

# RESULTS OF FIELD TREATABILITY TESTING OF ACTIVATED CARBON AND CHEMICAL TREATMENT/CROSS-FLOW MICROFILTRATION AT OPERABLE UNIT NO. 2, ROCKY FLATS PLANT

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## ABSTRACT

An Interim Measures/Interim Remedial Action (IM/IRA) was implemented for Operable Unit No. 2 at the Rocky Flats Plant to collect and treat surface water for the removal of volatile organic compounds, metals, and radionuclides. Preliminary results of the field testing program indicate that the selected treatment technologies can meet the standards that were established in the IM/IRA Decision Document. This paper discusses selection of the treatment technologies, the field testing program, preliminary results of field testing, and operational difficulties associated with the field test unit.

## INTRODUCTION

The Rocky Flats Plant was placed on the National Priorities List in 1989, and negotiation of an Interagency Agreement (IAG) was initiated at that time. The Final IAG between the U. S. Department of Energy (DOE), the U. S. Environmental Protection Agency, Region VIII, and the Colorado Department of Health (CDH) was signed in 1991. The IAG identifies 187 Individual Hazardous Substance Sites (IHSSs) that are grouped into 16 Operable Units according to priority. The IAG integrates the Comprehensive Environmental Response, Compensation and Liability Act/Superfund Amendments and Reauthorization Act responsibilities of the EPA and the Resource Conservation and Recovery Act responsibilities of the CDH into one document.

Based upon the historical presence of volatile organic compound (VOC) and radionuclide contamination within Operable Unit No. 2 (also known as the 903 Pad, Mound, and East Trenches Areas) surface water, an Interim Measures/Interim Remedial Action (IM/IRA) Plan was developed and implemented as part of the environmental restoration program under the IAG. The final Surface Water IM/IRA Plan and Environmental Assessment Decision Document was released March 8, 1991 (1).

The Surface Water IM/IRA Plan proposed a two phase Field Treatability Study (FTS) approach for initial treatment of the surface water. Results from the FTS would determine the modifications, if any, that need to be made to the treatment system to achieve effective remediation of the surface water. The first phase of the study was to investigate the removal of VOCs by the granular activated carbon (GAC) system. The second phase of the study was to investigate the chemical treatment/cross-flow filtration system for radionuclide/metal removal. Phase I testing occurred from March 1991 through April 1992, and at its conclusion, a treatability report was prepared presenting the results (2). Phase II testing began in April 1992 and continues today. A treatability report for Phase II will be available in the Fall of 1993. The Phase I and preliminary Phase II results are presented in this paper.

## BACKGROUND

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver. The plant site consists of approximately 400 acres and is surrounded by a 6,550 acre buffer zone. The Rocky Flats Plant is a government-owned, contractor-operated facility which historically manufactured components for nuclear weapons as part of the United States weapons complex. The current mission at the Rocky Flats Plant is to manage the transition to facility decontamination and disposition as well as environmental restoration, and eventual economic development of the site.

Operable Unit No. 2 consists of three areas which contain multiple IHSSs: the 903 Pad, the Mound, and the East Trenches Areas (Fig. 1). South Walnut Creek is located immediately to the north of Operable Unit No. 2, and flows to the east into a series of holding ponds (Ponds B-1 through B-5). Water discharged from the holding ponds is regulated under the National Pollutant Discharge Elimination System.

Surface water for the IM/IRA is collected from three locations within the South Walnut Creek drainage basin designated as SW-59, SW-61 and SW-132 (Fig. 1). SW-59 is located at a surface water seep. SW-61 and SW-132 are located at the outlets of surface water drainage culverts. Historically, contaminants in the water from these sources included: carbon tetrachloride (CCl<sub>4</sub>), tetrachloroethene (PCE), trichloroethene (TCE), vinyl chloride, 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethene (1,2-DCE), 1,1-dichloroethene (1,1-DCE), plutonium, and americium. Concentrations of these contaminants in the surface water generally exceed Applicable or Relevant and Appropriate Requirements (ARARs), which are identified in Ref. 1 and are shown for the contaminants actually detected during the FTS in Table I.

The flow of surface water at the collection locations is variable and highly dependent on seasonal precipitation. For example, for the period of May 1991 through April 1992, the average flow was 14 gpm, with the lowest average flows reported in January (5 gpm), February (4 gpm) and

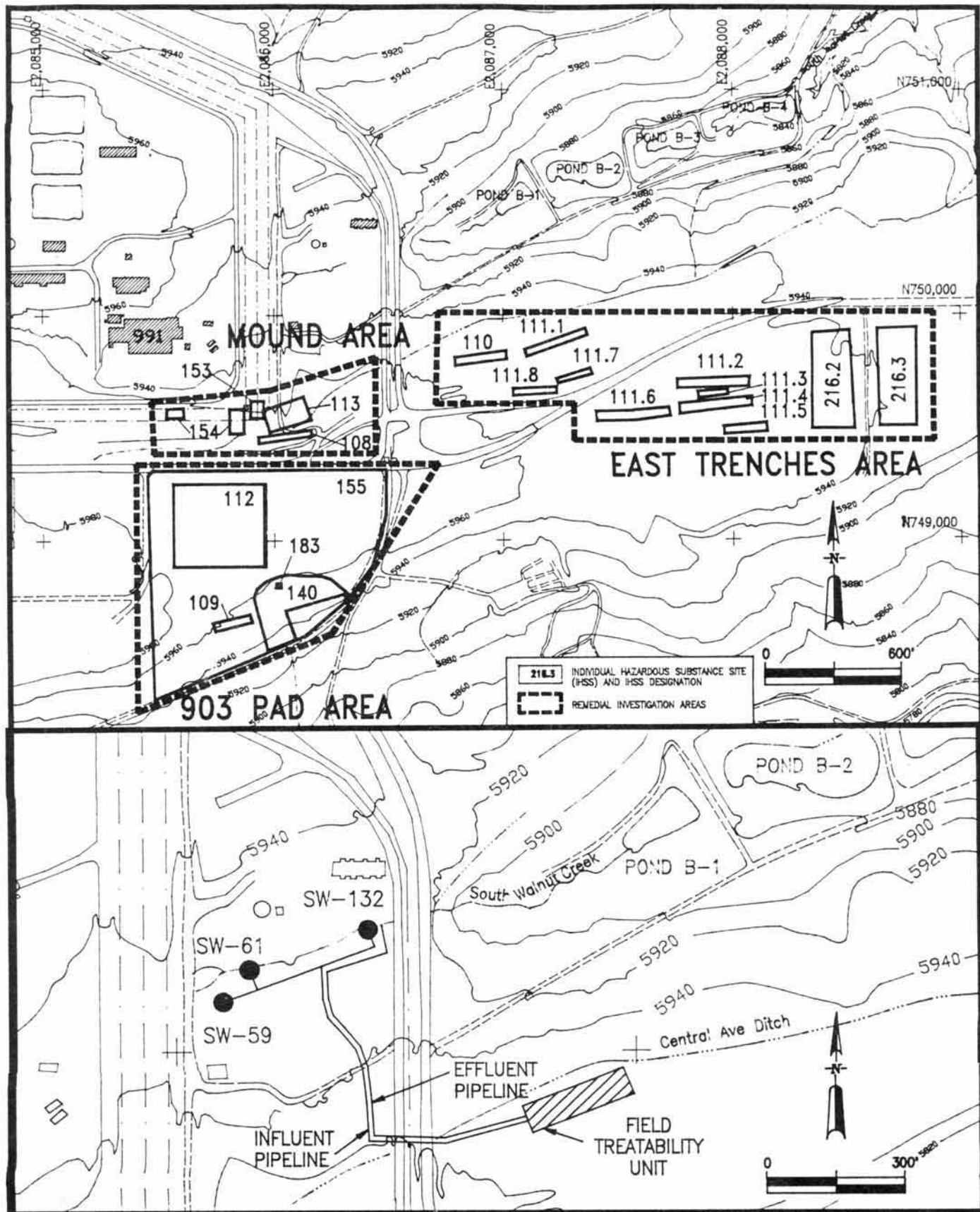


Fig. 1. Operable Unit No. 2 site map (top) and field treatability unit plot plan (bottom).

TABLE I  
Summary Of Analytical Data Field Treatability Study

			Treatment System Sampling Locations						Surface Water Collection Locations					
VOCs ( $\mu\text{g/L}$ )	Design Basis ( $\mu\text{g/L}$ )	ARAR ( $\mu\text{g/L}$ )	Influent		Between GAC		Effluent		SW-61		SW-59		SW-132	
			avg.	max.	avg.	max.	avg.	max.	avg.	max.	avg.	max.	avg.	max.
CCl <sub>4</sub>	219	5	6	8	<5	8	<5	<5	6	13	135	300	<5	<5
TCE	153	5	6	11	<5	6	<5	6	5	32	70	200	<5	<5
PCE	279	5	5	20	<5	8	<5	<5	4	34	73	170	<5	<5
1,2-DCE	142	5	16	43	8.6	39	<5 <sup>b</sup>	16	10	53	53	150	<5	7
Total Radionuclides (pCi/L)														
Pu <sup>c</sup>	3.3	0.05	<0.01	0.02	-	-	<0.01	<0.01	<0.01	0.03	0.03	0.05	<0.01	<0.01
Am <sup>c</sup>	0.5	0.05	<0.01	0.03	-	-	<0.01	0.02	0.03	0.04	0.52	4	<0.01	<0.01

<sup>a</sup> Development of the design basis is presented in Ref. 1.  
<sup>b</sup> Seven out of 58 samples exceeded ARAR due to breakthrough. Average of the 7 samples is 11.3  $\mu\text{g/L}$ .  
<sup>c</sup> Pu is plutonium 230/240. AM is americium 241.

mid-October (4 gpm). The contribution from the surface water seep is steady at approximately 0.5 gpm. The IM/IRA Decision Document established a design flow from all sources of 60 gpm. This design flow represents a capacity to handle above-average precipitation wet season flows, but not flows resulting from a major storm event.

#### TREATMENT TECHNOLOGY SELECTION

Several technologies were evaluated as part of the IM/IRA process for removal of both radionuclides metals and VOCs from the source water. Because the radionuclides were predicted to exist as colloidal particles, chemical treatment/cross-flow membrane filtration was selected for radionuclides and metals removal in preference to ion exchange. This system removes radionuclides and metals through precipitation/adsorption and filtration, and eliminates the need for suspended solids pre-treatment. As shown in Fig. 2, the chemical treatment/cross-flow membrane process consists of chemical addition (iron salts and lime to create a ferric hydroxide floc), filtration through a 0.1 micrometer cross-flow membrane filter, solids re-circulation, solids separation and dewatering, and final neutralization. The chemical addition is a pre-treatment step for initiating precipitation, co-precipitation, and adsorption of radionuclides and metals (i.e., conversion to the solid phase). The cross-flow membrane filter is in a shell and tube configuration with the membrane on the inside of the tubes. Permeate flow passes through the tubes perpendicular to the main flow at a low operating pressure. Efficiencies are expected to be greater than 99.8 percent.

GAC was chosen for VOC removal in preference to air stripping or advanced oxidation. GAC was chosen for its higher reliability and cost effectiveness. The process flow and

system design are illustrated in Fig. 2. During treatment, only two GAC units are on-line, a lead unit and a polishing unit.

#### RESULTS AND DISCUSSION

Samples were collected for chemical analysis at the collection locations, the influent to the lead GAC, between the lead and polishing GAC, and the effluent from the polishing GAC. During Phase I (GAC treatment only), fabric filtration units were installed between the flow equalization tank and the lead GAC unit to remove particulates.

Table I presents the concentrations of CCl<sub>4</sub>, TCE, PCE, and 1,2-DCE in the combined influent stream as well as in the individual source streams (i.e., SW-59, SW-61, and SW-132). CCl<sub>4</sub>, TCE, and PCE concentrations in the combined influent stream were at or slightly above their respective ARARs. The average concentration of 1,2-DCE in the combined influent was approximately three times greater than the ARAR concentration. However, the concentrations of these four VOCs in the combined influent were one to two orders of magnitude below the associated design basis concentrations. For example, the average and maximum TCE concentrations in the combined influent were 6 and 11 micrograms per liter ( $\mu\text{g/L}$ ) as compared to the design basis concentration of 153  $\mu\text{g/L}$ . The high basis of design concentrations were selected in part by assuming that the water quality at the SW-132 would be similar to SW-61 (data did not exist for SW-132 at the time of the design). However, 1,2-DCE was the only contaminant that was found to be present in the surface water collected at SW-132. The maximum 1,2-DCE concentration detected at SW-132 was 7  $\mu\text{g/L}$ , and on the average, the data indicate concentrations below the 5  $\mu\text{g/L}$  detection limit.

Table I shows that plutonium (Pu) and americium (Am) were found to be present in the combined surface water

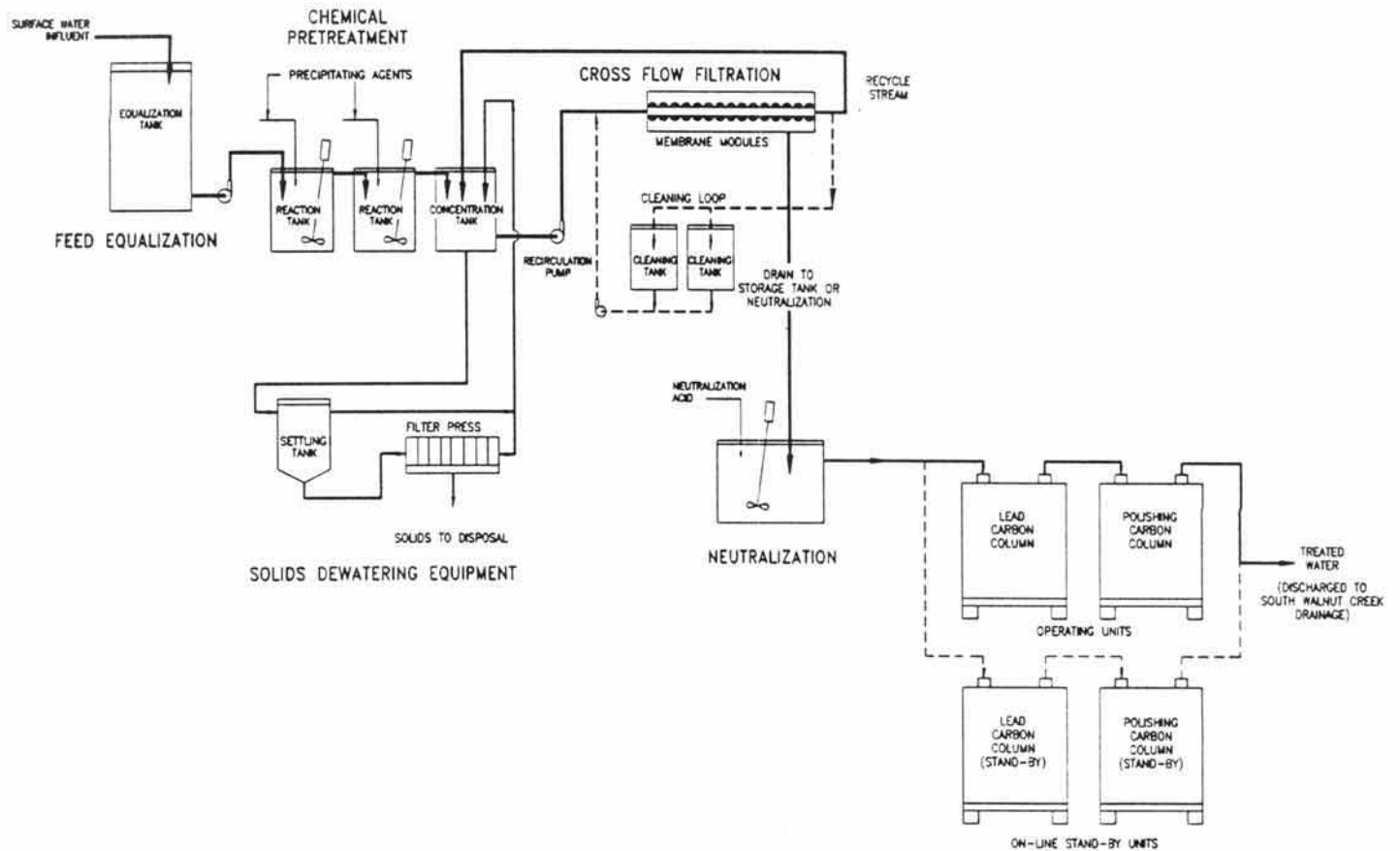


Fig. 2. South Walnut Creek Basin surface water IM/IRA treatment system process flow diagram.

influent at activities below ARAR (0.05 picocuries per liter [pCi/L]). Pu and Am activities were only 0.02 and 0.03 pCi/L in the combined influent. On the average, the Pu and Am activities were below their minimum detectable activities. Examination of the radionuclide data for the individual surface water stations suggests that SW-59 and SW-61 are sources of Pu and Am contamination in the combined influent stream. The highest Pu and Am activities were recorded for SW-59 and were only 0.05 and 4 pCi/L, respectively. However, these activities were considerably less than expected, as defined in the basis of design. Furthermore, neither Pu nor Am were found to be present at SW-132 during the study.

The relatively low or non-detectable levels of VOCs and radionuclides found to be present at SW-132 serves to reduce the overall concentration levels in the combined influent. Nonetheless, treatment by GAC effectively reduced the levels of these contaminants to below detection limit. Only one treated surface water sample out of 58 had a detectable TCE concentration (6  $\mu\text{g/L}$ ). As expected, the higher 1,2-DCE influent concentrations resulted in earlier breakthrough of this contaminant. Breakthrough resulted in the presence of 1,2-DCE above the ARAR in several of the effluent samples. Specifically, seven of the 58 effluent samples analyzed were found to contain 1,2-DCE at concentrations above ARAR. More timely rotation of the lead and polishing GAC units, based on available and newly collected operating data, will prevent breakthrough of 1,2-DCE.

Definitive conclusions regarding the performance of the treatment system in removing Pu and Am are not possible based on the available data. The average treatment system

influent and effluent Pu and Am activities were below the minimum detectable activities.

During Phase I, operational difficulties of the GAC treatment system occurred due to the presence of fine silt in the influent water. This was particularly a problem during periods of high precipitation, resulting in greater turbidity in the collected surface water. The silt was not amenable to removal by fabric prefilters with a five-micron nominal pore size which plugged too rapidly. Fabric filters with a 10-micron nominal pore size did not plug as rapidly, but required frequent changes during periods of high precipitation. Backwashing was used to remove silt from the GAC units. During Phase I testing, backwashing averaged once per week. However, backwashing was only partially effective, and the silt resulted in greater than expected carbon consumption rates. In Phase II, no operational difficulties have been encountered with the GAC treatment system and the lead GAC unit is removed from service after approximately four months of operation. Chemical analysis of spent GAC from Phase II have indicated "above background" levels of radionuclides.

The chemical dose added in the precipitation process is approximately 7.5 parts per million of iron salt. During high precipitation runoff events, a minimum of 20 mg/L of iron salt is needed to prevent the plugging of the membranes. Flushing with a 5 percent hydrogen peroxide wash solution followed by a 10 percent sulfuric acid wash solution has been found to effectively clean the membranes. Powdered activated carbon is added to the cleaning solutions to provide the scrubbing action needed to remove the solids from the membranes. Chemical analysis of the sludge that is produced showed a

maximum Pu activity of 0.08 (+/- 0.003) pCi/g and a maximum Am activity of 0.053 (+/- 0.017) pCi/g.

During the 3-month period from October through December 1992, treated effluent averaged 13 gpm (total volume of 1,713,163 gallons). Chemical consumption for this time period included 4,750 pounds of lime, 414 gallons of sulfuric acid, 236 pounds of ferric sulfate, 450 pounds of powdered activated carbon, and 80 gallons of hydrogen peroxide. Eleven thousand pounds of sludge (22 drums) were generated and 10,000 gallons of diesel fuel were used to power the system. These amounts are equivalent to 3,700, 7,259, and 155 gallons of treated water for each pound of lime and ferric sulfate consumed, and for each pound of sludge generated, respectively (3).

The long "turnaround" time required for the analysis of the water samples for radionuclides presented problems in optimizing the operation of the system. The low levels of radionuclides in the water require long counting times and thus preclude real time analysis of process performance. An attempt has been made to indirectly infer radionuclide contamination by measuring the number of particles in the one to 150 micron size by using a light obscuration particle counter. This technique assumes that the concentration of radionuclides in the treated water is related to the number of particles in the treated water. The correlation between the number of particles and the radionuclide concentration is still being evaluated.

### CONCLUSIONS

Treatment of South Walnut Creek surface water at its current chemical quality, which is not expected to change dramatically, results in an inconsequential reduction of poten-

tial risks to the public and environment. Indeed more risks may be created in the production of secondary waste streams (spent GAC, sludge, etc.) that require handling, transportation, and disposal. The field treatability unit results indicate that the GAC system can meet ARARs if breakthrough is monitored closely; however, the chemical precipitation/cross-flow microfiltration system performance is inconclusive because of the low concentration of radionuclides that are treated. Because the treatment system may have utility for treating organic and radionuclide contaminated groundwater or other surface waters that pose more significant risks, it is important the system be evaluated with respect to radionuclide removal effectiveness. Consideration is being given to eliminating surface water collection from SW-132 and possibly SW-61 in order to provide an influent with greater concentrations of VOCs and radionuclides, and allow conduct of a meaningful study of the treatment system performance.

### REFERENCES

1. DOE/RF, "Final Surface Water Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document, South Walnut Creek Basin, Operable Unit No. 2," DOE EA-0496, (March 8, 1991).
2. DOE/RF, "Final Summary and Analysis of Results, Field Treatability Study, Granular Activated Carbon Treatment System, Phase I, South Walnut Creek Basin, Surface Water Interim Measure/Interim Remedial Action, Operable Unit No. 2, Rocky Flats Plant, Golden, Colorado," (May 1992).
3. DOE/RF, "Quarterly Report for October 1992 through December 1992, Operable Unit No. 2, IM/IRA Surface Water Field Treatability Unit," (January 28, 1993).