranium and other colloiddally bound radionuclides (exhibiting good removal on anionic resins at higher pHs) may be efficiently removed on cationic resins at acidic pHs. This possibility will be evaluated in this TSWP.

- Tables 19-3 and 19-4 present the test conditions for the initial screening tests (capability tests) and the capacity tests for the adsorbents. The listed loading rates, adsorbent capacities, regeneration and rinse requirements are based on manufacturer recommendations. Note that the adsorbent capacities used are approximate and will depend on column operating conditions the characteristics of the composite raw water being tested.
- The tests were designed to minimize water usage. For the capability tests, the column diameter of 1.25 inches and bed depth of 18 inches specified are typical for column tests of adsorbents. For the capacity tests, the column diameters and bed depths were reduced as needed to reduce the volume of water required per test to less than 10 liters. Although these smaller column tests will still provide the necessary data with which to estimate adsorbent capacities and regenerant characteristics, larger column tests are required to accurately design and predict the performance of a full-scale system.
- Although sulfuric acid is typically used to regenerate some adsorbents in full-scale systems (e.g., typically more cost-effective), hydrochloric acid will be used in these bench-scale tests where acid concentrations greater than 1 percent are required to avoid problems with the precipitation of calcium sulfate. Note that the use of HCl will often result in slightly higher operating capacities than are achievable with sulfuric acid.

Non-Safety Related

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Table 19-3

CAPABILITY TESTS FOR ADSORBENTS										
Adsorbent			Water Loading							
Name	Sorbent	Form*	Flow Rate			Volume to Waste	Volume to Test	Total Volume	Total Test Time	
			(mL/min)	(gpm/ft ³)	(BV/min)	(BV)	(mL)	(mL)	(mL)	(min)
BIO-FIX	Biological	H+	230	1.9	0.25	3	2,800	4,000	6,800	30
Clinoptilolite	Natl. Zeolite	Na+	140	1.1	0.15	3	2,800	4,000	6,800	49
F-1	Act. Alumin	OH-	190	1.5	0.20	3	2,800	4,000	6,800	36
Filtrisorb 300	Act. Carbon	N/A	140	1.1	0.15	3	2,800	4,000	6,800	49
Brimac 216	Bone Char	N/A	230	1.9	0.25	3	2,800	4,000	6,800	30
SORBPLUS	Mixed-metal	N/A	93	0.75	0.10	3	2,800	4,000	6,800	73

*N/A = Not Applicable

Adsorbent			Predicted Breakthrough of Critical Component				
Name	Sorbent	Form*	Critical Component	Concen- tration* (mg/L as CaCO ₃)	Sorbent Capacity**	Breakthrough Volume (L)***	Breakthrough Time (minutes)***
BIO-FIX	Biological	H+	Hardness, Metals	379	4,000	10	43
Clinoptilolite	Natl. Zeolite	Na+	Hardness, Metals	379	8,000	20	140
F-1	Act. Alumin	OH-	Anions	475	4,500	9	47
Filtrisorb 300	Act. Carbon	N/A	Metals	20	2,500	120	860
Brimac 216	Bone Char	N/A	Metals	20	3,500	170	740
SORBPLUS	Mixed-metal	N/A	Anions	475	70,000	140	1,510

*N/A = Not Applicable

*Component concentrations from Table 19-2

**Operating capacity (est.)

***Breakthrough volumes and times must be less than the respective total volumes and test times for the wastewater loading tests.

Non-Safety Related

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Table 19-3

(Continued)

CAPABILITY TESTS FOR ADSORBENTS											
Adsorbent			Regeneration								
Name	Sorbent	Form*	Material	Sorbent		Flow Rate			Volume Req'd.*		Time Req'd. (min)
				Molarity (mmol/mL)	Capacity* (meq/mL)	(mL/min)	(gpm/ft ³)	(BV/min)	(BV)	(mL)	
BIO-FIX	Biological	H+	HCl	0.10	5.25	74	0.60	0.08	3	2,800	38
Clinoptilolite	Natl. Zeolite	Na+	NaCl	5.0	1.85	62	0.50	0.07	10	9,300	150
F-1	Act. Alumin	OH-	NaOH	1.0	3.3	250	2	0.27	3	2,800	11
Filtrisorb 300	Act. Carbon	N/A	Not Applicable								
Brimac 216	Bone Char	N/A	No information on regeneration procedure available at this time								
SORBPLUS	Mixed-metal	N/A	Not Applicable								

*N/A = Not Applicable

*Theoretical capacity

**Required bed volumes based on literature data referenced in Section 19.2.1

CAPABILITY TESTS FOR ADSORBENTS											
Adsorbent			Neutralization								
Name	Sorbent	Form*	Material	Sorbent		Flow Rate			Volume Req'd.*		Time Req'd. (min)
				Molarity (mmol/mL)	Capacity* (meq/mL)	(mL/min)	(gpm/ft ³)	(BV/min)	(BV)	(mL)	
BIO-FIX	Biological	H+	NaOH	0.25	5.25	74	0.60	0.08	2	1,850	25
Clinoptilolite	Natl. Zeolite	Na+	Not Required								
F-1	Act. Alumin	OH-	HCl	1.0	3.3	190	1.50	0.20	5.8	5,400	28
Filtrisorb 300	Act. Carbon	N/A	Not Applicable								
Brimac 216	Bone Char	N/A	No information on neutralization procedure available at this time								
SORBPLUS	Mixed-metal	N/A	Not Applicable								

*N/A = Not Applicable

*Theoretical capacity; used to calculate volume of regenerant required for F-1 alumina

**Required bed volume for BIO-FIX beads based on literature data referenced in Section 19.2.1; required bed volume for F-1 alumina based on theoretical capacity and excess required from the last page of this table.

Non-Safety Related

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Table 19-3

(Continued)

CAPABILITY TESTS FOR ADSORBENTS								
Adsorbent			Final Rinse (DI Water)					
			Flow Rate			Volume Required		Time Reqd. (min)
Name	Sorbent	Form*	(mL/min)	(gpm/ft ³)	BV/min	(BV)	(mL)	
BIO-FIX	Biological	H+	230	1.9	0.25	3	2780	12
Clinoptilolite	Natl. Zeolite	Na+	140	1.1	0.15	10	9300	66
F-1	Act. Alumin	OH-	190	1.5	0.20	10	9300	49
Filtrisorb 300	Act. Carbon	N/A	Not Required					
Brimac 216	Bone Char	N/A	Not Required					
SORBPLUS	Mixed-metal	N/A	Not Required					

*N/A = Not Applicable

Adsorbent			Backwash (DI Water)*	
Name	Sorbent	Form*	Flow Rate*	
			(mL/min)	(gpm/ft ²)
BIO-FIX	Biological	H+	410	5.0
Clinoptilolite	Natl. Zeolite	Na+	410	5.0
F-1	Act. Alumin	OH-	660	8.0
Filtrisorb 300	Act. Carbon	N/A	410	5.0
Brimac 216	Bone Char	N/A	410	5.0
SORBPLUS	Mixed-metal	N/A	1200	15.0

*N/A = Not Applicable

*Typical for 50 percent bed expansion

**Figures in italics are estimated

Table 19-3

(Concluded)

CAPABILITY TESTS FOR ADSORBENTS			
Constants		Bed Data	
Pi	3.1416	Diameter	2.00 inches
ft ³ to mL	28,320 mL/ft ³	Depth	18 inches
gal to mL	3,785 mL/gal	Volume	927 mL
in ³ to mL	16.39 mL/in ³		
lb to mg	453,590 mg/lb		
ft to in	12 in/ft		

Sample Quantities	
Volume	2,000 mL
Number	2 per test

Excess Regenerant/Neutralization Requirements*	
Sorbents	175% excess for sorbents (typical)

*Based on theoretical adsorbent capacities; used to calculate volume of F-1 neutralization solution required.

Non-Safety Related

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Table 19-4

CAPACITY TESTS FOR ADSORBENTS										
Adsorbent			Water Loading							
Name	Sorbent	Form*	Flow Rate			Volume to Waste (BV)	Volume to Test (mL)	Total Volume (mL)	Total Test Time (min)	
			(mL/min)	(gpm/ft ³)	(BV/min)					
BIO-FIX	Biological	H+	230	1.9	0.25	3	2,800	16,000	18,800	82
Clinoptilolite	Natl. Zeolite	Na+	70	1.1	0.15	3	1,400	16,000	17,400	250
F-1	Act. Alumin	OH-	210	1.5	0.20	3	3,100	16,000	19,100	91
Filtrisorb 300	Act. Carbon	N/A	10	0.9	0.15	3	240	16,000	16,240	1,600
Brimac 216	Bone Char	N/A	20	2.1	0.25	3	220	16,000	16,220	810
SORBPLUS	Mixed-metal	N/A	10	1.03	0.10	3	220	16,000	16,220	1,600

*N/A = Not Applicable

Adsorbent			Predicted Breakthrough of Critical Component				
Name	Sorbent	Form*	Critical Component	Concen- tration* (mg/L as CaCO ₃)	Sorbent Capacity**	Breakthrough Volume (L)	Breakthrough Time (minutes)
Clinoptilolite	Natl. Zeolite	Na+	Hardness, Metals	379	8,000	10	140
F-1	Act. Alumin	OH-	Anions	475	4,500	10	48
Filtrisorb 300	Act. Carbon	N/A	Metals	20	2,500	10	1,000
Brimac 216	Bone Char	N/A	Metals	20	3,500	10	500
SORBPLUS	Mixed-metal	N/A	Anions	475	70,000	10	1,000

*N/A = Not Applicable

*Component concentrations from Table 19-2

**Operating capacity (est.)

Table 19-4

(Continued)

CAPACITY TESTS FOR ADSORBENTS											
Adsorbent			Regeneration								
			Material	Sorbent		Flow Rate		Volume Req'd.**		Time Req'd. (min)	
Name	Sorbent	Form*		Molarity (mmol/mL)	Capacity* (meq/mL)	(mL/min)	(gpm/ft ³)	(BV/min)	(BV)		(mL)
BIO-FIX	Biological	H+	HCl	0.10	5.25	74	0.60	0.08	3	2,800	38
Clinoptilolite	Natl. Zeolite	Na+	NaCl	5.0	1.85	31	0.50	0.07	10	4,600	150
F-1	Act. Alumin	OH-	NaOH	1.0	3.3	280	2	0.27	3	3,100	11
Filtrisorb 300	Act. Carbon	N/A	Not Applicable								
Brimac 216	Bone Char	N/A	No information on regeneration procedure available at this time								
SORBPLUS	Mixed-metal	N/A	Not Applicable								

*N/A = Not Applicable

*Theoretical capacity

**Required bed volumes based on literature data referenced in Section 19.2.1

CAPACITY TESTS FOR ADSORBENTS											
Adsorbent			Neutralization								
			Material	Sorbent		Flow Rate		Volume Req'd.**		Time Req'd. (min)	
Name	Sorbent	Form*		Molarity (mmol/mL)	Capacity* (meq/mL)	(mL/min)	(gpm/ft ³)	(BV/min)	(BV)		(mL)
BIO-FIX	Biological	H+	NaOH	0.25	5.25	74	0.60	0.08	2	1,900	26
Clinoptilolite	Natl. Zeolite	Na+	Not Required								
F-1	Act. Alumin	OH-	HCl	1.0	3.3	210	1.50	0.20	5.7	5,900	28
Filtrisorb 300	Act. Carbon	N/A	Not Applicable								
Brimac 216	Bone Char	N/A	No information on neutralization procedure available at this time								
SORBPLUS	Mixed-metal	N/A	Not Applicable								

*N/A = Not Applicable

*Theoretical capacity

**Required bed volume for BIO-FIX beads based on literature data referenced in Section 19.2.1; required bed volume for F-1 alumina based on theoretical capacity and excess required from the last page of this table.

Table 19-4

(Continued)

CAPACITY TESTS FOR ADSORBENTS								
Adsorbent			Final Rinse (DI Water)					
Name	Sorbent	Form*	Flow Rate			Volume Required		Time Req'd. (min)
			(mL/min)	(gpm/ft ³)	BV/min	(BV)	(mL)	
BIO-FIX	Biological	H+	230	1.9	0.25	3	2,800	12
Clinoptilolite	Natl. Zeolite	Na+	70	1.1	0.15	10	4,600	66
F-1	Act. Alumin	OH-	210	1.5	0.20	10	10,000	48
Filtrisorb 300	Act. Carbon	N/A	Not Required					
Brimac 216	Bone Char	N/A	Not Required					
SORBPLUS	Mixed-metal	N/A	Not Required					

*N/A = Not Applicable

Adsorbent			Backwash (DI Water)*	
Name	Sorbent	Form*	Flow Rate*	
			(mL/min)	(gpm/ft ²)
BIO-FIX	Biological	H+	620	5.0
Clinoptilolite	Natl. Zeolite	Na+	310	5.0
F-1	Act. Alumin	OH-	1100	8.0
Filtrisorb 300	Act. Carbon	N/A	50	5.0
Brimac 216	Bone Char	N/A	50	5.0
SORBPLUS	Mixed-metal	N/A	100	15.0

*N/A = Not Applicable

*Typical for 50 percent bed expansion

**Figures in italics are estimated

Table 19-4

(Concluded)

CAPACITY TESTS FOR ADSORBENTS			
Bed Data			Sample Quantities
Adsorbent Type	Column Dia- meter (in.)	Media Depth (in.)	Media Volume (mL)
BIO-FIX	2	18	927
Brimac 216	0.75	10	72
Clinoptilolite	2	9	463
F-1	2	20	1030
Filtrisorb 300	0.75	11	80
SORBPLUS	0.75	10	72

Sample Quantities	
Sample Volume	2,000 mL
Test Volume	160% of breakthrough

Constants	
Pi	3.1416
ft ³ to mL	28,320 mL/ft ³
gal to mL	3,785 mL/gal
in ³ to mL	16.39 mL/in ³
lb to mg	453,590 mg/lb
ft to in	12 in/ft

Excess Regenerant/Neutralization Requirements*	
Sorbents	175% excess for sorbents (typical)

*Based on theoretical adsorbent capacities; used to calculate volume of F-1 neutralization solution required.

19.4 TASK DESCRIPTIONS

This section presents the step-by-step procedures to be followed in conducting the adsorption treatability study. The procedures are presented in two subsections:

- Capability test procedures
- Capacity test procedures

19.4.1 General Instructions for Adsorbent Testing

The adsorbents will be tested in single-column arrangements. Six adsorbents will be tested:

- Clinoptilolite (cation exchanger)
- SORBPLUS (anion adsorber)
- BIO-FIX (biological adsorbent)
- Filtrasorb 300 (granular activated carbon)
- Brimac 216 (bone charcoal)
- F-1 Alumina (granular activated alumina)

Single-column rather than two-column tests will be conducted with the above adsorbents because of their potential to remove selected cations and anions at different pH levels.

19.4.2 Capability Tests

The purpose of capability testing is to demonstrate the capability of selected adsorbents to remove the constituents of concern present in the Rocky Flats composite raw water. These tests are designed to demonstrate the capability of each of the adsorbents to produce an effluent that meets the anticipated treatment targets for one or more of the constituents of concern. However, these screening tests are not designed to optimize operating parameters, determine adsorbent capacities and breakthrough characteristics, or identify the quality and quantity of residuals requiring subsequent treatment and disposal.

The following is a generic procedure that can be used to individually test each adsorbent pair. The experimental setup for these capability tests is shown in Figure 19-2. The water feed rates, the regenerants and conditioners used, and the volumes of regenerants, conditioners, and rinse water required may differ for each adsorbent to be tested, but the steps required to conduct the screening tests are the same. The following steps outline the generic procedures to be followed to conduct the capability tests; Table 19-3 contains the list of adsorbents to be tested along with the water feed rates and types and quantities of regenerants and conditioners required or appropriate for each adsorbent. **Note that Steps 8 through 12 are only required for capacity testing; for capability testing, stop after Step 7.**

It is recommended that the capability test for each adsorbent be run three times at different pHs to evaluate the effect of pH on constituent removals: (1) acidic pH (3 to 4); (2) neutral pH (6 to 7); and (3) alkaline pH (9 to 10). These data can be used to develop relationships between the column effluent pH to effluent concentrations of the target constituents.

If an adsorbent is not capable of producing an effluent that meets the anticipated discharge limit for at least one of its target constituents (See Figure 19-1), capacity testing of that adsorbent is not required.

Plots or tables of effluent concentrations of the target constituents versus pH can then be prepared from analytical data from which the optimum pH to be used for capacity testing can be chosen. It is likely that the optimum pH for various constituents for any single adsorbent will vary; some constituents may be removed better at acidic pHs while others may exhibit better removal efficiencies at neutral to alkaline pHs. All other factors being equal, the pH to be used for the capacity tests shall be the pH of the raw water (approximately pH 7 to 9) to reduce chemical costs for pH adjustment. Additionally, an adsorbent pair can be dropped from further consideration/testing if the removal efficiency for any target constituent is less than that achieved by another adsorbent pair.

Appendix E contains several equations that can be used to assist with adsorbent capability tests.

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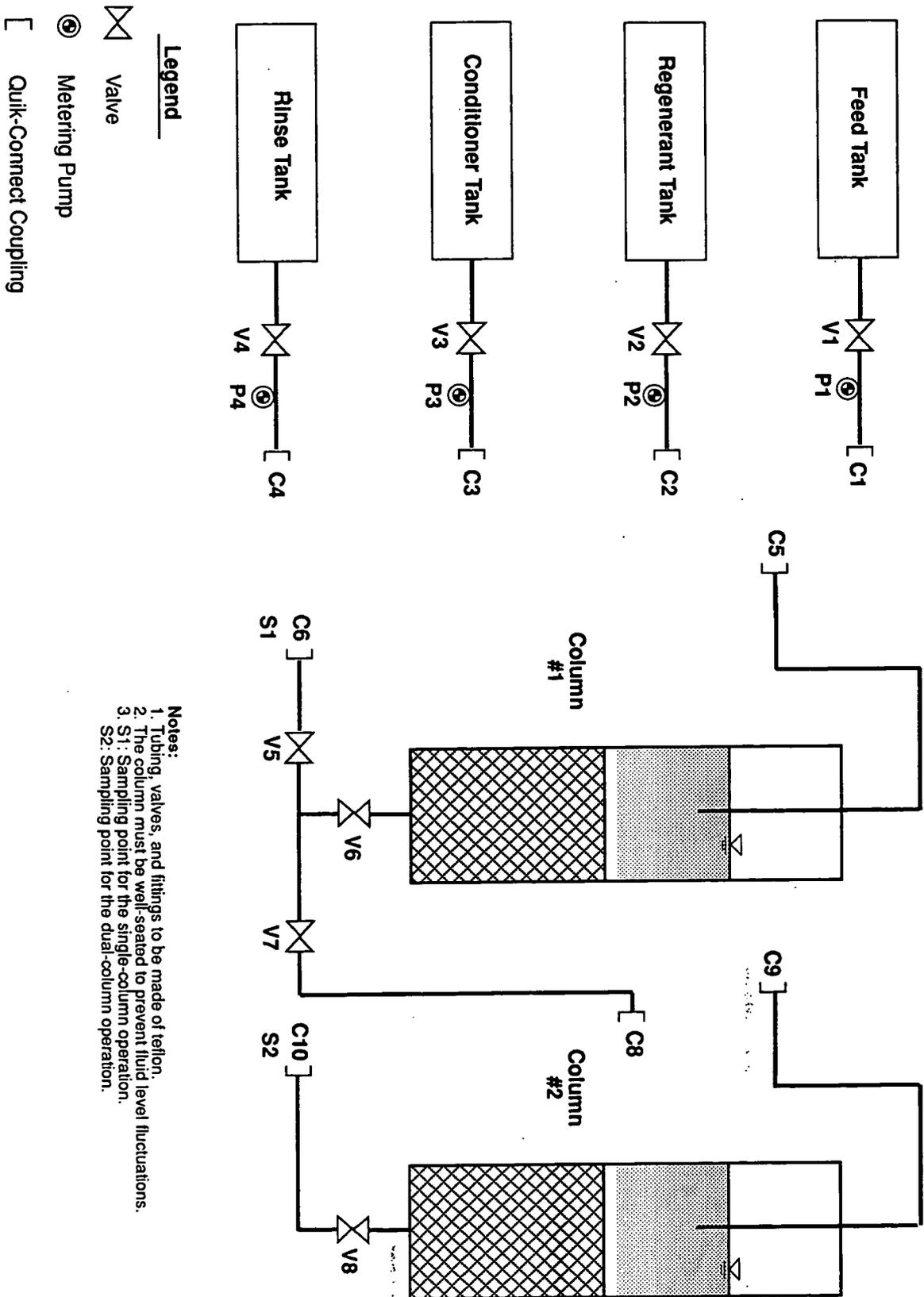


Figure 19-2
COLUMN APPARATUS

19.4.3 Capacity Tests

The purpose of capacity testing is to determine the adsorptive capacities, breakthrough characteristics, and quantities and characteristics of regenerant wastes produced for each of the adsorbents used to treat the Rocky Flats composite raw water. The experimental apparatus and test procedures are similar to those used during the capability tests with two primary differences: (1) the adsorbent bed volumes are sized such that breakthrough of various constituents will occur during the course of testing, enabling the adsorptive capacities and breakthrough characteristics to be determined; and (2) samples of the regenerant wastes will be collected for analysis, enabling an estimation of the quantities and characteristics of these wastes to be made.

Knowledge of the characteristics of the test water—including the concentrations of the constituents of concern along with the concentrations of the major cations and anions in solution—is necessary to design the experiments and obtain the data objectives listed above. At the present time, not all of these data are available and some assumptions were made as discussed earlier to estimate the raw water chemistry. Once the actual raw water chemistry is determined prior to testing, the adsorbent capacity test specifications listed in Table 19-4, may need to be recalculated. The procedure for modifying Table 19-4 based on a change in composite raw water chemistry is approximately as follows:

- Compute the actual concentrations of the critical components and estimate the breakthrough volumes and times required for each adsorbent tested based on the listed water flow rates and adsorbent characteristics.
- If necessary, adjust the water flow rates and adsorbent volumes such that the flow rates and breakthrough volumes for adsorbents tested in series are approximately equal or that the lagging column breaks through first. In all cases, the tests are designed so that the water volume to be tested is approximately 15 liters.

Because each of the adsorbents being tested have some capacity to remove both cations and anions, the adsorbents will be tested one at a time. This will help to identify the constituent removals attribu-

table to each adsorbent that might not otherwise be possible if two-column, in-series tests using different adsorbents in each column were performed.

The following is a generic procedure that is written for testing each adsorbent. The experimental setup for these capacity tests is shown in Figure 19-2. The water feed rates, the regenerants and conditioners used, and the volumes of regenerants, conditioners, and rinse water required may differ for each pair of adsorbents to be tested, but the steps required to conduct the capacity tests are the same. The following steps outline the generic procedures to be followed to conduct the capacity tests; Table 19-4 contains the list of adsorbents to be tested along with the water feed rates and types and quantities of regenerants and conditioners required appropriate for each adsorbent. Prior to testing, the pH of the feed water shall be adjusted to an optimum pH found during capability testing.

Appendix E contains several equations that can be used to assist with adsorption capacity tests.

Step 1—Individually Fill Columns with Adsorbent

- Hydrate the required volume of resins or adsorbents in laboratory-grade deionized water for 24 hours prior to filling the column.
- Ensure that all column apparatus valves (V1 through V8) are closed.
- Fill approximately one-half of Columns No. 1 and 2 with laboratory-grade deionized water. Set the rinse tank pump P4 to withdraw from one of the columns by connecting couplings C4 and C6 and opening valves V5 and V6 (Column No. 1), or connecting couplings C4 and C10 and opening valve V8 (Column No. 2).
- Pour the adsorbent-water slurry into the column to be filled until the media depth specified in Table 19-4 is obtained, draining excess water through the bottom of the column as needed using the rinse tank pump. Do not permit the water level to fall below the adsorbent level during this filling step.

- Stopper the top of the column and slowly fill with water using the rinse tank pump until the top inlet line is submerged 3 to 6 inches below the water level in the column.
- Close all valves.

Step 2—Individually Backwash Columns

- Use the rinse tank pump P4 to slowly feed deionized water into the bottom of a column by connecting couplings C4 and C6 and opening valves V4, V5, and V6 and out through C5 (Column No. 1), or by connecting couplings C4 and C10 and opening valves V4 and V8 (Column No. 2).
- Slowly increase the flow until a bed expansion of approximately 50 percent is obtained (see Table 19-4 for approximate backwash flow rates).
- Maintain this backwash flow until all air pockets are removed and all the particles have fluidized. Extremely small particles and debris should be allowed to pass out of the column during this time.
- After backwashing is complete, stop the rinse tank pump and close all valves. Discard the backwash water collected.

Step 3—Individually Regenerate Columns

This step is not required if the adsorbent is in the proper ionic form (see Table 19-4).

- Prepare the appropriate reagent solution to use to regenerate the adsorbent.

- Set the column for downflow regeneration by connecting C5 (Column No. 1), or C9 (Column No. 2) to the regenerant tank connection C2. Open valves V2, V5, and V6 (Column No. 1) or V2 and V8 (Column No. 2).
- Set the regenerant pump P2 to feed the regenerant solution required for the resin or adsorbent being tested at the rate and for the time specified in Table 19-4.
- After regeneration is complete, stop the regenerant pump and close all valves. Discard the regeneration solution collected.

Step 4—Individually Rinse Columns

This step is not required unless the adsorbent was regenerated in Step 3.

- Set the column for downflow rinse by connecting C5 (Column No. 1) or C9 (Column No. 2) to the rinse tank connection C4. Open valves V5 and V6 (Column No. 1) or V8 (Column No. 2).
- Set the rinse tank pump to feed rinse water at the rate and for the times specified for the initial and final rinses in Table 19-4.
- After the rinse is complete, stop the rinse tank pump and close all valves. Discard the rinse water collected.

Step 5--Individually Convert Adsorbents to Proper Ionic Form

This step is not required if the adsorbent is in the proper ionic form initially or after the regeneration step (see Table 19-4).

- Prepare the appropriate reagent solution to convert the adsorbent into the proper ionic form.
- Set the column for downflow conversion by connecting C5 (Column No. 1), or C9 (Column No. 2) to the conversion tank connection C3. Open valves V3, V5, and V6 (Column No. 1) or V3 and V8 (Column No. 2).
- Set the conversion pump P3 to feed the conversion solution at the rate and for the times specified in Table 19-4.
- After conversion is complete, stop the conversion pump and close all valves. Discard the reagent solution.

Step 6--Individually Rinse Columns

Repeat Step 4. This step is not required unless the adsorbent was converted in Step 5.

Step 7S--Test Column for Adsorbent Capability (Single-Column Operation)

- Set Column No. 2 for downflow feed by connecting C9 to the feed tank connection C1. Open valves V1 and V8.
- Set the feed tank pump to feed water to the column at the flow rate specified in Table 19-4.

- Start the feed tank pump and run approximately five bed volumes of water through Column No. 2 to displace the deionized water in the column (identified as "waste volume" in Table 19-4).
- Collect 50-mL samples of the raw feed and of the column effluent at S2 using the applicable ERM sampling SOP. Immediately test and record the pH of the two samples.
- Run the required amount of water (identified as test volume in Table 19-4) through Column No. 2 and collect consecutive samples (in series) of 2,000 mLs each at S2 during the test using the applicable ERM sampling SOP. Analyze each of the samples for the constituents listed in Table 19-5 using the analytical methods listed in Table 19-6.
- Collect a 50-mL sample of the column effluent at S1 using the applicable ERM sampling SOP. Immediately test and record the pH.
- Stop the feed tank pump and close all valves. Capability testing is complete. Follow Steps 8 through 12 for capacity testing.

Step 7D—Test Column for Adsorbent Capability (Dual-Column, In-Series Operation)

- Set the column for downflow feed (one at a time) by connecting C5 (Column No. 1) or C9 (Column No. 2) to the feed tank connection C1. Open valves V1, V5, and V6 (Column No. 1) or V1 and V8 (Column No. 2).
- Set the feed tank pump P1 to feed water to the columns at the flow rate specified in Table 19-4.
- Start the feed tank pump and run approximately five bed volumes of water through each column individually to displace the deionized water in the column (identified as "waste volume" in Table 19-4). Close all valves.

Table 19-5

SUMMARY OF SAMPLES AND ANALYSES FOR ADSORBENT TESTS

Test Configuration	No. of Samples ^a	Analyses ^b
Treatability influent (composite)	2 (Dup.)	TAL metals, Radionuclides, Water Quality Parameters (all)
Capability Test—BIO-FIX	2	TAL metals, Radionuclides, pH, Cations
Capability Test—Filtrisorb 300	2	TAL metals, Radionuclides, pH
Capability Test—Clinoptilolite	2	TAL metals, Radionuclides, pH, Cations
Capability Test—SORBPLUS	2	Selenium, Radionuclides, pH, Anions, Alkalinity
Capacity Test—BIO-FIX	12	TAL metals, Radionuclides, pH, Cations
Capacity Test—Filtrisorb 300	12	TAL metals, Radionuclides, pH
Capacity Test—Clinoptilolite/ SORBPLUS	12	TAL metals, Radionuclides, pH, Water Quality Parameters (all but solids)

^aThe number of samples for the capacity tests include two laboratory control samples for each test configuration.

^bTAL metals: beryllium, chromium (VI), iron, lead, manganese, mercury, selenium. Radionuclides: americium-241, plutonium-239,240, uranium-total Water Quality Parameters: Alkalinity, pH, Solids (TSS, TDS), Cations (calcium, magnesium, potassium, sodium), Anions (chloride, nitrate, nitrite, silica, sulfate).

TABLE 19-6
ANALYTICAL METHODS AND DETECTION LIMITS

Parameter	Analytical Method	Method Detection
TAL Metals		
Be, Fe, Mn	SW846/6010 (ICP)	0.3, 7, 2 µg/L, respectively
Cr (V1)	SW846/7195, 7196	5 µg/L
Pb	SW846/7421 (GFAA)	1 µg/L
Mg	SW846/7470 (CVA)	0.2 µg/L
Se	SW846/7740 (GFAA)	2 µg/L
Radionuclides		
Am-241	EMSL-LV-0539-17	0.01 pCi/L
Pu 239/240	EMSL-LV-0539-17	0.01 pCi/L
U (total)	EPA 908.0	0.6 pCi/L
Gross alpha and beta	SW846/9310	3 and 4 pCi/L, respectively
Water Quality Parameters		
Alkalinity	EPA 310.2	10 mg/L
pH	EPA150.1	0.1 units
Solids		
TSS	EPA 160.1	10 mg/L
TDS	EPA 160.2	4 mg/L
Cations		
Ca	SW846/7140	10 µg/L
Mg	SW846/7450	1 µg/L
K	SW846/7610	10 µg/L
Na	SW846/7770	2 µg/L
Anions		
Cl	SW846/9250	1 µg/L
NO ₃	SW846/9200	100 µg/L
NO ₂	EPA 354.1	10 µg/L
SO ₄	SW846/9035	10 µg/L
Silica	EPA 370.1	2 mg/L

- Set Columns No. 1 and 2 for downflow feed in series by connecting C5 (Column No. 1) to the feed tank connection C1 and C9 (Column No. 2) to C8 (Column No. 1). Close valve V5 and open all other valves.
- Collect 50 mL samples of the raw feed and the column effluents at S1 and S2. Immediately test and record the pH of the two samples.
- Run the required amount of water (identified as test volume in Table 19-4) through each column, and collect consecutive samples (in series) of 2,000 mLs each at S2 during the test using the applicable ERM sampling SOP. Eight samples will be collected during the test. Analyze each of the samples for the constituents listed in Table 19-5. Immediately after collecting each 2,000 mL sample at S2, collect one 50 mL sample at S1 by briefly opening valve V5 and closing valve V7. Immediately test and record pH of the sample collect at S1.
- Stop the feed tank pump and close all valves. Capability testing is complete. Follow Steps 8 through 12 for capacity testing.

Step 8—Individually Backwash Columns

- Repeat Step 2.

Step 9—Individually Regenerate Columns

- Set the column for downflow regeneration by connecting C5 (Column No. 1), or C9 (Column No. 2) to the regenerant tank connection C2. Open valves V2, V5, and V6 (Column No. 1) or V2 and V8 (Column No. 2).

- Set the regenerant pump P2 to feed the regenerant solution required for the adsorbent being tested at the rate and for the time specified in Table 19-4. Collect the effluent regenerant waste at S1 (regenerant sampling point for Column No. 1), or at S2 (regenerant sampling point for Column No. 2) using the applicable ERM sampling SOP. Dilute the sample collected with laboratory-grade deionized water to a final sample volume of 2,000 mL, and analyze the samples for the constituents listed in Table 19-5.
- After regeneration is complete, stop the regenerant pump and close all valves.

Step 10—Individually Rinse Columns

- Repeat Step 4.

Step 11—Individually Convert the Adsorbent to Proper Ionic Form

Repeat Step 5. This step is not required if the adsorbent is to be disposed of or is already in the proper ionic form (see Table 19-4).

Step 12—Individually Rinse Columns

Repeat Step 4. This step is not required unless the adsorbent was converted in the previous step.

19.4.4 Summary of Capability and Capacity Test Results

Based upon results from the capability tests, plots or tables of effluent concentrations of the target constituents versus pH can then be prepared from analytical data from which the optimum pH to be used for capacity testing can be chosen. It is likely that the optimum pH for various constituents for any single adsorbent pair will vary; some constituents may be removed better at acidic pHs while others may exhibit better removal efficiencies at neutral to alkaline pHs. All other factors being equal, the pH to be used for the capacity tests shall be set as close as possible to the pH of the raw water (approximately

pH 7 to 9) to reduce chemical costs for pH adjustment. Additionally, an adsorbent pair can be dropped from further consideration/testing if the removal efficiency for any given target constituent is less than that achieved by another adsorbent pair.

Two major types of data are typically collected from the capacity tests: saturation loading curves and elution curves. Saturation loading curves are made by plotting the concentrations of the target ions (in meq/L) in the second column effluent versus cumulative flow as measured in bed volumes. This will yield a normalized curve that, neglecting scale-up factors, should theoretically be the same for any size column under the same operating conditions. From these curves, the point at which the critical constituents broke through the adsorbent arrangement being tested can be identified and an estimate of the actual capacity of the adsorbent for each constituent can be calculated by multiplying the bed volumes of treated water before breakthrough by the influent concentration of the ion. If data for design were desired, this loading procedure would be repeated at different flow rates to determine whether any noticeable maximum in breakthrough capacity was achieved at a specific, optimum flow rate.

An elution curve is developed by plotting the constituent concentrations in the regenerant samples versus cumulative regenerant flow as measured in bed volumes using the same units as were used to develop the saturation loading curve. These data can be used to estimate the minimum volume of regenerant required to elute most of the adsorbed ions at the given regenerant concentration and flow rate. If data for design were required, additional runs at different regenerant concentrations and flow rates could be made to determine the level of regeneration that is optimum with respect to operating capacity of the adsorbent and regeneration efficiency.

19.5 SUMMARY OF SAMPLES AND ANALYSES

Table 19-5 summarizes the analyses that will be performed on the water feed and column effluent for the capability and capacity tests for adsorption. The raw water collected for use in these studies will not be filtered prior to use as the feedstock in these experiments. The analytical and QA/QC protocols specified in the EG&G, Rocky Flats GRRASP document, Version 2.1 (DOE, 1991) will be followed for all

analyses. The GRRASP methods follow EPA CLP or EPA-approved methods, and the specified QA/QC meets Level III and Level IV DQOs as described in Section 17.0 of this document.

19.6 TREATABILITY QA/QC SAMPLES

The treatability study are designed with preliminary adsorbent screening steps (capability tests) run at three different pHs followed by additional tests (capacity tests) on the adsorbents that appear to be promising. Because there are repetitive steps included for each material tested, replicate experiments are deemed unnecessary. Each capacity test that is performed with a different adsorbent configuration will be performed once using feed water and once using a laboratory control sample (distilled water blanks). The purpose for the distilled water blanks is to determine the contamination introduced from the reagents, equipment, and other materials used the treatability testing. If the project objectives can be achieved without a determination of the potential sources of contamination, then the method blank experiment and the associated analyses may be removed from the study. The two capacity tests will be performed side-by-side to allow for determining whether any contaminants are being introduced from the dose reagents (i.e., pH adjustment), adsorbents used, and procedural handling steps. Analyses of the control sample effluents and regenerant wastes will be analyzed for the same constituents as the water-loaded apparatus using the same adsorbent configuration. Additional QA/QC to determine the accuracy and precision will be in the form of laboratory QA/QC samples. These samples are described in Table 17-2.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 20

Revision: 1

Page: 1 of 2

Effective Date: _____

Organization: ERT

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TITLE: Data Management--
Adsorption Treatability Study

Approved By:

Name

(Date)

20.0 DATA MANAGEMENT--ADSORPTION TREATABILITY STUDY

The adsorption treatability study will generate observational data from the screening tests as well as analytical data from its effluents. This study will also generate pretreatment analytical data developed to characterize pretreatment surface water and groundwater. Observations of the tests will be documented in logbooks assigned to the laboratory personnel. The effluents may be analyzed by a laboratory unaffiliated with the Rocky Flats Plant. The laboratory shall have satisfactory QA/QC procedures to track and maintain custody of samples and data.

Procedures for logging of field sample collection activities are documented in the Treatability Study Sampling Plan, Appendix A.

At a minimum, the treatability testing logbooks will document the following:

- Testing procedures
- Departures from protocols and reasons for departures
- Instrument calibration
- Sampling methods
- Chemical additions
- Test observations

Standard bench sheets will be designed to allow uniform recording of the test conditions and observations.

Experimental results which are quantitative (such as pH) will be reported to the accuracy level of the measurement device.

Comprehensive data packages will be generated by the analytical laboratory for the metals analyses of the treatability effluents in accordance with the Level III analytical QA/QC requirements. Similar data packages will be generated for radionuclide and water quality parameters, so that the accuracy and the precision of the results can be independently verified. The analytical data packages will be tracked and managed according to the tests performed and laboratory QC group numbers assigned by the laboratory. Where applicable, QC data will also be obtained in an electronic format to facilitate data uploading into the project data base.

Monthly progress reports will also be prepared during the feasibility study testing. These reports will include the following:

- Waste stream studied
- Treatability test number
- Date sample collected
- Where sample stored prior to treatment
- Date treatment initiated
- Initial sample weight
- Date treatment concluded
- Final residue and unused sample weight
- Where residue stored prior to return to permitted storage area
- Date residue returned to permitted storage area

This information will be presented in a table format with one table per waste stream/process. This information will be provided to EG&G RCRA Permitting Division on a monthly basis.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 2100.WP.TS01.01

Section: 21
Revision: 1
Page: 1 of 3

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Organization: ERT

TITLE: Data Analysis and Interpretation—
Adsorption Treatability Study

Approved By:

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21.0 DATA ANALYSIS AND INTERPRETATION— ADSORPTION TREATABILITY STUDY

Upon completion of treatability testing, data will be presented and interpreted in accordance with Section 6.7 of the Treatability Studies Plan and Guidance for Conducting Treatability Studies Under CERCLA (EPA, 1989). Data will be summarized and evaluated to determine the validity of measurements and performance of the treatment processes. Section 3.0 of the RFP Quality Assurance Project Plan (QAPjP) describes the requirements for data reduction, validation, useability criteria, and reporting of data. Appendix C, an addendum of the QAPjP, addresses the specific QA requirements for performing treatability studies of IEA processes. Appendix C of the draft QAPjP is included as Appendix D of this document.

Plots or tables of effluent concentrations of the target constituents versus pH can be prepared from analytical data generated by the capability tests. It is likely that the optimum pH for various constituents for any single resin will vary; some constituents may be removed better at acidic pHs while others may exhibit better removal efficiencies at neutral to alkaline pHs. Selection of the optimum pHs for capacity testing should take into account (1) whether only one, two, or several resins were capable of removing any given target constituent, and (2) whether the selected optimum pH for a given resin is the same as the optimum pH for the resin with which it will be paired during capacity testing. Removal efficiency is also affected by resin sequencing especially when attempting to remove trace constituents.

Two major types of data will be collected from the capacity tests: saturation loading curves and elution curves. Saturation loading curves are made by plotting the concentrations of the target ions (in meq/L) versus cumulative flow as measured in bed volumes. This will yield a normalized curve that, neglecting scale-up factors, should theoretically be the same for any size column under the same operating conditions. From these curves, the point at which the critical constituents broke

through the resin system being tested can be identified and an estimate of the actual capacity of the resin for each constituent can be calculated by multiplying the bed volumes of treated water before breakthrough by the influent concentration of the ion.

An elution curve is developed by plotting the constituent concentrations in the regenerant samples versus cumulative regenerant flow as measured in bed volumes using the same units as were used to develop the saturation loading curve. These data can be used to estimate the minimum volume of regenerant required to elute most of the adsorbed ions at the given regenerant concentration and flow rate. If data for design were required, additional runs at different regenerant concentrations and flow rates could be made to determine the level of regeneration that is optimum with respect to operating capacity of the resin and regeneration efficiency.

21.1 MEASUREMENTS OF PERFORMANCE

Data checking to assess data for precision (for example, the relative percent difference for duplicate matrix spikes), accuracy (for example, the percent recovery of matrix spikes), and completeness (for example, the percentage of data that are valid) will be conducted in accordance with Functional Guidelines for Laboratory Data Validation (EPA, 1988). Where guidelines for data validation are not available, such as for water quality parameters and radionuclides, standard operating procedures will be prepared based on the analytical methods utilized and the QA/QC measures included in the analyses. The EMD OPS will allow uniform validation of the water quality parameter and radionuclide data. Qualified personnel not directly associated with the laboratory experiments or laboratory analyses will perform the data validation function at the direction of the treatability studies contractor. The verified/validated data will be reduced to graphical or tabular form for interpretation. Conclusions concerning the effectiveness of processes will be deduced directly from the treatability data and comparison with ARARs/TBCs. The implementation and cost of the processes will be indirectly deduced by calculations based on the treatability data.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 21

Revision: 1

Page: 3 of 3

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

Data consistency will be maintained by having the same laboratory technician make and record observations about the effectiveness of the test material. Engineering judgements will be observed by an experienced process engineer.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 22

Revision: 1

Page: 1 of 1

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TITLE: Residual Management-Adsorption Treatability Study

Approved By:

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22.0 RESIDUAL MANAGEMENT-ADSORPTION TREATABILITY STUDY

All liquid wastes generated during treatability testing will be stored in properly labeled 55-gallon U.S. Department of Transportation-approved (DOT) containers. Solid residues will be stored in 1-gallon resealable DOT metal containers. It is estimated that the amount of liquid waste, including used samples, will be 410 L and the amount of solid waste will be approximately 6 L by volume.

All unused treatability samples and residues will be returned to the Rocky Flats Plant under the Treatability Studies Exemption Rule. In accordance with 40 CFR 261.4(f), samples and residues will be returned within 90 days from the completion of treatability testing, or within 1 year from the sample shipment date from RFP to the facility. All unused samples will be contained separately from sample residues.

The outside contractor laboratory will be responsible for properly disposing of any unused portions of the effluent samples submitted for analyses, and incidental wastes generated during sample preparation and analysis.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 23

Revision: 1

Page: 1 of 2

Effective Date: _____

Organization: ERT

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Approved By:

TITLE: Adsorption Treatability Study Report

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23.0 ADSORPTION TREATABILITY STUDY REPORT

The adsorption treatability study results will be summarized in a Treatability Study Report. The report will be prepared upon completion of treatability study testing and will summarize the tests results and discuss any improvements or additional testing that may need to be conducted. The report will also describe the effectiveness of adsorption technology in removing metals and radionuclides from contaminated water and will identify any additional data needs. The format of the report will follow the format presented in the Guidance for Conducting Treatability Studies Under CERCLA (EPA, 1989). The format is presented in Table 23-1.

TABLE 23-1

ORGANIZATION OF THE ADSORPTION TREATABILITY STUDIES REPORT

-
1. Introduction
 - 1.1 Site description
 - 1.1.1 Site name and location
 - 1.1.2 History of operations
 - 1.1.3 Prior removal and remediation activities
 - 1.2 Waste stream description
 - 1.2.1 Waste matrices
 - 1.2.2 Pollutants/chemical
 - 1.3 Remedial technology description
 - 1.3.1 Treatment process and scale
 - 1.3.2 Operating features
 - 1.4 Previous treatability studies at the site
 2. Conclusions and Recommendations
 - 2.1 Conclusions
 - 2.2 Recommendations
 3. Adsorption Treatability Study Approach
 - 3.1 Test objectives and rationale
 - 3.2 Experimental design and procedures
 - 3.3 Equipment and material
 - 3.4 Sampling and Analysis
 - 3.4.1 Waste stream
 - 3.4.2 Treatment process
 - 3.5 Data management
 - 3.6 Deviations from the work plan
 4. Adsorption Results and Discussion
 - 4.1 Data analysis and interpretation
 - 4.1.1 Analysis of waste stream characteristics
 - 4.1.2 Analysis of treatability study data
 - 4.1.3 Comparison to test objectives
 - 4.2 Quality assurance/quality control
 - 4.3 Costs/schedule for performing the treatability study
 - 4.4 Key contacts
- References
- Appendices
- A. Data summaries
 - B. Standard operating procedures
-

Source: EPA, 1989.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 24

Revision: 1

Page: 1 of 2

Effective Date: _____

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Approved By:

TITLE: Adsorption Treatability Study Schedule

Name

(Date)

24.0 ADSORPTION TREATABILITY STUDY SCHEDULE

The Adsorption Treatability Study shall consist of three phases during a 31-week period. Prior to Phase I, approximately 3 weeks will be used to finalize sampling logistics. Phase I shall consist of 2 weeks to perform field sampling. Phase II shall consist of 2 weeks to perform the treatability studies followed by 15 weeks to receive and analyze the treatability studies data.

The treatability studies will be performed by running two treatability tests at a time, until all tests are complete, in order to achieve the 2-week schedule. Phase III shall consist of 13 weeks to develop, review and finalize the Treatability Study Report (TSR). An approximate project schedule to illustrate the timing, duration, and interrelationship between phases for the Adsorption Treatability Study is shown in Figure 24-1.

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▼ DELIVERABLES

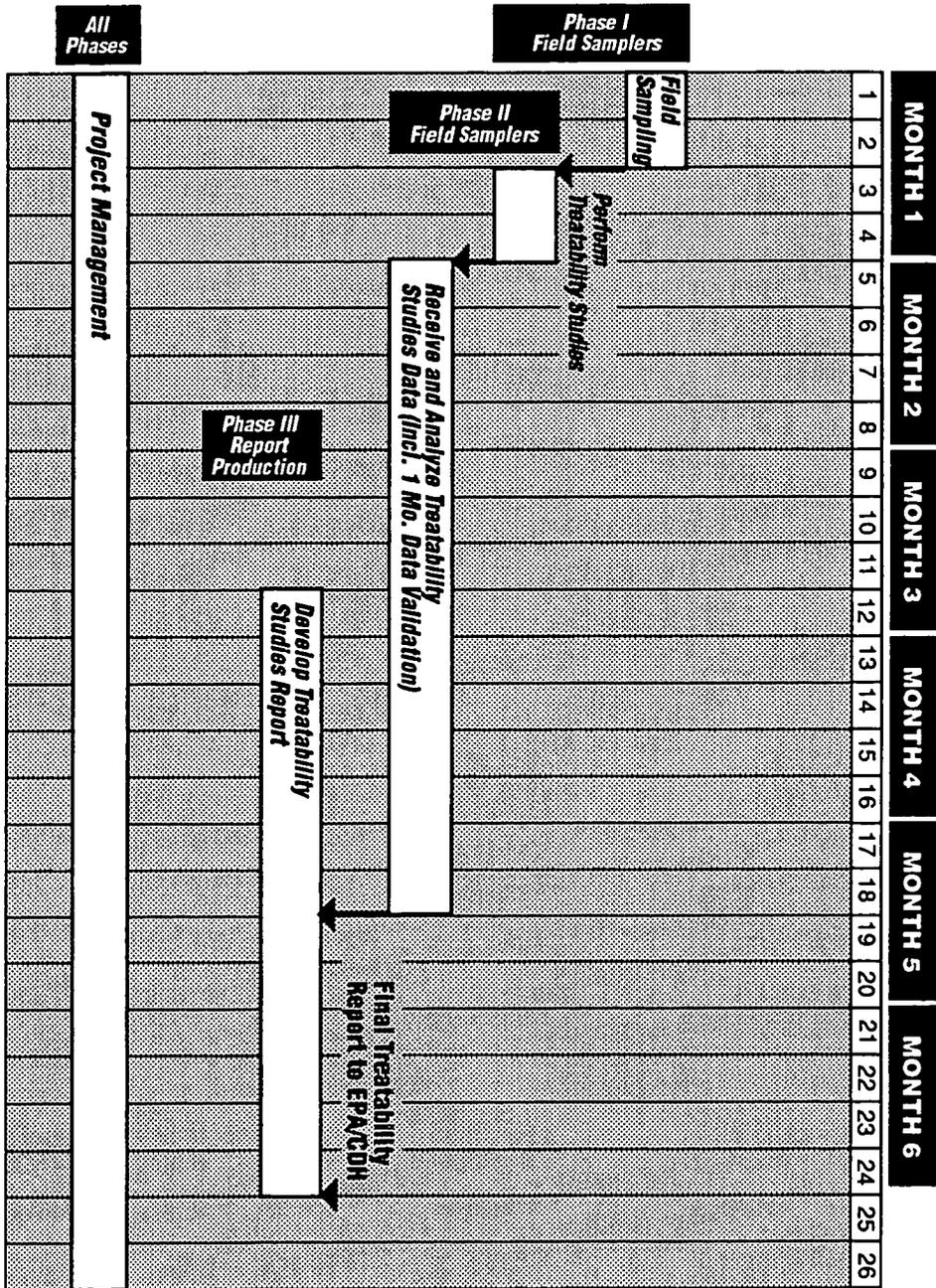


Figure 24-1
PROGRAM SCHEDULE FOR
AN ADSORPTION TREATABILITY STUDY

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Section 25
MANAGEMENT AND STAFFING
ADSORPTION TREATABILITY STUDY

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 25

Revision: 1

Page: 1 of 5

Effective Date: _____

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TITLE: Management and Staffing—
Adsorption Treatability Study

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Name (Date)

25.0 MANAGEMENT AND STAFFING—ADSORPTION TREATABILITY STUDY

This section describes the management approach and staffing for the adsorption treatability study. The lines of authority and responsibilities of each treatability study team member are described.

25.1 INTRODUCTION

The objective of project management during the adsorption treatability study is to direct and document project activities so that data and evaluations generated meet the goals and objectives of the TSWP.

Specific project management activities that shall occur throughout the adsorption treatability study, and include the following:

- Meetings
- Cost and schedule control
- Data management
- Quality control
- Health and safety

These activities shall be conducted to identify potential problems quickly enough to make necessary corrections and keep the project focused on its objectives, on schedule, and within budget.

25.2 PROJECT TEAM

The project team for the adsorption treatability study at the Rocky Flats Plant is comprised of individuals from various technical disciplines. This section discusses the responsibilities of the respective key management and personnel. Each project team member should review this section with particular interest as to each other's responsibilities. This understanding will help in overall project coordination and ensure understanding of the respective jobs to be done. Figure 25-1 depicts the adsorption treatability study project organization. The specific responsibilities of key management and personnel are described in the following subsection.

25.2.1 EG&G Program Manager

The EG&G program manager's role is to oversee and ensure the work progresses according to the priorities and objectives established during adsorption treatability study project planning. This role requires planning project scopes and deriving cost estimates for the specific tasks and activities described in the work plan. The EG&G program manager shall also facilitate the interaction among EG&G staff and contractor personnel.

25.2.2 Senior Review Team

The senior review team's responsibilities include continued quality control (QC) review of project deliverables. In general, these include the Adsorption Treatability Study Sampling Plan (TSSP) and the Adsorption Treatability Study Report (TSR).

25.2.3 Project Manager

The project manager (PM) is responsible for the coordination of all activities and tasks and project administration. The PM's responsibility includes quality control and technical excellence of all project aspects, and also extends to meeting assigned project budgets and schedules. The project manager shall be kept aware of major deviations from the scope and procedures established in the

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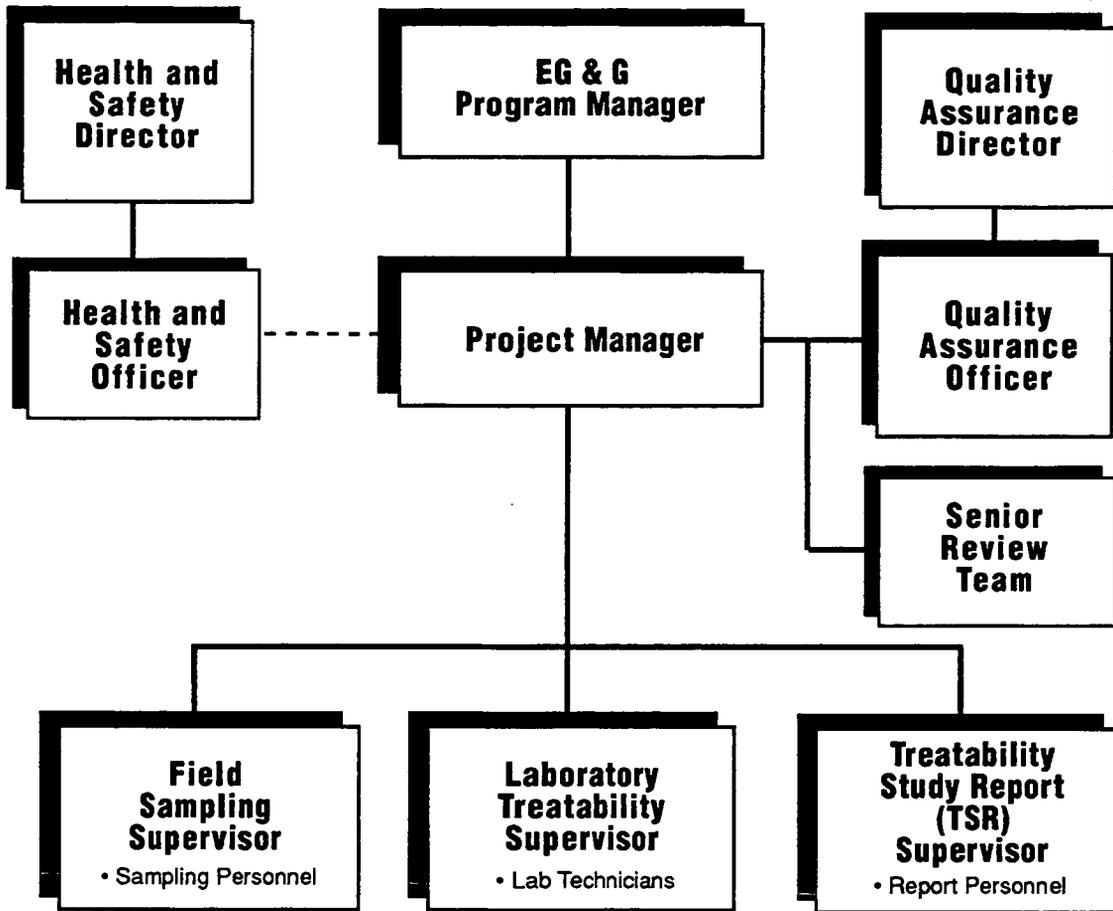


Figure 25-1
MANAGEMENT ORGANIZATION
 ROCKY FLATS ADSORPTION TSWP

TSWP prior to their implementation. The PM will ensure that deliverables clearly present the results of the adsorption treatability study.

25.2.4 Health and Safety Officer (HSO)

The HSO is responsible for the establishment and implementation of health and safety requirements, and any monitoring programs. The maintenance of Health and Safety Records and monitoring equipment is also the responsibility of this person. The HSO will monitor compliance with health and safety requirements through audits.

25.2.5 Quality Assurance Officer (QAO)

The QAO is responsible for the development and implementation of quality requirements, and monitors compliance through field and records audits. The QAO provides general oversight and guidance on quality issues, and sets procedures for equipment calibration and maintenance.

25.2.6 Sampling Field Supervisor

The sampling field supervisor shall be responsible for ensuring that the Sampling Plan for the adsorption treatability study (Appendix A of this document) is adhered to by sampling personnel, including proper identification of sampling locations, implementation of sample designation and sample handling procedures, use of proper sampling equipment, calibration and maintenance of equipment, and completion of required paperwork.

25.2.7 Laboratory Treatability Supervisor

The laboratory treatability supervisor's responsibilities include ensuring that treatability testing procedures are followed and documented, including proper sample designation and handling procedures, use of proper test equipment, and calibration and maintenance of test equipment.

25.2.8 Sampling Personnel

Sampling personnel responsibilities relate to both groundwater and surface water sampling. Their responsibilities include sample collection, sample documentation and chain of custody, initial packing of samples, shipment of samples, and decontamination of sampling equipment and vehicles.

25.2.9 Laboratory Technicians

The laboratory technicians shall be responsible for performing the adsorption treatability tests, maintaining equipment and materials, and following experimental procedures and analytical methods. Their responsibilities include the following:

- Daily documentation of adsorption treatability testing results and other pertinent information in log books.
- Proper sample collection, designation, documentation, and chain of custody of treatability samples for outside laboratory analysis.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 26
Revision: 0
Page: 1 of 3

Non-Safety Related

Final Draft

Effective Date: _____
Organization: ERT

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and Offsite Testing--
Adsorption Treatability Study

Approved By:

_____/_____/_____
Name (Date)

26.0 REGULATORY REQUIREMENTS FOR ONSITE AND OFFSITE TESTING-- ADSORPTION TREATABILITY STUDY

If the adsorption treatability study is conducted offsite, sample collection and shipping restrictions will be followed to comply with the Sample Exclusion Provision (40 CFR 261.4(d)) of RCRA. This provision includes environmental samples used in small-scale treatability studies and is referred to as the Federal Treatability Studies Exemption Rule. In accordance with this rule, samples that are collected, stored, or transported to an offsite laboratory or testing facility will be exempt from the RCRA generator and transporter requirements (40 CFR Parts 262 and 263) by following these guidelines:

- No more than 1,000 kilograms (kg) of the water to be used in the TS may be shipped to the offsite laboratory.
- Check the sample package—*before shipment*. It must not leak, spill, or vaporize from its packaging during shipment, and the transportation of each sample shipment must comply with U.S. Department of Transportation (DOT), U.S. Postal Service (USPS), or any other applicable regulations for shipping hazardous materials. All sample packages must surveyed for radioactivity following Rocky Flats Plant and DOT requirements. Packages must be appropriately labelled after surveys, according to DOT regulations. (49 CFR 173)
- Check the permit status of the laboratory or testing facility. The water samples can only be shipped to a laboratory or testing facility that is exempt under 40 CFR 261.4(f) or that has an appropriate RCRA permit or interim status. Since the

samples are anticipated to contain radionuclides, all laboratories (including analytical laboratories) handling the samples must be licensed by the Nuclear Regulatory Commission (NRC) or the applicable state agency if they have NRC licensing authority for handling, analyzing, treating, or storing radioactive material. The license must be inclusive of the radionuclides expected and allow amounts of those radionuclides in excess of the quantities anticipated.

If the adsorption treatability study is conducted onsite, substantive compliance with federal, state, or local requirements will be demonstrated.

The following information must be maintained for each individual waste stream:

- The date the sample was collected.
- The date the sample was received at the treatability studies unit.
- The total quantity, in kg, of "as received" waste in storage per day at the treatability studies facility.
- If the "as received" waste sample was stored prior to initiating the treatability test, state where it was stored.
- The quantities and types of waste subjected to the treatability studies.
- The date treatment was initiated, and the amount of "as received" waste introduced to treatment each day. (For example, if the treatment process is conducted in a glovebox, and an individual sample is treated in multiple runs, then the day the entire sample enters the glovebox is the date initiation of treatment for the sample.)
- The dates of initiation and conclusion of each treatability test.

- The final disposition of residues and unused samples from each adsorption treatability study (such as which RCRA-permitted hazardous waste storage area the residues and unused samples were stored in).
- Records of any spills or releases.
- Records that show compliance with the treatment rate limits, and the storage time and quantity limits, must be kept for a minimum of 3 years after completion of the treatability studies.

Monthly reporting will be required for the adsorption treatability studies. These reports will include the following:

- The waste stream studied
- The treatability test number
- The date the sample was collected
- Where sample was stored prior to treatment
- The date treatment was initiated
- The initial sample weight
- The date treatment concluded
- The final residue and unused sample weight
- Where the residue was stored prior to its return to the permitted storage area
- The date the residue was returned to permitted storage area

The requirements described in this section are summarized from 40 CFR 261.4(d), the Sample Exclusion Provision of RCRA, and are also taken from the TSP, which references the Sample Exclusion Provision.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 27

Revision: 0

Page: 1 of 5

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

TITLE: References

Approved By:

Name

_____/_____
(Date)

27.0 REFERENCES

A variety of manufacturer's products and bulletins were referred to in the ion exchange and adsorption processes described in Sections 6.0 and 19.0. These bulletins and product publications may be obtained from their respective manufacturers upon requests. Because these product-related publications are commercial documents, they are not available in a library as are the publications listed below.

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EG&G ROCKY FLATS PLANT
Treatability Study Work Plan for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 27

Revision: 0

Page: 2 of 5

Effective Date: _____

Non-Safety Related

Final Draft

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EG&G ROCKY FLATS PLANT
Treatability Study Work Plan for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 27

Revision: 0

Page: 3 of 5

Effective Date:

Organization: ERT

Non-Safety Related

Final Draft

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EG&G ROCKY FLATS PLANT
Treatability Study Work Plan for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 27

Revision: 0

Page: 4 of 5

Effective Date: _____

Organization: ERT

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Treatability Study Work Plan for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 27

Revision: 0

Page: 5 of 5

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

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EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix A

Revision: 1

Page: 1 of 21

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

TITLE: Appendix A, Sampling Plan

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Name

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APPENDIX A. SAMPLING PLAN

A.1 SAMPLING LOCATIONS AND PROCEDURES

This section describes proposed locations for collecting samples and proposed ratios at which waters from various locations should be blended to produce a composite sample with adequate numbers of constituents. The rationale used to select these locations will be described, along with required procedures for actual sample collection.

A.1.1 Rationale for Location Selection

Prior to detailing the selected locations to be sampled, a discussion of the rationale for selection will be useful. This rationale changed, based on examination of the data, during the development of this sampling plan.

Originally, it was intended to find one or two sample locations with above-ARARs concentrations of most of the 10 constituents to be addressed in this treatability study. The newly developed Rocky Flats Environmental Database System (RFEDS) was determined to be the best source of data from environmental sampling at the plant and should be used to determine sampling locations for this treatability study. The data search proceeded under this basis.

Data was obtained from RFEDS for all analyses from 1991 and 1992, for the ten chemicals of concern, where the laboratory flag was not "U" meaning undetected. After screening data to include only records flagged as "real" and "target," thereby eliminating duplicates and replicates, and including only concentrations for dissolved metal analyses, data base queries were performed to find samples where multiple constituents were found at levels greater than 120 percent of their

respective detection limits. Only one analysis had hits from three or more constituents (other than multiple isomers of the same radioisotope); a number of analyses were found with two hits.

At this stage, the decision was made to mix water from several locations to composite a sample with most of the ten constituents above detection limits. If this was not done, many more test runs would be required in the treatability study to test waters with only one or two of the constituents. Also, samples with nondissolved americium and plutonium were considered for the studies. These two components were added because they are expected to exist in RFP waters only in colloidal form, and because of indications that even these colloidal forms of the two metals might be captured.

Therefore, the data base was searched for hits at 100 x, 50 x, 10 x, and 1 x detection limit for each chemical. Uranium, plutonium, americium, iron, and selenium were present in samples at 100 x detection limits. Manganese was present at 50 x detection limit. Beryllium, chromium, and mercury were never detected at 10 x detection limit but were found in the 1 times file. Lead was never detected, in dissolved form, at any level over detection limit.

Sample numbers for each chemical were then obtained for each hit of that chemical in its highest concentration range. (For example, locations for each hit of uranium in the 100 x detection limit category were recorded.) Then, the complete history of analyses at each of those locations was examined to find which locations consistently had hits for the chemical in question as well as significant levels of other chemicals. For each chemical, the sampling locations were narrowed to a few choices where that chemical was found more than once and where other chemicals were also found, if such locations existed.

Finally, various combinations of waters from the samples in question were examined on spreadsheets to determine which waters at which ratios would produce a sample with the maximum number of chemicals over detection limit. One combination was found with seven chemicals over detection limit (all except beryllium, lead, and mercury) and another combination was found with six chemicals over detection limit (all except beryllium, lead, mercury, and chromium).

It is recognized that concentrations of chemicals at these locations could greatly vary from previous analyses, and that such variance could make these locations of little or no use for collecting water for the study. Therefore, the studies will be designed around the determined concentrations, but will be made flexible to accommodate variances.

A.1.2 Sampling Location Summary

Based on the rationale in the above section, sampling locations were selected. The optimum water for the studies was determined to be a mix of 40 percent water from groundwater well 09091, 30 percent water from groundwater well B206789, and 30 percent water from surface water source GS10. If, at the time of water collection for the treatability studies, the water quality is similar to these relative maximum values for these locations, a composite sample with 7 of the 10 constituents above detection limits should be developed. Table A-1 shows the results of a composite of these samples.

It is very probable that actual water quality from these locations will differ from that shown in Table A-1. In fact, it is possible that such water will contain no contaminants above detection limits. Therefore, water from each source should be analyzed prior to compositing. Based on these analyses, water from a certain location may be added at a different ratio than shown in Table A-1, or it may not be added at all. In such a case, water from alternate locations would be analyzed to determine its suitability for compositing. In addition to the three sources listed above, the sources listed in Table A-2 should be analyzed to determine possible use. Table A-2 is arranged to list potential locations by constituent. Figure A-1 illustrates the location of some of the sampling locations shown in Table A-1.

A.1.3 Sampling Procedures

Samples collected for initial analytical analysis and samples used in the Treatability Study shall be collected in accordance with Rocky Flats Plant Environmental Management Department Operating Procedures 5-21000-OPS-GW.5—Field Measurement of Groundwater Field Parameters,

Table A-1

COMPOSITE SAMPLE GENERATION-
 ION EXCHANGE AND ADSORPTION TREATABILITY STUDIES

Target Constituent	Locations and Concentrations			Composite Concentration	Detection Limit
	GW-09091	GW-B206789	SW-GS0271		
Americium	47.0			21.2	0.01
Beryllium				0.0	5
Chromium		8.0		3.6	10
Iron	14.0	23.0	76800.0	7696.7	100
Lead				0.0	
Manganese			1460.0	146.0	15
Mercury				0.0	0.2
Plutonium	355.0			159.8	0.01
Selenium		680.0		306.0	5
Uranium	1.0			0.5	0.05
Volume Ratio	0.45	0.45	0.10	1.0	

TABLE A-2

ALTERNATE SAMPLING LOCATIONS—ION EXCHANGE
AND ADSORPTION TREATABILITY STUDIES

Constituent	Sampling Locations
Selenium	1074
Manganese	0271
Uranium	01391, 09691
Americium	06991
Iron	7287, 0271, 1086
Plutonium	06991
Chromium	1186
Beryllium	B400389, 0260, 0271
Mercury	0386, 3086, 6986, B111189
Lead	No Locations Found

EG&G ROCKY FLATS PLANT
Treatability Study Work Plan for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix A

Revision: 1

Page: 8 of 21

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

5-21000-OPS-GW.6--Groundwater Sampling, 5-21000-OPS-SW.2--Field Measurement of Surface Water Field Parameters (as modified by DCN92.01 and DCN92.02), and 5-21000-OPS-SW.3--Surface Water Sampling (EG&G, 1991). Unfiltered treatability study samples from each sampling location shall be collected in 12-gallon plastic U.S. Department of Transportation (DOT)-34 drums that will be completely filled to minimize head space. Approximately 17 drums (for a total volume of 200 gallons collected for all samples) shall be filled at each of the three sampling locations for use in the treatability study. The amount of sample required for each test is based on the minimum quantity of liquid needed to perform the required analyses. Unfiltered analytical samples from each of the three sampling locations shall also be collected and submitted by sampling personnel for analysis (see Section A.4). All water samples will be analyzed before performing the treatability tests. The DOT-34 drums shall be transferred to the treatability study laboratory using chain-of-custody (COC) procedures (see Section A.6), following all required U.S. Environmental Protection Agency (EPA), and DOT regulations. Analytical samples shall be shipped to an analytical laboratory also using appropriate COC procedures (see Section A.6).

A.2 FIELD MEASUREMENT

Various indicator parameters (pH, dissolved oxygen, temperature, and specific conductivity) will be measured in groundwater and surface water samples. These measurements will be taken at each sampling event and sampling location. This section describes the procedures to be followed for field measurements.

A variety of equipment will be used during the field monitoring of water sample for subsequent use in the treatability study. Field equipment shall be calibrated and maintained per manufacturers' recommendations. Calibration procedures for each piece of field equipment shall be documented in the field log book.

A.3 FIELD DATA DOCUMENTATION AND PROCEDURES

Documentation of observations and data acquired in the field will provide a permanent record containing information on the handling and preparation of samples collected.

Field Data Documentation Procedures shall be consistent with the Rocky Flats Plant Environmental Management Department EMD OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples (EG&G, 1991). The applicable section from EMD OPS FO.13 Section 6.4 is addressed below.

A.3.1 Field Data Forms

All field descriptions, measurements, and observations shall be recorded on the appropriate field data form in accordance with FO.2, Field Document Control (EG&G, 1991). The original data forms shall be collected and filed on site by the subcontractor's designated data entry personnel. These forms are to be bound and submitted to EG&G accompanied by a transmittal letter on a monthly schedule for the entire duration of the task. This form is an example of data entries required for the Rocky Flats Environmental Data System (RFEDS) data base. Data may also be recorded in field logbooks if desired. Field data will be filled out at the time a sample is taken and shall include, but not be limited to, the following information:

- Sampling activity name and number
- Sampling point name and number
- Sample number¹
- Name(s) of collector(s) and others present¹
- Date and time of sample collection¹
- Sample container tag number (if appropriate)¹
- Preservative(s) used¹

¹Items to be documented on the COC form.

- Requested analyses¹
- Sample matrix¹
- Filtered/unfiltered¹
- Designation of QC Samples (Only for MS and MSD)¹
- Collection methods
- Chain-of-custody control numbers
- Field observations and measurements during sampling (comment section)
- Signature of responsible observer

A.3.2 Field Log

Bound and consecutively numbered Field Logs shall be maintained by sampling personnel at all times. All entries shall be made with indelible ink and signed and dated each day. Records shall contain sufficient information so that someone can reconstruct the activity in the absence of the person who took the notes.

A field log book shall be developed and maintained, and will contain the following information:

- Name and title of author, data and time of entry
- Personnel involved in activities
- Specific data collected

If an error is made in a Field Log assigned to an individual, that individual shall make corrections simply by crossing a line through the error and entering the correct information. The erroneous information shall not be obliterated. Any subsequent error discovered in a Field Log shall be corrected by the person who made the entry. All data corrections shall be initialed and dated.

A.4 SAMPLE CONTAINERS, VOLUMES, PRESERVATIVES, AND HOLDING TIMES

Collected groundwater and surface water samples shall be sent to the laboratory for subsequent analysis and/or use in the treatability study. Sample containers, volumes, preservatives, and holding times associated with samples collected for analysis shall be consistent with the Rocky Flats Plant Environmental Restoration Management (ERM) OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples (as modified by DCN92.01). Applicable sections from ERM OPS FO.13 Sections 6.0 and 6.1 are addressed below (EG&G, 1991).

A.4.1 Procedures

Procedures for the containerizing and preserving water samples follow strict criteria of the EPA's Contract Laboratory Program (CLP). Information presented herein is intended to present general guidelines for proper sample handling, and any deviations or modifications will be documented in the Scope of Work or specific Task Order.

A.4.2 Sample Containers and Preservatives

Only sample containers certified as clean by the manufacturer will be used for sample collection. The containers and preservatives may be obtained from the contracted analytical laboratory, their designated supplier, or a suitable chemical supply company. Any preservative(s) required may be added to the container by the contracted analytical laboratory, field sample team, sample manager, and/or onsite chemist prior to or during sample collection.

A.5 SAMPLE DESIGNATION SYSTEM

A sample designation system shall be used to identify each sample collected during the field sampling effort. The sample designation system shall provide a tracking procedure to allow retrieval of information about a particular sample and shall be consistent with the Rocky Flats Plant ERM

OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples (EG&G, 1991). The applicable section from ERM OPS FO.13 (Section 6.2) is addressed below.

A.5.1 Container Labeling and Decontamination

Prior to sample collection, sample containers shall be labeled by the sample manager or an assistant. Collection time and date shall be marked in the field by the sampler. The labels shall indicate:

- Activity name and/or number
- Unique sample number
- Sampling time and date
- Chemical preservative used
- Sample type (grab, composite)
- Analyses required
- Filtered/unfiltered
- Comments or special precautions, as needed
- Samplers Initials

The sample label shall be marked with a black waterproof pen. If needed, clear tape will be placed over labels before sampling to assure that the labels remain legible.

Subsequent to sampling, the exterior of the sample containers shall be decontaminated (according to ERM OPS FO.3, General Equipment Decontamination), (EG&G, 1991), placed in plastic bags, and put in coolers dedicated for sample and sample container transportation.

Note that 12-gallon samples will not be placed in coolers. Only smaller samples for laboratory analyses will be transported in coolers.

A.6 SAMPLE CUSTODY

A required part of this sampling and analytical program is the integrity of the sample from collection to data reporting. This includes the ability to trace the possession and handling of samples from the time of collection, through analysis, to final deposition. The documentation of the samples' history is referred to as "chain-of-custody." Sample custody procedures shall be consistent with the Rocky Flats Plant ERM OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples (as modified by DCN92.01). The applicable section from ERM OPS FO.13 (Section 6.3) is addressed below (EG&G, 1991).

A.6.1 Chain-of-Custody Record

Official custody of samples shall be maintained and documented from the time of collection until the time that valid analytical results have been obtained or the laboratory has been released to dispose of the sample. The sampling team shall be responsible for initiating the original chain-of-custody (COC) form and shall sign and date this form when relinquishing custody of samples to the sample manager. Upon receipt, the sample manager shall check the COC and all sample labels to ensure that all samples are accounted for and in good condition, and that no errors were made in labeling and/or completing the COC.

A sample is considered to be in a person's custody if any of the following conditions are met:

- The sample is in the person's physical possession.
- The sample is in line of sight of the person after he/she has taken possession.
- The sample is secured by that person so that any tampering can be detected.
- A sample is secured by the person in possession in an area which only authorized personnel can enter.

A.6.2 Chain-of-Custody Form

A four-page carbonless COC form shall be used for all sample shipments. The original and second (yellow) copy shall be included with the samples to be shipped enclosed in a plastic bag and taped inside the lid of the cooler. The third (pink) copy, along with a photocopy of the original, shall remain on file at the subcontractors on-site facility. The fourth (goldenrod) copy is for EG&G project managers requesting copies. The contract laboratory shall sign as having received the samples and return the yellow copy of the COC form to the project management office for verification by the QA/QC officer or their designee. The yellow and pink COC form copies shall then be matched and filed to complete the COC procedure.

The COC form shall include the following information:

- Contractor name/sampler name(s)
- Unique sample number and sample location
- Project number
- Date and time of sample collection
- Laboratory designation
- Sample matrix
- Sample container, preparation, and preservation information
- Condition of sample on receipt at the laboratory/out-of-spec reporting
- COC number
- Signature and date blocks for personnel relinquishing or receiving sample custody
- Space for additional comments
- Name and phone number of site contact person
- Analysis requested

A.6.3 Custody Seals

Custody seals are used to detect unauthorized handling of samples following collection, up to the time of analysis. Items such as gummed paper seals and custody tape may be used for this purpose. The seal shall be of the type that when attached to the container it will break when the container is opened. Seals shall be affixed to each sample container (for example each bottle or 12-gallon drum) before the samples leave the custody of the sampling personnel.

Shipping containers (such as coolers) shall also contain at least two custody seals to detect possible tampering. Clear tape should be placed over the seals to ensure that seals are not accidentally broken during shipment. A seal shall include the following information:

- Sampler's signature
- Date of collection

A.6.4 Tampering of Sampling Containers

If, at any time after samples have been secured, custody seals are identified as having been tampered with, this procedure shall be followed to ensure that sample integrity has not been compromised.

- Check with all personnel having access to sample coolers to verify possible inadvertent tampering.
- Check every sample container for any signs of tampering, such as loose lids, foreign objects in containers, broken or leaking containers.
- Check to ensure adequate and appropriate packaging.
- Document all findings of the incident in the sample manager's Field Log.

If it is determined that malicious tampering of samples has occurred and/or it is believed that sample integrity has been compromised, the subcontractor shall immediately contact EG&G.

If it can be determined that sample integrity has not been compromised based on the above criteria, document findings in the sample manager's Field Log and proceed with standard operating procedures.

A.7 SAMPLE PACKING AND SHIPPING

Packing and shipping of samples shall be consistent with the Rocky Flats Plant ERM OPS FO.13 titled, Containerizing, Preserving, Handling, and Shipping of Soil and Water Samples (EG&G, 1991). Applicable sections from ERM OPS FO.13 (Sections 5.1, 5.2, and 6.5) are addressed below:

A.7.1 Equipment List

The equipment and materials shown are the minimum that may be needed to ensure that proper procedures are followed for sample handling, packaging, and shipping.

- DOT-34 drums
- Sample containers/bottles
- Coolers
- Sample labels
- COC forms
- Decontamination equipment²
- Preservatives
- Baggies for containers
- Bubble wrap
- Vermiculite or equivalent

²Decontamination equipment and procedures are thoroughly discussed in the General Equipment Decontamination EMD OPS FO.13 (EG&G, 1991).

- Strapping and clear tape
- Custody seals
- Garbage bags
- Metal paint cans³

A.7.2 Department/Office Contact List

EG&G, or its designee, is responsible for obtaining the appropriate documentation for radiation (RAD) screening, and monitoring of all field samples for shipment off site (ERM OPS F0.18, Environmental Sample Radioactivity Content Screening) (EG&G, 1991).

The following departments will need to be contacted before sample shipment.

- **Construction Management Coordinator**—To obtain property passes for shipment of materials off site
- **Radiation Site Survey Office**—For radiation monitoring and clearance for the off site shipment of coolers
- **Onsite General Laboratories**—For radiological screening and categorization of field samples

A.7.3 Packaging and Shipping

Prior to commencement of field activities, the estimated levels of chemical and/or radiological contaminants shall be determined from known historical data for all matrices to be sampled by

³Large enough to accommodate sample containers.

EG&G or its designee. (ERM OPS F0.18, Environmental Sample Radioactivity Content Screening) (EG&G, 1991). Three levels of contaminant concentrations are defined as follows:

- **Low-Concentration Samples**—The contaminant of highest concern is present at less than 10 parts per million (ppm). Examples include background environmental samples.
- **Medium-Concentration Samples**—The contaminant of highest concern is present at a level greater than 10 ppm and less than 15 percent (150,000 ppm). Examples include material that is obviously weathered.
- **High-Concentration Samples**—At least one contaminant is present at a level greater than 15 percent. Samples from drums and tanks are assumed to be high concentration unless information indicates otherwise.

RAD screening of field samples shall be performed by EG&G at the Onsite General Laboratory. The RAD screening procedures determine which laboratory receives samples based on results of greater than (GT) or less than (LT) 50 picocuries/liter (pCi/L) for water samples. The RAD screening procedures also enable the subcontractor to follow applicable DOT guidelines for shipment of these environmental samples.

All sample containers will have been decontaminated and bagged in the field. Upon receipt and verification of sample containers and COC forms, the following steps shall be taken:

- The designated laboratory will be notified prior to shipment if samples collected in the field are suspected of containing any other substance for which the laboratory personnel should take additional safety precautions.
- Contact the Radiation Site Survey Office so that all containers to be shipped off site can be radiologically cleared.

- Obtain Property Passes signed by the Construction Management Coordinator and the Radiation Site Survey Officer so that coolers may be shipped off site.
- Line sample cooler with a large plastic bag.
- Place approximately 3 inches of vermiculite in the bottom of the cooler.
- Wrap glass containers in bubble pack.
- Verify that all samples requiring screening have reported estimated radiological activity levels.
- Place bagged and wrapped sample containers upright in the cooler with approximately 1 inch between them.
- Fill the cooler approximately three-quarters full of vermiculite, making sure that sample containers are securely packed.
- Fill the cooler with vermiculite.
- Seal the signed COC forms in a plastic bag and tape them to the underside of the lid of the cooler.
- Tape the drain of the cooler shut.
- Wrap strapping tape around the cooler in two locations to secure the lid.
- Place the air bill on top of the cooler. If more than one cooler is sent to the same laboratory, an address label and a manifest label are needed.

- Place "This Side Up" labels on all four sides and "Fragile" labels on the top and two sides of the cooler.
- Place an "Environmental Samples" label on top of cooler. For coolers over 75 pounds, an additional "Heavy Weight" label is required in the top, upper left corner of the cooler.
- Place signed and dated COC seals in two locations to seal the cooler lid so that tampering will be evident.

The following steps shall be taken for samples estimated to contain medium and/or high level concentrations:

- Enclose all sample containers in clear plastic bags.
- Pack all medium and high level water and soil samples in metal paint cans.
- Label paint cans with sample number of sample contained inside.
- Surround contents of can with non-combustible, absorbent packing material.
- Pack sealed paint cans or plastic-enclosed sample bottles in shipment container.
- Use a metal ice chest for shipment (do *not* use cardboard or styrofoam containers to ship samples).
- Surround contents with non-combustible, absorbent packing material (do *not* use earth or ice packing materials).
- Tape paper work in plastic bags under cooler lid.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plan for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix A

Revision: 1

Page: 21 of 21

Effective Date:

Organization: ERT

Non-Safety Related

Final Draft

- Close cooler and seal with custody seals.

Sample coolers may be received by courier at a predetermined area at the Rocky Flats Plant. If arrangement cannot be made, a company vehicle is required to deliver sample coolers to the laboratory and/or courier office.

A.7.4 Air Bills and Bills of Lading

If samples are sent by mail, the package shall be registered with return receipt requested. If sent by common carrier, a bill of lading or air bill shall be used. Freight bills, Postal Service receipts, and bills of lading shall be retained as part of the field files.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix B

Revision: 2

Page: 1 of 24

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

Approved By:

TITLE: Appendix B,
Sample Health and Safety Plan

Name _____ (Date) / / _____

APPENDIX B. SAMPLE HEALTH AND SAFETY PLAN

The following section is a sample of the health and safety plan for the treatability study. When the laboratory contractor is selected, this contractor will develop a detailed site-specific health and safety plan for the work to be performed.

HEALTH AND SAFETY PLAN

This health and safety plan (HSP) is an example HSP. A HSP will be kept onsite during field activities and will be reviewed and updated as necessary.

1.0 PROJECT INFORMATION AND DESCRIPTION

CLIENT OR OWNER:

PROJECT NO:

PROJECT MANAGER:

OFFICE:

SITE NAME: Rocky Flats Plant

SITE ADDRESS: Golden, CO

DATE HEALTH AND SAFETY PLAN PREPARED:

DATE(S) OF INITIAL VISIT:

DATE(S) OF SITE WORK:

SITE ACCESS:

LOCATION:

The Rocky Flats Plant (RFP) site is located in northern Jefferson County approximately 16 miles northwest of Denver. It is comprised of 6,550 acres of federally owned land. Major administrative and manufacturing buildings are located within RFP security area of 400 acres. The remaining 6,150 acres comprise the buffer zone surrounding RFP complex.

SITE OPERATIONS:

The RFP is a government owned, contractor-operated facility, which is part of the nationwide nuclear weapons production complex. EG&G Rocky Flats, Inc. became the prime contractor at RFP on January 1, 1990, and is the existing contractor to date. RFP fabricates nuclear weapon components from plutonium, uranium, and other nonradioactive materials (principally beryllium and stainless steel).

THIS PAGE RESERVED FOR SITE MAP

**NOTE LOCATIONS OF SUPPORT, DECONTAMINATION, AND EXCLUSION ZONES;
SITE TELEPHONE; FIRST AID STATION**

2.0 PROJECT ORGANIZATION AND TASKS TO BE PERFORMED UNDER THIS PLAN

2.1 PROJECT ORGANIZATION

2.2 DESCRIPTION OF TASKS

The treatability study objective is to investigate bench scale testing of ion exchange and adsorption processes to remove metals and radionuclides from surface and groundwater at Rocky Flats Plant (RFP) site. Groundwater samples and surface water samples will be collected. No new wells will be drilled.

Bench scale testing will be conducted in an onsite laboratory. The following techniques would be tested for the treatability studies:

To be developed

3.0 HAZARD EVALUATION AND CONTROL

3.1 HEAT AND COLD STRESS

3.1.1 GUIDELINES FOR WORKING IN TEMPERATURE EXTREMES WHILE WEARING PERSONAL PROTECTIVE EQUIPMENT (PPE)

Temperature	Work Cycle	Rest Cycle	Control Measures
<32° F or <55° F & raining	2 hrs	15 min	Review cold stress in safety meeting. Rest in a warm area. Drink at least 8 ounces of warm non-caffeinated, non-alcoholic beverage at each rest break. Schedule a mid-day lunch break of at least 30 minutes in a warm area to begin not later than 5 hours after startup.
72° to 77° F	2 hrs	5 min	Review heat stress in safety meeting. Take resting pulse rate before beginning work. Drink 8 ounces of cool water before beginning work, and 4 ounces at rest break. Have ice available.
77° to 82° F	2 hrs	5 min	As above, but seated rest break. Monitor pulse rate. (See below.)
82° to 87° F	60 min	15 min	As above, but rest area to be shaded.
87° to 90° F	30 min	15 min	As above. Try to provide a shaded work area.
>90° F	15 min	15 min	As above. Provide a shaded area with seats in the work area for team members to use as needed. Try to reschedule work to avoid mid-day heat.

PULSE CRITERIA. Take resting radial (wrist) pulse at start of work day; record it. Measure radial pulse for 30 seconds as rest period begins. Pulse not to exceed 110 beats per minute (bpm), or 20 bpm above resting pulse. If pulse exceeds this criteria, reduce work load and/or shorten the work cycle by one third, and observe for signs of heat stress. No team member is to return to work until his/her pulse has returned to <110 bpm, or resting pulse +20 bpm.

3.1.2 SYMPTOMS AND TREATMENT OF HEAT AND COLD STRESS

Heat Stroke	Heat Exhaustion	Frostbite	Hypothermia
Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high body temperature.	Pale, clammy, moist skin; profuse sweating; weakness; normal temperature; headache; dizzy; vomiting.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Cool victim rapidly by soaking in cool (not cold) water. Get medical attention immediately!!	Remove victim to a cool, air conditioned place. Loosen clothing, place in head low position. Have victim drink cool (not cold) water.	Remove victim to a warm place. Rewarm area quickly in warm (not hot) water. Have victim drink warm fluids--not coffee or alcohol. Do not break any blisters. Elevate the injured area and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids--not coffee or alcohol. Get medical attention.

3.2 PHYSICAL (SAFETY) HAZARDS AND CONTROLS (REFERENCE STANDARD OF PRACTICE (SOP))	
Hazard	Engineering or Administrative Controls
Flying debris/objects	Provide shielding and PPE.
Noise > 85 dBA	Noise protection and monitoring required.
Steep terrain/unstable surface	Brace and shore equipment.
Build-up of explosive gases	Provide 20 lb A,B,C fire extinguisher and ventilation.
Build-up of static electricity	No spark sources within 50 feet of an excavation, heavy equipment, or UST removal. Ground as appropriate.
Gas cylinders	Make certain gas cylinders are properly anchored and chained. Keep cylinders away from ignition sources.
High pressure hose rupture	Check to see that fitting and pressurized lines are in good repair before using.
Electrical shock	Make certain third wire is properly grounded. Do not work on electrical wiring unless qualified to do so.
Suspended loads	Work not permitted under suspended loads.
Moving vehicles	Back-up alarm required for heavy equipment. Observer remains in contact with operator and signals safe back-up. Personnel to remain outside of turning radius.
Overhead electrical wires	Heavy equipment (e.g. drill rig) to remain at least 15 feet from overhead powerline for powerlines of 50 kV or less. For each Kv > 50 increase distance 1/2 foot.
Buried utilities, drums, tanks, and so forth.	Locate buried utilities, drums, tanks, etc. prior to digging or drilling and mark location.
Slip, trip, fall hazards due to muddy work areas	Use wood pallets or similar devices in muddy work areas.
Back injury	Use proper lifting techniques, or provide mechanical lifting aids.
Confined space entry	Permit and safety plan required.
Trenches/excavations	Make certain trench meets OSHA standard before entering. All excavations > 5 feet deep must be sloped or shored. Excavations > 4 feet deep must have a ladder every 25 feet. If not entering trench, remain 2 feet from edge of trench at all times.
Protruding objects	Flag visible objects.

3.3 TICK BITES, LYME DISEASE, AND ROCKY MOUNTAIN SPOTTED FEVER (RMSF)

Check often for tick bites. If bitten, carefully remove tick with tweezers, making certain to remove pincers, being careful not to crush the tick. After removing the tick, wash your hands. Disinfect area, and dress. If the tick resists or cannot be completely removed, seek medical attention.

Look for symptoms of lyme disease or RMSF. Lyme: rash that looks like a "bull's-eye", with small welt in center, several days to weeks after tick bite. RMSF: Rash comprising red spots under skin, 3 to 10 days after tick bite. For both, chills, fever, headache, fatigue, stiff neck, bone pain. If symptoms appear, seek medical attention.

3.4 RADIOLOGICAL HAZARDS AND CONTROLS

Exposure to ionizing radiation can cause cancer. However, recognizing the risks from radiation, recommendations for working with radioactivity and exposures to members of the public have been issued by the International Commission on Radiological Protection (ICRP) and the U.S. National Council on Radiation Protection and Measurements (NCRP). Furthermore, these recommendations have been promulgated into standards and regulations by the EPA, the U.S. Nuclear Regulatory Commission (Chapter 10 of the Code of Federal Regulations), and the Occupational Safety and Health Administration (OSHA; Chapter 29 of the Code of Federal Regulations). For work related to DOE sites, the DOE has issued Orders providing criteria for protection of health and safety and the environment. The basis of the recommendations on radiation by the ICRP and NCRP is to minimize radiation exposures and to develop criteria to ensure that the risks to radiation workers are equal to or less than those in the safety industries. The general basis for the criteria for radiation exposures to the general population is a factor of 10 or more reduction below occupational exposures, plus ensuring that the risk from the exposures is less than the risks to which people are exposed to in normal life (ICRP 26 and NCRP 91).

3.5 HAZARDS POSED BY CHEMICALS BROUGHT ONSITE

The Project Manager is to request Material Safety Data Sheets (MSDSs) from the client, or contractors and subcontractors for chemicals that employees are potentially exposed to.

Chemical	Location
To be developed	Treatability Laboratory Treatability Laboratory Treatability Laboratory Treatability Laboratory Treatability Laboratory Treatability Laboratory Treatability Laboratory

3.6 OCCUPATION EXPOSURE TO HAZARDOUS CHEMICALS IN LABORATORIES

A laboratory chemical hygiene program will be established according to OSHA 29 CFR 1910.1450.

7

3.7 KNOWN CONTAMINANTS OF CONCERN					
Contaminant	Location and Highest Concentration (solid media: mg/kg or liquid media: ug/l)	PEL, REL, or TLV (ppm)	IDLH (ppm)	Symptoms and Effects of Exposure	PIP
Aluminum					
Arsenic					
Barium					
Beryllium					
Cadmium					
Chromium					
Iron					
Lead					
Manganese					
Mercury					
Nickel					
Selenium					
Plutonium					
Radium					
Uranium					

Note 1: Lower value of PEL, REL, or TLV listed. Note 4: Location refers to physical location. Abbreviations specify media:
 Note 2: NL = no limit found in reference materials. A (AIR) D (DRUMS) F (FLYASH) GW (GROUNDWATER) L (LAGOON) TK (TANK)
 Note 3: PIP = photoionization potential S (SOIL) SL (SLUDGE) SW (SURFACE WATER)

3.8 POTENTIAL ROUTES OF EXPOSURE		
DERMAL: All	INHALATION: All	OTHER: Puncture wound and ingestion; all

4.0 PERSONNEL

4.1 EMPLOYEES MEDICAL AND TRAINING REQUIREMENTS

Personnel must meet the medical surveillance, 40-hour initial training, 3-day on-the-job experience, and 8-hour annual refresher training requirements of OSHA 29CFR1910.120. Copies of training and medical certifications will be kept by the project health and safety officer. Employees designated "SSC" have received 8 hours of supervisor and 8 hours of instrument training and can serve as site safety coordinator (SSC) for the level of protection indicated. There must be one SSC present during any task performed in exclusion or decontamination zones with the potential for exposure to safety and health hazards. Employees designated "FA-CPR" are currently certified by the American Red Cross, or equivalent, in first aid and CPR. There must be one FA-CPR designated employee present during any task performed in exclusion or decontamination zones with the potential for exposure to safety and health hazards. The "buddy system" requirements of OSHA 29CFR1910.120 are to be met at all times.

Employee Name	Office	Responsibility	SSC/FA-CPR
		Field Team Leader	
		Site Safety Coordinator	Level () SSC; FA-CPR

4.2 HEALTH AND SAFETY AND FIELD TEAM CHAIN OF COMMAND AND PROCEDURES

4.2.1 CLIENT

4.2.2 CONTRACTOR

4.2.3 SUBCONTRACTOR

5.0 PERSONAL PROTECTIVE EQUIPMENT (PPE) SPECIFICATION ¹ (REFERENCE STANDARD OF PRACTICE)							
Task	Level	Body	Foot	Head ²	Eye	Hand	Respirator
Groundwater and surface water sampling	D	Cotton coveralls on tyveks	Neoprene steel-toed boots	Hardhat	Safety glasses and side shields, splashproof goggles	Depends on contaminants	None required
Laboratory analysis	D	Laboratory coat or rubber apron	Street shoes		Splashproof goggles	Latex gloves	None required
Groundwater and surface water sampling	C	Tyveks or saranex or PVC-coated coveralls	Neoprene steel-toed boots with latex covers	Hardhat	Safety glasses with side shields or splashproof goggles	Depends on contaminants	APR, full face, MSA Ultratwin or equivalent, cartridges:
Groundwater and surface water sampling	B	Saranex coveralls or PVC-coated coveralls	Neoprene steel-toed boots with latex covers	Hardhat	Safety glasses with side shield or splashproof goggles	Depends on contaminants	Positive pressure demand SCBA: MSA Ultralite or equivalent
Note 1: Modifications: Note 2: The SSC shall specify hardhat areas.							

6

5.1 REASONS TO UPGRADE OR DOWNGRADE LEVEL OF PROTECTION	
Upgrade	Downgrade
<ul style="list-style-type: none"> Request of individual performing task. Change in work task that will increase contact or potential contact with hazardous materials. Occurrence or likely occurrence of gas or vapor emission. Known or suspected presence of dermal hazards. Instrument action levels (Section 6.0) exceeded. 	<ul style="list-style-type: none"> New information indicating that situation is less hazardous than originally thought. Change in site conditions that decreases the hazard. Change in work task that will reduce contact with hazardous materials.

6.0 AIR MONITORING EQUIPMENT SPECIFICATION (REFERENCE CH2M HILL SOP HS-06)

Instrument	Tasks	Action Levels		Frequency	Calibration
Photoionization Detector (PID):	Groundwater and surface water sampling	0 to 1 ppm ^{ab} 1 to 5 ppm ^{ab} 5 to 50 ppm ^{ab} > than 50 ppm ^{ab}	Level D Level C Level B Stop work; re-evaluate	Prior to purging well	Daily
Flame Ionization Detector (FID): OVA-128	Groundwater and surface water sampling	0 to 1 ppm ^{ab} 1 to 5 ppm ^{ab} 5 to 50 ppm ^{ab} > than 50 ppm ^{ab}	Level D Level C Level B Stop work; re-evaluate	Prior to purging well	Daily
Radiation Meter: Alpha Scintillation Detector	Groundwater and surface water sampling and in treatability study laboratory	Bckgrnd > 3 x Bckgrnd > 2 mR/hr	Continue work Consult RHM ⁶ Establish REZ ⁷	Prior to purging well as needed in treatability laboratory	Daily

Note 1: expl = explosion Note 2: pot = potential Note 3: def = deficient Note 4: ab = above background
 Note 5: N/A = not applicable Note 6: RHM = Radiation Health Manager Note 7: REZ = radiation exclusion zone

6.1 CALIBRATION SPECIFICATION

Instrument	Gas	Span	Reading	Method
PID: HNU, 10.2 ev probe	100 ppm isobutylene	9.8 ± 2.0	55 ppm	1.5 l/m reg T-tubing 0.25 l/m reg direct tubing
PID: HNU, 11.7 ev probe	100 ppm isobutylene	5.0 ± 2.0	68 ppm	1.5 l/m reg T-tubing 0.25 l/m reg direct tubing
FID: OVA-128	100 ppm methane	3.0 ± 1.5	100 ppm	1.5 l/m reg T-tubing

6.2 RADIOLOGICAL MONITORING EQUIPMENT AND PROCEDURES

Radiation Exposure:

Radiation exposure levels will be continuously monitored with portable instrumentation. Depending on the site, such instrumentation may include a simple personal monitor such as a Victoreen "Mini-Rad," ranging to more sophisticated portable G.M. or scintillation radiation detector instruments. Choice of instrumentation will be based on the site hazard evaluation and will be made after consultation with the company Radiation Health Officer (RHO).

Personnel Monitoring (External and Internal Dosimetry):

Personnel will wear thermoluminescent dosimeters (TLDs) for measurement of external radiation dose. In addition, self-reading dosimeters (SRDs) are required for work in radiation areas (areas where the exposure rate is greater than 2.5 mR/hr). TLDs will be processed on at least a quarterly basis.

Personnel who work in radiologically controlled areas will participate in a routine bioassay (internal dosimetry) program. This program will include baseline sampling to determine if previous uptakes of radioactive material have occurred, as well as routine bioassay sampling during fieldwork to detect any uptake of radioactive material. The scope of the bioassay program will be site-specific and must be determined in advance with the assistance of the company RHO.

Posting:

Areas where radioactive materials are present and/or elevated radiation fields may be present, must be posted as a Controlled Area at a minimum. When exposure rates reach 2.5 mR/hr or greater, the area must be posted as a "Radiation Area" at a minimum.

Contamination Control:

Samples taken in a radiologically controlled area (or at a site where radioactive materials may be present) will be surveyed with a G.M. pancake detector to determine gross beta/gamma contamination levels, and with an alpha scintillation detector if alpha contamination is suspected. Instruments or equipment used for well data or sample collection and analysis will be surveyed with a G.M. pancake detector as they are withdrawn from the well or borehole. Intermittent checks for alpha contamination will be made if alpha contamination is a possibility.

Personnel working in a radiologically controlled area must monitor periodically (at a minimum between samples, at breaks, and prior to exit from the site) for personal contamination. Proper techniques for checking for personal contamination shall be used. Limits for equipment are listed in Table 1.

Radiation Work Permits:

A Radiation Work Permit (RWP) is required in advance for work for which any of the following conditions are anticipated or possible:

- When an individual may receive a radiation dose in excess of 20 mrem to the total body or 300 mrem to the extremities during the work shift.
- When an individual may be exposed to airborne concentrations of radioactive material in excess of the 40-hr week guide for that material (Derived Air Concentration [DAC] or Maximum Permissible Concentration [MPC]).
- If radiologically controlled area posting is required to control the spread of known or suspected contamination.
- When intrusive characterization efforts may encounter radioactive contaminants of unknown types and/or concentrations.

Health Physics Coverage:

Health physics technicians are assigned monitoring responsibilities for locations with known radioactive contamination or radiation exposure rates greater than background. These technicians are responsible for determining natural background radiation exposure levels in areas known to be free of contamination, delineating areas of elevated radiation exposure and/or contamination, and monitoring personnel and equipment for radiation exposure and contamination.

Action Levels—External Radiation Exposure:

- Background to 2.5 mR/hr—continue routine operations.
- 2.5 mR/hour to 10 mR/hr—alert level; recheck for proper operation of radiation monitoring equipment, monitor radiation level every 10 minutes; take special care to minimize the possibility of inhalation or ingestion of related materials. Notify the Project Manager and the PGDP staff. If the area is outside of posted radiation areas, determine the boundary for the area above 2.5 mR/hr and mark and post it as a radiation area as specified in DOE 5480.11 and the CH2M HILL RSP manual. An RWP is required for work in a radiation area. If an RWP has not been approved in advance, work must stop until an RWP is initiated and approved.
- Above 10 mR/hr—provide for orderly shutdown of sampling or monitoring operations without sacrifice of program integrity. Determine area of radiation readings above 2.5 mR/hr and post it. Notify Project Manager and the PGDP staff, and do not reenter area until plan is amended.
- Above 20 mR/hour—provide for orderly shutdown of sampling and monitoring activities and evacuate area as quickly as possible. Notify Project Manager and PGDP staff. Working from outside the area, determine the boundary for the area above 2.5 mR/hr and mark and post it.
- In accordance with DOE and NRC regulations, if project work activities result in radiation levels in any area outside of the site such that a major portion of a person's body could be exposed to a dose of 5 mrem over 1 hour or 100 mrem over a period 5 consecutive days, the area will be posted as a radiation area and secured to minimize the potential for radiation exposure to members of the public.

Action Levels—Surface Contamination:

DOE Order 5480.11 specifies radiation levels of surface contamination for uncontrolled release of materials. The levels are the same as those in U.S. NRC Regulatory Guide 1.86 and American National Standards Institute, Inc. (ANSI) draft Standard N13.12. Surveys of material or equipment for unrestricted release will be conducted using RSP Procedure 7.0, "Evaluation of Surface Contamination on Articles to be Released for Unrestricted Use." In most cases, information on the isotopic breakdown of contamination will not be available because clearance surveys will be performed using gross α and gross β/γ counting techniques. The release criteria species in Table 1 are therefore set at the most restrictive limits recommended by DOE and NRC for unknown isotopes.

Table 1 Recommended Maximum Contamination Guide for Unrestricted Release of Equipment or Material			
Direct Survey		Transferrable (Smear Survey)	
Alpha	Beta Gamma	Alpha	Beta Gamma
DPM/100 cm ²		DPM/100 cm ²	
200	1,000	20	200 ^a
^a Except I-125, I-129, and Ac-227 for which the guide is 20 DPM/100 cm ² .			
Note: No 100 cm ² area to average greater than this value.			

These criteria for surface contamination will be used for assessing surface contamination of sampling equipment and boots and clothing. The control of surface contamination is important for health and safety and is also important to prevent contamination of samples. Fixed and removable contamination levels should be determined using the most sensitive instrumentation available.

Portable field instrumentation (i.e., thin-end window GM detectors for beta-gamma, and alpha scintillation detectors) should be used at a minimum during sampling operations to determine gross fixed plus removable contamination levels.

Removable contamination levels should be determined using low contamination background smear counting systems. Removable surveys should be conducted periodically (at least twice each day) during field sampling operations.

RESIDUALS HANDLING:

Precipitate and used filters from the treatability studies laboratory may contain residual radionuclides. This section will address proper handling techniques.

7.0 DECONTAMINATION SPECIFICATION (REFERENCE STANDARDS OF PRACTICE)

Personnel	Sample Equipment	Heavy Equipment
• Boot wash/rinse	• Wash/rinse equipment	• Power wash
• Glove wash/rinse	• Solvent rinse equipment	• Steam clean
• Outer glove removal	• Solvent disposal method:	• Water disposal method:
• Body suit removal		
• Inner glove removal		
• Respirator removal		
• Hand wash/rinse		
• Face wash/rinse		
• Shower ASAP		
• PPE disposal method:		
• Water disposal method:		

7.1 DIAGRAM OF PERSONNEL DECONTAMINATION LINE

Blank area for the diagram of personnel decontamination line.

8.0 SPILL CONTAINMENT PROCEDURES

Blank area for spill containment procedures.

9.0 WORK PROCEDURES

9.1 WORK PRACTICES

- No spark sources within exclusion or decontamination zones or laboratory.
- Avoid visibly contaminated areas.
- No eating, drinking, or smoking in contaminated areas, or exclusion or decontamination zones.
- SSC to establish areas for eating, drinking, smoking.
- No contact lenses in exclusion or decontamination zones.
- No facial hair that would interfere with respirator fit if Level C or B is anticipated.
- Site work will be performed during daylight hours whenever possible. Any work conducted during hours of darkness will require enough illumination intensity "to read a newspaper without difficulty."

9.2 SITE CONTROL MEASURES

- Site safety coordinator (SSC) to conduct site safety briefing (see below) before starting field activities, or as tasks and site conditions change.
- SSC records safety briefing attendance in logbook, and documents topics discussed.
- Post OSHA job site poster in a central and conspicuous location at the site.
- Determine wind direction.
- Establish work zones: support, decontamination, and exclusion zones, and delineate work zones with flagging or cones as appropriate. Support zone upwind of site.
- Establish decontamination procedures, including respirator decontamination procedures, and test.
- Utilize access control at the entry and exit from each work zone.
- Chemicals to be stored in proper containers.
- MSDSs are available for onsite chemicals employees exposed to.
- Establish onsite communications. These should consist of:
 - Line of sight/hand signals
 - Air horn
 - Two-way radio or cellular phone if available
- Establish emergency signals. For example:
 - Grasping throat with hand--EMERGENCY--HELP ME
 - Grasping buddy wrist--LEAVE AREA NOW
 - Thumbs up--OK, UNDERSTOOD
 - Two short blasts on air horn--ALL CLEAR
 - Continuous air horn--EMERGENCY--EVACUATE
- Establish offsite communications.
- Establish "buddy" system.
- Establish procedures for disposal of material generated onsite.
- Initial air monitoring conducted by SSC in appropriate level of protection.
- SSC to conduct periodic inspections of work practices to determine effectiveness of this plan. Deficiencies to be noted and corrected.
- Site safety briefing topics: general discussion of health and safety plan; site specific hazards; location of work zones; PPE requirements; equipment; special procedures; emergencies.
- Laboratory analyses are to be conducted in a certified laboratory safety ventilation hood.

10.0 EMERGENCY RESPONSE PLAN (REFERENCE STANDARD OR PRACTICE)

10.1 PRE-EMERGENCY PLANNING

The SSC performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with the facility and local emergency service providers as appropriate.

- Locate nearest telephone to the site and inspect onsite communications.
- Locate chemical, safety, radiological, biological hazards.
- Confirm and post emergency telephone numbers and route to hospital.
- Post site map marked with location of emergency equipment and supplies.
- Review emergency response plan for applicability to any changed site conditions, alterations in onsite operations, or personnel availability.
- Evaluate capabilities of local response teams.
- Where appropriate and acceptable to the client, inform emergency room/ambulance service and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment and supplies.
- Review emergency procedures for personnel injury, exposures, fires, explosions, chemical and vapor releases with field personnel.
- Locate onsite emergency equipment and supplies of clean water.
- Verify local emergency contacts, hospital routes, evacuation routes, and assembly points.
- Drive route to hospital.
- Review names of onsite personnel trained in first aid and CPR.
- Review notification procedures for contacting CH2M HILL's medical consultant and team member's occupational physician.
- Rehearse the emergency response plan once prior to site activities.
- Brief new workers on the emergency response plan.

10.2 EMERGENCY EQUIPMENT AND SUPPLIES

The SSC marks the locations of emergency equipment on the site map and posts the map in the support zone.

- 20 lb ABC fire extinguisher
- Industrial first aid kit
- Facility emergency equipment:
- Additional emergency equipment:

10.3 EMERGENCY MEDICAL TREATMENT	
<ul style="list-style-type: none"> • The SSC will assume charge during a medical emergency until the ambulance arrives, or the injured person is admitted to the emergency room. • Prevent further injury. • Initiate first aid and CPR. • Call the ambulance and hospital. • Determine if decontamination will make injury worse. Yes—seek medical treatment immediately. • Make certain that injured person is accompanied to emergency room. • Notify the Project Manager of the injury. • Notify the District or Regional Health and Safety Manager. • Notify the injured person's human resources department. • Prepare an incident report to the Site Health and Safety Officer. 	
10.4 EVACUATION	
<ul style="list-style-type: none"> • Evacuation routes will be designated by SSC prior to beginning of work. • Onsite and offsite assembly points will be designated prior to beginning of work. • Personnel will exit the exclusion zone and assemble at the onsite assembly point upon hearing the emergency signal for evacuation of the exclusion zone. • Personnel will assemble at the offsite point upon hearing the emergency signal for a site evacuation. • The SSC and a "buddy" will remain onsite after the site has been evacuated (if possible) to assist local responders and advise them of the nature and location of the incident. • SSC accounts for all personnel in the onsite assembly zone. • A person designated by the SSC (prior to work) will account for personnel at the offsite assembly area. • The SSC is to write up the incident as soon as possible after it occurs, and submit a report to the Corporate Director Health and Safety. 	
10.5 EVACUATION ROUTES AND ASSEMBLY POINTS	
10.6 EVACUATION SIGNALS	
Exclusion Zone	Site

11.0**EMERGENCY RESPONSE TELEPHONE NUMBERS****SITE ADDRESS:****Phone:****Police:
Address:****Phone: 911 (verify)****Fire:
Address:****Phone: 911 (verify)****Ambulance:
Address:****Phone: 911 (verify)****Water:****Phone:****Gas:****Phone:****Electric:****Phone:****Hospital:
Address:****Phone:****Route To Hospital: (Refer to map Page 20.)****11.1 GOVERNMENT AGENCIES INVOLVED IN PROJECT****Federal:****Phone:****State:****Phone:****Local:****Phone:**

THIS PAGE RESERVED FOR MAP OF ROUTE TO HOSPITAL

12.0 EMERGENCY CONTACTS	
Medical Consultant	Occupational Physician (Regional or Local)
Corporate Director Health and Safety Name: Phone:	Site Safety Coordinator (SSC) Name: Phone:
District Health and Safety Manager (DHSM) Name: Phone:	Regional Manager Name: Phone:
Regional Health and Safety Manager (RHSM) Name: Phone:	Project Manager Name: Phone:
Radiation Health Manager (RHM) Name: Phone:	Regional Human Resources Department Name: Phone:
Client	Corporate Human Resources Department Name: Phone: If an injury occurs, notify the injured person's personnel office as soon as possible after obtaining medical attention for the injured. Notification <u>MUST</u> be made within 24 hours of the injury.

13.0 PLAN APPROVAL

This site safety plan has been written for use by _____ claims no responsibility for its use by others, unless specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if these conditions change.

PLAN WRITTEN BY:

DATE:

PLAN APPROVED BY:

DATE:

13.1 PLAN AMENDMENTS

DATE: CHANGES MADE BY:

CHANGES TO PLAN:

APPROVED:

DATE:

13.2 PLAN AMENDMENTS

DATE: CHANGES MADE BY:

CHANGES TO PLAN:

APPROVED:

DATE:

14.0 ATTACHMENTS TO PLAN

Attachment 1: Employee signoff

Attachment 2: Form 533

Attachment 3: Applicable MSDSs

ATTACHMENT 2

**FORM 533
RECORD OF HAZARDOUS WASTE FIELD ACTIVITY**

SITE NAME:
SITE SAFETY COORDINATOR:
PROJECT NUMBER:
RECORD OF ACTIVITIES FOR (DATES):

EMPLOYEE NAME/NUMBER	TOTAL DAYS ONSITE	DAYS IN LEVEL B	DAYS IN LEVEL C	DAYS IN LEVEL D	DAYS AS SSC LEVEL B	DAYS AS SSC LEVEL C	DAYS AS SSC LEVEL D	ACTIVITIES PERFORMED

ATTACHMENT 3
APPLICABLE MSDSs

This attachment will be added to conform to site-specific requirements.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix C

Revision: 2

Page: 1 of 14

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

Approved By:

TITLE: Appendix C,
Quality Assurance Addendum for the Ion
Exchange Treatability Study Work Plan

_____/_____/_____
Name (Date)

APPENDIX C. QUALITY ASSURANCE ADDENDUM FOR THE ION EXCHANGE TREATABILITY STUDY WORK PLAN

This appendix consists of the Quality Assurance Addendum (QAA) for the IX Treatability Study Work Plan. This QAA supplements the "Rocky Flats Plant Sitewide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities" (QAPjP). (The IX TSWP refers to those sections of the Treatability Study Work Plans for Ion Exchange and Adsorption Process covering only the IX Process.)

The Rocky Flats Plant (RFP) Treatability Studies Plan (TSP) identified ion exchange as a candidate remediation technology to evaluate for the removal of metals and radionuclides in groundwater and surface water. The purpose of the IX Treatability Study Work Plan is to describe the testing procedures for screening selected IX media for their capability to remove metals and selected radionuclides from groundwater and surface water samples collected from the RFP. The purpose of this QAA is to establish the study-specific management and process quality controls that are applicable to the treatability tests described in the Treatability Study Work Plan for IX Processes.

The IX treatability tests will consist of bench-scale, multiple-column tests on selected resins and polymers to determine the relative effectiveness of the IX process. In order to select the most appropriate materials for removing each contaminant, operational characteristics of the resins, such as loading capacity, regeneration properties, and breakthrough characteristics will be investigated.

C.1 ORGANIZATION AND RESPONSIBILITIES

The overall organization of EG&G Rocky Flats and the Environmental Restoration (ER) Management Organization responsible for implementing the ER Program activities at the RFP is presented in Section 1.0 of the QAPjP. Functional responsibilities are also described in Section 1.0 of the QAPjP.

The project-specific organization for the IX treatability tests described in the IX Treatability Study Work Plan (TSWP) is presented in Figure C-1.

C.2 QUALITY ASSURANCE PROGRAM

The QAPjP was written to address QA controls and requirements for implementing ER Program activities, as required by the RFP Interagency Agreement (IAG). The content of the QAPjP was driven by Department of Energy (DOE) Order 5400.1, the RFP QA Manual (RF QAM), and the IAG. DOE 5400.1 and the RF QAM both require a QA program to be implemented based on American Society of Mechanical Engineers (ASME) NQA-1, "Quality Assurance Requirements for Nuclear Facilities." The IAG specifies development of a QAPjP in accordance with the Environmental Protection Agency (EPA) QAMS-005/80, "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans." The 18-element format of NQA-1 was selected as the basis for both the QAPjP and subsequent QAAs with the applicable elements of QAMS-005/80 incorporated where appropriate. Figure 2-1 of Section 2.0 of the QAPjP illustrates where the 16 QA elements of QAMS-005/80 are integrated into the QAPjP and also into this QAA. Section 2.0 of the QAPjP also identifies other DOE Orders and QA requirements documents to which the QAPjP and this QAA are responsive.

The quality assurance requirements addressed in the QAPjP are applicable to the IX treatability tests, unless specified otherwise in this QAA. Where sitewide administrative and process controls are applicable to IX tests, the applicable section of the QAPjP is referenced in this QAA. Study-specific quality administrative and process controls that are applicable to the IX treatability testing (that may not have been addressed on a sitewide basis in the QAPjP) are addressed in this QAA. Many

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7/2/93
2/24/93

CHECKED BY *J. Stewart*
APPROVED BY *J. Stewart*

Douville
02/24/93

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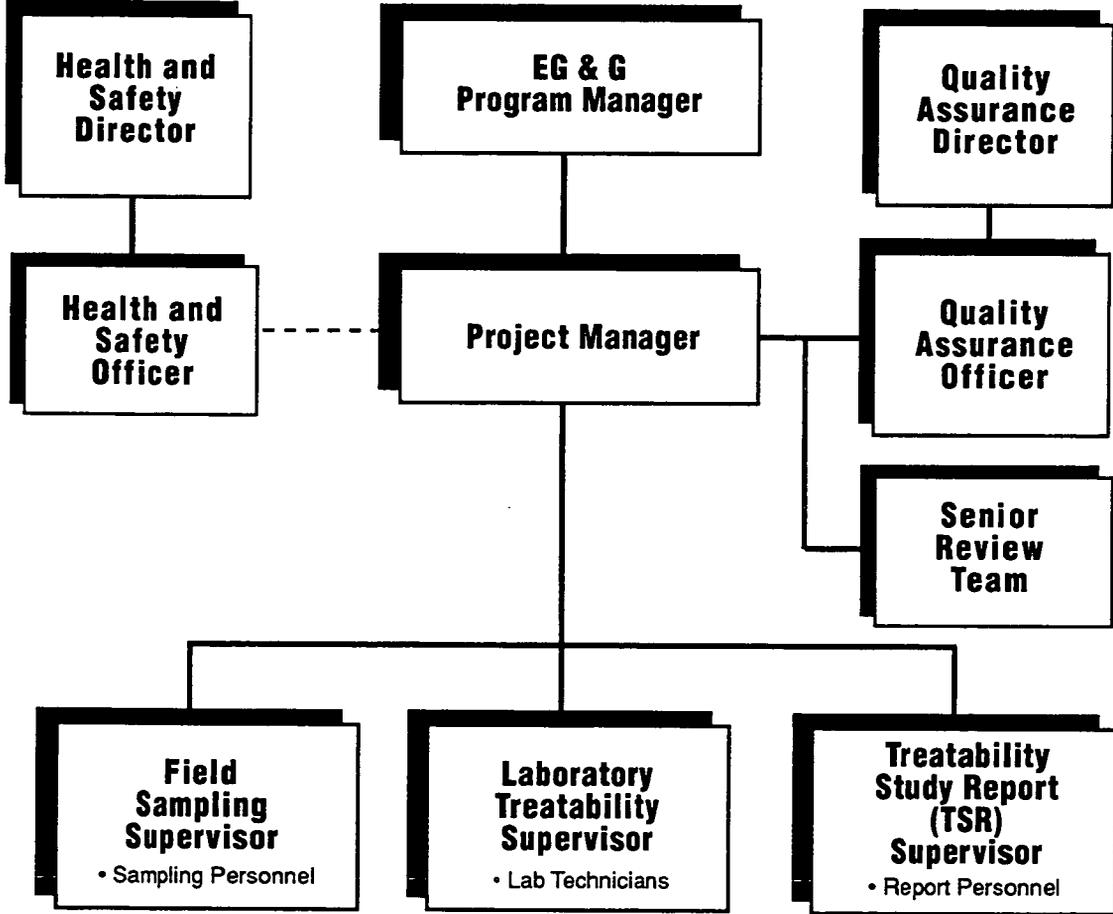


Figure C-1
MANAGEMENT ORGANIZATION
ROCKY FLATS ION EXCHANGE TSWP

of the quality process controls specific to the IX testing to be conducted are addressed in the IX TSWP and are referenced in this QAA.

C.2.1 Training

The minimum personnel qualification and training requirements that are applicable to EG&G and subcontractor staff for RFP ER Program activities are addressed in Section 2.0 of the QAPjP. All EG&G and subcontractor staff working on the IX treatability tests, including those collecting ground-water and surface water samples from the RFP, shall be trained in the procedures that are applicable to their assigned tasks. These procedures include the IX bench-scale testing procedures described in Section 6.0 of the TSWP, the EM Operating procedures referenced in Appendix A of the TSWP, and the laboratory analytical procedures that are applicable to the analytical methods referenced in Section 6.0. In addition to procedures training, EG&G and subcontractor personnel shall receive training on the applicable process control requirements of the QAPjP and the IX TSWP (including this QAA). Training may consist of formal classroom training, on-the-job training, briefings, or reading assignments. Training must be recorded, with verifiable documentation of training submitted to the EG&G Project Manager prior to implementing the IX sample collection and testing activities described in the IX TSWP.

EG&G and subcontractor personnel shall also be qualified to perform the tasks they have been assigned. Personnel qualifications must be documented, with documentation of qualification verified by the EG&G Project Manager in accordance with EM administrative procedure 3-21000-ADM-02.02, Personnel Qualifications.

C.2.2 Quality Assurance Reports to Management

A QA summary report will be prepared annually or at the conclusion of the IX treatability testing activities (whichever is more frequent) by the EG&G Environmental Quality Support Manager (EQSM). This report should include a summary of field operation and sampling oversight inspections, laboratory assessments, surveillance, and a report on data verification/validation results.

C.3 DESIGN CONTROL AND CONTROL OF SCIENTIFIC INVESTIGATIONS

C.3.1 Design Control

The IX TSWP describes the experimental design and contains the detailed testing procedures for the treatability study for the IX processes. The work plan also identifies the objectives of the treatability tests; specifies the sampling, testing, analysis, and data management requirements; identifies applicable field operations and sampling procedures to provide controls for the sampling process; and presents the methods to be used to evaluate and report the results of the multicolumn bench-scale tests. As such, the IX TSWP is considered the environmental investigation control plan for the IX treatment process evaluation.

C.3.2 Data Quality Objectives

The development of Data Quality Objectives (DQOs) for the IX treatability study was presented in Section 4.0 of the IX TSWP. The DQOs were established in general accordance with the 3-stage process described in EPA/540/G-87/003 (OSWER Directive 9335.0-7B), Data Quality Objectives for Remedial Response Activities and Appendix A of the QAPjP. Table 4-1 of the IX TSWP summarizes the data needs, the sample collection and analysis activities necessary to generate the type of data needed to evaluate the IX treatability tests, identifies the appropriate analytical levels for the contaminants of concern, and summarizes the data uses for the components of IX treatability study.

Data quality is typically measured in terms of precision, accuracy, representativeness, comparability, and completeness (also referred to as PARCC parameters). Precision, accuracy, and completeness are quantitative measures of data quality, while representativeness and comparability are qualitative statements that express the degree to which sample data represent actual conditions and describe the confidence of one data set to another. These parameters are defined in Appendix A of the QAPjP. Precision and accuracy objectives for analytical measurements of Target Analyte List metals, radionuclides of interest, and the water quality parameters are as specified in Appendix A of the QAPjP (these objectives consist of the historical measures of precision and accuracy for the method

of analysis, and ± 20 percent recovery and 20 percent relative percent difference for total dissolved solids for accuracy and precision respectively).

C.3.3 Sampling Locations and Sampling Procedures

Sampling associated with the IX treatability study consists of collecting groundwater and surface water samples for conducting the treatability tests (referred to as treatability study samples), influent and effluent water samples prior to and following the initial column screening tests (referred to in Table 4-1 of the IX TSWP as capability tests).

Tables A-1 and A-2 in Appendix A of the IX TSWP describes how sampling locations will be selected at the RFP for collecting the groundwater and surface water treatability study samples. subsection A.1.2 identifies the EM Operating Procedures that will be adhered to when collecting these treatability study samples.

The concentration of TAL metals, radionuclides, Chromium IV, and water quality parameters (which are identified in Table 4-2 of the IX TSWP) in groundwater and surface water from the sampling locations at the RFP will be determined prior to initial column testing (i.e., influent water) by collecting samples for analysis at the same time the treatability study samples are collected. Influent characterization samples will be collected in the same manner, from the same locations, at the same time as the groundwater and surface water samples are collected for testing (i.e., according to the EM OPS identified in subsection A.1.2). These samples will be screened for radioactivity levels in accordance with EM OPS 5-21000-OPS-FO.18, Environmental Radioactivity Content Screening, prior to shipment to the laboratory for analyses. Indicator parameters shall be measured in the field according to OPS identified in subsection A.1.2.

The concentration of TAL metals and radionuclides in column effluent will be determined for the initial screening tests by collecting samples for laboratory analysis as described in Step 7 of Section 6.4.2 of the IX TSWP. These samples will be collected by running the column effluent line into

samples bottles rather than the effluent tank. In addition to these samples, the pH of the effluent will be measured prior to and following collection of these samples.

The detailed IX column tests will be conducted such that breakthrough of various contaminants will occur during the course of testing. After a sufficient amount of composite raw water (RFP groundwater and surface water) is run through the column to achieve breakthrough, samples of the regenerant waste will be collected from the effluent line for analyses of TAL metals and radionuclides. In order to determine when breakthrough occurs, samples will be collected periodically during the column tests and screened at the testing laboratory for metal and radionuclides concentration by the testing contractor.

C.3.4 Analytical Procedures

Influent and effluent water samples and regenerate waste water samples that are sent to analytical laboratories for analyses of TAL metal and radionuclide concentrations will be analyzed according to EPA Contract Laboratory Program (CLP) methods referenced in Parts A and B of the RFP General Radiochemistry and Routine Analytical Services Protocol (GRRASP). The concentration of water quality parameters in initial test influent waters that are identified in Table 4-2 of the IX TSWP, shall be determined according to the analytical methods referenced in Table 44 of Part A of the GRRASP.

C.3.5 Equipment Decontamination

Sampling equipment that is used at more than one field location shall be decontaminated between sampling locations in accordance with OPS-FO.03, General Equipment Decontamination.

C.3.6 Quality Control

Quality control requirements for surface and groundwater samples collected for characterization of influent test water shall consist of collecting an equipment rinsate blank from at least one of the four sample locations for analysis of TAL metals and radionuclides and water quality parameters of

interest. At the discretion of the project manager, a duplicate influent characterization sample may be collected along with the influent characterization samples. Trip blanks are not required, since organics will not be analyzed for.

Quality control for analyzing effluent from the initial screening tests shall consist of collecting duplicate samples of effluent from each column test for analysis as specified in Step 7 of subsection 6.4.2 of the TSWP.

Laboratory analytical quality control (QC) requirements applicable to the IX treatability study are identified in Table 4-2 of the IX TSWP.

C.3.7 Quality Assurance Monitoring

To assure the overall quality of the IX treatability testing, EG&G may conduct field inspections of the surface and groundwater sampling process and surveillance of the column testing at the testing laboratory. Field inspections, if conducted, shall be performed in accordance with the requirements of Section 10.0 of the QAPjP. Surveillance of the column testing, if conducted, shall be performed in accordance with requirements of Section 18.0 of the QAPjP.

C.3.8 Data Reduction, Validation, and Reporting

Observational data from screening tests and analytical data from treatability influent and effluent characterization will be managed as specified in Section 7.0 of the IX TSWP. Analytical data will be evaluated to determine validity of the data in accordance with the data validation guidelines identified in Section 3.0 of the QAPjP. The treatability study results will be presented in a treatability study report prepared at the conclusion of the treatability study. The report will follow the format presented in EPA's Guidance for Conducting Treatability Studies Under CERCLA.

C.4 PROCUREMENT DOCUMENT CONTROL

Procurement documents for items and services, including services for conducting the IX treatability study and laboratory analysis of influent and effluent water samples, shall be prepared, handled, and controlled in accordance with the requirements and methods specified in Section 4.0 of the QAPjP.

C.5 INSTRUCTIONS, PROCEDURES, AND DRAWINGS

The IX TSWP describes the field sampling and laboratory testing activities to be performed. The IX TSWP will be reviewed and approved in accordance with the requirements for instructions, procedures, and drawings outlined in Section 5.0 of the QAPjP.

The EM OPS that are applicable for collection of surface and groundwater samples and management and handling of samples and field data are identified in Appendix A of the IX TSWP. The OPS identified have been approved in accordance with the requirements specified in Section 5.0 of the QAPjP. Any additional quality-affecting procedures proposed for use but not identified in here or in the IX TSWP (including Appendix A) will be developed and approved as required by Section 5.0 of the QAPjP prior to performing the affected activity.

Changes and variances to approved operating procedures and the IX TSWP shall be documented through preparation of Document Change Notices (DCNs), which will be prepared, reviewed, and approved in accordance with requirements specified in Section 5.0 of the QAPjP.

C.6 DOCUMENT CONTROL

The following documents will be controlled in accordance with Section 6.0 of the QAPjP:

- Treatability Study Work Plan for Ion Exchange Process.

- "Rocky Flats Plant Sitewide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities" (QAPjP).
- EM Operating Procedures (all operating procedures specified in the IX TSWP).

C.7 CONTROL OF PURCHASED ITEMS AND SERVICES

Subcontractors who provide services to support the IX treatability study will be selected and evaluated as outlined in Section 7.0 of the QAPjP. This includes preaward evaluation/audit of proposed subcontractors as well as periodic assessment of the acceptability of subcontractor performance during the program. Any items or materials that are purchased for use during the IX treatability study that have the potential of affecting the quality of the data should be inspected upon receipt.

C.8 IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA

IX treatability study samples and laboratory analytical samples shall be identified and controlled in accordance with Section 8.0 of the QAPjP. This includes identifying samples, establishing the chain-of-custody (COC) of samples, recording the information in COC forms, and handling, storing and shipping of samples in accordance with 5-21000-OPS-FO.13, Containerizing, Preserving, Handling, and Shipping Samples. An exception to the container requirements of FO.13 for the treatability study samples consists of collecting samples for shipment to the testing laboratory in 12-gallon plastic drums.

C.9 CONTROL OF PROCESSES

The overall processes of collecting and analyzing samples and conducting IX treatability study tests requires control. The processes are controlled by adhering to the IX TSWP and the sampling and analytical procedures identified therein.

C.10 INSPECTION

Inspection of field sampling activities shall be conducted in accordance with Section 10.0 of the QAPjP.

C.11 TEST CONTROL

The IX treatability testing process will be controlled by adhering to the experimental design and testing procedures described in Section 6.0 of the IX TSWP. Additional detailed testing procedures may be developed as additional knowledge of the specific characteristics of the treatability study water becomes available. All observations, parameter inputs (e.g., flow volumes, time, chemical additions), and parameter measurements (e.g., flow rate and pH) will be recorded in laboratory testing logbooks.

C.12 CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)

Laboratory equipment that is used in the IX treatability study will be identified in logbooks by model number and manufacturer's serial number, or suitable substitute identification number. Laboratory equipment will include a pH meter and peristaltic pump. The equipment will be used, calibrated, and maintained in accordance with the manufacturer's instructions. A file shall be maintained by the testing contractor that contains:

- Specific model and instrument serial number
- Operating instructions
- Routine preventative maintenance procedures, including a list of critical spare parts to be provided or made available

- Calibration methods, frequency, and description of the calibration solutions
- Standardization procedures (traceability to nationally recognized standards)
- Source of calibration standard solutions, as applicable

C.13 HANDLING, STORAGE, AND SHIPPING

IX treatability study and influent and effluent samples shall be packaged, transported, and stored in accordance with Appendix A of the IX TSWP and 5-21000-OPS-FO.13.

C.14 STATUS OF INSPECTION, TEST, AND OPERATIONS

The requirements for the identification of inspection, test, and operating status specified in Section 14.0 of the QAPjP do not apply to the IX treatability study.

C.15 CONTROL OF NONCONFORMANCES

The requirements for the identification, control, evaluation, and disposition of nonconforming items, samples, and data will be implemented as specified in Section 15.0 of the QAPjP. Nonconformances identified by the laboratory testing contractor shall be submitted to EG&G for processing as outlined in the QAPjP.

C.16 CORRECTIVE ACTION

The requirements for the identification, documentation, and verification of corrective actions for conditions adverse to quality will be implemented as outlined in Section 16.0 of the QAPjP. Conditions adverse to quality identified by the testing contractor shall be documented and submitted to EG&G for processing as outlined in the QAPjP.

C.17 QUALITY ASSURANCE RECORDS

QA records produced during implementation of the IX treatability study will be handled and managed in accordance with the requirements of Section 17.0 of the QAPjP and 3-21000-ADM-17.01, Records Management. QA records to be produced during this study include but are not limited to the following:

- Field sampling data forms from the sampling and operations OPS identified in Appendix A of the IX TSWP (field sampling records shall be submitted to the ER records custodian in accordance with OPS-FO.02, Field Document Control).
- Analytical laboratory data packages, which will include the information specified for data packages specified in Parts A and B of the GRRASP.
- IX treatability testing logbooks.
- Standard bench sheets, as applicable.
- Monthly progress reports.
- IX Treatability testing procedures.
- IX Treatability Study Report.

C.18 QUALITY VERIFICATION

The requirements for the verification of quality shall be implemented as specified previously in subsection C.3.7 of this appendix.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix C

Revision: 2

Page: 14 of 14

Effective Date: _____

Organization: ERT

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A Readiness Review shall be conducted by the EQSM prior to implementing the IX Treatability study (including prior to collecting treatability study surface and groundwater samples). The readiness review will determine if all activity prerequisites have been met that are required to begin work. The applicable requirements of the QAPjP, the IX TSWP (including Appendix A), and this QAA will be addressed.

C.19 SOFTWARE CONTROL

The requirements for the control of software are not applicable to the IX treatability study.

EG&G ROCKY FLATS PLANT
Treatability Studies Work Plan for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix D

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Page: 1 of 14

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Organization: ERT

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Final Draft

Approved By:

TITLE: Appendix D,
Quality Assurance Addendum to the
Adsorption Treatability Study Work Plan

Name

(Date)

APPENDIX D. QUALITY ASSURANCE ADDENDUM TO THE ADSORPTION TREATABILITY STUDY WORK PLAN

This appendix consists of the Quality Assurance Addendum (QAA) for the Treatability Study Work Plan for Adsorption Processes. This QAA supplements the "Rocky Flats Plant Sitewide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities" (QAPjP). (The Adsorption TSWP refers to those sections of the Treatability Study Work Plans for Ion Exchange and Adsorption Processes covering only the adsorption process.)

The Rocky Flats Plant (RFP) Treatability Studies Plan (TSP) identified adsorption as a candidate remediation technology to evaluate for the removal of metals and radionuclides in groundwater and surface water. The purpose of the Adsorption Treatability Study Work Plan is to describe the testing procedures for screening selected adsorption media for their capability to remove metals and selected radionuclides from groundwater and surface water samples collected from the RFP. The purpose of this QAA is to establish the study-specific management and process quality controls that are applicable to the treatability tests described in the Treatability Study Work Plan for Adsorption Processes.

The adsorption treatability tests will consist of bench-scale, multiple-column tests on selected adsorbents to determine the relative effectiveness of the process. In order to select the most appropriate materials for removing each contaminant, operational characteristics of the adsorbents, such as loading capacity, regeneration properties, and breakthrough characteristics will be investigated.

D.1 ORGANIZATION AND RESPONSIBILITIES

The overall organization of EG&G Rocky Flats and the Environmental Restoration (ER) Management Organization responsible for implementing the ER Program activities at the RFP is presented in Section 1.0 of the QAPjP. Functional responsibilities are also described in Section 1.0 of the QAPjP.

The project-specific organization for the adsorption treatability tests described in the Adsorption Treatability Study Work Plan (TSWP) are presented in Figure D-1.

D.2 QUALITY ASSURANCE PROGRAM

The QAPjP was written to address QA controls and requirements for implementing ER Program activities, as required by the RFP Interagency Agreement (IAG). The content of the QAPjP was driven by Department of Energy (DOE) Order 5400.1, the RFP QA Manual (RF QAM), and the IAG. DOE 5400.1 and the RF QAM both require a QA program to be implemented based on American Society of Mechanical Engineers (ASME) NQA-1, "Quality Assurance Requirements for Nuclear Facilities." The IAG specifies development of a QAPjP in accordance with the Environmental Protection Agency (EPA) QAMS-005/80, "Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans." The 18-element format of NQA-1 was selected as the basis for both the QAPjP and subsequent QAAs with the applicable elements of QAMS-005/80 incorporated where appropriate. Figure 2-1 of Section 2.0 of the QAPjP illustrates where the 16 QA elements of QAMS-005/80 are integrated into the QAPjP and also into this QAA. Section 2.0 of the QAPjP also identifies other DOE Orders and QA requirements documents to which the QAPjP and this QAA are responsive.

The quality assurance requirements addressed in the QAPjP are applicable to the adsorption treatability tests, unless specified otherwise in this QAA. Where sitewide administrative and process controls are applicable to adsorption tests, the applicable section of the QAPjP is referenced in this QAA. Study-specific quality administrative and process controls that are applicable to the adsorption treatability testing that may not have been addressed on a sitewide basis in the QAPjP are

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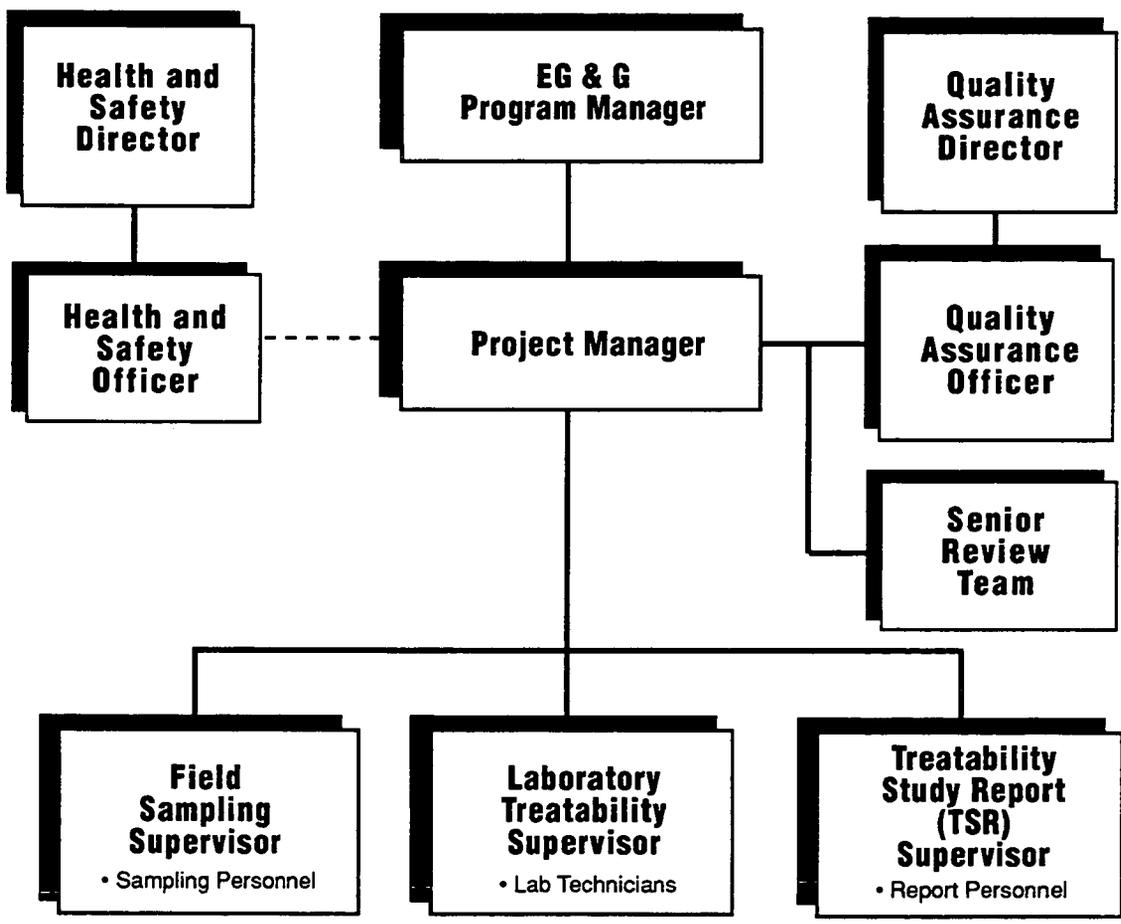


Figure D-1
MANAGEMENT ORGANIZATION
 ROCKY FLATS ADSORPTION TSWP

addressed in this QAA. Many of the quality process controls specific to the adsorption testing to be conducted are addressed in the adsorption TSWP and are referenced in this QAA.

D.2.1 Training

The minimum personnel qualification and training requirements that are applicable to EG&G and subcontractor staff for RFP ER Program activities are addressed in Section 2.0 of the QAPjP. All EG&G and subcontractor staff working on the adsorption treatability tests, including those collecting groundwater and surface water samples from the RFP, shall be trained in the procedures that are applicable to their assigned tasks. These procedures include the adsorption bench-scale testing procedures described in Section 19.0 of the TSWP, the ERM Operating procedures referenced in Appendix A of the TSWP, and the laboratory analytical procedures that are applicable to the analytical methods referenced in Section 19.0. In addition to procedures training, EG&G and subcontractor personnel shall receive training on the applicable process control requirements of the QAPjP and the adsorption TSWP (including this QAA). Training may consist of formal classroom training, on-the-job training, briefings, or reading assignments. Training must be recorded, with verifiable documentation of training submitted to the EG&G Project Manager prior to implementing the adsorption sample collection and testing activities described in the adsorption TSWP.

EG&G and subcontractor personnel shall also be qualified to perform the tasks they have been assigned. Personnel qualifications must be documented, with documentation of qualification verified by the EG&G Project Manager in accordance with ERM administrative procedure 3-21000-ADM-02.02, Personnel Qualifications.

D.2.2 Quality Assurance Reports to Management

A QA summary report will be prepared annually or at the conclusion of the adsorption treatability testing activities (whichever is more frequent) by the EG&G Environmental Quality Support Manager (EQSM). This report should include a summary of field operation and sampling oversight inspections, laboratory assessments, surveillance, and a report on data verification/validation results.

D.3 DESIGN CONTROL AND CONTROL OF SCIENTIFIC INVESTIGATIONS

D.3.1 Design Control

The adsorption TSWP describes the experimental design and contains the detailed testing procedures for the treatability study for the adsorption processes. The work plan also identifies the objectives of the treatability tests; specifies the sampling, testing, analysis, and data management requirements; identifies applicable field operations and sampling procedures to provide controls for the sampling process; and presents the methods to be used to evaluate and report the results of the multicolumn bench scale tests. As such, the adsorption TSWP is considered the environmental investigation control plan for the adsorption treatment process evaluation.

D.3.2 Data Quality Objectives

The development of Data Quality Objectives (DQOs) for the adsorption treatability study was presented in Section 17.0 of the adsorption TSWP. The DQOs were established in general accordance with the three-stage process described in EPA/540/G-87/003 (OSWER Directive 9335.0-7B), Data Quality Objectives for Remedial Response Activities, and Appendix A of the QAPjP. Table 17-1 summarizes the data needs, the sample collection and analysis activities necessary to generate the type of data needed to evaluate the treatability tests, identifies the appropriate analytical levels for the contaminants of concern, and summarizes the data uses for the components of adsorption treatability study.

Data quality is typically measured in terms of precision, accuracy, representativeness, comparability, and completeness (also referred to as PARCC parameters). Precision, accuracy, and completeness are quantitative measures of data quality, while representativeness and comparability are qualitative statements that express the degree to which sample data represent actual conditions and describe the confidence of one data set to another. These parameters are defined in Appendix A of the QAPjP. Precision and accuracy objectives for analytical measurements of Target Analyte List metals, radionuclides of interest, and the water quality parameters are as specified in Appendix A of the

QAPjP (these objectives consist of the historical measures of precision and accuracy for the method of analysis, and +20% recovery and 20% relative percent difference for total dissolved solids for accuracy and precision respectively).

D.3.3 Sampling Locations and Sampling Procedures

Sampling associated with the adsorption treatability study consists of collecting groundwater and surface water samples for conducting the treatability tests (referred to as treatability study samples), influent and effluent water samples prior to and following the initial column screening tests (referred to in Table 17-1 of the adsorption TSWP as adsorption capability tests), and samples of regenerate wastes from the detailed column tests (referred to in Table 17-1 as adsorption capacity tests).

Appendix A of the TSWP describes how sampling locations will be selected at the RFP for collecting the groundwater and surface water treatability study samples. Subsection A.1.2 identifies the ERM Operating Procedures that will be adhered to when collecting these treatability study samples.

The concentration of TAL metals, radionuclides, Chromium IV, and water quality parameters (which are identified in Table 17-2 of the TSWP) in groundwater and surface water from the sampling locations at the RFP will be determined prior to initial column testing (i.e., influent water) by collecting samples for analysis at the same time the treatability study samples are collected. Influent characterization samples will be collected in the same manner, from the same locations, at the same time as the groundwater and surface water samples are collected for testing (i.e., according to the ERM OPS identified in subsection A.1.2). These samples will be screened for radioactivity levels in accordance with ERM OPS 5-21000-OPS-FO.18, Environmental Radioactivity Content Screening, prior to shipment to the laboratory for analyses. Indicator parameters shall be measured in the field according to OPS identified in subsection A.1.2.

The concentration of TAL metals and radionuclides in column effluent will be determined for the initial screening tests by collecting samples for laboratory analysis as described in Step 7 of subsection 19.4.3 of the adsorption TSWP. These samples will be collected by running the column

effluent line into samples bottles rather than the effluent tank. In addition to these samples, the pH of the effluent will be measured prior to and following collection of these samples.

The detailed adsorption column tests will be conducted such that breakthrough of various contaminants will occur during the course of testing. After a sufficient amount of composite raw water (RFP groundwater and surface water) is run through the column to achieve breakthrough, the regenerate samples of the regenerate waste will be collected from the effluent line for analyses of TAL metals and radionuclides. In order to determine when breakthrough occurs, samples will be collected periodically during the column tests and screened at the testing laboratory for metal and radionuclides concentration by the testing contractor.

D.3.4 Analytical Procedures

Influent and effluent water samples and regenerate waste water samples that are sent to analytical laboratories for analyses of TAL metal and radionuclide concentrations will be analyzed according to EPA Contract Laboratory Program (CLP) methods referenced in Parts A and B of the RFP General Radiochemistry and Routine Analytical Services Protocol (GRRASP). The concentration of water quality parameters in initial test influent waters that are identified in Table 17-2 of the adsorption TSWP, shall be determined according to the analytical methods referenced in Table 44 of Part A of the GRRASP.

D.3.5 Equipment Decontamination

Sampling equipment that is used at more than one field location shall be decontaminated between sampling locations in accordance with OPS-FO.03, General Equipment Decontamination.

D.3.6 Quality Control

Quality control requirements for surface and groundwater samples collected for characterization of influent test water shall consist of collecting an equipment rinsate blank from at least one of the four

sample locations for analysis of TAL metals and radionuclides and water quality parameters of interest. At the discretion of the project manager, a duplicate influent characterization sample may be collected along with the influent characterization samples. Trip blanks are not required, since organics will not be analyzed for.

Quality control for analyzing effluent from the initial screening tests shall consist of collecting duplicate samples of effluent from each column test for analysis as specified in Step 7 of subsection 19.4.3 of the TSWP.

Laboratory analytical quality control (QC) requirements applicable to the adsorption treatability study are identified in Table 17-2 of the adsorption TSWP.

D.3.7 Quality Assurance Monitoring

To assure the overall quality of the adsorption treatability testing, EG&G may conduct field inspections of the surface and groundwater sampling process and surveillance of the column testing at the testing laboratory. Field inspections, if conducted, shall be performed in accordance with the requirements of Section 10.0 of the QAPjP. Surveillance of the column testing, if conducted, shall be performed in accordance with requirements of Section 18.0 of the QAPjP.

D.3.8 Data Reduction, Validation, and Reporting

Observational data from screening tests and analytical data from treatability influent and effluent characterization will be managed as specified in Section 20.0 of the adsorption TSWP. Analytical data will be evaluated to determine validity of the data in accordance with the data validation guidelines identified in Section 3.0 of the QAPjP. The treatability study results will be presented in a treatability study report prepared at the conclusion of the treatability study. The report will follow the format presented in EPA's Guidance for Conducting Treatability Studies Under CERCLA.

D.4 PROCUREMENT DOCUMENT CONTROL

Procurement documents for items and services, including services for conducting the treatability study and laboratory analysis of influent and effluent water samples, shall be prepared, handled, and controlled in accordance with the requirements and methods specified in Section 4.0 of the QAPjP.

D.5 INSTRUCTIONS, PROCEDURES, AND DRAWINGS

The adsorption TSWP describes the field sampling and laboratory testing activities to be performed. The adsorption TSWP will be reviewed and approved in accordance with the requirements for instructions, procedures, and drawings outlined in Section 5.0 of the QAPjP.

The ERM OPS that are applicable for collection of surface and groundwater samples and management and handling of samples and field data are identified in Appendix A of the TSWP. The OPS identified have been approved in accordance with the requirements specified in Section 5.0 of the QAPjP. Any additional quality-affecting procedures proposed for use but not identified in here or in the adsorption TSWP (including Appendix A) will be developed and approved as required by Section 5.0 of the QAPjP prior to performing the affected activity.

Changes and variances to approved operating procedures and the adsorption TSWP shall be documented through preparation of Document Change Notices (DCNs), which will be prepared, reviewed, and approved in accordance with requirements specified in Section 5.0 of the QAPjP.

D.6 DOCUMENT CONTROL

The following documents will be controlled in accordance with Section 6.0 of the QAPjP:

- Treatability Study Work Plan for Ion Exchange and Adsorption Processes

- 'Rocky Flats Plant Sitewide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies and RCRA Facility Investigations/Corrective Measures Studies Activities' (QAPjP)
- ERM Operating Procedures (all operating procedures specified in the adsorption TSWP).

D.7 CONTROL OF PURCHASED ITEMS AND SERVICES

Subcontractors that provide services to support the adsorption treatability study will be selected and evaluated as outlined in Section 7.0 of the QAPjP. This includes preaward evaluation/audit of proposed subcontractors as well as periodic assessment of the acceptability of subcontractor performance during the program. Any items or materials that are purchased for use during the adsorption treatability study that have the potential of affecting the quality of the data should be inspected upon receipt.

D.8 IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA

Treatability study samples and laboratory analytical samples shall be identified and controlled in accordance with Section 8.0 of the QAPjP. This includes identifying samples, establishing custody of samples, and handling, storing and shipping of samples in accordance with 5-21000-OPS-FO.13, Containerizing, Preserving, Handling, and Shipping Samples. An exception to the container requirements of FO.13 for the treatability study samples consists of collecting samples for shipment to the testing laboratory in 12-gallon plastic drums.

D.9 CONTROL OF PROCESSES

The overall processes of collecting and analyzing samples and conducting treatability study tests requires control. The processes are controlled by adhering to the adsorption TSWP and the sampling and analytical procedures identified therein.

D.10 INSPECTION

Inspection of field sampling activities shall be conducted in accordance with Section 10.0 of the QAPjP.

D.11 TEST CONTROL

The treatability testing process will be controlled by adhering to the experimental design and testing procedures described in Section 19.0 of the adsorption TSWP. Additional detailed testing procedures may be developed as additional knowledge of the specific characteristics of the treatability study water becomes available. All observations, parameter inputs (e.g., flow volumes, time, chemical additions), and parameter measurements (e.g., flow rate and pH) will be recorded in laboratory testing logbooks.

D.12 CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)

Laboratory equipment that is used in the treatability study will be identified in log books by model number and manufacturer's serial number, or suitable substitute identification number. Laboratory equipment will include a pH meter and peristaltic pump. The equipment will be used, calibrated, and maintained in accordance with the manufacturer's instructions. A file shall be maintained by the testing contractor that contains:

- Specific model and instrument serial number
- Operating instructions
- Routine preventative maintenance procedures, including a list of critical spare parts to be provided or made available
- Calibration methods, frequency, and description of the calibration solutions
- Standardization procedures (traceability to nationally recognized standards)
- Source of calibration standard solutions, as applicable

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix D

Revision: 2

Page: 12 of 14

Effective Date: _____

Organization: ERT

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D.13 HANDLING, STORAGE, AND SHIPPING

Treatability study and influent and effluent samples shall be packaged, transported, and stored in accordance with Appendix A of the TSWP and 5-21000-OPS-FO.13.

D.14 STATUS OF INSPECTION, TEST, AND OPERATIONS

The requirements for the identification of inspection, test, and operating status specified in Section 14.0 of the QAPjP do not apply to the adsorption treatability study.

D.15 CONTROL OF NONCONFORMANCES

The requirements for the identification, control, evaluation, and disposition of nonconforming items, samples, and data will be implemented as specified in Section 15.0 of the QAPjP. Nonconformances identified by the laboratory testing contractor shall be submitted to EG&G for processing as outlined in the QAPjP.

D.16 CORRECTIVE ACTION

The requirements for the identification, documentation, and verification of corrective actions for conditions adverse to quality will be implemented as outlined in Section 16.0 of the QAPjP. Conditions adverse to quality identified by the testing contractor shall be documented and submitted to EG&G for processing as outlined in the QAPjP.

D.17 QUALITY ASSURANCE RECORDS

QA records produced during implementation of the adsorption treatability study will be handled and managed in accordance with the requirements of Section 17.0 of the QAPjP and

3-21000-ADM-17.01, Records Management. QA records to be produced during this study include but are not limited to the following:

- Field sampling data forms from the sampling and operations OPS identified in Appendix A of the TSWP (field sampling records shall be submitted to the ER records custodian in accordance with OPS-FO.02, Field Document Control).
- Analytical laboratory data packages, which will include the information specified for data packages specified in Parts A and B of the GRRASP
- Treatability testing logbooks
- Standard bench sheets, as applicable
- Monthly progress reports
- Treatability testing procedures
- Adsorption Treatability Study Report

D.18 QUALITY VERIFICATION

The requirements for the verification of quality shall be implemented as specified previously in subsection F.3.7 of this appendix.

A Readiness Review shall be conducted by the EQSM prior to implementing the adsorption Treatability study (including prior to collecting treatability study surface and groundwater samples). The readiness review will determine if all activity prerequisites have been met that are required to begin work. The applicable requirements of the QAPJP, the TSWP (including Appendix A), and this QAA will be addressed.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix D

Revision: 2

Page: 14 of 14

Effective Date: _____

Organization: ERT

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D.19 SOFTWARE CONTROL

The requirements for the control of software are not applicable to the adsorption treatability study.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Appendix E

Revision: 1

Page: 1 of 4

Effective Date: _____

Organization: ERT

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Approved By:

TITLE: Appendix E—Example Calculations For Ion Exchange and
Adsorption Capability and Capacity Tests

Name

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APPENDIX E. EXAMPLE CALCULATIONS FOR ION EXCHANGE AND ADSORPTION CAPABILITY AND CAPACITY TESTS

WATER LOADING

- Flow rate: input value (either in mL/min, gpm/ft³, or bed volumes/min; other two-unit values are calculated).

PREDICTED BREAKTHROUGH

- Concentration, resin capacity: input values
- Breakthrough volume:

$$\frac{[\text{Resin Capacity (mg/L as CaCO}_3\text{)} \times \text{Bed Volume(L)}]}{\text{Critical Component Concentration (mg/L as CaCO}_3\text{)}}$$

- Breakthrough time:

$$\frac{\text{Breakthrough Volume (mL)}}{\text{Flow Rate (mL/min)}}$$

WATER LOADING

- Volume to waste, volume to test: input values

- Total test time:

$$\frac{\text{Volume to Test (mL)}}{\text{Flow Rate (mL/min)}}$$

REGENERATION (IX RESINS)/CONVERSION (IX RESINS)

- Regenerant, solution strength, solution density: input values
- Normality:

$$\frac{[\text{Solution Strength (\%)} \times \text{Solution Density (mg/mL)}]}{\text{Reagent Equivalent Weight (mg/meq)}}$$

Note: The solution strength is expressed as decimal.

REGENERATION (ADSORBENTS)/NEUTRALIZATION (ADSORBENTS)

- Material, Molality: input values

REGENERATION/CONVERSION/NEUTRALIZATION (BOTH PROCESSES)

- Resin/sorbent capacities, flow rates: input values
- Volume required (when calculated using theoretical capacities; all IX resins, neutral for F-1 alumina):

$$\frac{[\text{Bed Volume (mL)} \times \text{Resin Capacity (meq/L as CaCO}_3\text{)} \times \text{Excess Regenerant Required (\%)} \times \text{Reagent Equivalent Wgt (mg/meq)}]}{[\text{Solution Density (mg/mL)} \times \text{Solution Strength (\%)}]}$$

Note: The excess regenerant required and the solution strength are expressed as decimal.

- Volume required (when based on literature data; all sorbent regenerations, neutralization for BIO-FIX beads): input value.
- Time required:

$$\frac{\text{Volume Required (mL)}}{\text{Flow Rate (mL/min)}}$$

INITIAL RANGE (IX RESINS ONLY)

- Flow rate: equal to regenerate flow rate
- Volume required: equal to bed volume
- Time required:

$$\frac{\text{Volume Required (mL)}}{\text{Flow Rate (mL/min)}}$$

FINAL RINSE (ALL PROCESSES)

- Flow rate: equal to water-loading rate
- Volume required: input value
- Time required:

$$\frac{\text{Volume Required (mL)}}{\text{Flow Rate (mL/min)}}$$

EG&G ROCKY FLATS PLANT
Treatability Studies Work Plan
for an Ion Exchange Process

Manual: 21000.WP.TS01.01

Section: Appendix E

Revision: 0

Page: 4 of 4

Effective Date: _____

Organization: ERT

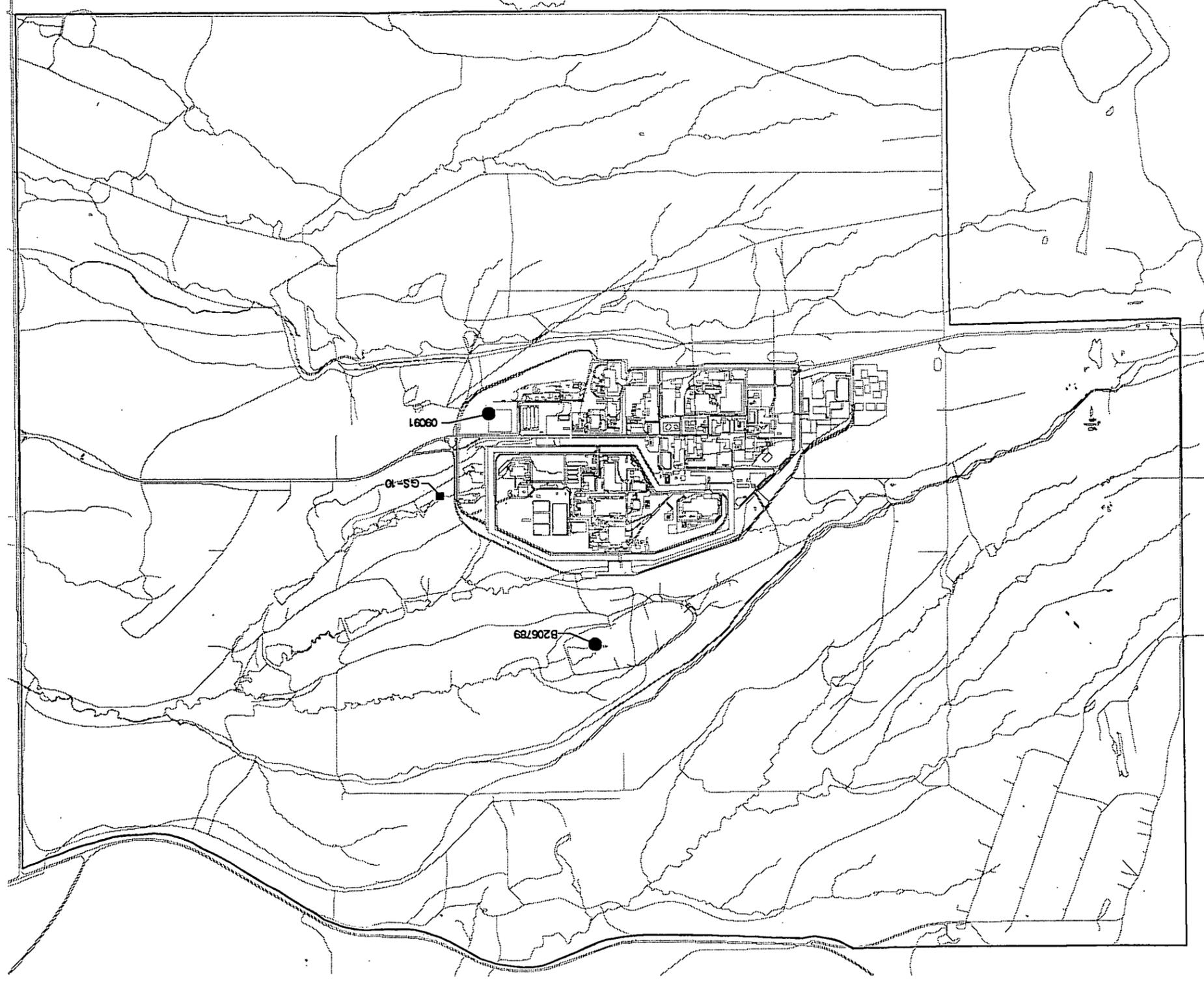
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BACKWASH

- Flow rate: input value.

BASE MAPPING SOURCE: EG&G



■ SURFACE WATER GAGING STATION
● GROUNDWATER WELLS

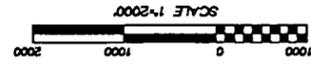


Figure A-1
Groundwater and Surface Water
Sampling Locations
Rocky Flats Ion Exchange and Adsorption
Treatability Studies Work Plan
Rocky Flats Plant
Golden, CO

NOTICE

All drawings located at the end of the document.

FINAL DRAFT

**TREATABILITY STUDY WORK PLAN
FOR ION EXCHANGE PROCESSES
AND
TREATABILITY STUDY WORK PLAN
FOR ADSORPTION PROCESSES**

ROCKY FLATS PLANT

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

ENVIRONMENTAL RESTORATION PROGRAM

February 1993

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ADMIN RECORD

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REVIEWED FOR CLASSIFICATION/UCNI
BY <u>G. T. Ostdiek</u> 870
DATE <u>3-31-97</u>

EG&G ROCKY FLATS PLANTS
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Table of Contents

Revision: 2

Page: 1 of 16

Effective Date: _____

Organization: ERT

Non-Safety Related

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Approved By:

TITLE: Table of Contents

Name

(Date)

<u>Section</u>	<u>Page</u>
EXECUTIVE SUMMARY	ES-1
1.0 INTRODUCTION—ION EXCHANGE TREATABILITY STUDY	1-1
1.1 OBJECTIVES	1-2
2.0 PROJECT DESCRIPTION—ION EXCHANGE TREATABILITY STUDY	2-1
2.1 BACKGROUND INFORMATION	2-1
2.1.1 Location	2-2
2.1.2 Climatology and Meteorology	2-2
2.1.3 Geology and Hydrogeology	2-2
2.2 TREATMENT GOALS/ARARs	2-5
2.3 DESCRIPTION OF CONTAMINANTS	2-6
2.4 TREATABILITY STUDY OVERVIEW	2-10
3.0 REMEDIAL TECHNOLOGY DESCRIPTION—ION EXCHANGE PROCESS	3-1
4.0 DATA QUALITY OBJECTIVES—ION EXCHANGE TREATABILITY STUDY	4-1
4.1 STAGE 1—IDENTIFYING DECISION TYPES	4-2
4.2 STAGE 2—IDENTIFYING DATA USES/NEEDS	4-3
4.2.1 Identifying Data Uses	4-3
4.2.2 Identifying Data Types	4-3
4.2.3 Identifying Data Quality and Quantity Needs	4-6
4.2.4 Evaluating Sampling/Analysis Options	4-7
4.2.5 Reviewing PARCC Parameter Information	4-7
4.3 STAGE 3—DESIGN DATA COLLECTION PROGRAM	4-9
4.4 SUMMARY OF DATA QUALITY OBJECTIVES	4-9
5.0 EQUIPMENT AND MATERIALS—ION EXCHANGE TREATABILITY STUDY	5-1
5.1 EQUIPMENT CALIBRATION, CALIBRATION RECORDS, AND CONTROL	5-1

6.0 EXPERIMENT DESIGN AND PROCEDURES—ION EXCHANGE TREATABILITY STUDY	6-1
6.1 TEST OBJECTIVES	6-1
6.2 SCREENING AND SELECTION OF RESINS	6-2
6.2.1 Ion Exchange Resins to be Tested	6-3
6.2.2 Ion Exchange Resins Not Selected for Testing	6-11
6.3 KEY ASSUMPTIONS	6-12
6.4 TASK DESCRIPTIONS	6-26
6.4.1 Capability Tests	6-26
6.4.2 Capacity Tests	6-27
6.4.3 Summary of Capability and Capacity Test Results	6-40
6.5 SUMMARY OF SAMPLES AND ANALYSES	6-41
6.6 TREATABILITY QA/QC SAMPLES	6-41
7.0 DATA MANAGEMENT—ION EXCHANGE TREATABILITY STUDY	7-1
8.0 DATA ANALYSIS AND INTERPRETATION—ION EXCHANGE TREATABILITY STUDY	8-1
8.1 MEASUREMENTS OF PERFORMANCE	8-2
9.0 RESIDUAL MANAGEMENT—ION EXCHANGE TREATABILITY STUDY	9-1
10.0 ION EXCHANGE TREATABILITY STUDY REPORT	10-1
11.0 ION EXCHANGE TREATABILITY STUDY SCHEDULE	11-1
12.0 MANAGEMENT AND STAFFING—ION EXCHANGE TREATABILITY STUDY	12-1
12.1 INTRODUCTION	12-1
12.2 PROJECT TEAM	12-1
12.2.1 EG&G Program Manager	12-2
12.2.2 Senior Review Team	12-2
12.2.3 Project Manager	12-2
12.2.4 Health and Safety Officer (HSO)	12-4
12.2.5 Quality Assurance Officer (QAO)	12-4
12.2.6 Sampling Field Supervisor	12-4
12.2.7 Laboratory Treatability Supervisor	12-4
12.2.8 Sampling Personnel	12-5
12.2.9 Laboratory Technicians	12-5

13.0 REGULATORY REQUIREMENTS FOR ONSITE AND OFFSITE TESTING— ION EXCHANGE TREATABILITY STUDY	13-1
14.0 INTRODUCTION—ADSORPTION TREATABILITY STUDY	14-1
14.1 OBJECTIVES	14-2
15.0 PROJECT DESCRIPTION—ADSORPTION TREATABILITY STUDY	15-1
15.1 BACKGROUND INFORMATION	15-1
15.1.1 Location	15-2
15.1.2 Climatology and Meteorology	15-2
15.1.3 Geology and Hydrogeology	15-2
15.2 TREATMENT GOALS/ARARs	15-5
15.3 DESCRIPTION OF CONTAMINANTS	15-6
15.4 ADSORPTION TREATABILITY STUDY OVERVIEW	15-10
16.0 REMEDIAL TECHNOLOGY DESCRIPTION—ADSORPTION PROCESS	16-1
17.0 DATA QUALITY OBJECTIVES—ADSORPTION TREATABILITY STUDY	17-1
17.1 STAGE 1—IDENTIFYING DECISION TYPES	17-2
17.2 STAGE 2—IDENTIFYING DATA USES/NEEDS	17-3
17.2.1 Identifying Data Uses	17-3
17.2.2 Identifying Data Types	17-3
17.2.3 Identifying Data Quality and Quantity Needs	17-6
17.2.4 Evaluating Sampling/Analysis Options	17-7
17.2.5 Reviewing PARCC Parameter Information	17-7
17.3 STAGE 3—DESIGN DATA COLLECTION PROGRAM	17-9
17.4 SUMMARY OF DATA QUALITY OBJECTIVES	17-9
18.0 EQUIPMENT AND MATERIALS—ADSORPTION TREATABILITY STUDY	18-1
18.1 EQUIPMENT CALIBRATION, CALIBRATION RECORDS, AND CONTROL	18-1
19.0 EXPERIMENT DESIGN AND PROCEDURES—ADSORPTION TREATABILITY STUDY	19-1
19.1 TEST OBJECTIVES	19-1

19.2	SCREENING AND SELECTION OF ADSORBENTS	19-2
19.2.1	Adsorbents to be Tested	19-2
19.2.2	Adsorbents Not Selected for Testing	19-11
19.3	KEY ASSUMPTIONS	19-14
19.4	TASK DESCRIPTIONS	19-28
19.4.1	General Instructions for Adsorbent Testing	19-28
19.4.2	Capability Tests	19-28
19.4.3	Capacity Tests	19-31
19.4.4	Summary of Capability and Capacity Test Results	19-40
19.5	SUMMARY OF SAMPLES AND ANALYSES	19-41
19.6	TREATABILITY QA/QC SAMPLES	19-42
20.0	DATA MANAGEMENT-ADSORPTION TREATABILITY STUDY	20-1
21.0	DATA ANALYSIS AND INTERPRETATION-ADSORPTION TREATABILITY STUDY	21-1
21.1	MEASUREMENTS OF PERFORMANCE	21-2
22.0	RESIDUAL MANAGEMENT-ADSORPTION TREATABILITY STUDY	22-1
23.0	ADSORPTION TREATABILITY STUDY REPORT	23-1
24.0	ADSORPTION TREATABILITY STUDY SCHEDULE	24-1
25.0	MANAGEMENT AND STAFFING-ADSORPTION TREATABILITY STUDY	24-1
25.1	INTRODUCTION	25-1
25.2	PROJECT TEAM	25-1
25.2.1	EG&G Program Manager	25-2
25.2.2	Senior Review Team	25-2
25.2.3	Project Manager	25-2
25.2.4	Health and Safety Officer (HSO)	25-4
25.2.5	Quality Assurance Officer (QAO)	25-4
25.2.6	Sampling Field Supervisor	25-4
25.2.7	Laboratory Treatability Supervisor	25-4
25.2.8	Sampling Personnel	25-5
25.2.9	Laboratory Technicians	25-5
26.0	REGULATORY REQUIREMENTS FOR ONSITE AND OFFSITE TESTING- ADSORPTION TREATABILITY STUDY	26-1

Non-Safety Related

Final Draft

27.0 REFERENCES	27-1
APPENDIX A—SAMPLING PLAN	A-1
A.1 SAMPLING LOCATIONS AND PROCEDURES	A-1
A.1.1 Rationale for Location Selection	A-1
A.1.2 Sampling Location Summary	A-3
A.1.3 Sampling Procedures	A-3
A.2 FIELD MEASUREMENT	A-8
A.3 FIELD DATA DOCUMENTATION AND PROCEDURES	A-9
A.3.1 Field Data Forms	A-9
A.3.2 Field Log	A-10
A.4 SAMPLE CONTAINERS, VOLUMES, PRESERVATIVES, AND HOLDING TIMES	A-11
A.4.1 Procedures	A-11
A.4.2 Sample Containers and Preservatives	A-11
A.5 SAMPLE DESIGNATION SYSTEM	A-11
A.5.1 Container Labeling and Decontamination	A-12
A.6 SAMPLE CUSTODY	A-13
A.6.1 Chain-of-Custody Record	A-13
A.6.2 Chain-of-Custody Form	A-14
A.6.3 Custody Seals	A-15
A.6.4 Tampering of Sampling Containers	A-15
A.7 SAMPLE PACKING AND SHIPPING	A-16
A.7.1 Equipment List	A-16
A.7.2 Department/Office Contact List	A-17
A.7.3 Packaging and Shipping	A-17
A.7.4 Air Bills and Bills of Lading	A-21
APPENDIX B—HEALTH AND SAFETY PLAN	1
1.0 PROJECT INFORMATION AND DESCRIPTION	1

2.0	PROJECT ORGANIZATION AND TASKS TO BE PERFORMED UNDER THIS PLAN	3
2.1	Project Organization	3
2.2	Description of Tasks	3
3.0	HAZARD EVALUATION AND CONTROL	4
3.1	Heat and Cold Stress	4
3.1.1	Guidelines For Working in Temperature Extremes While Wearing Personal Protective Equipment (PPE)	4
3.1.2	Symptoms and Treatment of Heat and Cold Stress	4
3.2	Physical (Safety) Hazards and Controls	5
3.3	Tick Bites, Lyme Disease, and Rocky Mountain Spotted Fever (RMSF)	6
3.4	Radiological Hazards and Controls	6
3.5	Hazards Posed By Chemicals Brought Onsite	6
3.6	Occupation Exposure to Hazardous Chemicals in Laboratories	6
3.7	Known Contaminants of Concern	7
3.8	Potential Routes of Exposure	7
4.0	PERSONNEL	8
4.1	Employees Medical and Training Requirements	8
4.2	Health and Safety and Field Team Chain of Command and Procedures	8
4.2.1	Client	8
4.2.2	Contractor	8
4.2.3	Subcontractor	8
5.0	PERSONAL PROTECTIVE EQUIPMENT (PPE) SPECIFICATION	9
5.1	Reasons To Upgrade or Downgrade Level of Protection	9
6.0	AIR MONITORING EQUIPMENT SPECIFICATION	10
6.1	Calibration Specification	11
6.2	Radiological Monitoring Equipment and Procedures	11
7.0	DECONTAMINATION SPECIFICATION	15
7.1	Diagram of Personnel Decontamination Line	15
8.0	SPILL CONTAINMENT PROCEDURES	15

9.0	WORK PROCEDURES	16
9.1	Work Practices	16
9.2	Site Control Measures	16
10.0	EMERGENCY RESPONSE PLAN	17
10.1	Pre-Emergency Planning	17
10.2	Emergency Equipment and Supplies	17
10.3	Emergency Medical Treatment	18
10.4	Evacuation	18
10.5	Evacuation Routes and Assembly Points	18
10.6	Evacuation Signals	18
11.0	EMERGENCY RESPONSE TELEPHONE NUMBERS	19
11.1	Government Agencies Involved in Project	19
12.0	EMERGENCY CONTACTS	21
13.0	PLAN APPROVAL	22
13.1	Plan Amendments	22
13.2	Plan Amendments	22
14.0	ATTACHMENTS TO PLAN	22
	Attachment 1—Employee Signoff	23
	Attachment 2—Form 533, Record of Hazardous Waste Field Activity	24
	Attachment 3—Applicable MSDSs	25

APPENDIX C—QUALITY ASSURANCE ADDENDUM FOR THE ION EXCHANGE TREATABILITY
STUDY WORK PLAN C-1

C.1	ORGANIZATION AND RESPONSIBILITIES	C-2
C.2	QUALITY ASSURANCE PROGRAM	C-2
	C.2.1 Training	C-4
	C.2.2 Quality Assurance Reports to Management	C-4
C.3	DESIGN CONTROL AND CONTROL OF SCIENTIFIC INVESTIGATIONS	C-5
	C.3.1 Design Control	C-5
	C.3.2 Data Quality Objectives	C-5
	C.3.3 Sampling Locations and Sampling Procedures	C-6

C.3.4	Analytical Procedures	C-7
C.3.5	Equipment Decontamination	C-7
C.3.6	Quality Control	C-7
C.3.7	Quality Assurance Monitoring	C-8
C.3.8	Data Reduction, Validation, and Reporting	C-8
C.4	PROCUREMENT DOCUMENT CONTROL	C-9
C.5	INSTRUCTIONS, PROCEDURES, AND DRAWINGS	C-9
C.6	DOCUMENT CONTROL	C-9
C.7	CONTROL OF PURCHASED ITEMS AND SERVICES	C-10
C.8	IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA	C-10
C.9	CONTROL OF PROCESSES	C-10
C.10	INSPECTION	C-11
C.11	TEST CONTROL	C-11
C.12	CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)	C-11
C.13	HANDLING, STORAGE, AND SHIPPING	C-12
C.14	STATUS OF INSPECTION, TEST, AND OPERATIONS	C-12
C.15	CONTROL OF NONCONFORMANCES	C-12
C.16	CORRECTIVE ACTION	C-12
C.17	QUALITY ASSURANCE RECORDS	C-13
C.18	QUALITY VERIFICATION	C-13
C.19	SOFTWARE CONTROL	C-14

APPENDIX D—QUALITY ASSURANCE ADDENDUM TO THE ADSORPTION TREATABILITY STUDY
WORK PLAN D-1

D.1	ORGANIZATION AND RESPONSIBILITIES	D-2
D.2	QUALITY ASSURANCE PROGRAM	D-2
	D.2.1 Training	D-4
	D.2.2 Quality Assurance Reports to Management	D-4
D.3	DESIGN CONTROL AND CONTROL OF SCIENTIFIC INVESTIGATIONS	D-5
	D.3.1 Design Control	D-5
	D.3.2 Data Quality Objectives	D-5
	D.3.3 Sampling Locations and Sampling Procedures	D-6
	D.3.4 Analytical Procedures	D-7
	D.3.5 Equipment Decontamination	D-7
	D.3.6 Quality Control	D-7
	D.3.7 Quality Assurance Monitoring	D-8
	D.3.8 Data Reduction, Validation, and Reporting	D-8
D.4	PROCUREMENT DOCUMENT CONTROL	D-9
D.5	INSTRUCTIONS, PROCEDURES, AND DRAWINGS	D-9

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Table of Contents

Revision: 2

Page: 9 of 16

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

D.6	DOCUMENT CONTROL	D-9
D.7	CONTROL OF PURCHASED ITEMS AND SERVICES	D-10
D.8	IDENTIFICATION AND CONTROL OF ITEMS, SAMPLES, AND DATA	D-10
D.9	CONTROL OF PROCESSES	D-10
D.10	INSPECTION	D-11
D.11	TEST CONTROL	D-11
D.12	CONTROL OF MEASURING AND TEST EQUIPMENT (M&TE)	D-11
D.13	HANDLING, STORAGE, AND SHIPPING	D-12
D.14	STATUS OF INSPECTION, TEST, AND OPERATIONS	D-12
D.15	CONTROL OF NONCONFORMANCES	D-12
D.16	CORRECTIVE ACTION	D-12
D.17	QUALITY ASSURANCE RECORDS	D-12
D.18	QUALITY VERIFICATION	D-13
D.19	SOFTWARE CONTROL	D-14

APPENDIX E—EXAMPLE CALCULATIONS FOR ION EXCHANGE AND ADSORPTION
CAPABILITY AND CAPACITY TESTS

Non-Safety Related

Final Draft

LIST OF TABLES, ION EXCHANGE PROCESS

2-1	Analyte Concentrations and ARARs	2-7
2-2	List of Chemicals Reported Above ARARs in Two or More Operable Units	2-11
4-1	Data Needs to Fulfill Specific Objectives for the Ion Exchange Treatability Study	4-4
4-2	Summary of Laboratory QA/QC Criteria	4-10
5-1	Equipment and Materials—Ion Exchange Treatability Study	5-2
5-2	Chemical Supplies—Ion Exchange Treatability Study	5-3
6-1	Rocky Flats Composite Sample Generation	6-14
6-2	Rocky Flats Raw Composite Water Chemistry	6-15
6-3	Capability Tests for Ion Exchange Resins	6-17
6-4	Capacity Tests for Ion Exchange Resins	6-21
6-5	Summary of Samples and Analyses for Ion Exchange Resin Tests	6-36
6-6	Analytical Methods and Detection Limits	6-37
10-1	Organization of the Ion Exchange Treatability Study Report	10-2
A-1	Composite Sample Generation	A-4
A-2	Alternate Sampling Locations	A-5

LIST OF TABLES, ADSORPTION PROCESS

15-1	Analyte Concentrations and ARARs	15-7
15-2	List of Chemicals Reported Above ARARs in Two or More Operable Units	15-11
16-1	Analyte Concentrations and ARARs	16-7
16-2	List of Chemicals Reported Above ARARs in Two or More Operable Units	16-11
17-1	Data Needs to Fulfill Specific Objectives for the Adsorption Treatability Study	17-4
17-2	Summary of Laboratory QA/QC Criteria	17-10
18-1	Equipment and Materials—Adsorption Treatability Study	18-2
18-2	Chemical Supplies—Adsorption Treatability Study	18-3
19-1	Rocky Flats Composite Sample Generation	19-16
19-2	Rocky Flats Raw Composite Water Chemistry	19-18
19-3	Capability Tests for Adsorbents	19-20
19-4	Capacity Tests for Adsorbents	19-24
19-5	Summary of Samples and Analyses for Adsorbent Tests	19-37
19-6	Analytical Methods and Detection Limits	19-38

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Table of Contents

Revision: 2

Page: 11 of 16

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

23-1 Organization of the Adsorption Treatability Studies Report 23-2

A-1 Composite Sample Generation A-4

A-2 Alternate Sampling Locations A-5

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01
Section: Table of Contents
Revision: 2
Page: 12 of 16
Effective Date: _____
Organization: ERT

Non-Safety Related

Final Draft

LIST OF FIGURES, ION EXCHANGE PROCESS

2-1	Location of Rocky Flats Plant	2-3
2-2	Rocky Flats Plant Boundaries and Buffer Zone	2-4
6-1	Constituent Removal Effectiveness of the Resins to be Tested	5-13
6-2	Column Apparatus	5-28
11-1	Program Schedule for the Ion Exchange Treatability Study	11-2
12-1	Management Organization, Rocky Flats Ion Exchange TSWP	12-3
C-1	Management Organization	C-3

LIST OF FIGURES, ADSORPTION PROCESS

15-1	Location of Rocky Flats Plant	15-3
15-2	Rocky Flats Plant, Boundaries and Buffer Zone	15-4
16-1	Removal Effectiveness of the Adsorbents to be Tested for the Constituents of Concern	16-3
16-2	Column Apparatus	16-4
19-1	Removal Effectiveness of the Adsorbents to be Tested for the Constituents of Concern	19-15
19-2	Column Apparatus	19-30
24-1	Program Schedule for an Adsorption Treatability Study	24-2
25-1	Management Organization, Rocky Flats Adsorption TSWP	25-3
D-1	Management Organization	D-3

LIST OF ACRONYMS

The following is a list of acronyms used throughout both the ion exchange and adsorption treatability study work plans.

AA	atomic absorption
Al	aluminum
ARARs	Applicable or Relevant and Appropriate Requirements
As	arsenic
AWQC	Ambient Water Quality Criteria
Ba	barium
BACK	Statewide Background Minimum
Be	beryllium
BV	bed volume
CCB	Continuing Calibration Blank
CCR	Colorado Code of Regulations
CCV	Continuing Calibration Verification
Cd	cadmium
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHWA	Colorado Hazardous Waste Act
CLP	Contract Laboratory Program
cm	centimeters
CMS	corrective measures study (or studies)
COC	chain of custody
CWQCC	Colorado Water Quality Control Commission
Cr	chromium
CRDL	Contact Required Detection Limit
CRP	community relations plan
CVA	Cold Vapor Analysis
CWA	Clean Water Act
DOE	Department of Energy
DOT	Department of Transportation
DQO	data quality objective
DWR	Colorado Division of Water Resources
EC	electrical conductivity
EMD OPS	Environmental Management Department Operating Procedures
EPA	Environmental Protection Agency
ER	environmental restoration
Fe	iron
FIDLER	Field Instrument for Detection of Low Energy Radiation
FS	feasibility study

Non-Safety Related

Final Draft

FSP	field sampling plan
ft	foot/feet
GAC	Granular Activated Carbon
GC/MS	gas chromatography/mass spectroscopy
GFAA	Graphite Furnace Atomic Absorption
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
GT	greater than
HEA	Health Effects Assessment
Hg	mercury
HSL	Hazardous Substance List
HSO	Health and Safety Officer
HSP	Health and Safety Plan
IAG	Inter-Agency Agreement
ICB	Initial Calibration Blank
ICP	inductively coupled plasma
ICS	Interference Check Sample
ICV	Initial Calibration Verification
IDL	Initial Detection Limit
in	inches
in/hr	inch(es) per hour
IX	ion exchange
kg	kilograms
km	kilometer
LSID	Lower State Interceptor Ditch
l or L	liter
lb	pounds
LCS	Laboratory Control Sample
LT	less than
M	molar
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mCi/km ²	microcurie per square kilometer
MDAs	minimum detectable activities
mg/l or mg/L	milligrams per liter
mi	mile
ml or mL	milliliter
Mn	manganese
µm	micrometers
mm	millimeters
Mn	manganese
MS	mass spectroscopy
MSD	matrix spike duplicate
MSL	mean sea level
mv	millivolt
Ni	nickel

Non-Safety Related

Final Draft

NRC	Nuclear Regulatory Commission
OU	Operable Unit
PARCC	precision, accuracy, representativeness, completeness, and comparability
Pb	lead
PB	preparation blank
pCi/g	picocuries per gram
pCi/l or pCi/L	picocuries per liter
PM	Project manager
ppb	parts per billion
PPE	Personal Protective Equipment
ppm	parts per million
Pu	plutonium
PuO ₂	Plutonium Dioxide
QAA	Quality Assurance Addendum
QAO	Quality Assurance Officer
QA/QC	Quality Assurance/Quality Control
QAPJP	Quality Assurance Project Plan
QAPP	Quality Assurance Project Plan
Ra	radium
RAD	radiation
RCRA	Resource Conservation and Recovery Act
redox	reduction/oxidation
RFDs	Reference doses
RFEDS	Rocky Flats Environmental Database System
RFI	RCRA facility investigation
RFP	Rocky Flats Plant
RI	remedial investigation (CERCLA)
RMSF	Rocky Mountain Spotted Fever
RPD	relative percent difference
SAS	Special Analytical Services
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SA/SB	strong acid/strong base resins
Sb	Antimony
SDWA	Safe Drinking Water Act
Se	selenium
SOP	Standard Operating Procedure
SOPA	Standard Operating Procedure Addendum
SOW	Statement of Work
SPHEM	Superfund Public Health Evaluation Manual
SW	Surface water
TAL	target analyte list
TBC	to be considered
TDS	total dissolved solids
TSP	Rocky Flats Site-Wide Treatability Studies Plan

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Table of Contents

Revision: 2

Page: 16 of 16

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

TSR Treatability Studies Report
TSSP Treatability Studies Sampling Plan
TSWP Treatability Study Work Plans
U uranium
uCi/m² microcurie per square meter
USID Upper South Interceptor Ditch
USPS United States Postal Service
UV ultraviolet
v volt
VOA volatile organic analysis
VOC volatile organic compound
WA/WB weak acid/weak base resins
WQC Water Quality Criteria
WQCC Water Quality Control Commission

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: Executive Summary

Revision: 0

Page: ES-1 of 2

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

TITLE: Executive Summary

Approved By:

_____/_____/_____
Name (Date)

EXECUTIVE SUMMARY

These Treatability Study Work Plans (TSWP) describe the steps necessary to perform two separate treatability studies in order to demonstrate the effectiveness of different types of ion exchange (IX) resins and adsorption media for removing metals and radionuclides from surface water and groundwater at the Rocky Flats Plant (RFP).

Existing analytical records for samples collected at the RFP indicate that surface water and groundwater in some areas of the RFP have metal and radionuclide constituents. The objective of the IX and Adsorption Treatability Studies described in these Work Plans is to evaluate different IX or adsorption media, respectively, to determine which are most effective in removing those metal and radionuclide constituents.

The target metals and radionuclides, which are in solution in surface water and groundwater at the RFP, include a broad range of materials. The known chemistry of these materials indicates that a single ion exchange resin or adsorbent will not be effective in removing all of the target metals and radionuclides. For this reason, the experiment designs for each treatability study include the testing of several types of ion exchange and adsorbent media, respectively.

In Sections 6.0 and 19.0, Experiment Design and Procedures, the targeted metals and radionuclides for each experiment task are discussed in more detail. In general, ion exchange and adsorbent media will be first tested to determine their capabilities to remove metals and radionuclides from the water. Media that show sufficient capability are then tested to determine their capacities for removing the targeted constituents. The experiments were designed using the Rocky Flats Environmental Database System (RFEDS) to select sample locations. However, both ground and surface water volumes and makeup can vary depending on seasonal and precipitation changes. Sitewide sample locations were screened to develop a sampling plan designed to obtain water containing as many

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01
Section: Executive Summary
Revision: 0
Page: ES-2 of 2
Effective Date: _____
Organization: EHT

Non-Safety Related Final Draft

of the targeted constituents as possible. The basis for the experimental design is documented so that after the sample waters have been collected and analyzed, the correct experiment procedures can be modified based on the concentrations in the test waters.

A report will be written for each treatability study containing raw data, analysis of results, and conclusions regarding the experiment's effectiveness. The planned table of contents of each Treatability Study report is included in Sections 10.0 and 24.0 of this document.

If these treatability studies show that IX and/or adsorption processes are an effective means of reducing metals and radionuclides in surface water and groundwater at the RFP, it is anticipated that the selected processes will be tested in a demonstration unit at the RFP.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 1

Revision: 2

Page: 1 of 2

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

Approved By:

TITLE: Introduction-Ion Exchange Treatability Study

Name

(Date)

1.0 INTRODUCTION-ION EXCHANGE TREATABILITY STUDY

This document presents the work plan for conducting ion exchange (IX) tests at the U.S. Department of Energy (DOE) Rocky Flats Plant.

The final Inter-Agency Agreement (IAG) stated that DOE would develop a Treatability Studies Plan (TSP) to evaluate candidate remedial technologies for the general types of contamination encountered sitewide at the RFP. The TSP (DOE, 1991a) presented treatment technologies applicable to remediation efforts at two or more operable units (OUs). This treatability study is designed to provide information for the individual OU Feasibility Study/Corrective Measures Studies (FS/CMS) without having to perform individual OU-specific treatability studies.

The TSP identified IX as one of the technologies to be tested. This technology was selected for removal of metals and radionuclides in groundwater and surface water. The purpose of this work plan is to describe the testing procedures for screening selected IX media for their capabilities to remove the selected metals and radionuclides from groundwater and surface water. IX media that show significant capabilities to absorb metals and radionuclides will be further tested to determine their capacities. Experimental procedures have been designed to allow for variation in the concentration of targeted constituents in performing an effective treatability study.

An additional purpose of the IX treatability study is to establish basic limitations of the IX technology for use in the technologies and alternatives evaluation phases of the FS/CMS to be conducted at each OU.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 1

Revision: 2

Page: 2 of 2

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

1.1 OBJECTIVES

The overall objective of the IX treatability study is to evaluate the effectiveness of the various IX media as a potential treatment alternative in reducing the volume, toxicity, or mobility of selected metals and radionuclides from Rocky Flats surface water and groundwater. The individual resins will first be tested to determine their capability for reducing the concentration of beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium in the onsite waters at Rocky Flats (TSP, DOE, 1991a). Media that show sufficient capabilities will be further tested to determine their capacities and breakthrough times, as well as the ion exchange resins' regeneration abilities. Measurements of performance are described in Subsection 8.1 of this document.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 2

Revision: 0

Page: 1 of 11

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

Approved By:

TITLE: Project Description—Ion Exchange
Treatability Study

_____/_____/_____
Name (Date)

2.0 PROJECT DESCRIPTION—ION EXCHANGE TREATABILITY STUDY

This section provides background information on the Rocky Flats Plant (RFP) site and summarizes the contaminants of concern for the IX treatability study. A discussion of the type of study to be conducted is also included.

2.1 BACKGROUND INFORMATION

The RFP is a government-owned, contractor-operated facility that is part of the nationwide nuclear weapons production complex. The primary mission of the RFP is to fabricate nuclear weapon components from plutonium, uranium, and nonradioactive metals (the later primarily being beryllium and stainless steel). The nuclear weapon component parts made at the Plant are shipped elsewhere for final assembly. The RFP also formerly reprocessed components for recovery of plutonium after they were removed from obsolete weapons. Other activities at the RFP formerly included research and development in metallurgy, machining, nondestructive testing, chemistry, physics, engineering, and environmental management.

Both radioactive and nonradioactive wastes are generated in the production process. Current waste handling practices involve onsite storage of hazardous and radioactive mixed wastes and offsite disposal of solid radioactive materials at other DOE facilities. However, both storage and disposal of hazardous and radioactive wastes occurred onsite in the past. Preliminary assessments under the Environmental Restoration (ER) Program identified some of the past onsite storage and disposal locations as potential sources of environmental contamination.

Details concerning the site's location, climatology and meteorology, and geology and hydrogeology that can potentially affect the remediation methodology and implementation are included in the following subsections. Various studies have been conducted at the RFP to characterize

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 2

Revision: 0

Page: 2 of 11

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

environmental media and to assess the extent of radiological and chemical contaminant releases to the environment. More information on these subjects may be found in the TSP.

2.1.1 Location

The RFP is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver (Figure 2-1). Other surrounding cities include Boulder, Westminster, and Arvada, which are located less than 10 miles to the northwest, east, and southeast, respectively. Major buildings are located within the approximate 400-acre security area of the RFP. The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 2-2).

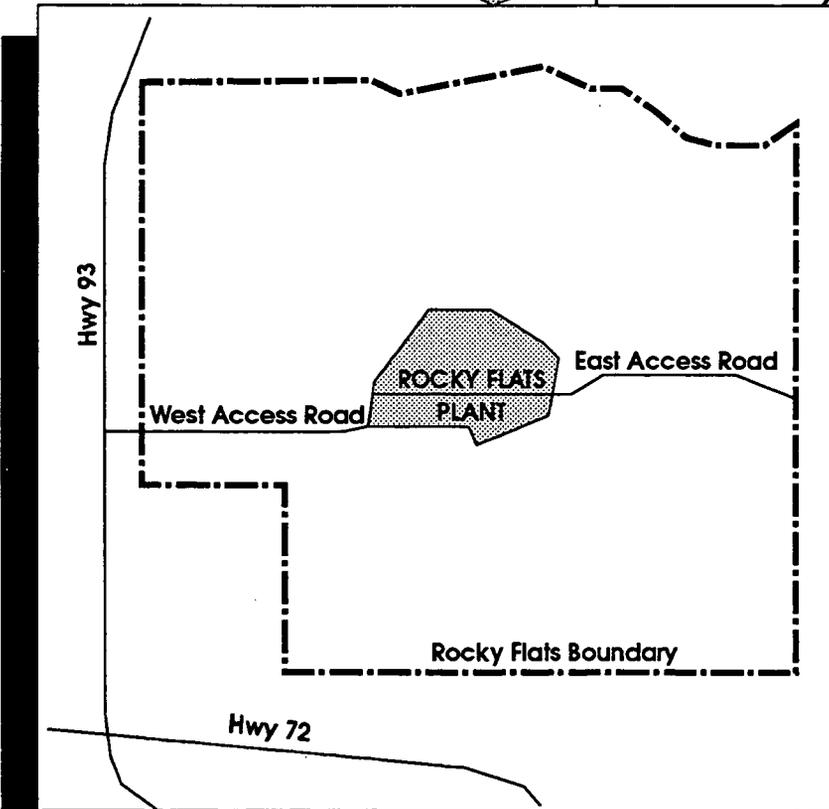
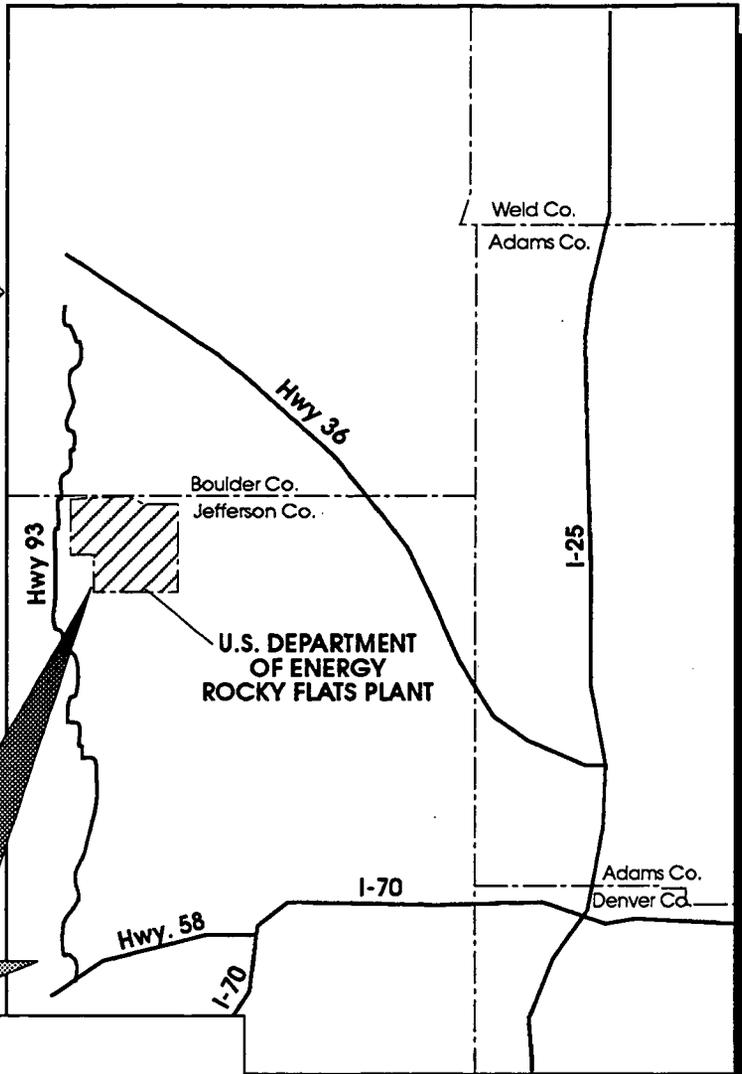
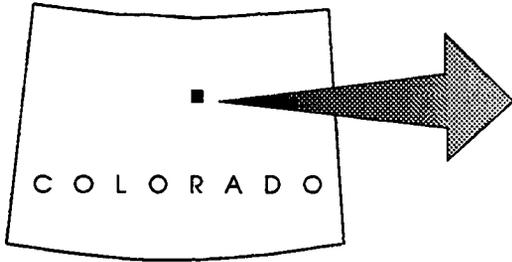
2.1.2 Climatology and Meteorology

The area surrounding the RFP has a semiarid climate characteristic of much of the central Rocky Mountain region. Approximately 40 percent of the 15-inch annual precipitation falls during the spring season—much of it as wet snow. Thunderstorms (occurring from June to August) account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, falling from October through May (DOE, 1980).

2.1.3 Geology and Hydrogeology

The stratigraphic section that pertains to the RFP includes, in descending order, unconsolidated surficial units (Rocky Flats Alluvium, various other alluvial deposits, valley fill alluvium, and colluvium), the Arapahoe Formation, the Laramie Formation, and Fox Hills Sandstone. Groundwater occurs under unconfined conditions in both the surficial and shallow bedrock units. In addition, confined groundwater flow occurs in deeper bedrock sandstones (such as the Fox Hills Sandstone formation). More information on these subjects may be found in the TSP.

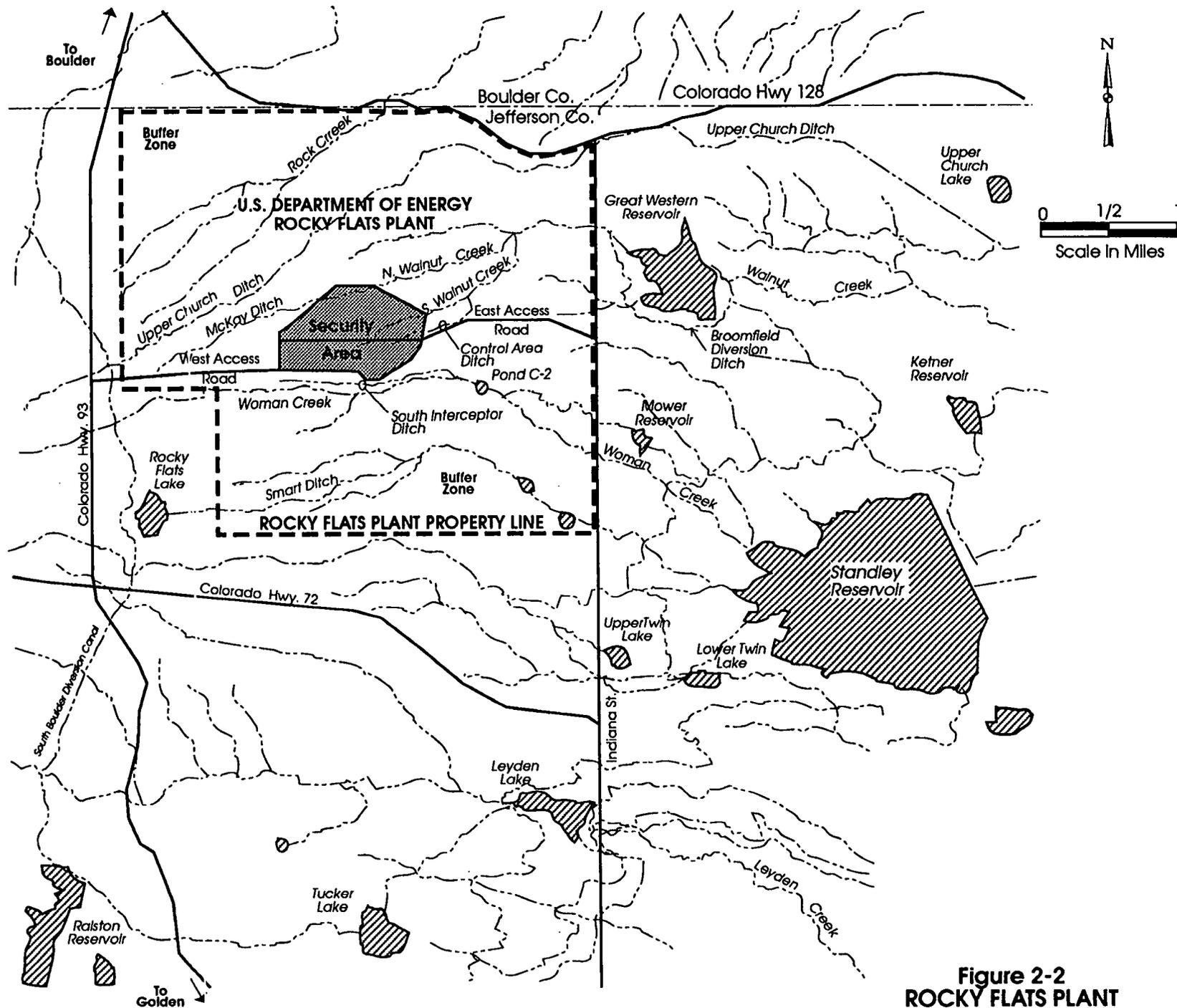
DRAWN BY	H. DOUVILLE	CHECKED BY	2/23/93	DRAWING RFP TSWP 1014A NUMBER
	10/31/91	APPROVED BY	2/24/93	



Source: DOE, 1991a

**Figure 2-1
LOCATION OF
ROCKY FLATS PLANT**

DRAWN BY	H. DOUVILLE	CHECKED BY	2/23/93	DRAWING RFP TSWP 1013A NUMBER
	10/31/91	APPROVED BY	2/24/93	
<i>Conrad G. Stewart</i>				



Source: DOE, 1991a

**Figure 2-2
ROCKY FLATS PLANT
BOUNDARIES AND BUFFER ZONE**

2.2 TREATMENT GOALS/ARARs

This section presents the treatment (or performance) goals for the IX TSWP, which are to meet the potential Applicable or Relevant and Appropriate Requirements (ARARs) and to-be-considered standards (TBCs) for the RFP associated with the groundwater (GW) and surface water (SW).

The TSP presented the potential ARARs and TBCs for the RFP. The potential ARARs/TBCs for groundwater and surface water are based on chemicals suspected to be present at RFP and the following current federal and state health and environmental statutes and regulations:

- Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) applied to both surface and groundwater.
- Clean Water Act (CWA) Water Quality Criteria (WQC) applied to surface water.
- RCRA Subpart F Groundwater Concentration Limits (40 CFR 264.94) applied to groundwater.
- Colorado Department of Health (CDH) surface water standards for Woman Creek and Walnut Creek (5 CCR 1002-8, Section 3.8.0, amended February 15, 1990) applied to surface water.
- CDH Water Quality Control Commission (WQCC) statewide and classified groundwater area standards (5 CCR 1002-8, Section 3.11) applied to groundwater.

In addition to the potential ARARs/TBCs, health effects assessment (HEA) criteria or "action levels" developed by Environmental Protection Agency (EPA) for carcinogens and systemic toxicants were considered as possible or potential cleanup goals in the TSP.

Where ARARs did not exist for a particular metal or radionuclide, or where existing ARARs are not protective of human health or the environment, TBC criteria, guidances, proposed standards, and advisories were evaluated for use. In Table 2-1, the "Potential ARARs" column does not contain an entry whenever ARARs do not exist for a particular radionuclide.

The goal of the IX treatability study will be to evaluate various types of ion exchange media for their effectiveness in removing specified metals and radionuclides from groundwater and surface water. The resulting conclusions will be used in support of the FS/CMS.

Sitewide potential ARARs/TBCs were selected for comparison to sitewide maximum and minimum analyte concentrations. This process is described in the following subsection.

2.3 DESCRIPTION OF CONTAMINANTS

Summaries of the potentially hazardous substances found within groundwater, surface water, soils, and wastes at the RFP were also presented in the TSP. The TSP identified metals and radionuclides as contaminants of concern in groundwater and surface water for several OUs. This section presents the contaminants to be addressed by the IX treatability study.

Potential standards were selected for comparison to maximum and minimum analyte levels. MCLs were selected as the principal standards for both surface water and groundwater. The appropriate state standard was used for groundwater where there was no MCL. The state agricultural value was not considered in determining the appropriate state standard. In cases where the state standard was below the current analytical detection limit, the detection limit was used as the default value. For surface water, the lowest federal Water Quality Criteria (WQC) was used where there was no MCL, unless the WQC was below detection limit, in which case the detection limit was used. The appropriate state standard was used for surface water where there was no MCL or Ambient Water Quality Criteria (AWQC), unless this value was below detection limit, in which case the detection limit was used. The lowest systemic or carcinogenic HEA criterion was used for surface water and

TABLE 2-1¹
ANALYTE CONCENTRATIONS AND ARARS

Parameter	Groundwater (mg/l)			Surface Water (mg/l)		
	Maximum ²	Minimum ³	Potential ARAR	Maximum ²	Minimum ³	Potential ARAR
METALS (TOTAL AND DISSOLVED)						
Beryllium	0.029 (E)	0.005	0.10	0.09 (E)	0.005 ⁴	0.005
Chromium	0.172 BR (F)	0.010	0.05	0.298 (A)	0.010	0.05
Iron	57.1 (F)	0.100	0.30	3220 (A)	0.100	0.30
Lead	0.21 J BR (B)	0.005	0.050	0.516 (A)	0.005	0.050
Manganese	6 (F)	0.015	0.050	27.7 (A)	0.015	0.050
Mercury	0.006 (E)	0.0002	0.002	3.97 (E)	0.0002	0.002
Selenium	3.2 (E)	0.005	0.010	0.55 (A)	0.005	0.010

¹Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.

²Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.

³Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).

⁴Present in laboratory blank.

Notes: J = Analyzed below detection limit.
 BR = Bedrock (including some weathered bedrock).

TABLE 2-1^a

ANALYTE CONCENTRATIONS AND ARARS
(Continued)

Parameter	Groundwater (pCi/l)			Surface Water (pCi/l)		
	Maximum ²	Minimum ³	Potential ARAR	Maximum ²	Minimum ³	Potential ARAR
RADIONUCLIDES (TOTAL AND DISSOLVED)						
Americium 241	2.3 (E)	0.01		90 (A)	0.01	30
Plutonium 239 +240	4.6 (G)	0.01	15(a)	120 (A)	0.01	15(a)
Uranium 233 + 234	723 (G)	0.6		861 (A)	0.60	
Uranium 235	9 (F)	0.6		65.5(A)	0.60	
Uranium 235 + 236	0.009 (G)	0.6		1.192 (G)	0.60	
Uranium 238	190 (F)	0.6		366 (A)	0.60	
Uranium (Total)	63.7 (B)	0.6		1023 (A)	0.60	5

¹Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.

²Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.

³Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).

⁴Present in laboratory blank.

Notes: J = Analyzed below detection limit.
BR = Bedrock (including some weathered bedrock).

Non-Safety Related

Final Draft

TABLE 2-1*

ANALYTE CONCENTRATIONS AND ARARS
 (Concluded)

Parameter	Groundwater (pCi/l)			Surface Water (pCi/l)		
	Maximum ²	Minimum ³	Potential ARAR	Maximum ²	Minimum ³	Potential ARAR

References:

Note: Analytical data received prior to October 1988 not subjected to validation procedure. Some of the contaminant values reported in this table have not yet been validated, and the analyte list may be changed after the data are validated.

- (A) EG&G. February 22, 1991a, Surface Water and Sediment Geochemical Characterization Report, Draft Copy.
- (B) U.S. DOE. April 2, 1990c, Final Phase II Remedial Investigation/Feasibility Study Workplan (Alluvial), OU 2, Draft Copy.
- (C) U.S. DOE. January 11, 1991a, Proposed Surface Water Interim Measures, Interim Remedial Action Plan/Environmental Assessment and Decision Document South Walnut Creek Basin, OU 2, Final Draft.
- (D) U.S. DOE. January 24, 1991b, Phase II Remedial Investigation/Feasibility Study Workplan (Bedrock), OU 2, Draft Copy.
- (E) U.S. DOE. October 1990d, Phase III Remedial Investigation/Feasibility Study Workplan 881 Hillside Area, OU 1, Final Draft.
- (F) EG&G. March 1, 1991b, 1990 Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Plant, Draft Copy.
- (G) EG&G. May 1991, Unpublished data (see note to reference).

¹Source: Table 4-2, Rocky Flats Final Treatability Studies Plan, EG&G, June 3, 1991.

²Maximum concentration may be a one-time measurement. Values include both recent and historic data. Letters in parentheses indicate the reference source from the list at the end of this table.

³Value given is detection or quantitation limit for analysis, in accordance with Statement of Work for General Radiochemistry and Routine Analytical Services Protocol (GRRASP), Version 2.1 (DOE, 1991).

⁴Present in laboratory blank.

Notes: J = Analyzed below detection limit.
 BR = Bedrock (including some weathered bedrock).

groundwater for those chemicals which had no MCL, WQC, or state standard. Where HEA criteria were below the detection limit, the detection limit was used.

Table 2-1 presents the maximum and minimum concentrations of all metals and radionuclides analyzed for and the potential standard associated with each contaminant. Table 2-2 lists the OUs that contain these contaminants in levels above the potential standard.

The TSP identified the following metals and radionuclides for a sitewide evaluation of IX as a remediation technology for the following (metals): beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium.

2.4 IX TREATABILITY STUDY OVERVIEW

General laboratory-scale testing will be conducted on all of the chosen resins to determine the relative effectiveness of the IX resins. The actual testing procedures are detailed in Section 6.0 of this document.

The overall objective of the IX treatability study is to evaluate the effectiveness of the various IX media as a potential treatment alternative in reducing the volume, toxicity, or mobility of selected metals and radionuclides from Rocky Flats surface water and groundwater. The individual resins will first be tested to determine their capabilities for reducing the concentration of beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium in the onsite waters at Rocky Flats. Media that show sufficient capability will be further tested to determine their capacity and breakthrough times, as well as the IX resins regeneration ability.

Upon completion of the IX treatability study, the results will be reviewed in order to determine if there is sufficient information to evaluate this technology for the FS/CMSs without further testing for various OUs. If more information is necessary, the information needed will be described in the treatability study summary report. The review process is described in Section 8.0 of this document.

TABLE 2-2

LIST OF CHEMICALS REPORTED ABOVE
 ARARs IN TWO OR MORE OPERABLE UNITS

Contaminant	Operable Units (Two or More)	
	Reported in Groundwater	Reported in Surface Water
METALS		
Beryllium		1,6, LSID
Chromium	1,2,4,7	1,2,4,7 USID, LSID
Iron	1,2,4	1,2,4,5,6,7, LSID, USID
Lead	2,4	1,2,4,5,6,7, LSID, USID
Manganese	1,2,4,7	1,2,4,5,6,7, LSID, USID
Mercury		1,4,6
Selenium	1,2,4,7	1,2,4,5,6,7, LSID
RADIONUCLIDES		
Americium 241		
Plutonium 239 + 240		2,4
Uranium (total)		1,2,4,5,6,7, USID

Notes: BACK = Sitewide Background Maximum
 USID = Upper South Interceptor Ditch
 LSID = Lower South Interceptor Ditch

Source: DOE, 1991a.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 3
Revision: 2
Page: 1 of 1

Non-Safety Related

Final Draft

Effective Date: _____
Organization: ERT

TITLE: Remedial Technology Description--
Ion Exchange Process

Approved By:

Name

_____/_____
(Date)

3.0 REMEDIAL TECHNOLOGY DESCRIPTION-- ION EXCHANGE PROCESS

This section provides a general overview of the IX remedial technology. At the Rocky Flats Plant (RFP), this process potentially provides an effective means of removing dissolved metals and radio-nuclides from surface water and groundwater.

The modern ion exchange process mainly utilizes synthetic resin. Such resins contain groups that have either a positive or negative electrical charge. Bound onto these charge groups are free ions of the opposite charge. The electrically charged solute, with a stronger attraction to the resin active sites than the free ions, adhere to the active sites after displacing the free ion. The process is stoichiometrically limited to the number of active sites available on the resin, so resin capacity is usually independent of the solute concentration. Ion exchange resins to be screened in this treatability study include strong acid, strong base, weak acid, weak base, metals-chelating, and specialty resins.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 4

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Page: 1 of 17

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

Approved By:

TITLE: Data Quality Objectives—Ion Exchange
Treatability Study

_____/_____/_____
Name (Date)

4.0 DATA QUALITY OBJECTIVES—ION EXCHANGE TREATABILITY STUDY

The overall objective of the IX treatability study is to evaluate the effectiveness of the various IX media as a potential treatment alternative in reducing the volume, toxicity, or mobility of selected metals and radionuclides from Rocky Flats surface water and groundwater. The resins will first be tested individually, to determine their capability for reducing the concentration of beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium in the onsite waters at Rocky Flats. Media that show sufficient capability will be further tested to determine their capacity and breakthrough times, as well as the ion exchange resins' regeneration abilities.

This treatability study is designed to screen and test different types of ion exchange resins to determine the effectiveness of the ion exchange process. In order to select the most appropriate materials for removing each constituent, the operational characteristics of the resins, such as loading capacity, regeneration properties, and breakthrough characteristics, will be investigated.

A primary objective of this TSWP is to investigate a broad range of ion exchange resins. Resin manufacturers have been contacted, and a literature search has been conducted for this TSWP. Based upon these efforts, and after having evaluated the broad range of materials, the most appropriate resins have been selected for treatability study testing. Both the range evaluation and the final selection process are described in Section 6.0.

Data quality objectives (DQOs) express qualitative and quantitative statements describing the quality and quantity of data required by the treatability studies. Developing DQOs relies on the following three stage process:

- Stage 1—Identify decision types
- Stage 2—Identify data uses/needs

- **Stage 3**—Design a data collection program

4.1 STAGE 1—IDENTIFYING DECISION TYPES

Of the three stages above, Stage 1 has already been completed as part of the TSP. The Final TSP Report identified the treatability study program goals and objectives and the technical approach. The overall objective of the IX treatability study program is to provide information to support the Feasibility Studies or Corrective Measure Studies (FS/CMS) to be conducted at each of the 16 Operable Units (OUs). As such, the TSP identified potentially applicable technologies for remediating the types of wastes and waste matrices that may be common to more than one OU, in addition to generating data required to evaluate and screen technologies and/or alternatives. Ultimately, the information obtained from the sitewide and specific OU treatability studies will provide data to support the final remedy selection and design process.

The TSP followed a process of identifying potentially applicable technologies based on a literature/data base search and review of other available information. The potentially applicable technologies were evaluated in a two-step screening process. The preliminary screening identified those technologies suitable for application at Rocky Flats. The final screening identified the technologies appropriate for consideration in the sitewide treatability testing.

This TSWP fulfills the Stages 2 and 3 DQO process. The following discussion describes specific elements addressed in Stage 2, consistent with the Data Quality Objectives for Remedial Response Activities (EPA, 1987). These elements include:

- Data uses
- Data types
- Data quality needs
- Data quantity needs
- Sampling/analysis options
- Precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters

4.2 STAGE 2—IDENTIFYING DATA USES/NEEDS

Stage 2 of the DQO process defines data uses and specifies the data types needed to meet the project objectives. As noted above, the DQOs presented reflect the treatability studies screened in Stage 1. Table 4-1 describes the data needed to fulfill the specific objectives for the ion exchange treatability study, the type of activity used to collect the data, the analytical level, and the intended data use.

4.2.1 Identifying Data Uses

Data uses for the Stage 2 Treatability Studies include determining the original concentrations of the CLP target analyte list (TAL), radionuclides, and water quality parameters for the treatability influent. The data will be useful for verifying suitable process selections, but will not fulfill all the needs for designing such a process.

4.2.2 Identifying Data Types

Data types include analytical results to assess treatment effectiveness. The ion exchange study will generate analytical data measuring the following data types:

- pH
- Flow rates of influent sample water and regeneration solution
- Analytical data measuring concentrations of metals and radionuclides in the process effluents and regenerant wastes
- Physical measurements (volumetric, weight) will be made to establish the bed volumes

TABLE 4-1

**DATA NEEDS TO FULFILL SPECIFIC OBJECTIVES
FOR AN ION EXCHANGE TREATABILITY STUDY**

Treatability Study Influent

Data Need: Establish influent concentrations for a composite groundwater/surface water sample before initiating the treatability studies.

Activity: Collect representative samples from the two selected groundwater and surface water locations. Composite the samples using flow-proportioned amounts. Analyze the unfiltered composite. Filter and analyze a sample of the composite.

DQO Levels: pH—Level II
(Refer to Table 4-2 Metals and Radionuclides—Level III
in this document) Cr (VI)—Level III
Water Quality Parameters—Level III

Data Use: Use the data in calculating the performance or removal efficiency for each treatability test

Capability Tests

Data Need: Demonstrate the capability of six different ion exchange resins for removing metals and radionuclides from surface water and groundwater using different cationic or anionic regenerants and conditioners.

Activity: Conduct two-column bench scale tests. Evaluate Amberlite 200C, Amberlite DP-1, Amberlite IRC-718, HiPAC-PEI, Dianex TS-200, and Amberlite IRA-938 resins for removal of targeted metals and radionuclides. Measure pH and flow rate.

DQO Levels: pH and flow rate—Level II
(Refer to Table 4-2 Metals and radionuclides—Level III
in this document) Cr (VI)—Level III
Water Quality Parameters—Level III

Data Use: Determine the relative capabilities of the six ion exchange resins to produce an effluent that meets the anticipated treatment targets for one or more of the constituents of concern. Use this data to select the optimum pH for the capacity tests.

TABLE 4-1

**DATA NEEDS TO FULFILL SPECIFIC OBJECTIVES
FOR AN ION EXCHANGE TREATABILITY STUDY
(Concluded)**

Capacity Tests

Data Need:	Determine the exchange capacities, breakthrough characteristics, and quantities and characteristics of regenerant wastes produced for each of the resins using the optimum pH identified for each resin tested in the capacity tests.
Activity:	Conduct small two-column bench scale tests. Based on pH results of capability tests, evaluate resins to determine breakthrough characteristics and the exchange capacities. In addition, samples of the regenerant wastes will be analyzed to provide estimates of the wastes quantities and characteristics.
DQO Levels: (Refer to Table 4-2 in this document)	pH and flow rate—Level II Metals and radionuclides—Level III Cr (VI)—Level III Water Quality Parameters—Level III
Data Use:	Determine the relative capacities of the six ion exchange resins for loading the constituents of concern and for generating low quantities and favorable regenerant wastes characteristics.

- Other characteristics and parameters may include electrical conductivity, temperature, and other (unspecified) measurements.

4.2.3 Identifying Data Quality and Quantity Needs

EPA defines five levels of analytical data (EPA, 1987 modified) associated with data quality for treatability studies. The analytical levels correspond with those noted in Table 4-1.

- **Level I**—Field screening or analysis with portable instruments. This level provides an indication of contamination presence and has few QA/QC requirements.
- **Level II**—Field analyses with more sophisticated portable instruments or mobile laboratory. The data quality associated with this level depends on the QA/QC steps used. Data concentrations are usually reported in concentration ranges.
- **Level III**—Analyses of organics and inorganics are performed in an offsite analytical laboratory that may or may not involve contract laboratory program (CLP) procedures. The detection limits will be similar to those specified by the CLP. Level III uses rigorous QA/QC.
- **Level IV**—Analyses encompass the hazardous substance list (HSL) organic and inorganic parameters by sophisticated laboratory instrumentation such as gas chromatography/mass spectroscopy (GC/MS), atomic absorption (AA), and inductively coupled plasma (ICP). Detection limits reach the low parts-per-billion levels. This analytical level also provides tentative identification of non-HSL parameters. Data require validation to evaluate compliance with rigorous QA/QC requirements. Level IV procedures are appropriate to develop data of known quality.

Note: The radionuclides analyses would generally be considered Level V because they are not "CLP" analyses; however, the level of QA/QC included in the EG&G Rocky Flats GRRASP

Version 2.1 (DOE, 1991) is equivalent to that of "CLP" analyses. As such, the radionuclide analyses are considered to meet the Level IV data requirements.

- **Level V**—Analyses using nonstandard analytical methods. Method development or method modification may be required for specific constituents or detection limits.

Table 4-1 specifies the appropriate analytical levels for the data needs and data uses described in the table. Stage 2 treatability studies typically rely on Levels II through IV as reflected in Table 4-1.

Section 6.0 of this report describes the rationale for sampling frequencies and quantities for the ion exchange treatability study.

4.2.4 Evaluating Sampling/Analysis Options

Data collection activities must be designed to obtain maximum use of the data. The sampling/analysis approach for the IX treatability study is based on guidelines provided in the TSP. If treatability results indicate that additional analyses or sampling are necessary, modifications will be made to the sampling analysis program. This will be done to avoid performing additional redundant studies. Section 6.0 describes the sampling/analysis options in more detail.

4.2.5 Reviewing PARCC Parameter Information

PARCC (precision, accuracy, representativeness, completeness, comparability) parameters are indicators of data quality. Precision, accuracy, and completeness goals consider the analyses to be performed and the required analytical levels. Criteria established to meet PARCC requirements will be used to evaluate the data useability for data collected as part of the IX treatability study.

Table 6-6 of this document describes the analytical requirements for this treatability study. The analytical program specifies the use of analytical methods referenced in the EG&G Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP, Version 2.1) (DOE, 1991) for all

analytes. These analytical methods are appropriate for meeting the data quality requirements for analytical levels II through V. The precision, accuracy, and completeness parameters for analytical levels II through V are discussed below along with the comparability and representativeness for all analytical levels. The DQOs specified for the precision, accuracy, and completeness will be used in evaluating the quality and useability of the laboratory data.

Precision and accuracy objectives for the treatability study data will be evaluated based on the control limits specified in the referenced analytical method and/or in data validation guidelines. For the radionuclide analyses, the accuracy objectives specified in the GRRASP will be followed. The specified criteria for precision and accuracy are summarized as QA/QC criteria in subsection 4.4.

For each sample taken and analysis performed in the treatability study, the objective for achieving useable data points is 90 percent.

Comparability is a qualitative parameter that expresses the confidence with which one data set can be compared with another. In order to achieve comparability, work performed as part of the treatability study will follow approved sampling and analysis plans, use standardized analytical protocols, collect data following Environmental Restoration Management Operating Procedures (ERM OPS), and report data in consistent units of measurement.

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. It is a qualitative parameter that is most concerned with the proper design of the sampling program. The Sampling Plan described in Appendix A of this document and the referenced ERM OPS describe the rationale for the sample program to provide for representative samples. In designing the IX treatability study, statistical considerations were evaluated in selection of sample numbers.

4.3 STAGE 3--DESIGN DATA COLLECTION PROGRAM

The Stage 3 DQO process includes discussions of the following elements, consistent with Data Quality Objectives for Remedial Response Activities (EPA, 1987):

- Data collection components
- Sampling and analysis plan

To accomplish this, the elements identified in Stages 1 and 2 were assembled and the Sampling Plan (Appendix A of this document) was prepared. Analytical methods are indicated in subsection 6.4.3, Table 6-6. A brief summary of all samples to be collected is presented in Table 6-5 including sample type, number of samples, and analyses. QA/QC samples are listed in Table 4-2.

4.4 SUMMARY OF DATA QUALITY OBJECTIVES

Table 4-2 presents the QA/QC criteria for the Levels III and IV laboratory analyses proposed for the IX treatability study. No specific criteria are set for electrical conductivity and pH measurements other than multiple readings and those procedures prescribed by the instrument manufacturer. Reagent dosages primarily involve physical measurements of the volume and/or weights. Standard laboratory scales and volumetric devices are used for this purpose. Other than "good laboratory practices," no specific criteria are set for physical measurements. The weights and volumes will be estimated using the correct stoichiometry and the calculations will be double-checked for accuracy. The water quality parameters are to be determined only for the treatability influent. These analyses will be performed consistent with the Level III goals.

TABLE 4-2
SUMMARY OF LABORATORY QA/QC CRITERIA

Analyses	Frequency of QA/QC	QA/QC Criteria
TAL METALS:		
Initial Calibration	Daily (once every 24 hours).	ICP ¹ : A blank and a minimum of one standard in proper operating range GFAA ² : A blank and three standards in proper operating range. CVA ³ : A blank and four standards
Initial Calibration Verification (ICV)	Immediately after the initial calibration.	The measured value must be within 90 to 110 percent of the true value.
Continuing Calibration Verification (CCV)	Once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The measured value must be within 90 to 110 percent of the true value.
Contract Required Detection Limit (CRDL) Standard	A minimum of twice per 8 hours or at the beginning and the end of the sample run.	ICP ¹ : At two times the CRDL or Initial Detection Limit (IDL); whichever is greater. Report the data. GFAA ² : At CRDL or IDL; whichever is greater. Report the data.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
 (Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Initial Calibration Blank (ICB)	Immediately after ICV, and once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the 10 samples prior to the noncompliant blank.
Continuing Calibration Blank (CCB)	Immediately after ICB, and once every 10 samples or 2 hours; also at the beginning and the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the 10 samples prior to the noncompliant blank.
Preparation Blank (PB)	Once per 20 samples, a group ⁶ of samples, or 14 days, whichever is most frequent.	The blank concentrations must be below CRDL or the lowest sample concentration must be at least 10 times the blank concentration. Otherwise, redigest and reanalyze all samples.
ICP ^a Interference Check Sample (ICS)	At the beginning and the end of a sample run, or twice per 8 hours.	The ICS results must be within 80 to 120 percent of the true value.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

TABLE 4-2
SUMMARY OF LABORATORY QA/QC CRITERIA
(Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Matrix Spike	Once per 20 samples, group of samples, or 14 days—whichever is most frequent.	The spiked sample results (after subtracting the original sample result) must be within 75 to 125 percent of the spiked value for sample concentrations, not exceeding four times the spike concentration. A post-digestion spike is required for ICP analyses if the spike criteria are not met.
Post Digestion Spike	In the event the matrix spike criteria are not met, once per 20 samples, group of samples, or 14 days—whichever is most frequent.	Spike the digestate at two times the sample level or the CRDL, whichever is greater. Report the data.
Duplicate Analysis	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	The relative percent difference (RPD) for sample concentrations greater than five times the CRDL must be within 20 percent for the duplicate pair. For concentrations below five times the CRDL, the duplicate results must be within +/-CRDL of the original value.
Laboratory Control Sample (LCS)	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	The LCS results must be within 80 to 120 percent of the true value. Otherwise, the samples must be redigested and reanalyzed.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

Non-Safety Related

Final Draft

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
 (Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
ICP ¹ Serial Dilution	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	For sample concentrations above 50 times the IDL, the serially diluted results must be within 90 to 110 percent of the original sample concentrations.
Instrument Detection Limit	Once every 3 calendar months.	IDL is calculated as three times the standard deviation of seven consecutive determinations per day for 3 nonconsecutive days (a total of 21 measurements). The IDLs must meet or exceed the CRDLs.
ICP ¹ Interelement Correction Factors	Once every year, or after major instrument adjustments.	Report the factors.
ICP ¹ Linear Range	Once every 3 months.	The linear range standard must measure between 95 to 105 percent of the true value. Sample results cannot be reported beyond this value.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

Non-Safety Related

Final Draft

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
 (Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Standard Addition (GFAA) ²	As required by the GFAA analytical scheme in the CLP Statement of Work (SOW).	The analytical spike recovery must be between 85 to 115 percent of the spiked amount. If not, samples with absorbance greater than 50 percent of the spiked sample absorbance must be analyzed by addition of three levels of standards. The coefficient of variance for the standard addition results must be 0.995 or better.
RADIONUCLIDES:⁴		
Instrument Background	Once every month.	Count for a minimum of 12 hours, and report.
Instrument Calibration	Once every week.	Report the data.
Efficiency Check Standards	Once every week.	Counted until 2,000 counts ⁷ (units of measure) recorded.
Laboratory Control Sample	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	Prepare and count the same as the samples. The measured value must be within three standard deviations of the true value, and the relative percent error not to exceed 10 percent. For tritium, gross alpha, and gross beta activities, the relative percent error must not exceed 15 percent.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
 (Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
Duplicate Sample	Once per 10 samples, group of samples, or 14 days' group—whichever is most frequent.	Prepare and count the same as the samples. The measured value must be within three standard deviations of the weighted average and its associated standard error.
Preparation Blank	Once per 20 samples, group of samples, or 14 days' group—whichever is most frequent.	Prepare and count the same as the samples. Report the data.
Minimum Detectable Activities (MDAs)	All samples.	The count duration should be optimized so that the required method detection limits are achieved.
Chemical Recovery	All samples.	Recovery for uranium isotopes must be within 30 to 105 percent. Recoveries for plutonium and americium isotopes must be within 20 to 105 percent.
WATER QUALITY PARAMETERS:⁵		
Instrument Calibration	Daily (once every 24 hours).	One blank and at least three standards in the proper operating range. The correlation coefficient must be 0.995 or greater.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO_x, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
 (Continued)

Analyses	Frequency of QA/QC	QA/QC Criteria
ICV	Immediately after the initial calibration.	The ICV must be within 85 to 115 percent of the true value.
CCV	Immediately after the initial calibration.	The CCV must be within 85 to 115 percent of the true value.
ICB	Immediately after ICV, and before the samples.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the samples prior to the noncompliant blank.
CCB	Immediately after ICB, and once every 20 samples; also at the end of the sample run.	The absolute value of the blank may not exceed the CRDL. Otherwise, correct the problem and reanalyze the samples prior to the noncompliant blank.
PB	If applicable to the method, once per 20 samples, group of samples, or 14 days—whichever is most frequent.	The blank concentrations must be below CRDL, or the lowest sample concentration must be at least five times the blank concentration. Otherwise, redigest and reanalyze all samples.

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

TABLE 4-2

SUMMARY OF LABORATORY QA/QC CRITERIA
 (Concluded)

Analyses	Frequency of QA/QC	QA/QC Criteria
LCS	Once every 20 samples, group of samples, or 14 days—whichever is most frequent.	The LCS recoveries must be within 80 to 120 percent of the true value.
Duplicate Sample	Once every 20 samples, a group of samples, or 14 days—whichever is most frequent.	The relative percent difference (RPD) between the duplicate pair must not exceed 20 percent.
Matrix Spike	Once every 20 samples, group of samples, or 14 days—whichever is most frequent.	Matrix spike recoveries must be within 75 to 125 percent for the samples with concentrations not exceeding four times the spike concentration

¹ICP = Inductively Coupled Plasma. Metals analyzed by ICP include Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, and Zn.

²GFAA = Graphite Furnace Atomic Absorption. Metals analyzed by GFAA include As, Pb, Se, and Tl.

³CVA = Cold Vapor Analysis. Mercury is analyzed by CVA.

⁴Radionuclides include Pu239/240, Am241, U (total), Ra226, and tritium.

⁵Water quality parameters include Cl, NO₂/NO₃, NO₃, SO₄, and total dissolved solids (TDS). The QA/QC for chromium (VI) also follows the water quality parameter protocols.

⁶There should be no more than 20 samples per group; samples can be grouped in less than 20 items.

⁷Counts = Unit of radioactive measure.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans
for Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 5

Revision: 0

Page: 1 of 3

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

TITLE: Equipment and Materials—
Ion Exchange Treatability Study

Approved By:

_____/_____/_____
Name (Date)

5.0 EQUIPMENT AND MATERIALS—ION EXCHANGE TREATABILITY STUDY

The equipment and materials necessary for performing the ion exchange treatability tests are listed in Tables 5-1 and 5-2. The equipment listed in Table 5-1 is sufficient to run two capability or two capacity tests simultaneously.

5.1 EQUIPMENT CALIBRATION, CALIBRATION RECORDS, AND CONTROL

Laboratory equipment used in the IX treatability study (such as a pH meter and a peristaltic pump) will be identified in the log book(s) by manufacturer's serial number or another suitable unique number. This equipment will be used and calibrated in strict accordance with the manufacturer's instructions. Records of calibration techniques/procedures, source of calibration standard solutions, and date/time of calibration will be maintained in the laboratory log books. The date/time of the last calibration of each instrument will be entered on a label which is attached to the instrument.

Manufacturer's operation, calibration, and maintenance instructions will be kept in close proximity to the equipment during the entire duration of the IX treatability study. Equipment/instruments will be maintained in accordance with the manufacturer's instructions.

Table 5-1

EQUIPMENT AND MATERIALS—ION EXCHANGE TREATABILITY STUDY

Item	Quantity ¹
Feed tanks, 7.5 gallon min.	2
Solution tanks, 2.0 gallon min., teflon (two feed, one regen., one conversion, one rinse, one extra)	6
Metering pump, 0-75 mL/min, reversible flow ¹ (minimum flow = 2.9 mL/min; regen./conversion pumps, rinse pumps—low capacity)	4
Metering pump, 25-500 mL/min, reversible flow ¹ (regeneration/conversion pumps, rinse/backwash pumps—high capacity)	4
Metering pump, 10-250 mL/min, reversible flow ¹ (feed pumps)	2
Laboratory columns, 1.25-in I.D. x 36-in long, glass (two IX capability tests)	4
Laboratory columns, 0.75-in I.D. x 48-in long, glass (two IX capacity tests)	4
Assorted teflon tubing, valves, and fittings	
Assorted laboratory glassware, equipment, accessories, and supplies	

¹All wetted parts to be teflon unless otherwise noted.

Table 5-2

CHEMICAL SUPPLIES—ION EXCHANGE TREATABILITY STUDY

Compound	Quantity
Hydrochloric acid, 37 percent (technical or reagent grade)	2,000 mL
Sulfuric acid, 95 to 98 percent (technical or reagent grade)	100 mL
Sodium hydroxide, beads or pellets (technical or reagent grade)	500 g
Ammonium hydroxide (technical or reagent grade)	100 mL
Sodium chloride (technical grade)	1,000 g

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans
for Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 6
Revision: 0
Page: 1 of 42

Non-Safety Related

Final Draft

Effective Date: _____
Organization: ERT

TITLE: Experiment Design and Procedures--
Ion Exchange Treatability Study

Approved By:

_____/_____/_____
Name (Date)

6.0 EXPERIMENT DESIGN AND PROCEDURES—ION EXCHANGE TREATABILITY STUDY

This section describes the general approach and the detailed procedures to be followed in performing the treatability study for the IX process.

6.1 TEST OBJECTIVES

The overall objective of the IX treatability study is to evaluate the effectiveness of the various IX media as a potential treatment alternative in reducing the volume, toxicity, or mobility of selected metals and radionuclides from Rocky Flats surface water and groundwater. The individual resins will first be tested in small columns to determine their capabilities for reducing the concentrations of beryllium, chromium, iron, lead, manganese, mercury, selenium, americium, plutonium, and uranium in the composite sample waters at Rocky Flats. Media that show sufficient capabilities will be further tested in columns to determine their capacities and breakthrough times, as well as the ion exchange resins' regeneration abilities.

The effectiveness of the IX resins in removing the contaminants of concern will be evaluated in bench-scale column tests. The specific objectives of bench-scale treatability testing are as follows:

- Screen and select different types of resins for use in treatability testing such as weak and strong acid, weak and strong base, metals-chelating, and specialty (for example, ion-specific) resins.
- Conduct bench-scale column tests to determine the capability of each of the selected resins to remove the contaminants of concern.

- Conduct bench-scale column tests to determine the capacities, breakthrough characteristics, and quantities and characteristics of regenerant wastes expected for each of the resins.

6.2 SCREENING AND SELECTION OF RESINS

This section contains descriptions of the ion exchange resins that were considered for use during treatability testing. The process to select resins for initial screening was based on the requirements listed in Attachment No. 2 of EG&G's Statement of Work and past experience. The following screening criteria were used:

- Capable of removing one or more of the contaminants of concern present in the Rocky Flats water
- Able to be tested in bench-scale columns
- Commercially available for testing at the Rocky Flats facility

Descriptions of all of the resins selected for testing are presented in subsection 6.2.1. Descriptions of the resins screened, but not selected for testing, along with the reason(s) they were not selected, are presented in subsection 6.2.2. It was assumed during the screening and selection process that only one resin from each class of resins would be tested if there were no data suggesting that any significant performance difference would be expected. For example, there are a number of specific metal ion exchange resins commercially available from different sources that are similar in physical characteristics and functionality. For these cases, an educated choice was made based on available literature and past experience.

6.2.1 Ion Exchange Resins to be Tested

No single ion exchange resin is capable of meeting the potential ARARs for all of the contaminants of concern because of the limited selectivities of the resins (either for cations or anions), and the diversity of the target constituents in the Rocky Flats composite raw water—cations, anions, and radionuclides present as ions or in colloidal form. In cases like this, systems containing two or more resins—either combined together in a mixed-bed column (for instance, mixed-bed demineralizers) or arranged in separate in-series columns—are commonly used. A mixed-bed column typically produces a cleaner effluent than a comparable two-column system can at a lower capital cost. However, operating costs of mixed-bed systems are typically higher because the resin capacities are lower (requiring more frequent regenerations) and because they are more susceptible to organic fouling than are the in-series columns (Applebaum, 1968). For the purposes of this TSWP, the majority of the resins will be tested in individual columns connected in series—two columns per test—because this arrangement provides more flexibility during treatability testing (for instance, effluent samples can be collected from just the first column, if desired) and because treatment in the leading column may precondition the stream for better performance of the second column.

In addition to the general resin screening criteria discussed earlier, other considerations important to testing in-series pairs of resin pairs include:

- The ability to meet the total dissolved solids (TDS) anticipated effluent limit of 500 mg/L
- The impact of the raw water TDS concentration on removal efficiencies of the contaminants of concern
- Minimization of generated secondary wastes

- The ability to remove colloidal materials (some radionuclides adsorb preferentially to colloids)
- Minimization of water required for testing

For TDS removal, non-selective weak and strong acid resins (for cation removal) and non-selective weak and strong base resins (for anion removal) were considered. Strong acid resins in the hydrogen form exchange hydrogen for other cations; strong base resins in the hydroxide form exchange hydroxide for other anions. They are commonly used together in applications where effluent TDS concentrations less than 5 mg/L are required (for instance, demineralization). The weak acid resins typically remove only that part of the total cations present equivalent to the amount of bicarbonate alkalinity in the water, and convert the alkalinity to carbonic acid that can be stripped from the column effluent. Therefore, the TDS removed by weak acid resins includes both the exchanged cations as well as the bicarbonate anions. Weak base resins are typically effective at removing only the free mineral acidity present in the water, including chlorides, sulfates, and nitrates.

For heavy metals removal in the mid to low ppb range, metals-chelating and metal-specific resins are commonly used. Two important factors affecting the selectivity of these resins for various metals are the pH and TDS (i.e., competing ions) concentration of the water to be treated. For many metals-chelating and metal-specific resins, selectivity is enhanced as pH and TDS concentrations are reduced. For example, the predicted effluent concentrations of ferrous iron (Fe^{2+}) at two different effluent pHs and calcium ion (Ca^{2+}) concentrations using the metals-chelating resin Amberlite IRC-718 manufactured by Rohm and Haas are shown below.

**Predicted Effluent Concentrations of Fe^{2+}
Resin: Amberlite IRC-718**

	$Ca^{2+} = 1 \text{ mg/L}$	$Ca^{2+} = 100 \text{ mg/L}$
pH = 2	0.0073	0.73
pH = 4	0.35	35

These data assume that the concentrations of the ferrous and calcium ions retained on the resin are equal. Figures calculated from selectivity coefficients are listed in the manufacturer's product bulletin. Maximizing TDS removals to enhance removal efficiencies of low concentration metal contaminants can be done by using strong acid and strong base resins in a series. However, the use of these resins results in the generation of relatively large quantities of secondary wastes for two reasons: (1) regenerant requirements range from 3 to 5 milliequivalents (meq) of regenerant per meq of resin capacity versus 1.5 to 2.0 meq regenerant per meq resin for weak acid and weak base resins (Rohm and Haas, 1990); and (2) TDS removals are significantly higher than for other more contaminant-selective types of resins. These two competing factors, along with a knowledge of the approximate water composition and the anticipated treatment targets for the constituents of concern, were taken into account in the resin selection process.

Based on these considerations, six different ion exchange resins were selected for inclusion in this TSWP. They are:

- Rohm and Haas Amberlite 200C (strong acid cation exchange resin)
- Rohm and Haas Amberlite IRA-938 (strong base anion exchange resin)
- ChromatoChem HiPAC-PEI (metals-chelating resin)
- Dianex TS-200 (metals-selective resin)
- Rohm and Haas DP-1 (weak acid cation exchange resin selective for metals)
- Rohm and Haas IRC-718 (metals-chelating resin)

The 200C and the IRA-938 resins were included to remove TDS. Additionally, the IRA-938 resin is particularly effective at removing negatively charged colloids (typical for waters in the neutral to alkaline pH range) and is reportedly effective at removing radioactive colloids. No other weak acid or weak base resins were selected for testing to remove TDS primarily due to uncertainties regarding the actual water composition and variability, and consequently, uncertainties regarding their capabilities in meeting the anticipated TDS limit in full-scale systems. Four metals-selective resins were chosen for testing because the physical properties, selectivity, and reaction kinetics of the resins are

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans
for Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 6

Revision: 0

Page: 6 of 42

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

significantly different. A mercury-selective resin (TS-200) was chosen because it is unlikely that the anticipated treatment target for mercury can be met with any of the other resins to be tested.

This TSWP uses several resins manufactured by Rohm and Haas. Other manufacturers sell resins with similar physical and chemical characteristics and similar functionality. No attempt was made to evaluate the relative merits of similar resins from competing manufacturers. The focus was on selecting various resin functional types (for instance, strong acid) that could be used to achieve the treatment targets.

The remainder of this section contains detailed descriptions of the typical uses and performance characteristics of the resins chosen for testing as part of this TSWP. Unless otherwise noted, the information presented in these descriptions was taken from the manufacturers' product bulletins and not specifically referenced in Section 27.0. However, where literature data were used to support the performance claims of the manufacturers, specific references to the literature are included in the text and referenced in Section 27.0. The address and telephone numbers of each of the resin manufacturers are given below.

Resin Manufacturers Address List

Mr. Joe Silvia
Rohm and Haas Company
Separation Technologies Division
9399 West Higgins Road, Suite 920
Rosemont, IL 60018
(800) 323-4165

Mr. Gary Jones
Dianex Systems, Inc.
231 South Transit Street
Lockport, NY 14094
(716) 433-1442

Mr. Richard Hammen
ChromatoChem, Inc.
2837 Fort Missoula Road
Missoula, MT 59801-7407
(800) 426-7227

6.2.1.1 Amberlite 200C®

Amberlite 200C is a macroreticular strongly acidic cation exchange resin manufactured by Rohm and Haas. Typical applications include condensate polishing, deionization, and production of ultra-pure water in conjunction with other treatment systems. It is effective in removing both monovalent and polyvalent metal cations from solution and also is effective in removing some large organic molecules. Although no data were available on the effectiveness of 200C to remove radionuclides, it is possible that the resin will be capable of producing an effluent that approaches or meets the anticipated treatment targets for each of the cationic constituents of concern present as cations in solution, based on its known effectiveness in removing the more highly concentrated common metal cations.

Amberlite 200C has an approximate operating exchange capacity of 55,000 mg CaCO₃/L resin. It can be regenerated using a 4 to 10 percent solution of hydrochloric acid (H⁺ form) or a 10 to 26 percent (saturated) solution of sodium chloride (Na⁺ form). Recommended loading rates are from 1 to 3 gpm/ft³. There is no pH limitation, and the maximum operating temperature is 275°F.

6.2.1.2 Amberlite IRA-938

Amberlite IRA-938 is a macroreticular, strongly basic anion exchange resin manufactured by Rohm and Haas. Its relatively large pore size distribution is specifically designed for the removal of colloidal substances (such as silica), hydrous metal oxides, and various high molecular weight organic compounds. It is also reportedly well-suited for the removal of radioactive colloids.

IRA-938 has an approximate operating exchange capacity of 25,000 mg CaCO₃/L. Resin regeneration is typically a two-step process: (1) hot acid wash (10 percent or 3M HCl at 130°F) to solubilize retained colloidal silicates and metal oxides, and (2) regeneration using a hot caustic solution (4 percent or 1M NaOH at 130°F) to strip silica and to put the resin in the OH⁻ form. Recommended loading rates are from 1 to 5 gpm/ft³. There is no pH limitation, and the maximum operating temperature is 140°F.

6.2.1.3 HIPAC-PEI

HiPAC-PEI is a silica-based metals-chelating resin manufactured by ChromatoChem. It is a new technology that uses immobilized polyethyleneimine (PEI) as the metals chelating molecule. One of the main differences between the HiPAC-PEI and other metals chelating resins is its use of a long, hydrophilic, chemically stable linker molecule to which the PEI molecule is attached at the terminus while being covalently bonded at its silica surface base. This configuration reportedly increases the overall kinetics of the adsorption/chelation reactions, thereby decreasing the relative amount of resin required to meet effluent discharge limits as compared with other chelating resins.

The resin has been tested on the bench-scale to evaluate the removal of heavy metals from acid mine drainage (Hammen et al., no date). The resin has a very low selectivity for alkali and alkaline earth metals and exhibits a metal ion binding affinity of the following order:



This selectivity of the HiPAC-PEI may allow the removal of the heavy metals without having to soften or completely deionize the raw water, thereby potentially reducing the overall regenerant and secondary waste disposal costs. No data were available on the effectiveness of HiPAC-PEI to remove radionuclides. However, research and development is reportedly now underway to develop resins that will specifically select for various radionuclides (Hammen, 1992).

HiPAC-PEI has an approximate metals exchange capacity of 0.7 mmol M^{2+} /mL resin (17,000 mg CaCO_3 /L resin), based on tests for copper removal from acid mine drainage. The recommended hydraulic loading rates are from 600 to 1,200 bed volumes per hour, approximately one to two orders of magnitude higher than conventional resins. The resin can be regenerated using a 1 percent solution of sulfuric acid to put the resin in the H^+ form, followed by neutralization with a 1 percent ammonium hydroxide solution. The operating pH range is from 1 to 12. No temperature limitation was reported by the manufacturer.

6.2.1.4 Dianex TS-200

Dianex TS-200 is a mercury-selective chelating resin manufactured by Dianex Systems. The selectivity for mercury is based on the use of both thiol and sulfonic acid functional groups attached to the resin matrix. It is typically used to remove trace amounts of mercury from process waters (such as mercury cell effluents in the chloralkali industry). TS-200 also shows an affinity for other heavy metals as well (such as cadmium, lead, and copper are listed in the manufacturer's product bulletin). However, while these other heavy metals will initially be adsorbed, they will eventually be displaced by mercury during the course of a loading cycle. No data were available on the effectiveness of TS-200 to remove radionuclides.

TS-200 has an operating exchange capacity for mercury of approximately 80 g Hg/L resin (40,000 mg CaCO₃/L resin) at influent mercury concentrations up to 4 mg/L (the maximum detected mercury concentration in samples collected to date at Rocky Flats). The resin can be regenerated using a concentrated hydrochloric acid solution. The maximum recommended hydraulic loading rate is 10 bed volumes per hour. The recommended pH range is from zero to 13 at a maximum operating temperature of 140°F.

6.2.1.5 Amberlite DP-1

Amberlite DP-1 is a macroreticular weakly acidic cation exchange resin manufactured by Rohm and Haas. DP-1 in the sodium form is commonly used to soften waters for industrial use due to its selectivity for divalent cations (such as alkaline earth metals). DP-1 has also proven to be effective in removing many trace metals such as iron, zinc, copper, cobalt, chromium, and cadmium from various industrial waste streams. The heavy metals are preferentially removed from the water, displacing the alkaline earth metals and leaving the alkali metals in solution. No data were available on the effectiveness of DP-1 to remove radionuclides.

DP-1 has an approximate operating exchange capacity of over 40 kg/ft³ (90,000 mg CaCO₃/L resin) after regeneration using a 6 percent hydrochloric acid solution followed by treatment with a 4 per-

cent sodium hydroxide solution to put the resin in the sodium form. Recommended loading rates are from 2 to 4 gpm/ft³. The recommended pH range is from 4.5 to 14 at a maximum temperature of 250°F.

6.2.1.6 Amberlite IRC-718

Amberlite IRC-718 is a macroreticular chelating cation exchange resin manufactured by Rohm and Haas that has a high affinity for heavy metal cations over alkali or alkaline earth metals. Typical applications include trace metals removal from process streams, removal and recovery of metal ions from plating baths and rinse waters in the electroplating industry, and recovery of heavy metals from hydrometallurgical waste streams. The selectivity of IRC-718 often allows the removal of the heavy metals without having to soften or completely deionize the raw water, thereby potentially reducing the overall regenerant and secondary waste disposal costs. No data were available on the effectiveness of IRC-718 to remove radionuclides.

IRC-718 was evaluated in bench-scale tests for possible use at the Hanford DOE facility in Richland, Washington (CH2M HILL, 1992). It was preceded in a two-column test by DP-1 in the Na⁺ form to reduce hardness and increase the selectivity of the IRC-718 resin for various metals. Two of the target metals—lead and mercury—are also constituents of concern at the RFP. In the Hanford tests, lead concentrations were reduced from 5 µg/L to less than 0.4 µg/L.

IRC-718 has an approximate operating exchange capacity of 50,000 mg CaCO₃/L resin in the sodium form. It can be regenerated using a 6 percent hydrochloric acid solution and neutralized using a 1 percent sodium hydroxide solution. Recommended loading rates are from 1 to 4 gpm/ft³. The recommended pH range is from 1.5 to 14 at a maximum temperature of no greater than 150°F. Changes in pH affect the relative selectivity of the resin with lower pHs (resulting in a pH range of 2 to 4) and lower TDS concentrations contributing to better heavy metals selectivities (see subsection 6.2.1).

6.2.2 Ion Exchange Resins Not Selected for Testing

Several other types of ion exchange resins were considered, but not chosen for inclusion in this TSWP. A brief description of each resin follows, along with the reason for its exclusion.

6.2.2.1 Weak Acid Resins for TDS Removal

A weak acid resin in the H^+ form can be used to remove cations in an amount equivalent to the bicarbonate alkalinity present in the water. At the same time, the bicarbonate alkalinity is converted to carbonic acid, which can be stripped from the treated water. Depending on the raw water composition and the other treatment processes employed, the TDS of the treated water may or may not achieve the anticipated TDS limit of 500 mg/L. Due to the necessity for the composition of the water to be treated in the full-scale treated water system to be better defined, both in terms of average composition and variability, it was conservatively decided to use only a strong acid resin for TDS removal. Therefore, no weak acid resins were included for testing in the H^+ form.

6.2.2.2 Duolite GT-73

Duolite GT-73 is a mercury-selective ion exchange resin manufactured by Rohm and Haas. It was successfully tested and selected for use as part of the new 300 Area water treatment facility at the Hanford DOE reservation in Washington (CH2M HILL, 1992). However, Rohm and Haas recently discontinued production of the resin on a short-term basis, and no supply of the resin will be available for testing for at least 6 to 12 months. In terms of performance and functionality, it is similar to the Dianex T-200 resin already being tested. For these reasons, GT-73 was not selected for testing at Rocky Flats.

6.3 KEY ASSUMPTIONS

Several assumptions were made in specifying the test conditions under which the ion exchange treatability study will be performed:

- The constituents that are expected to be removed by each of the resins being tested are presented in Figure 6-1. Evaluation of potential effectiveness was based on manufacturers' literature data and similarities between ionic species.
- The water to be tested will be a composite of water samples collected from several locations (as noted in Appendix A of this document). Table 6-1 presents the water characteristics at the three sampling locations proposed for use in testing—09091-GW, B206789-GW, and GS10-SW and the calculated composite concentrations based on the volume ratios indicated. Historical records were used to estimate the parameter concentrations at each location where available. In the case of the carbon dioxide system, the concentrations of the different inorganic carbon species were estimated based on the measured bicarbonate concentrations and equilibrium considerations assuming that the total inorganic carbon content remains constant. Where measured concentrations of significant ions were missing (for example, sulfate), assumed values were used that resulted in an approximate ionic balance in the composite water.
- Table 6-2 presents the composite raw water chemistry of the composite sample. The pH of the water was varied until the dissolved CO₂ concentration based on the equilibrium between the calculated aqueous inorganic carbon species approximately equaled the dissolved CO₂ concentration based on the equilibrium between atmospheric CO₂ and dissolved CO₂ (equil.).
- The physicochemical forms of the ionic species listed in Tables 6-1 and 6-2 were determined based on the following conventions: (1) cations exist in solution as

FIGURE 6-1

CONSTITUENT REMOVAL EFFECTIVENESS FOR THE RESINS TO BE TESTED

Ion Exchange Resins	Type	Heavy Metals							Radionuclides		
		Be	Cr	Fe	Pb	Mn	Hg	Se	Am	Pu	U
Amberlite 200C	Strong acid cation resins	●	○ ¹	●	●	▣	●	○	■	■	○
Amberlite DP-1	Weak acid cation resin	●	○	●	●	●	●	○	NI	NI	○
Amberlite IRC-718	Metals chelating resin	NI	○	○ ²	●	○	●	○	NI	NI	○
Amberlite IRA-938	Strong base anion resin	○	●	○	○	○	○	●	○	○	●
Dianex TS-200	Hg-selective chelating resin	NI	○	■	●	■	●	○	NI	NI	○
HiPAC PEI	Metals chelating resin	NI	○	●	○	○	●	○	NI	NI	○

¹It is assumed that the Cr will be present in the hexavalent state.

²It is assumed that Fe II will be present in dissolved form, while FE III will be present in particulate form and therefore will settle out of the water before testing. This resin is not effective at removing Fe II, but is effective at removing Fe III.

- Notes: ● = Target constituent.
 ■ = Potentially effective.
 ○ = Not effective.
 ▣ = The manganese is not effectively removed by Amberlite 200C.
 NI = No information available to evaluate effectiveness.

The anticipated removal effectiveness of these resins are based on the assumed ionic species shown in Table 6-2.

Table 6-1

ROCKY FLATS COMPOSITE SAMPLE GENERATION					
Parameter	Unit	Constituent Concentrations at Location*:			Composite Concentrations
		09091-GW	B206789-GW	GS10-SW	
Cations					
Americium	pCi/L	47.0	0.0	0.0	18.8
Beryllium	ug/L	0.0	0.0	0.0	0.0
Calcium	ug/L	110,000.0	165,000.0	37,300.0	104,690.0
Iron	ug/L	14.0	23.0	35,500.0	10,662.5
Lead	ug/L	0.0	0.0	0.0	0.0
Magnesium	ug/L	10,100.0	42,500.0	7,840.0	19,142.0
Manganese	ug/L	0.0	0.0	946.0	283.8
Mercury**	ug/L	0.1	0.1	0.1	0.1
Plutonium	pCi/L	355.0	0.0	0.0	142.0
Potassium	ug/L	1,860.0	3,600.0	3,150.0	2,769.0
Sodium	ug/L	7,960.0	150,000.0	15,100.0	52,714.0
Anions					
Bicarbonate	ug/L	293,000.0	165,000.0	230,000.0	235,700.0
Carbonate	ug/L	0.0	0.0	0.0	0.0
Chloride	ug/L	45,000.0	89,200.0	100,000.0	74,760.0
Chromium	ug/L	0.0	8.0	34.5	12.8
Nitrate/Nitrite	ug/L	7,500.0	8,300.0	9,000.0	8,190.0
Selenium	ug/L	0.0	680.0	0.0	204.0
Silicon	ug/L	7,860.0	5,470.0	21,400.0	11,205.0
Sulfate	ug/L	100,000.0	100,000.0	100,000.0	100,000.0
Uranium	pCi/L	1.0	0.0	0.0	0.4
Miscellaneous					
TSS	ug/L	9,700,000.0	42,000.0	100,000.0	3,922,600.0
TDS (meas.)	ug/L	270,000.0	1,140,000.0	560,000.0	618,000.0
TDS (calc.)	ug/L	583,000.0	730,000.0	560,000.0	620,000.0
Ctotal	umol/L	6,000	3,300	4,100	4,600.0
pH	-	7.0	7.0	7.5	
Carbon Dioxide System					
[CO2]aq	umol/L	1,200	600	300	
[HCO3-]	umol/L	4,800	2,700	3,800	
[CO3=]	umol/L	0	0	0	
Volume Ratio		0.4	0.3	0.3	

*Note: Figures in italics are assumed values

**No mercury detected in any of the samples

Equilibrium Constants (at 20 deg. C)	
pK1	6.381 mol/L
pK2	10.377 mol/L

Molecular Weights (g/mol)	
CO2	44.0
HCO3-	61.0
CO3=	60.0

Table 6-2

ROCKY FLATS RAW COMPOSITE WATER CHEMISTRY					
Parameter	Molecular Weight	Equiv. per Mole	Concentration		
			Mass Basis (ug/L)*	Molar Basis (umol/L)	As CaCO3 (ug/L)
Cations					
Americium*	243.0	Unknown	18.8	Not defined	
Beryllium	9.0	2	0.0	0.0	0
Calcium	40.1	2	104,690.0	2,610.7	261,072
Hydrogen	1.0	1	0.0	0.0	0
Iron	55.8	2	10,662.5	191.1	19,108
Lead	207.2	2	0.0	0.0	0
Magnesium	24.3	2	19,142.0	787.7	78,774
Manganese	54.9	2	283.8	5.2	517
Mercury	200.6	2	0.1	0.0	0
Plutonium*	244.0	Unknown	142.0	Not defined	
Potassium	39.1	1	2,769.0	70.8	3,541
Sodium	23.0	1	52,714.0	2,291.9	114,596
Total Heavy Metals**					19,600
Total Cations			190,000	5,960	478,000
Anions					
Bicarbonate	60.0	1	264,272.0	4,404.5	220,226
Carbonate	61.0	2	11,278.0	184.9	18,488
Chloride	35.5	1	74,760.0	2,105.9	105,296
Chromium (as CrO4)	52.0	6	12.8	0.3	75
Hydroxide	17.0	1	117.0	6.9	345
Nitrate/Nitrite***	62.0	1	8,190.0	132.1	6,605
Selenium (as SeO4)	79.0	2	204.0	2.6	258
Silicon (as HSiO3)	28.1	1	11,205.0	398.8	19,938
Sulfate	96.1	2	100,000.0	1,040.6	104,058
Uranium*	238.0	Unknown	0.4	Not defined	
Total Anions			470,000	8,280	475,000

*Concentrations (mass basis) of radionuclides in units of pCi/L; ionic species unknown

**Excludes chromium

***Concentrations (mass basis) calculated on nitrate basis

Miscellaneous Parameters		Equilibrium Constants (at 20 deg. C)	
pH	9.0	Water:	
Ctotal	4,600 umol C/L (fixed)	pKw	14.161 (mol/L)*2
Dissolved CO2	10.6 umol C/L (calc.)	CO2 System:	
Dissolved CO2	12.3 umol C/L (equil.)	pPCO2	3.5 atm
TSS	3,923 mg/L	pKH	1.41 mol/L/atm
TDS	620 mg/L	pK1	6.381 mol/L
Alkalinity	239 mg/L as CaCO3	pK2	10.377 mol/L
Hardness	359 mg/L as CaCO3		

individual atoms with a charge number equal to each atom's most stable oxidation state;¹ (2) of the common anions listed, bicarbonate, chloride, hydroxide, and nitrate/nitrite exist as monovalent ions in solution while carbonate and sulfate exist as divalent ions; (3) the assumed ionic forms of chromium (CrO_4^{2-}) hexavalent, selenium (SeO_4^{2-}), and silicon (HSiO_3^-) are common forms when the pH is in the neutral to alkaline range and the redox potential (E_h) is positive (e.g., oxidizing) (Dragun, 1988), typical for many ground and surface waters.

- The physicochemical forms of the radionuclides in solution are unknown. Identification of each radionuclide as either a cationic or an anionic species was based on past experience of Rocky Flats staff and scientific judgement. It is known that some radionuclides exist as negatively charged colloids in solution despite the fact that electrochemical considerations suggest the more likely form would be cationic (such as the uranyl ion UO_2^{2+} that predominates at a pH greater than 10, and a positive redox potential [Dragun 1988]). One explanation for this effect is that particulates found in natural waters—typically negatively charged at neutral to alkaline pHs— attract and hold the uranyl ions through electrostatic attraction. Since these particulates (such as clays and organic materials) can become positively charged at acidic pHs, removal of uranium and other colloiddally bound radionuclides (exhibiting good removal on anionic resins at higher pHs) may be efficiently removed on cationic resins at acidic pHs. This possibility will be evaluated in this TSWP.
- Tables 6-3 and 6-4 present the test conditions for the initial screening tests (capability tests) and the capacity tests for the IX resins. The listed loading rates, resin capacities, regeneration and rinse requirements are based on manufacturer recommendations. Note that the resin capacities used are approximate and will

¹The only exception is iron, which is most stable at an oxidation state of 3. However, Fe^{3+} forms the highly insoluble $\text{Fe}(\text{OH})_3$ under conditions typically found in many ground and most surface waters. Since the samples listed in Figure 6-1 will not be filtered prior to analysis, both the Fe^{2+} and Fe^{3+} oxidation states could be present. However, in commercial applications, filtering is a common practice to prevent the fouling of IX resins, and therefore, the Fe^{2+} state is the one most likely to be present.

Table 6-3

CAPABILITY TESTS FOR ION EXCHANGE RESINS										
Resin			Water Loading							
Name	Resin Type	Ionic Form	Flow Rate			Volume to Waste		Volume to Test	Total Volume	Total Test Time
			(mL/min)	(gpm/ft ³)	(BV/min)	(BV)	(mL)	(mL)	(mL)	(min)
200C	Strong Acid	H+	70	1.5	0.19	5	1,800	4,000	5,800	80
IRA-938	Strong Base	OH-	70	1.5	0.19	5	1,800	4,000	5,800	80
200C	Strong Acid	H+	100	2.0	0.28	5	1,800	4,000	5,800	60
DP-1	Weak Acid	Na+	100	2.0	0.28	5	1,800	4,000	5,800	60
200C	Strong Acid	H+	70	1.5	0.19	5	1,800	4,000	5,800	80
IRC-718	Weak Acid	Na+	70	1.5	0.19	5	1,800	4,000	5,800	80
200C	Strong Acid	H+	100	2.0	0.28	5	1,800	4,000	5,800	60
HiPAC-PE	Weak Acid	Na+	100	2.0	0.28	5	1,800	4,000	5,800	58
200C	Strong Acid	H+	70	1.5	0.19	5	1,800	4,000	5,800	80
TS-200	Weak Acid	H+	70	1.5	0.19	5	1,800	4,000	5,800	80

Resin			Predicted Breakthrough of Critical Component				
Name	Resin Type	Ionic Form	Critical Component	Concentration* (mg/L as CaCO ₃)	Resin Capacity**	Breakthrough Volume (L)***	Breakthrough Time (minutes)***
200C	Strong Acid	H+	Cations	478	55,000	42	600
IRA-938	Strong Base	OH-	Anions	475	25,000	19	270
200C	Strong Acid	H+	Cations	478	55,000	42	420
DP-1	Weak Acid	Na+	Metals	20	90,000	1,700	17,000
200C	Strong Acid	H+	Cations	478	55,000	42	600
IRC-718	Weak Acid	Na+	Metals	20	50,000	920	13,000
200C	Strong Acid	H+	Cations	478	55,000	42	420
HiPAC-PE	Weak Acid	Na+	Metals	20	17,000	310	3,100
200C	Strong Acid	H+	Cations	478	55,000	42	600
TS-200	Weak Acid	H+	Mercury	4.99E-05	40,000	2.91E+08	4.15E+09

*Component concentrations from Table 6-2

**Operating capacity (est.)

***Breakthrough volumes and times must be less than the respective total volumes and test times for the wastewater loading

Table 6-3 (Continued)

CAPABILITY TESTS FOR ION EXCHANGE RESINS												
Resin			Regeneration									
Name	Resin Type	Ionic Form	Regenerant	Solution Strength (%)	Solution Density (mg/mL)	Solution Normality (meq/mL)	Resin Capacity* (meq/mL)	Flow Rate (mL/min)	Flow Rate (gpm/ft ³)	Flow Rate (BV/min)	Volume Req. (mL)	Time Req. (min)
200C	Strong Acid	H+	HCl	6.0%	1027.9	2.0	1.65	12	0.25	0.03	1,400	120
IRA-938	Strong Base	OH-	HCl**	10.0%	1,050.4	3.0	0.5	12	0.25	0.03	400	30
200C	Strong Acid	H+	HCl	6.0%	1027.9	2.0	1.65	12	0.25	0.03	1,400	120
DP-1	Weak Acid	Na+	HCl	6.0%	1027.9	2.0	2.5	12	0.25	0.03	940	80
200C	Strong Acid	H+	HCl	6.0%	1027.9	2.0	1.65	12	0.25	0.03	1,400	120
IRC-718	Weak Acid	Na+	HCl	6.0%	1027.9	2.0	1.1	12	0.25	0.03	410	30
200C	Strong Acid	H+	HCl	6.0%	1027.9	2.0	1.65	12	0.25	0.03	1,400	120
HiPAC-PE	Weak Acid	Na+	HCl	0.75%	1005.0	0.21	0.95	12	0.25	0.03	2,900	240
200C	Strong Acid	H+	HCl	6.0%	1027.9	2.0	1.65	12	0.25	0.03	1,400	120
TS-200	Weak Acid	H+	Resin is not readily regenerable									

*Theoretical capacity; used to calculate volume of regenerant required

**Temperature of regenerant: 120 degrees F plus or minus 10 degrees F

Resin			Conversion to Proper Ionic Form									
Name	Resin Type	Ionic Form	Regenerant	Solution Strength (%)	Solution Density (mg/mL)	Solution Normality (meq/mL)	Resin Capacity* (meq/mL)	Flow Rate (mL/min)	Flow Rate (gpm/ft ³)	Flow Rate (BV/min)	Volume Req. (mL)	Time Req. (min)
200C	Strong Acid	H+	Not Required									
IRA-938	Strong Base	OH-	NaOH**	4.0%	1,025.3	1.0	0.5	12	0.25	0.03	700	60
200C	Strong Acid	H+	Not Required									
DP-1	Weak Acid	Na+	NaOH	4.0%	1025.3	1.0	2.5	12	0.25	0.03	1,500	130
200C	Strong Acid	H+	Not Required									
IRC-718	Weak Acid	Na+	NaOH	1.0%	1,009.5	0.25	1.1	12	0.25	0.03	2,800	230
200C	Strong Acid	H+	Not Required									
HiPAC-PE	Weak Acid	Na+	NaOH	0.05%	1,000.0	0.01	0.95	12	0.25	0.03	48,200	4,020
200C	Strong Acid	H+	Not Required									
TS-200	Weak Acid	H+	Not Required									

*Theoretical capacity; used to calculate volume of regenerant required

**Temperature of regenerant: 120 degrees F plus or minus 10 degrees F

Table 6-3 (Continued)

CAPABILITY TESTS FOR ION EXCHANGE RESINS											
Resin			Initial Rinse (DI Water)*			Final Rinse (DI Water)*					
Name	Resin Type	Ionic Form	Flow Rate (mL/min)	Volume Required (mL)	Time Reqd. (min)	Flow Rate (mL/min)	Flow Rate (gpm/ft ³)	Flow Rate (BV/min)	Volume Required (BV)	Volume Required (mL)	Time Reqd. (min)
200C	Strong Acid	H+	12	360	30	70	1.5	0.19	9	3300	50
IRA-938	Strong Base	OH-	12	360	30	70	1.5	0.19	9	3300	50
200C	Strong Acid	H+	12	360	30	70	1.5	0.19	9	3300	50
DP-1	Weak Acid	Na+	12	360	30	100	2.0	0.28	9	3300	30
200C	Strong Acid	H+	12	360	30	70	1.5	0.19	9	3300	50
IRC-718	Weak Acid	Na+	12	360	30	100	2.0	0.28	9	3300	30
200C	Strong Acid	H+	12	360	30	70	1.5	0.19	9	3300	50
HiPAC-PE	Weak Acid	Na+	12	360	30	100	2.0	0.28	9	3300	30
200C	Strong Acid	H+	12	360	30	70	1.5	0.19	9	3300	50
TS-200	Weak Acid	H+	Not Required			Not Required					

*Temperature of IRA-938 rinsewater: 120 degrees F plus or minus 10 degrees F

Resin			Backwash (DI Water)*	
Name	Resin Type	Ionic Form	Flow Rate (mL/min)	Flow Rate (gpm/ft ²)
200C	Strong Acid	H+	180	5.5
IRA-938	Strong Base	OH-	20	0.7
200C	Strong Acid	H+	180	5.5
DP-1	Weak Acid	Na+	150	4.5
200C	Strong Acid	H+	180	5.5
IRC-718	Weak Acid	Na+	100	3.0
200C	Strong Acid	H+	180	5.5
HiPAC-PE	Weak Acid	Na+	100	3.0
200C	Strong Acid	H+	180	5.5
TS-200	Weak Acid	H+	100	3.0

*Typical for 50 percent bed expansion; figures in italics are estimated

Non-Safety Related

Final Draft

Table 6-3 (Concluded)

CAPABILITY TESTS FOR ION EXCHANGE RESINS				
Regenerant Solutions			Bed Data	
Regenerant Type	Concentration (%)	Density at 20 deg C (mg/mL)	Diameter	1.25 inches
HCl	0.75%	1005.0	Depth	18 inches
HCl	6.0%	1027.9	Volume	362 mL
HCl	10.0%	1050.4	Sample Quantities	
NaOH	0.05%	1,000.0	Volume	2,000 mL
NaOH	1.0%	1,009.5	Number	2 per test
NaOH	4.0%	1,025.3	Solution Equivalent Weights	
Excess Regenerant Requirements*			HCl	36.5 g/eq
Strong	400% excess for SA/SB resins		NaOH	40.0 g/eq
Weak	175% excess for WA/WB resins		Conversion Factors	
*Based on theoretical resin capacities.			Pi	3.1416
SA/SB: Strong Acid and Strong Base resins			ft ³ to mL	28,320 mL/ft ³
WA/WB: Weak Acid and Weak Base resins			gal to mL	3,785 mL/gal
			in ³ to mL	16.39 mL/in ³
			lb to mg	453,590 mg/lb
			ft to in	12 in/ft

Table 6-4

CAPACITY TESTS FOR ION EXCHANGE RESINS										
Resin			Water Loading*							
Name	Resin Type	Ionic Form	Flow Rate			Volume to Waste	Volume to Test	Total Volume	Total Test Time	
			(mL/min)	(gpm/ft ³)	(BV/min)	(BV)	(mL)	(L)	(L)	(hours)
200C	Strong Acid	H+	35	3.0	0.40	5	400	16.0	16.4	7.8
IRA-938	Strong Base	OH-	35	1.5	0.20	5	900	14.6	15.5	7.4
200C	Strong Acid	H+	23	2.0	0.26	5	400	16.0	16.4	12
DP-1	Weak Acid	Na+	23	2.0	0.26	5	400	640	640	464
200C	Strong Acid	H+	23	2.0	0.26	5	400	16.0	16.4	12
IRC-718	Weak Acid	Na+	23	2.0	0.26	5	400	352	352	255
200C	Strong Acid	H+	23	2.0	0.26	5	400	16.0	16.4	12
HIPAC-PEI	Weak Acid	Na+	23	2.0	0.26	5	400	121	121	90
200C	Strong Acid	H+	23	2.0	0.26	5	400	16.0	16.4	12
TS-200	Weak Acid	H+	23	2.0	0.26	5	400	1.12E+08	1.12E+08	8.08E+07

*Test volumes and test times used shall be the smaller of the two listed for each pair of resins.

Resin			Predicted Breakthrough of Critical Component				
Name	Resin Type	Ionic Form	Critical Component	Concentration* (mg/L as CaCO ₃)	Resin Capacity**	Breakthrough Volume (L)	Breakthrough Time (hours)
200C	Strong Acid	H+	Cations	478	55,000	10.0	4.8
IRA-938	Strong Base	OH-	Anions	475	25,000	9.1	4.3
200C	Strong Acid	H+	Cations	478	55,000	10.0	7.2
DP-1	Weak Acid	Na+	Heavy Metals	20	90,000	400	290
200C	Strong Acid	H+	Cations	478	55,000	10.0	7.2
IRC-718	Weak Acid	Na+	Heavy Metals	20	50,000	220	160
200C	Strong Acid	H+	Cations	478	55,000	10.0	7.2
HIPAC-PEI	Weak Acid	Na+	Heavy Metals	20	17,000	75	50
200C	Strong Acid	H+	Cations	478	55,000	10.0	7.2
TS-200	Weak Acid	H+	Mercury	4.99E-05	40,000	6.97E+07	5.05E+07

*Component concentrations from Table 6-2

**Operating capacity

Non-Safety Related

Final Draft

Table 6-4 (Continued)

CAPACITY TESTS FOR ION EXCHANGE RESINS												
Resin			Regeneration									
Name	Resin Type	Ionic Form	Regenerant	Solutio Strengt (%)	Solution Density (mg/mL)	Normality (meq/mL)	Resin Capacity* (meq/mL)	Flow Rate			Volume Reqd. (mL)	Time Reqd. (min)
								(mL/min)	(gpm/ft ³)	(BV/min)		
200C	Strong Acid	H+	HCl	6.0%	1027.9	1.7	1.65	2.9	0.25	0.03	340	120
IRA-938	Strong Base	OH-	HCl**	10.0%	1,050.4	2.9	0.5	5.8	0.25	0.03	121	21
200C	Strong Acid	H+	HCl	6.0%	1027.9	1.7	1.65	2.9	0.25	0.03	340	120
DP-1	Weak Acid	Na+	HCl	6.0%	1027.9	1.7	2.5	2.9	0.25	0.03	220	76
200C	Strong Acid	H+	HCl	6.0%	1027.9	1.7	1.65	2.9	0.25	0.03	340	120
IRC-718	Weak Acid	Na+	HCl	6.0%	1027.9	1.7	1.1	2.9	0.25	0.03	99	34
200C	Strong Acid	H+	HCl	6.0%	1027.9	1.7	1.65	2.9	0.25	0.03	340	120
HiPAC-PE	Weak Acid	Na+	HCl	0.75%	1005.0	0.21	0.95	2.9	0.25	0.03	700	240
200C	Strong Acid	H+	HCl	6.0%	1027.9	1.7	1.65	2.9	0.25	0.03	340	120
TS-200	Weak Acid	H+	Resin is not readily regenerable									

*Theoretical capacity; used to calculate volume of regenerant required

**Temperature of regenerant: 120 degrees F plus or minus 10 degrees F

Resin			Conversion to Proper Ionic Form									
Name	Resin Type	Ionic Form	Regenerant	Solutio Strengt (%)	Solution Density (mg/mL)	Normality (meq/mL)	Resin Capacity* (meq/mL)	Flow Rate			Volume Reqd. (mL)	Time Reqd. (min)
								(mL/min)	(gpm/ft ³)	(BV/min)		
200C	Strong Acid	H+	Not Required									
IRA-938	Strong Base	OH-	NaOH**	4.0%	1,025.3	1.0	0.5	5.8	0.25	0.03	340	59
200C	Strong Acid	H+	Not Required									
DP-1	Weak Acid	Na+	NaOH	4.0%	1,025.3	1.0	2.5	2.9	0.25	0.03	370	130
200C	Strong Acid	H+	Not Required									
IRC-718	Weak Acid	Na+	NaOH	1.0%	1009.5	0.25	1.1	2.9	0.25	0.03	660	230
200C	Strong Acid	H+	Not Required									
HiPAC-PE	Weak Acid	Na+	NaOH	0.05%	1,000.0	0.00	0.95	2.9	0.25	0.03	11,560	3,990
200C	Strong Acid	H+	Not Required									
TS-200	Weak Acid	H+	Not Required									

Non-Safety Related

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Table 6-4 (Continued)

CAPACITY TESTS FOR ION EXCHANGE RESINS											
Resin			Initial Rinse (DI Water)*			Final Rinse (DI Water)*					
Name	Resin Type	Ionic Form	Flow Rate (mL/min)	Volume Required (mL)	Time Reqd. (min)	Flow Rate (mL/min)	Flow Rate (gpm/ft ³)	Flow Rate (BV/min)	Volume Required (BV)	Volume Required (mL)	Time Reqd. (min)
200C	Strong Acid	H+	2.9	90	30	20	1.5	0.23	9	800	40
IRA-938	Strong Base	OH-	5.8	170	30	30	1.5	0.17	9	1600	50
200C	Strong Acid	H+	2.9	90	30	20	1.5	0.23	9	800	40
DP-1	Weak Acid	Na+	2.9	90	30	20	2.0	0.23	9	800	40
200C	Strong Acid	H+	2.9	90	30	20	1.5	0.23	9	800	40
IRC-718	Weak Acid	Na+	2.9	90	30	23	2.0	0.26	9	800	30
200C	Strong Acid	H+	2.9	90	30	20	1.5	0.23	9	800	40
HiPAC-PE	Weak Acid	Na+	2.9	90	30	23	2.0	0.26	9	800	30
200C	Strong Acid	H+	2.9	90	30	20	1.5	0.23	9	800	40
TS-200	Weak Acid	H+	Not Required			Not Required					

*Temperature of IRA-938 rinsewater: 120 degrees F plus or minus 10 degrees F

Resin			Backwash (DI Water)*	
Name	Resin Type	Ionic Form	Flow Rate (mL/min)	Flow Rate (gpm/ft ²)
200C	Strong Acid	H+	60	5.5
IRA-938	Strong Base	OH-	8	0.7
200C	Strong Acid	H+	60	5.5
DP-1	Weak Acid	Na+	50	4.5
200C	Strong Acid	H+	60	5.5
IRC-718	Weak Acid	Na+	30	3.0
200C	Strong Acid	H+	60	5.5
HiPAC-PE	Weak Acid	Na+	30	3.0
200C	Strong Acid	H+	60	5.5
TS-200	Weak Acid	H+	30	3.0

*Typical for 50 percent bed expansion; figures in italics are estimated

Table 6-4

(Concluded)

CAPACITY TESTS FOR ION EXCHANGE RESINS		
Regenerant Solutions		Sample Quantities
Regenerant Concentration	Density at 20 deg C	Sample Volume 2,000 mL
Type (%)	(mg/mL)	Test Volume 160% of breakthrough
HCl 0.75%	1005.0	
HCl 6.0%	1027.9	
HCl 10.0%	1050.4	
NaOH 0.05%	1,000.0	
NaOH 1.0%	1,009.5	
NaOH 4.0%	1,025.3	
Constants		
Pi	3.1416	
ft ³ to mL	28,320 mL/ft ³	
gal to mL	3,785 mL/gal	
in ³ to mL	16.39 mL/in ³	
lb to mg	453,590 mg/lb	
ft to in	12 in/ft	
Excess Regenerant Requirements*		
Strong	400% excess for SA/SB resins	
Weak	175% excess for WA/WB resins	
Solution Equivalent Weights		
HCl	36.5 g/eq	
NaOH	40 g/eq	

*Based on theoretical resin capacities.

SA/SB: Strong Acid and Strong Base resins

WA/WB: Weak Acid and Weak Base resins

Column Data		Resin Type					
Dimension	Unit	200C	DP-1	iPAC-PE	IRA-938	IRC-718	TS-200
Diameter	inches	0.750	0.750	0.750	0.750	0.750	0.750
Depth	inches	12	12	12	24	12	12
Volume	mL	87	87	87	174	87	87

depend on column operating conditions and the characteristics of the water being tested.

- The tests were designed to minimize composite raw water usage. For the capability tests, the column diameter of 1.25 inches and bed depth of 18 inches specified are typical for column tests of resins. For the capacity tests, the column diameters and bed depths were reduced as needed to reduce the volume of composite raw water required per test to less than 10 liters. Although these smaller column tests will still provide the necessary data with which to estimate resin capacities and regenerant characteristics, larger column tests are required to accurately design and predict the performance of a full-scale system.
- Although sulfuric acid is typically used to regenerate many resins in full-scale systems (e.g., typically more cost-effective), hydrochloric acid will be used in these bench-scale tests where acid concentrations greater than 1 percent are required to avoid problems with the precipitation of calcium sulfate. Note that the use of HCl will often result in slightly higher operating capacities than are achievable with sulfuric acid.
- To reduce the amounts of composite raw water required for testing, it was assumed that the resins will be purchased in the proper ionic form and that the resins will not be regenerated prior to capability testing. However, it should be noted that fresh resin may permanently lose a portion of its operating capacity (in the range of 5 to 15 percent) following the first regeneration. If sufficient composite raw water is available, it is recommended that the resins be initially loaded to exhaustion, regenerated, and then tested for capacity. As an alternative (although not preferred), the resin may be pre-exhausted with a synthetic electrolyte solution. This "pre-exhaustion" is termed "conditioning" and should be done for the capacity tests. This will provide a more realistic measurement of resin capacity.

6.4 TASK DESCRIPTIONS

This section presents the general procedures to be followed in conducting the ion exchange treatability study. The procedures are presented in two subsections:

- Capability test procedures
- Capacity test procedures

The resins will be tested in arrangements similar to in a full-scale installation. (These arrangements are due to the interferences observed between cation and anion exchange at the RFP ion exchange pilot plant.) Five arrangements will be tested:

- Amberlite 200C (strong acid)/Amberlite IRA-938 (strong base)
- Amberlite 200C (strong acid)/Amberlite DP-1 (weak acid/metals selective)
- Amberlite 200C (strong acid)/Amberlite IRC-718 (metals chelating)
- Amberlite 200C (strong acid)/ChromatoChem HiPAC-PEI (metals chelating)
- Amberlite 200C (strong acid)/Dianex TS-200 (mercury-selective)

The Amberlite 200C is used before the metals selective and metals chelating resins to reduce the concentration of alkaline earth metals in the raw water and thereby increase the selectivity of the later resins for heavy metals. Testing of the mercury-selective resin will be dependent on whether any detectable quantities of mercury can be obtained in the composite water.

6.4.1 Capability Tests

The purpose of capability testing is to demonstrate the capability of selected ion exchange resins to remove the constituents of concern present in the Rocky Flats composite raw water. These tests are designed to demonstrate the capability of each of the resins to produce an effluent that meets the anticipated treatment targets for one or more of the constituents of concern. However, these screening tests are not designed to optimize operating parameters, determine resin capacities and

breakthrough characteristics, or identify the quality and quantity of residuals requiring subsequent treatment and disposal.

The following is a generic procedure that can be used to test each resin pair. The experimental setup for these capability tests is shown in Figure 6-2. The water feed rates, the regenerants and conditioners used, and the volumes of regenerants, conditioners, and rinse water required may differ for each resin to be tested, but the steps required to conduct the screening tests are the same. The following steps (located in subsection 6.4.2) outline the generic procedures to be followed to conduct the capability tests; Table 6-3 contains the list of resins to be tested along with the water feed rates and types and quantities of regenerants and conditioners required or appropriate for each resin. Note that Steps 8 through 12 are only required for capacity testing; for capability testing, stop after Step 7.

It is recommended that the capability test for each resin be run three times at different pHs to evaluate the effect of pH on constituent removals: (1) acidic pH (3 to 4); (2) neutral pH (6 to 7); and (3) alkaline pH (9 to 10). These data can be used to develop relationships between the column effluent pH to effluent concentrations of the target constituents.

Appendix E contains equations that may be useful for ion exchange capability tests.

6.4.2 Capacity Tests

The purpose of capacity testing is to determine the resin capacities, breakthrough characteristics, and quantities and characteristics of regenerant wastes produced for each of the resins used to treat the Rocky Flats composite raw water. The experimental apparatus and test procedures are similar to those used during the capability tests with two primary differences: (1) the resin bed volumes are sized such that breakthrough of various constituents will occur during the course of testing, enabling the resin capacities and breakthrough characteristics to be determined; and (2) samples of the regenerant wastes will be collected for analysis, enabling an estimation of the quantities and characteristics of these wastes to be made.

DRAWN BY	H. Douville	CHECKED BY	<i>P. Smith</i>	7/23/93	DRAWING NUMBER	RF102XC
	02/19/93	APPROVED BY				

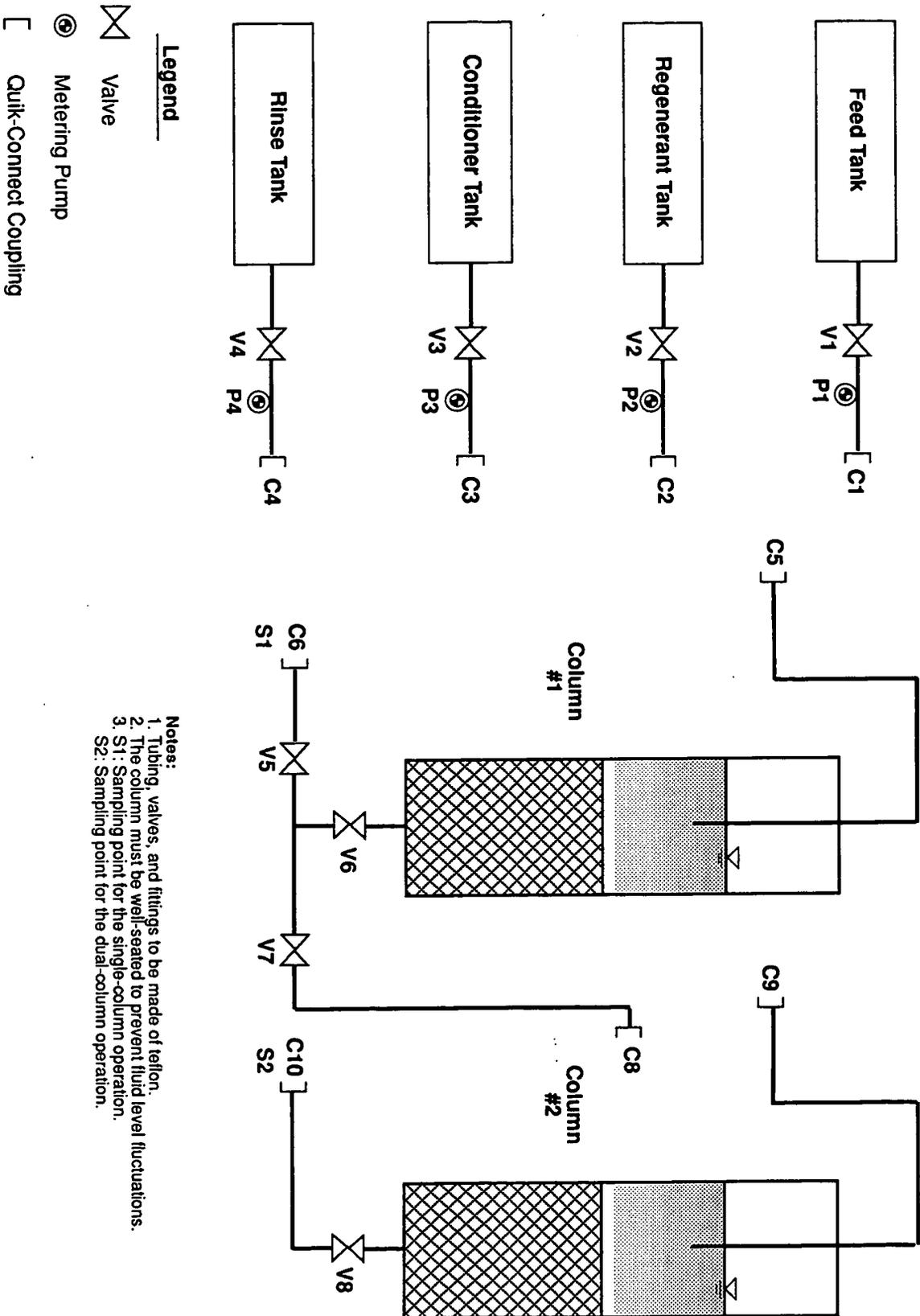


Figure 6-2
COLUMN APPARATUS

Knowledge of the characteristics of the test composite raw water—including the concentrations of the constituents of concern along with the concentrations of the major cations and anions in solution—is necessary to design the experiments and obtain the data objectives listed above. At the present time, not all of these data are available and some assumptions were made as discussed earlier to estimate the raw water chemistry. Once the actual raw water chemistry is determined prior to testing, the IX resin capacity test specifications listed in Table 6-4 may need to be recalculated. The procedure for modifying Table 6-4, based on a change in water chemistry, is approximately as follows:

- Compute the actual concentrations of the critical components and estimate the breakthrough volumes and times based on the listed water flow rates and resin characteristics required for each resin tested.
- If necessary, adjust the water flow rates and resin volumes such that the flow rates and breakthrough volumes for resins tested in series are approximately equal (strong acid/strong base pair) or that the strong acid column breaks through first. In all cases, the tests are designed so that the water volume to be tested is approximately 15 liters.

Due to the potential for column interferences (as observed in the RFP ion exchange pilot plant), these capacity tests will be conducted in a two-column, in-series configuration with a different resin in each column. Bench-scale testing of columns in a series is necessary both to estimate final effluent concentrations accurately for various constituents as well as to estimate the actual resin capacities, breakthrough characteristics, and regenerant waste quantities and characteristics expected in the full-scale system.

Note that breakthrough is defined as the point during the test when the first column becomes exhausted and the concentration of the critical component—in this case, cations for the Amberlite 200C—begins to rapidly increase in the first column effluents of the cations present in the raw Rocky Flats water. Sodium will be the constituent most likely to break through first, based on selectivity

considerations, and will not be retained to any operable extent or any of the second column resins. Therefore, breakthrough of sodium in the second column effluent will be indicative of resin exhaustion in the first column.

In the case of the strong acid/strong base pair (200C/IRA-938), the volume of the IRA-938 resin was specified so that breakthrough of its target constituents—anions—will occur at approximately the same time as breakthrough of cations will occur from the 200C resin, based on the reported operating capacities of the two resins. This will enable an estimate of both resins operating capacities to be made from the capacity test data. In the case of the other resin pairs, it is not feasible due to time, water volume, and other constraints in design experiments to achieve breakthrough of the critical components from the second columns (for example, metals selective/chelating resins). Subsequent tests of either the bench-scale or pilot-scale level to estimate the actual operating capacity of the metals selective/chelating resins could be designed based on the following:

1. Determine the leakage rate of the various target cationic metals from the strong acid/strong base capacity test results
2. Design a two-column capacity test such that the capacity of the strong acid column is not exceeded before the capacity of the metals resin column is reached based on the leakage rate of the metals determined above, and the selectivity of the resins for these metals, based on capacity test results.

The selectivity of a metals resin for a particular target metal can be measured by estimating the removal efficiency of the metal on the resin from mass balance consideration, based on the total mass of a particular metal added to the system, the masses of the metal recovered during regeneration of each resin, and the mass of the metal remaining in the second column effluent. Therefore, although the capacity of the metals resins cannot be determined in those tests, analysis of the regenerant wastes is still required to quantitatively estimate metals resin selectivities and removal efficiencies.

The following is a generic procedure that is written for testing pairs of resins. The experimental setup for these capacity tests is shown in Figure 6-2. The water feed rates, the regenerants and conditioners used, and the volumes of regenerants, conditioners, and rinse water required may differ for each pair of resins to be tested, but the steps required to conduct the capacity tests are the same. The following steps outline the generic procedures to be followed to conduct the capacity tests; Table 6-4 contains the list of resins, to be tested along with the water feed rates and types and quantities of regenerants and conditioners that are required appropriate for each resin. Prior to testing, the pH of the feed water shall be adjusted to an optimum pH found during capability testing.

Appendix E contains equations that may be useful for ion exchange capability tests.

Step 1—Individually Fill Columns with Resin

- Hydrate the required volume of resins in laboratory-grade deionized water for 24 hours prior to filling the column.
- Ensure that all column apparatus valves (V1 through V8) are closed.
- Fill approximately one-half of Columns No. 1 and 2 with laboratory-grade deionized water. Set the rinse tank pump P4 to withdraw from one of the columns by connecting couplings C4 and C6 and opening valves V5 and V6 (Column No. 1), or connecting couplings C4 and C10 and opening valve V8 (Column No. 2).
- Pour the resin-water slurry into the column to be filled until the media depth specified in Table 6-4 is obtained, draining excess water through the bottom of the column as needed using the rinse tank pump. Do not permit the water level to fall below the resin level during this filling step. The resins shall be placed into the columns as follows: Column No. 1—strong acid resin, and Column No. 2—strong base or metals selective/metals-chelating resin.

- Stopper the top of the column and slowly fill with water using the rinse tank pump until the top inlet line is submerged 3 to 6 inches below the water level in the column.
- Close all valves.

Step 2—Individually Backwash Columns

- Use the rinse tank pump P4 to slowly feed deionized water into the bottom of a column by connecting couplings C4 and C6 and opening valves V4, V5, and V6 (Column No. 1), or by connecting couplings C4 and C10 and opening valves V4 and V8 (Column No. 2).
- Slowly increase the flow until a bed expansion of approximately 50 percent is obtained (see Table 6-4 for approximate backwash flow rates).
- Maintain this backwash flow until all air pockets are removed and all the particles have fluidized. Extremely small particles and debris should be allowed to pass out of the column during this time.
- After backwashing is complete, stop the rinse tank pump and close all valves. Discard the backwash water collected.

Step 3—Individually Regenerate Columns

This step is not required if the resin is in the proper ionic form (see Table 6-4).

- Prepare the appropriate reagent solution to use to regenerate the resin.

- Set the column for downflow regeneration by connecting C5 (Column No. 1) or C9 (Column No. 2) to the regenerant tank connection C2. Open valves V2, V5, and V6 (Column No. 1), or V2 and V8 (Column No. 2).
- Set the regenerant pump P2 to feed the regenerant solution required for the resin being tested at the rate and for the time specified in Table 6-4.
- After regeneration is complete, stop the regenerant pump and close all valves. Discard the regeneration solution collected.

Step 4—Individually Rinse Columns

This step is not required unless the resin was regenerated in Step 3.

- Set the column for downflow rinse by connecting C5 (Column No. 1) or C9 (Column No. 2) to the rinse tank connection C4. Open valves V5 and V6 (Column No. 2) or V8 (Column No. 2).
- Set the rinse tank pump to feed rinse water at the rate and for the times specified for the initial and final rinses in Table 6-4.
- After the rinse is complete, stop the rinse tank pump and close all valves. Discard the rinse water collected.

Step 5—Individually Convert the Resins to Proper Ionic Form

This step is not required if the resin is in the proper ionic form initially or after the regeneration step (see Table 6-4).

- Prepare the appropriate reagent solution to convert the resin into the proper ionic form.
- Set the column for downflow conversion by connecting C5 (Column No. 1), or C9 (Column No. 2) to the conversion tank connection C3. Open valves V3, V5, and V6 (Column No. 1) or V3 and V8 (Column No. 2).
- Set the conversion pump P3 to feed the conversion solution at the specified rate and for the times in Table 6-4.
- After conversion is complete, stop the conversion pump and close all valves. Discard the reagent solution.

Step 6—Individually Rinse Columns

Repeat Step 4. This step is not required unless the resin was converted in Step 5.

Step 7S—Test Column for Resin Capacity (Single-Column Operation)

- Set Column No. 2 for downflow feed by connecting C9 to the feed tank connection C1. Open Valves V1 and V8.
- Set the feed tank pump to feed water to the column at the flow rate specified in Table 6-4.

- Start the feed tank pump and run approximately five bed volumes of water through Column No. 2 to displace the deionized water in the column (identified as "waste volume" in Table 6-4).
- Collect 50-mL samples of the raw feed and of the column effluent at S2 using the applicable ERM sampling SOP. Immediately test and record the pH of the two samples.
- Run the required amount of water (identified as test volume in Table 6-4) through Column No. 2 and collect consecutive samples (in series) of 2,000 mLs each at S2 during the duration of the test using the applicable ERM sampling SOP. Analyze each of the samples for the constituents listed in Table 6-5, using the analytical methods listed in Table 6-6.
- Collect a 50-mL sample of the column effluent at S1 using the applicable ERM sampling SOP. Immediately test and record the pH.
- Stop the feed tank pump and close all valves.

Capability testing is complete. Follow Steps 8 through 12 for capacity testing.

Step 7D—Test Column for Resin Capacity (Dual-Column, In-Series Operation)

- Set the column for downflow feed (one at a time) by connecting C5 (Column No. 1) or C9 (Column No. 2) to the feed tank connection C1. Open valves V1, V5, and V6 (Column No. 1) or V1 and V8 (Column No. 2).
- Set the feed tank pump P1 to feed water to the columns at the flow rate specified in Table 6-4.

Table 6-5

SUMMARY OF SAMPLES AND ANALYSES FOR ION EXCHANGE RESIN TESTS

Test Configuration	No. of Samples ¹	Analyses ²
Treatability influent (composite)	2 (Dup.)	TAL metals, Radionuclides, Water Quality Parameters (all)
Capability Test-200C/IRC-938	2	TAL metals, Radionuclides, Water Quality Parameters (all)
Capability Test-200C/DP-1	2	TAL metals, Radionuclides, Water Quality Parameters (all but anions)
Capability Test-200C/IRC-718	2	TAL metals, Radionuclides, Water Quality Parameters (all but anions)
Capability Test-200C/HiPAC-PEI	2	TAL metals, Radionuclides, Water Quality Parameters (all but anions)
Capability Test-200C/TS-200	2	TAL metals, Radionuclides, Water Quality Parameters (all but anions)
Capacity Test-200C/IRA-938	8	TAL metals, Radionuclides, Water Quality Parameters (all)
Capacity Test-200C/DP-1		TAL metals, Radionuclides, Water Quality Parameters (all but anions)
Capacity Test-200C/IRC-718	8	TAL metals, Radionuclides, Water Quality Parameters (all but anions)
Capacity Test-200C/HiPAC-PEI	8	TAL metals, Radionuclides, Water Quality Parameters (all but anions)
Capacity Test-200C/TS-200	8	
Laboratory grade deionized water	2 (Dup.)	TAL metals, Radionuclides, Water Quality Parameters (all)

¹The number of samples for the capacity tests include two laboratory control samples for each test configuration.

²TAL metals: beryllium, chromium (VI), iron, lead, manganese, mercury, selenium. Radionuclides: americium-241, plutonium-239,240, uranium-total Water Quality Parameters: Alkalinity, pH, Solids (TSS, TDS), Cations (calcium, magnesium, potassium, sodium), Anions (chloride, nitrate, nitrite, silica, sulfate).

Table 6-6
ANALYTICAL METHODS AND DETECTION LIMITS

Parameter	Analytical Method	Method Detection Limits
TAL Metals		
Be, Fe, Mn	SW846/6010 (ICP)	0.3, 7, 2 µg/L, respectively
Cr (VI)	SW846/7195, 7196	5 µg/L
Pb	SW846/7421 (GFAA)	1 µg/L
Hg	SW846/7470 (CVA)	0.2 µg/L
Se	SW846/7740 (GFAA)	2 µg/L
Radionuclides		
Am-241	EMSL-LV-0539-17	0.01 pCi/L
Pu-239/240	EMSL-LV-0539-17	0.01 pCi/L
U (total)	EPA 908.0	0.6 pCi/L
Gross alpha and beta	SW846/9310	3 and 4 pCi/L, respectively
Water Quality Parameters		
Alkalinity	EPA 310.2	10 mg/L
pH	EPA 150.1	0.1 units
Solids		
TSS	EPA 160.1	10 mg/L
TDS	EPA 160.2	4 mg/L
Cations		
Ca	SW846/7140	10 µg/L
Mg	SW846/7450	1 µg/L
K	SW846/7610	10 µg/L
Na	SW846/7770	2 µg/L
Anions		
Cl	SW846/9250	1 µg/L
NO ₃	SW846/9200	100 µg/L
NO ₂	EPA 354.1	10 µg/L
SO ₄	SW846/9035	10 µg/L
Silica	EPA 370.1	2 mg/L

- Start the feed tank pump and run approximately five bed volumes of water through each column individually to displace the deionized water in the column (identified as "waste volume" in Table 6-4). Close all valves.
- Set Columns No. 1 and 2 (for downflow feed) in series by connecting C5 (Column No. 1) to the feed tank connection C1, and C9 (Column No. 2) to C8 (Column No. 1). Close valve V5 and open all other valves.
- Collect 50 mL samples of the raw feed and the column effluents at S1 and S2. Immediately test and record the pH of the two samples.
- Run the required amount of water (identified as test volume in Table 6-4) through each column and collect consecutive samples (in series) of 2,000 mLs each at S2 for the duration of the test using the applicable ERM sampling SOP. Eight samples will be collected during the test. Analyze each of the samples for the constituents listed in Table 6-5. Immediately after collecting each 2,000 mL sample at S2, collect one 50 mL sample at S1 by briefly opening valve V5 and closing valve V7 using the applicable ERM sampling SOP. Immediately test and record the pH of the sample collected at S1.
- Stop the feed tank pump and close all valves.

Capability testing is complete. Follow Steps 8 through 12 for capacity testing.

Step 8—Individually Backwash Columns

Repeat Step 2.

Step 9—Individually Regenerate Columns

- Set the column for downflow regeneration by connecting C5 (Column No. 1) or C9 (Column No. 2) to the regenerant tank connection C2. Open valves V2, V5, and V6 (Column No. 1) or V2 and V8 (Column No. 2).
- Set the regenerant pump P2 to feed the regenerant solution required for the resin being tested at the rate and for the time specified in Table 6-4. Collect the effluent regenerant waste at S1 (regenerant sampling point for Column No. 1) or at S2 (regenerant sampling point for Column No. 2) using the applicable ERM sampling SOP. Dilute the sample collected with laboratory-grade deionized water to a final sample volume of 2,000 mL, and analyze the samples for the constituents listed in Table 6-5.
- After regeneration is complete, stop the regenerant pump and close all valves.

Step 10—Individually Rinse Columns

Repeat Step 4.

Step 11—Individually Convert the Resin to Proper Ionic Form

Repeat Step 5. This step is not required if the resin is to be disposed of or is already in the proper ionic form (see Table 6-4).

Step 12—Individually Rinse Columns

Repeat Step 4. This step is not required unless the resin was converted in the previous step.

6.4.3 Summary of Capability and Capacity Test Results

Based upon results from the capability tests, plots or tables of effluent concentrations of the target constituents versus pH can then be prepared from analytical data from which the optimum pH to be used for capacity testing can be chosen. It is likely that the optimum pH for various constituents for any single resin pair will vary; some constituents may be removed better at acidic pHs while others may exhibit better removal efficiencies at neutral to alkaline pHs. All other factors being equal, the pH to be used for the capacity tests shall be set as close as possible to the pH of the raw water (approximately pH 7 to 9) to reduce chemical costs for pH adjustment. Additionally, a resin pair can be dropped from further consideration/testing if the removal efficiency for any given target constituent is less than that achieved by another resin pair.

Two major types of data are typically collected from the capacity tests: saturation loading curves and elution curves. Saturation loading curves are made by plotting the concentrations of the target ions (in meq/L) in the second column effluent versus cumulative flow as measured in bed volumes. This will yield a normalized curve that, neglecting scale-up factors, should theoretically be the same for any size column under the same operating conditions. From these curves, the point at which the critical constituents broke through the pairs of resin columns being tested can be identified, and an estimate of the actual capacity of the resin for each constituent can be calculated by multiplying the bed volumes of treated water before breakthrough by the influent concentration of the ion. If data for design were desired, this loading procedure would be repeated at different flow rates to determine whether any noticeable maximum loading in breakthrough capacity was achieved at a specific, optimum flow rate.

For the TSWP tests, a saturation loading curve shall be developed for the strong acid resin (breakthrough of Na^+ and possible other cations), and the strong base resin (breakthrough of Cl^- and possibly other anions). Although Na^+ and Cl^- are not target ions, the higher concentrations of those ions in the column will reduce the selectivity of these resins (and the downstream metals resins) for other trace target constituents. As previously discussed, saturation loading curves for the metals resins cannot be developed based on the data to be collected.

An elution curve is developed by plotting the constituent concentrations in the regenerant samples versus cumulative regenerant flow as measured in bed volumes using the same units as were used to develop the saturation loading curve. These data can be used to estimate the minimum volume of regenerant required to elute most of the adsorbed ions at the given regenerant concentration and flow rate. If data for design were required, additional runs at different regenerant concentrations and flow rates could be made to determine the level of regeneration that is optimum with respect to operating capacity of the resin and regeneration efficiency.

For the TSWP tests, elution curves cannot be developed because only one regenerant sample will be collected for analysis. However, the concentrations of the target constituents in the regenerant samples will be measured to estimate (1) resin capacity (strong acid and strong base resins); and (2) resin removal efficiencies for specific target constituents (all resins) based on mass balance considerations. Without analyzing the regenerant wastes, there would be no method to accurately estimate the proportion of the total mass of contaminant removed by each of the two resin pairs.

6.5 SUMMARY OF SAMPLES AND ANALYSES

Table 6-5 summarizes the analyses that will be performed on the composite raw water feed and column effluent for the capability and capacity tests for ion exchange. The composite raw water collected for use in these studies must be filtered prior to use as the feedstock in these experiments. The analytical and QA/QC protocols specified in the EG&G, Rocky Flats GRRASP document, Version 2.1 (DOE 1991) will be followed for all analyses. The GRRASP methods follow EPA-approved methods, and the specified QA/QC meets Level III DQOs as described in Section 4.0 of this document.

6.6 TREATABILITY QA/QC SAMPLES

The IX treatability study is designed with preliminary resin screening steps (capability tests) run at three different pHs followed by additional tests (capacity tests) on the resins that appear to be promising. Because there are repetitive steps included for each material tested, replicate experi-

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans
for Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 6

Revision: 0

Page: 42 of 42

Effective Date: _____

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ments are deemed unnecessary. Each capacity test that is performed with a different resin arrangement will be performed once using composite raw water and once using a laboratory control sample (distilled water blanks). The purpose for the distilled water blanks is to determine the contamination introduced from the reagents, equipment, and other materials used in the treatability testing. If the project objectives can be achieved without a determination of the potential sources of contamination, then the method blank experiment and the associated analyses may be removed from the study. The two capacity tests will be performed side-by-side to allow for determining whether any contaminants are being introduced from the dose reagents (such as pH adjustment), resins used, and procedural handling steps. Analyses of the control sample effluents and regenerant wastes will be analyzed for the same constituents as the composite raw water-loaded apparatus using the same resin configuration. Additional QA/QC to determine the accuracy and precision will be in the form of laboratory QA/QC samples. These samples are described in Table 4-2.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 7

Revision: 1

Page: 1 of 2

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

TITLE: Data Management—
Ion Exchange Treatability Study

Approved By:

_____/_____/_____
Name (Date)

7.0 DATA MANAGEMENT—ION EXCHANGE TREATABILITY STUDY

The IX treatability study will generate observational data from the screening tests as well as analytical data for the treatability effluents. The studies will also generate pretreatment analytical data developed to characterize pretreatment surface water and groundwater. Observations of the tests will be documented in logbooks assigned to the laboratory personnel. The effluents may be analyzed by a laboratory unaffiliated with the Rocky Flats Plant. The laboratory shall have satisfactory QA/QC procedures to track and maintain custody of samples and data.

Procedures for logging of field sample collection activities are documented in the Ion Exchange Treatability Study Sampling Plan in Appendix A.

At a minimum, the treatability testing logbooks will document the following:

- Testing procedures
- Departures from protocols and reasons for departures
- Instrument calibration
- Sampling methods
- Chemical additions
- Test observations

Standard bench sheets will be designed to allow uniform recording of the test conditions and observations.

Experimental results which are quantitative (such as pH) will be reported to the accuracy level of the measurement device.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
an Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 7

Revision: 1

Page: 2 of 2

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

Comprehensive data packages will be generated by the analytical laboratory for the metals analyses of the treatability effluents in accordance with the Level III analytical QA/QC requirements. Similar data packages will be generated for radionuclide and water quality parameters, so that the accuracy and the precision of the results can be independently verified. The analytical data packages will be tracked and managed according to the tests performed and laboratory QC group numbers assigned by the laboratory. Where applicable, QC data will also be obtained in an electronic format to facilitate data uploading into the project data base.

Monthly progress reports will also be prepared during the feasibility study testing. These reports will include the following:

- Waste stream studied
- Treatability test number
- Date sample collected
- Where sample stored prior to treatment
- Date treatment initiated
- Initial sample weight
- Date treatment concluded
- Final residue and unused sample weight
- Where residue stored prior to return to permitted storage area
- Date residue returned to permitted storage area

This information will be presented in a table format with one table per waste stream/process. This information will be provided to EG&G RCRA Permitting Division on a monthly basis.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 8
Revision: 1
Page: 1 of 2

Non-Safety Related

Final Draft

Effective Date: _____
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TITLE: Data Analysis and Interpretation—
Ion Exchange and Treatability Study

Approved By:

_____/_____/_____
Name (Date)

8.0 DATA ANALYSIS AND INTERPRETATION—ION EXCHANGE TREATABILITY STUDY

Upon completion of IX treatability testing, data will be presented and interpreted in accordance with Section 6.7 of the TSP and Subsection 3.11 of the Guidance for Conducting Treatability Studies Under CERCLA (EPA, 1989). Data will be summarized and evaluated to determine the validity of measurements and performance of the treatment processes. Section 3.0 of the RFP Quality Assurance Project Plan (QAPjP) describes the requirements for data reduction, validation, useability criteria, and reporting of data. Appendix C, an addendum of the QAPjP, addresses the specific QA requirements for performing treatability studies of ion exchange processes. (The draft QAPjP is included as Appendix C of this document.)

Plots or tables of effluent concentrations of the target constituents versus pH can be prepared from analytical data generated by the capability tests. It is likely that the optimum pH for various constituents for any single resin will vary; some constituents may be removed better at acidic pHs while others may exhibit better removal efficiencies at neutral to alkaline pHs. Selection of the optimum pHs for capacity testing should take into account (1) whether only one, two, or several resins were capable of removing any given target constituent, and (2) whether the selected optimum pH for a given resin is the same as the optimum pH for the resin with which it will be paired during capacity testing. Removal efficiency is also affected by resin sequencing especially when attempting to remove trace constituents.

Two major types of data will be collected from the capacity tests: saturation loading curves and elution curves. Saturation loading curves are made by plotting the concentrations of the target ions (in meq/L) versus cumulative flow as measured in bed volumes. This will yield a normalized curve that, neglecting scale-up factors, should theoretically be the same for any size column under the same operating conditions. From these curves, the point at which the critical constituents broke through the resin system being tested can be identified and an estimate of the actual capacity of

the resin for each constituent can be calculated by multiplying the bed volumes of treated water before breakthrough by the influent concentration of the ion.

An elution curve is developed by plotting the constituent concentrations in the regenerant samples versus cumulative regenerant flow as measured in bed volumes using the same units as were used to develop the saturation loading curve. These data can be used to estimate the minimum volume of regenerant required to elute most of the adsorbed ions at the given regenerant concentration and flow rate. If data for design were required, additional runs at different regenerant concentrations and flow rates could be made to determine the level of regeneration that is optimum with respect to operating capacity of the resin and regeneration efficiency.

8.1 MEASUREMENTS OF PERFORMANCE

Data checking to assess data for precision (for example, the relative percent difference for duplicate matrix spikes), accuracy (for example, the percent recovery of matrix spikes), and completeness (for example, the percentage of data that are valid) will be conducted in accordance with Functional Guidelines for Laboratory Data Validation (EPA, 1988). The ERM OPS will allow uniform validation of the water quality parameter and radionuclide data. Qualified personnel not directly associated with the laboratory experiments or laboratory analyses will perform the data validation function at the direction of the IX treatability study project manager. The verified/validated data will be reduced to graphical or tabular form for interpretation. Conclusions concerning the effectiveness of processes will be deduced directly from the treatability data and comparison with ARARs/TBCs. The implementation and cost of the processes will be indirectly deduced by calculations based on the treatability data.

Data consistency will be maintained by having the same laboratory technician make and record observations about the effectiveness of the test material. Engineering judgements will be observed by an experienced process engineer.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 9

Revision: 1

Page: 1 of 1

Effective Date: _____

Organization: ERT

Non-Safety Related

Final Draft

TITLE: Residual Management—
Ion Exchange Treatability Study

Approved By:

_____/_____/_____
Name (Date)

9.0 RESIDUAL MANAGEMENT—ION EXCHANGE TREATABILITY STUDY

All liquid wastes generated during treatability testing will be stored in properly labeled 55-gallon U.S. Department of Transportation-approved (DOT) containers. Solid residues will be stored in 1-gallon resealable DOT metal containers. It is estimated that the amount of liquid waste, including used samples, will be 410 L and the amount of solid waste will be approximately 6 L by volume.

All unused IX treatability samples and residues will be returned to the Rocky Flats Plant under the Treatability Studies Exemption Rule. In accordance with 40 CFR 261.4(f), samples and residues will be returned within 90 days from the completion of treatability testing, or within 1 year from the sample shipment date from RFP to the facility. All unused samples will be contained separately from sample residues.

The outside contractor laboratory will be responsible for properly disposing of any unused portions of the effluent samples submitted for analyses, and incidental wastes generated during sample preparation and analysis.

EG&G ROCKY FLATS PLANT
Treatability Study Work Plans for
Ion Exchange and Adsorption Processes

Manual: 21000.WP.TS01.01

Section: 10

Revision: 1

Page: 1 of 2

Effective Date: _____

Organization: ERT

Non-Safety Related

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TITLE: Ion Exchange Treatability Study Report

Approved By: _____

Name

(Date)

10.0 ION EXCHANGE TREATABILITY STUDY REPORT

The ion exchange treatability study results will be summarized in an IX Treatability Study Report. The report will be prepared upon completion of IX treatability study testing and will summarize the tests results and discuss any improvements or additional testing that may need to be conducted. The report will also describe this technology's effectiveness in removing metals and radionuclides from contaminated water and will identify any additional data needs. The format of the report will follow the format presented in the Guidance for Conducting Treatability Studies Under CERCLA (EPA, 1989). The format is presented in Table 10-1.

TABLE 10-1

ORGANIZATION OF THE ION EXCHANGE TREATABILITY STUDY REPORT

-
1. Introduction
 - 1.1 Site description
 - 1.1.1 Site name and location
 - 1.1.2 History of operations
 - 1.1.3 Prior removal and remediation activities
 - 1.2 Waste stream description
 - 1.2.1 Waste matrices
 - 1.2.2 Pollutants/chemical
 - 1.3 Remedial technology description
 - 1.3.1 Treatment process and scale
 - 1.3.2 Operating features
 - 1.4 Previous treatability studies at the site
 2. Conclusions and Recommendations
 - 2.1 Conclusions
 - 2.2 Recommendations
 3. Ion Exchange Treatability Study Approach
 - 3.1 Test objectives and rationale
 - 3.2 Experimental design and procedures
 - 3.3 Equipment and material
 - 3.4 Sampling and Analysis
 - 3.4.1 Waste stream
 - 3.4.2 Treatment process
 - 3.5 Data management
 - 3.6 Deviations from the work plan
 4. Results and Discussion
 - 4.1 Data analysis and interpretation
 - 5.1.1 Analysis of waste stream characteristics
 - 5.1.2 Analysis of treatability study data
 - 5.1.3 Comparison to test objectives
 - 4.2 Quality assurance/quality control
 - 4.3 Costs/schedule for performing the treatability study
 - 4.4 Key contacts
- References
- Appendices
- A. Data summaries
 - B. Standard operating procedures
-

Source: EPA, 1989.