

**DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES
881 HILLSIDE AREA (OU-1)
TECHNICAL MEMORANDUM NO. 10**

Final

*Department of Energy
Rocky Flats Plant
Golden, Colorado*

ENVIRONMENTAL RESTORATION PROGRAM

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TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
List of Acronyms	iii
1.0 Introduction	1
2.0 Development of Remedial Action Objectives and Preliminary Remediation Goals . . .	3
2.1 Contaminants Identified in the RFI/RI by Media	5
2.2 Potential Exposure Routes (Pathways) and Receptors	5
2.3 Remedial Action Objectives	9
2.4 Development of Preliminary Remediation Goals	10
2.4.1 Potential Applicable or Relevant and Appropriate Requirements	11
2.4.2 Preliminary Remediation Goals Based on 10^{-6} as the Point-of-Departure	16
2.4.3 Recommended Preliminary Remediation Goals	25
3.0 References	28
Appendix A - PRG Calculation Spreadsheets	
Appendix B - Potential Surface Water ARARs	

FIGURES

<u>Figure #</u>	<u>Page</u>
1-1 881 Hillside Area and Individual Hazardous Substance Site Locations	2
2-1 CMS/FS Logic Flow Diagram	4

TABLES

<u>Table #</u>	<u>Page</u>
2-1 Contaminants Identified in the RFI/RI by Media	6
2-2 Potential Groundwater ARARs - National Primary Drinking Water Standards	14
2-3 Statewide and Basin-Specific Groundwater Standards	15
2-4 Groundwater - Risk-Based Preliminary Remediation Goals	21
2-5 Surface Soil - Risk-Based Preliminary Remediation Goals	24
2-6 Comparison of Risk-Based PRGs, ARARs, and Existing Concentrations	27

LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
BRA	Baseline Risk Assessment
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
COC	Contaminant of Concern
CRS	Colorado Revised Statutes
DOE	Department of Energy
EE	Environmental Evaluation
EPA	Environmental Protection Agency
FR	Federal Register
FS	Feasibility Study
GRA	General Response Action
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
OSWER	Office of Solid Waste and Emergency Response
OU-1	Operable Unit 1
OU-2	Operable Unit 2
OU-5	Operable Unit 5
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PHE	Public Health Evaluation

LIST OF ACRONYMS (Continued)

PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RFP	Rocky Flats Plant
RI	Remedial Investigation
RRG	Revised Remediation Goal
SID	South Interceptor Ditch
TBC	To-Be-Considered
USC	United States Code
VOC	Volatile Organic Compound

1.0 INTRODUCTION

The purpose of this Technical Memorandum is to document the process by which objectives and goals for remediation were established for the 881 Hillside Area (Operable Unit 1 [OU-1]) of the Department of Energy's (DOE) Rocky Flats Plant (RFP). The memorandum is written in accordance with the *Rocky Flats Interagency Agreement* (IAG) dated January 1991 (IAG 1991). Section IX.A.1 of the IAG statement of work requires that remedial action objectives (RAOs) "...be documented in a technical memorandum to be submitted to the U.S. Environmental Protection Agency (EPA) and/or the State of Colorado for review." As outlined in the IAG, these objectives "...shall specify the contaminants and media of interest, exposure pathways and receptors, and EPA and State accepted levels or ranges of levels for each exposure route." This memorandum includes the information required by the IAG as well as a discussion on the methodology used to develop preliminary remediation goals (PRGs) and revised remediation goals (RRGs) based on the point-of-departure concept described in the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP) (EPA 1990).

With this in mind, the primary focus of the Technical Memorandum is to present PRGs for minimizing residual risk to human health and the environment which could result from exposure to contaminated soils and/or groundwater related to the operable unit as a whole, or to any of the Individual Hazardous Substance Sites (IHSSs) which make up the operable unit. Figure 1-1 shows the approximate location of these IHSSs, and also the operable unit boundaries. The french drain, installed as an Interim Measure/Interim Remedial Action (IM/IRA) to intercept contaminated groundwater downgradient of OU-1, is located between the OU's southern boundary and the South Interceptor Ditch (SID), running parallel to the SID from a point just west of Building 881, to a point just east of IHSS 119.1. Detailed information regarding the operable unit physical characteristics and the nature and extent of contamination can be found in the *Final Phase III RFI/RI Report* (hereinafter referred to as the RFI/RI [DOE 1993]).

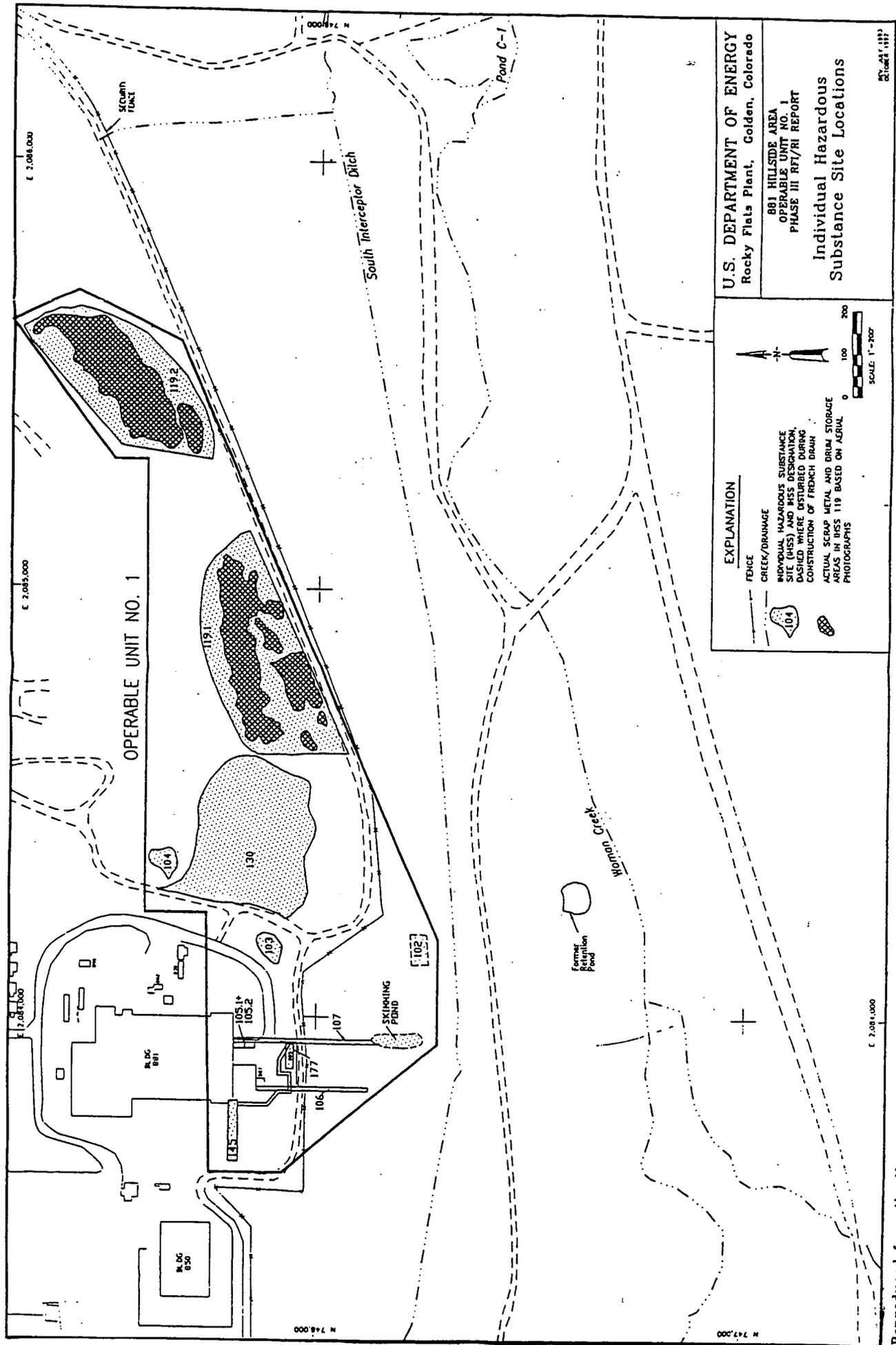


Figure 1-1. 881 Hillside Area and Individual Hazardous Substance Site Locations

2.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

Remedial action objectives are established early in the process of conducting the Corrective Measures Study/Feasibility Study (CMS/FS) as it is necessary to define preliminary goals for a remedial action prior to formulating alternatives for that action. Figure 2-1 is a modified graphic presentation of the CMS/FS process as taken from the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988a) (hereinafter referred to as the RI/FS or CERCLA RI/FS guidance, where the term "CERCLA" refers to the Comprehensive Environmental Response, Compensation, and Liability Act). The figure shows where RAOs and PRGs are established, and illustrates the sequential relationship between the development of RAOs and PRGs and the various phases of the CMS/FS. As illustrated in the figure, until appropriate remedial action objectives and preliminary remediation goals are established, general response actions (GRAs) cannot be developed and combined into remedial action alternatives. The figure also shows that although RAOs and PRGs are established early in the CMS/FS process, PRGs may be modified on the basis of several factors. If required, RRGs are used as substitutes for the initial PRGs.

In order to develop appropriate RAOs and PRGs for OU-1, contaminants which had the potential to pose a significant risk to human health were first identified in the Environmental Evaluation (EE) and Public Health Evaluation (PHE) portions of the Baseline Risk Assessment (BRA). According to the EE, the current concentrations of VOCs in groundwater, and PAHs and PCBs in soils, are potentially toxic to ecological receptors. However, the restricted distribution of these contaminants limits the duration and frequency of contact with receptors and therefore limits exposure. Actual exposure estimations suggest that while some contaminants occur at potentially toxic levels, the contaminated areas are not large enough to result in a significant threat to the populations of plants and animals in the OU-1 area. Based on these results, there are no contaminants identified in the EE that would require more stringent PRGs than those presented for human health protection. The following sections present the contaminants that are identified in the RFI/RI, and the methodology by which RAOs and PRGs were developed.

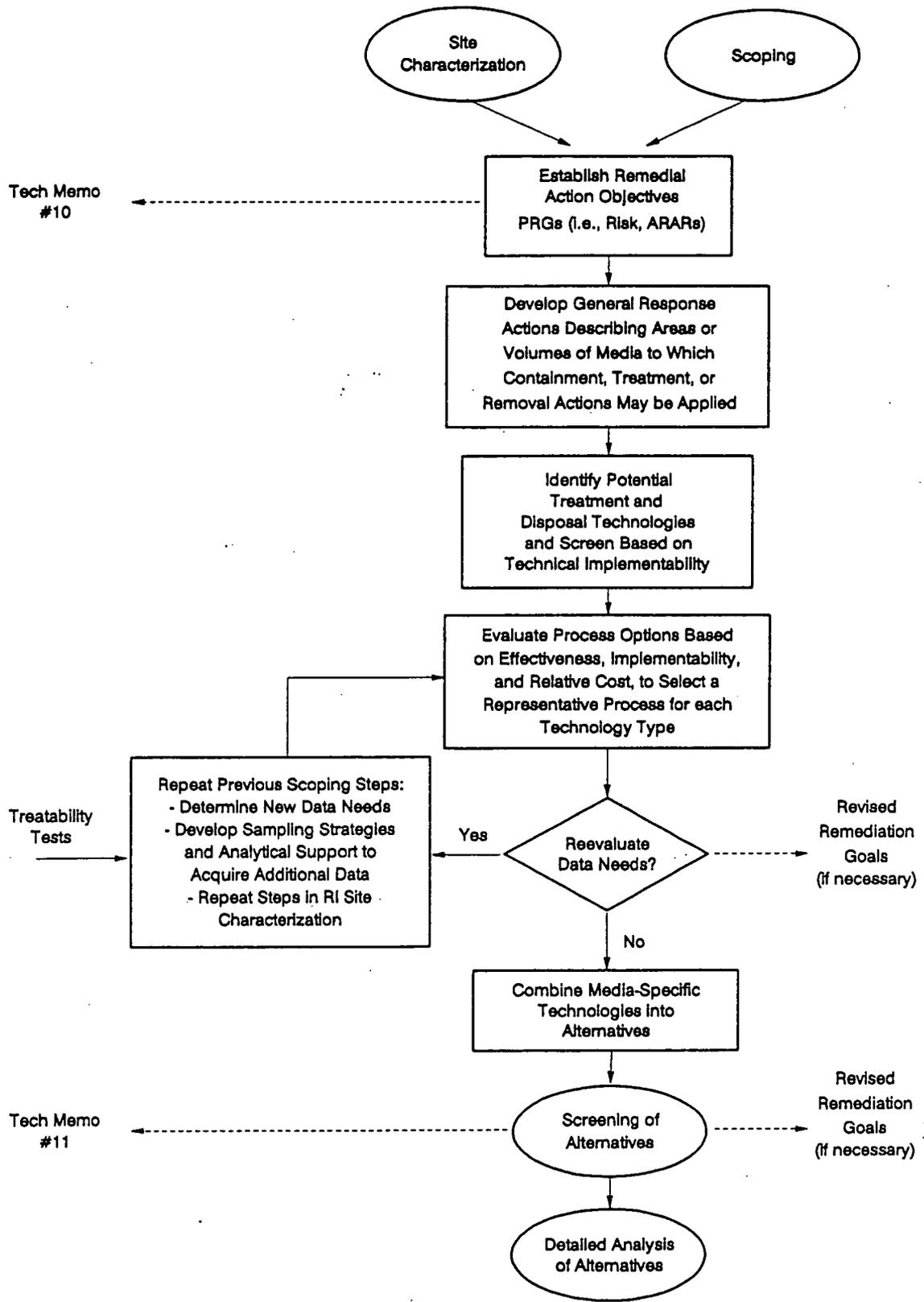


Figure 2-1. CMS/FS Logic Flow Diagram

2.1 Contaminants Identified in the RFI/RI by Media

The list of contaminants originally identified in the RFI/RI is presented in Table 2-1. This list presents the complete list of chemicals that were identified as contaminants during the characterization phase of the RFI/RI for OU-1, prior to being subjected to the multi-level screening process by which contaminants are identified for inclusion in the PHE and EE. The screening process narrows the list of potential contaminants which merit further consideration as risk contributors, and is presented in detail in the RFI/RI report. Contaminants that survive the risk-based screening process are designated as contaminants of concern (COC) in the BRA.

Although the table includes all of the contaminants and media that were originally identified in the RFI/RI report, some of these media do not contain any contaminants in concentrations that result in a carcinogenic risk greater than 10^{-6} , nor a hazard index greater than one, and therefore do not require evaluation in the OU-1 CMS/FS. These media are presented as shaded areas in the table. For the purposes of the OU-1 CMS/FS, only those contaminants indicated for the media of groundwater and surface soils are addressed in this technical memorandum. In addition, remediation of surface soil contaminants will actually be addressed administratively under Operable Unit 2 (OU-2), due to the source of the low-level plutonium contamination being in this operable unit. Surface soil contaminants are included here to provide a transition between the OU-1 RFI/RI report and the OUs 1 and 2 CMS/FS reports. Surface soil RAOs and PRGs included in this document will be revisited in the relevant OU-2 documents.

2.2 Potential Exposure Routes (Pathways) and Receptors

During the course of the PHE, site, population, and land use data were analyzed in order to devise several representative exposure scenarios (potentially exposed receptors) for assessing the risk to current and future human health from identified COCs at the 881 Hillside Area. For each of these scenarios, pathways were traced which represented exposure routes from the source to potential receptors.

**Table 2-1.
Contaminants Identified in the RFI/RI by Media**

Contaminant	Ground Water	Surface Soil	Subsurface Soil ^a	Surface Water ^a	Sediment ^a
Volatile Organic Compounds					
Carbon Tetrachloride	X		X		
Chloroform	X		X		
1,1-Dichloroethane	X			X	
1,2-Dichloroethane	X		X	X	
1,1-Dichloroethene	X		X	X	
1,2-Dichloroethene	X			X	
cis-1,2-Dichloroethene	X				
Tetrachloroethene	X		X	X	
Toluene	X		X	X	X
Total Xylenes	X		X	X	
1,1,1-Trichloroethane	X		X	X	X
1,1,2-Trichloroethane	X				
Trichloroethene	X		X	X	
Metals					
Selenium	X				
Vanadium	X				
Radionuclides					
Americium		X	X	X	X
Uranium		X	X		
Plutonium		X	X	X	X
PCBs					
AROCLOR-1248		X			
AROCLOR-1254		X			X

Table 2-1.
(Continued)

Contaminant	Ground Water	Surface Soil	Subsurface Soil ^a	Surface Water ^a	Sediment ^a
Semi-Volatile Organic Compounds					
Acenaphthene		X	X		
Acenaphthylene		X	X		
Anthracene		X	X		
Benzo(a)anthracene		X	X		
Benzo(a)pyrene		X	X		
Benzo(b)fluoranthene		X	X		X
Benzo(ghi)perylene		X	X		
Benzo(k)fluoranthene		X	X		X
Chrysene		X	X		X
Dibenzo(a,h)anthracene		X			
Fluoranthene		X	X		X
Fluorene		X	X		
Indeno(1,2,3-cd)pyrene		X	X		
2-Methylnaphthalene			X		
Naphthalene	X	X	X		
Phenanthrene		X	X		X
Pyrene		X	X		X

X Contaminant is a COC which has been detected in the medium.

^a Contaminants in shaded media did not result in a cancer risk greater than 10^{-6} , nor a hazard index greater than one.

Pathway elements were examined relative to the results of the Phase III field investigation which indicated that contamination exists in groundwater, surface soils, subsurface soils, sediments, and surface waters. The contaminants identified in these areas included volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), inorganic contaminants, and radionuclides. The contaminant release mechanisms evaluated were leaching, volatilization, resuspension of particulates by wind, etc. Potential transport media identified were surface water, groundwater, air, soil, and biota. The exposure route (the route of entry into the human body) for these media included ingestion, inhalation, and dermal contact. In accordance with the *Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation (Part A)* (EPA 1989), if any of the above-mentioned pathway elements is missing, the projected receptor will not receive a chemical or radionuclide dosage and no excess risk will exist from that contaminant.

The results of the BRA indicate that only the media of groundwater and surface soils present a risk greater than the acceptable risk range of 10^{-4} to 10^{-6} . The risk to a human receptor from exposure to groundwater COCs is driven primarily by the exposure routes of ingestion, inhalation of volatiles, and dermal contact. For a future on-site resident, this risk is on the order of 10^{-3} to 10^{-2} .

Likewise, the risk to a human receptor from exposure to surface soil COCs is driven primarily by the exposure routes of ingestion of vegetables, ingestion of soil, inhalation of particulates, and dermal contact. For a future on-site resident, this risk is on the order of 10^{-3} . It should be noted, however, that this risk is based on OU-1 sitewide average radionuclide concentrations. These average radionuclide concentrations include a few areas of high contaminant concentrations (i.e., "hot spots") that are limited in extent and only exist within the boundaries of IHSSs 119.1 and 119.2. The risk to a future on-site resident, excluding the hot spots, is more on the order of 10^{-5} .

Because the media of groundwater and surface soils are the only media that generate a significant risk to human health, they are the only media requiring remedial action evaluation under OU-1. Isolated locations of elevated radionuclide concentrations are considered hot spots

which are subject to the RAOs and PRGs presented for surface soils.

2.3 Remedial Action Objectives

RAOs are contaminant- and medium-specific goals for protecting human health and the environment. In developing appropriate RAOs, the RI/FS guidance states that "...objectives should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited." The guidance also specifies that in order to quantify RAOs, PRGs are developed that provide an identification of what an acceptable contaminant level or range of levels would be for each exposure route of concern. Note that a risk range is presented for those RAOs that specify a protectiveness level. The range is necessary since PRGs are estimated based on a risk level of 1×10^{-6} for each contaminant. Depending on the number of contaminants present, the summed residual risk may therefore be slightly higher than 1×10^{-6} , hence the defined acceptable range. The RAOs for OU-1 are:

- 1) Prevent the inhalation of, ingestion of, and/or dermal contact with VOCs and inorganic contaminants in groundwater that would result in a total excess cancer risk greater than 10^{-4} to 10^{-6} for carcinogens, and/or a hazard index greater than or equal to one for non-carcinogens.
- 2) Prevent the inhalation of, ingestion of, and/or dermal contact with PAHs, PCBs, and radionuclides in surface soils that would result in a total excess cancer risk greater than 10^{-4} to 10^{-6} for carcinogens, and/or a hazard index greater than or equal to one for non-carcinogens.
- 3) Prevent exposure to carcinogenic radionuclides in surface soil hot spots that would result in an excessive short-term risk to a human receptor.

These RAOs were developed using appropriate regulatory guidelines (i.e., EPA RI/FS guidance and NCP) and by examining the relevant COCs and their associated exposure pathways. The PRGs developed for these RAOs are based on current EPA regulations and are discussed in detail in Section 2.4. RAOs were only developed for human health criteria since, as previously discussed, the EE found that there were no risk drivers that warranted remedial action beyond that required for protection of human health. Also, surface soil hot spots do not present a current long-term risk, but do present a potential short-term risk to workers if

disturbed, therefore they are included in the development of RAOs. The second RAO listed above also applies to the surface soil hot spots, since, in general, the medium of surface soils will be addressed under OU-2. This second RAO is included here to provide the basis for the surface soil hot spot PRGs which are presented later in the document.

2.4 Development of Preliminary Remediation Goals

The policy for developing preliminary remediation goals, found in the NCP, is to make use of "readily available information, such as chemical-specific ARARs or other reliable information". Where ARARs or "to-be-considered" (TBC) criteria are not available, PRGs are developed on the basis of a 10^{-6} point-of-departure for risk for each chemical within a given medium. This also applies when ARARs are not considered sufficiently protective because of the presence of multiple contaminants or multiple pathways of exposure. For OU-1, both risk-based and ARAR-based PRGs are presented. These values are contrasted, where applicable, in Section 2.4.3.

Note that PRGs developed at this stage are considered initial goals which may be modified through the course of the CMS/FS. Following requirements established in the NCP, final remediation goals are not selected until the remedy selection phase of the CMS/FS. The ARARs presented in Section 2.4.1, as well as the risk-based PRGs, can be considered initial cleanup goals; however, exact criteria for final remediation will be selected as the CERCLA process proceeds. Either set of criteria could be used, a combination could be used, or revised PRGs could be used if necessary. The decision as to whether or not revised PRGs are required is based on the criteria described in the preamble to the NCP (55 Federal Register [FR] 8717, March 8, 1990) which states that,

Preliminary remediation goals ... may be revised ... based on the consideration of appropriate factors including, but not limited to: exposure factors, uncertainty factors, and technical factors.

Referring to the detailed analysis of alternatives, the preamble also states that,

The final selection of the appropriate risk level is made when the remedy is selected based on the balancing criteria.

Generally, chemical-specific ARARs take precedence over risk-based PRGs, however, as noted above, final cleanup goals will depend on a variety of factors and will be agreed upon by the participating agencies (i.e., DOE, EPA, and the Colorado Department of Health [CDH]).

2.4.1 Potential Applicable or Relevant and Appropriate Requirements

Section 121(d)(2) of CERCLA provides a statutory basis for determining ARARs in a remedial action context. With respect to any hazardous substance, pollutant, or contaminant that will remain on site, Section 121(d)(2) of CERCLA states that,

If any standard, requirement, criteria or limitation under any federal environmental law ... or any [stringent] promulgated standard, requirement, criteria or limitation under a state environmental or facility siting law . . . is legally applicable to the hazardous substance concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance, pollutant or contaminant, the remedial action shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance, pollutant or contaminant which at least attains such legally applicable or relevant and appropriate standard, requirement, criteria or limitation. 42 United States Code (USC) -----§ 9621(d)(2).

where "applicable requirements" are those

... cleanup standards, standards of control, or other substantive environmental protection requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant or contaminant at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

According to the NCP and the *CERCLA Compliance with Other Laws Manual* (EPA 1988b),

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, or state environmental or facility siting laws that,

while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site so that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

The identification of chemical-specific ARARs was conducted in accordance with CERCLA guidance and the requirements of the NCP (40 Code of Federal Regulations [CFR] Part 300.430(e)(2)(i)). Chemical-specific requirements under a variety of Federal and State laws were reviewed to evaluate which ones could be considered chemical-specific ARARs for OU-1. State of Colorado and Federal requirements were examined specific to the contaminants and media at OU-1.

Potential chemical-specific ARARs for the groundwater medium beneath OU-1 are the Federal maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) promulgated under the Safe Drinking Water Act (40 CFR Parts 141 - 149). This interpretation was made for the following reasons:

- 1) The Federal Drinking Water Standards (i.e., MCLs) are considered chemical-specific ARARs, according to the identification of ARARs that is required under Section 121(d) of CERCLA, as amended. MCLGs are also required to be considered under Section 121(d) of CERCLA. It has been EPA's position that nonenforceable MCLGs established at zero are not appropriate for cleanup at a CERCLA site for a number of reasons (See EPA's comment and responses in the Preamble to Subpart E of NCP Final Rule - 55 FR 8751-8752). However, the use of non-zero MCLGs for cleanup of a site are to be considered according to the circumstances of the release and in cases involving multiple contaminants or pathways involving cumulative risk above 10^{-4} . For this reason, MCLGs are also considered chemical-specific ARARs for OU-1.
- 2) Although the State of Colorado has adopted Classifications and Water Quality Standards for Groundwater-3.12.0 (Title 5 Colorado Code of Regulations [CCR] 1002-8) pursuant to 24-4-103(5) and 24-4-103(11) Colorado Revised Statutes (CRS), these standards are not considered ARARs for OU-1, applying the doctrine of sovereign immunity. Traditionally, sovereign immunity is a doctrine which precludes a litigant from asserting an otherwise meritorious cause of action against a sovereign unless the sovereign consents to suit. Any waiver of the National Government's sovereign immunity must be unequivocal. Waivers of immunity must be construed strictly in favor of the sovereign and not enlarged

beyond what the language requires. The Clean Water Act waives federal sovereign immunity for requirements "respecting control and abatement of water pollution" in 33 U.S.C. Section 1323(a). However, the statute does not define whether "water" includes surface water and groundwater. Thus, while the focus of the statute is on surface water, the issue is whether the regulatory provisions of the statute may be extended to regulation of groundwater. Because the statute does not apply "clearly and unambiguously" to groundwater, DOE reserves its right to argue that the United States has not waived its sovereign immunity to permit State groundwater regulation of any kind at a federal facility. Since the State groundwater regulations are arguably not enforceable at a federal facility, the State groundwater regulations can not be ARARs at a federal facility. The State groundwater standards are listed as TBCs and will be considered in determining clean up standards for the Record of Decision.

- 3) The State of Colorado does have drinking water standards promulgated pursuant to CRS 25-1-107, 25-1-108, 25-1-109, and 25-1-114, and approved by EPA. However, a comparison of the State drinking water standards to the Federal Drinking Water Standards demonstrates that the State standards are not more stringent than the Federal standards. If drinking water standards are considered chemical-specific ARARs for OU-1, then the Federal standards should be the designated ARARs according to 40 CFR 300.400 (g)(4).
- 4) The standards for groundwater protection under the RCRA regulations of 40 CFR 264.92 - 264.94 are similar to the requirements under the Safe Drinking Water Act. The RCRA standards use MCLs as the maximum concentration of constituents for groundwater in the uppermost aquifer. Selection of the MCLs under the Safe Drinking Water Act will serve the same or similar purpose as selection of the MCLs under the RCRA groundwater protection standards. RCRA groundwater protection standards are considered action-specific ARARs for any actions involving the groundwater beneath OU-1, and will therefore be included in Technical Memorandum #11.

The contaminants under consideration for OU-1 groundwater are identified in Table 2-2 along with their appropriate MCLs and MCLGs. State groundwater standards are identified in Table 2-3 and are considered TBCs for the purposes of OU-1.

Soil-specific chemical requirements under State and Federal laws do not exist for the contaminants identified in OU-1. (i.e., there are not any established protective levels for surface soil contamination based on risk to human health and/or the environment). There are, however, some chemical-specific guidelines and criteria available that specify waste concentration limits

Table 2-2
Potential Groundwater ARARs
National Primary Drinking Water Standards^a
($\mu\text{g/L}$)

Chemical	Federal MCL ^b	Federal MCLG ^{b,c}
Volatile Organic Compounds		
Carbon Tetrachloride	5	0
Chloroform (total trihalomethanes)	<100	—
1,1-Dichloroethane	—	—
1,2-Dichloroethane	5	0
1,1-Dichloroethene	7	7
1,2-Dichloroethene	—	—
cis-1,2-Dichloroethene	70	70
Tetrachloroethene	5	0
Toluene	1000	1000
Total Xylenes	10000	10000
1,1,1-Trichloroethane	200	200
1,1,2-Trichloroethane	5	3
Trichloroethene	5	0
Metals		
Selenium	50	50
Vanadium	—	—
Semi-Volatile Organic Compounds		
Naphthalene	—	—

^a None of the listed COCs have an associated secondary or proposed MCL or MCLG, although they would be TBCs if available.

^b From 40 CFR Parts 141 and 142; effective January 17, 1994.

^c Non-zero MCLGs are considered chemical-specific ARARs, and are equivalent to MCLs.

**Table 2-3
Statewide and Basin-Specific
Groundwater Standards
($\mu\text{g/L}$)**

Chemical	State Standard ^a	Practical Quantitation Limit (PQL)
Volatile Organic Compounds		
Carbon Tetrachloride	0.3	1.0
Chloroform	6/0.19 ^c	1.0
1,1-Dichloroethane	—	—
1,2-Dichloroethane	0.4	1.0
1,1-Dichloroethene	7	1.0
1,2-Dichloroethene	—	—
cis-1,2-Dichloroethene	70 ^b	1.0
Tetrachloroethene	5/0.8 ^c	1.0
Toluene	1000	1.0
Total Xylenes	10000 ^b	1
1,1,1-Trichloroethane	200	1.0
1,1,2-Trichloroethane	3/0.6 ^c	1.0
Trichloroethene	5	1.0
Metals		
Selenium	10 ^d /20 ^e	—
Vanadium	100 ^e	—
Semi-Volatile Organic Compounds		
Naphthalene	—	—

^a CDH/Water Quality Control Commission, Basic Standards for Groundwater, 3.11.0, effective 3/30/94.

^b Listed as drinking water MCL in State groundwater standards Table A.

^c CDH/Water Quality Control Commission, Classification and Water Quality Standards for Ground Water, 3.12.0; effective 1/31/94.

^d Measured as a dissolved concentration.

^e Agricultural standard.

(e.g., RCRA delisting requirements or RCRA treatment standards specific to land disposal). These criteria and/or guidelines have been evaluated as TBCs.

One of the few requirements available for surface soil contamination is based on the State of Colorado's radiation control standards (6 CCR 1007-1, 4.19) which present a derived alpha activity limit for disposal of materials in soil (5 pCi/g). The derived alpha activity limit is an action-specific requirement according to EPA's guidance on identification of ARARs. In general, due to the lack of sufficient standards, a risk-based approach is suggested for establishing surface soil PRGs.

2.4.2 Preliminary Remediation Goals Based on 10^{-6} as the Point-of-Departure

The methodology for implementing risk-based concentrations as PRGs is described in the NCP and the RI/FS guidance. Clarification of the 10^{-6} point-of-departure concept is also included in the preamble to the NCP and in the EPA's Office of Solid Waste and Emergency Response (OSWER) directive entitled, *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)* (EPA 1991a) (hereinafter referred to as the PRG guidance). In describing how the point-of-departure concept is applied for the development of PRGs, the directive explicitly states that for each chemical in a particular medium, "by setting the total risk for carcinogenic effects at a target risk level of 10^{-6} , ... it is possible to solve for the concentration term (i.e., risk-based PRG)." The "total risk" in this quote refers to the total risk summed across all pathways in a medium for a single chemical. For non-carcinogens, "the total risk for non-carcinogenic effects is set at a hazard index of 1 for each chemical in a particular medium."

Risk-based PRGs for OU-1 were calculated using the scenario where it is assumed that a hypothetical future on-site resident will ingest groundwater at the source. Originally, the following exposure routes for the future on-site resident were evaluated in the PHE:

- Inhalation of Indoor VOCs From Basement Vapor
- Inhalation of Particulates
- Soil Ingestion

- Dermal Contact with Soil
- Sediment Ingestion
- Dermal Contact with Sediment
- Surface Water Ingestion
- Dermal Contact with Surface Water
- Ingestion of Homegrown Vegetables/Fruit
- Groundwater Ingestion
- Dermal Contact with Groundwater
- Inhalation of VOCs from Indoor Water Use

Similarly, the following exposure routes for the future on-site commercial worker and ecological reserve researcher were evaluated in the PHE:

- Inhalation of Indoor VOCs From Basement Vapor (commercial worker only)
- Inhalation of Particulates
- Soil Ingestion
- Dermal Contact with Soil
- Sediment Ingestion
- Dermal Contact with Sediment
- Surface Water Ingestion
- Dermal Contact with Surface Water

Of the exposure routes listed above, those involving the media of surface water and sediments were not considered for PRG development as part of the OU-1 CMS/FS. These media are adjacent to OU-1 and will be addressed in OU-5. Additionally, these media do not present a risk greater than 10^{-6} , nor a hazard index greater than one, and therefore do not warrant risk-based PRGs. Likewise, subsurface soils do not present a risk greater than 10^{-6} , nor a hazard index greater than one. For these reasons, only the media of surface soils and groundwater are addressed in the following calculations.

Groundwater PRG calculations are presented in the following order. First, risk equations are presented by pathway. Next, the equations are solved for concentration. And finally, a numerical example is presented. This sequence is repeated for surface soil PRG calculations. For both media, the 1×10^{-6} risk level is used to calculate PRGs for carcinogenic effects, as well

as the hazard index equal to one value for noncarcinogenic effects. For the following calculations the methodology is presented for PRGs involving carcinogenic effects. Appendix A details any changes which occur in the formulas when calculating noncarcinogenic effects. Tables included herein which present PRGs for either media include the most restrictive PRG calculated from either starting point (i.e., 1×10^{-6} or 1).

Groundwater PRGs were calculated using the following exposure routes:

- Groundwater Ingestion
- Dermal Contact with Groundwater
- Inhalation of VOCs from Indoor Water Use

The risk equations for these routes are presented below.

Groundwater Ingestion:

$$\text{Risk} = \frac{\text{CW} \times \text{IR} \times \text{EF} \times \text{ED} \times \text{SF}_o}{\text{BW} \times \text{AT}} \quad (1)$$

where:

- CW = Chemical concentration in water (mg/liter)
 IR = Ingestion rate (liter/day)
 EF = Exposure frequency (days/year)
 ED = Exposure duration (years)
 BW = Body weight (kg)
 AT = Averaging time (period over which exposure is averaged - days)
 SF_o = Oral slope factor (mg/kg/day)⁻¹

Dermal Contact with Groundwater:

$$\text{Risk} = \frac{\text{CW} \times \text{SA} \times \text{PC} \times \text{ET} \times \text{EF} \times \text{ED} \times \text{CF} \times \text{SF}_o}{\text{BW} \times \text{AT}} \quad (2)$$

where:

CW	=	Chemical concentration in water (mg/liter)
SA	=	Skin surface area available for contact (cm ²)
PC	=	Chemical-specific dermal permeability constant (cm/hr)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
CF	=	Volumetric conversion factor for water (1 liter/1000 cm ³)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days)
SF _o	=	Oral slope factor (mg/kg/day) ⁻¹

The surface area available for contact is dependent on the exposure media and pathway. Residents exposed to groundwater during showering are assumed to be exposed over their entire skin area.

Inhalation of VOCs from Indoor Water Use:

$$\text{Risk} = \frac{\text{CA} \times \text{IhR} \times \text{EF} \times \text{ED} \times \text{SF}_i}{\text{BW} \times \text{AT}} \quad (3)$$

where:

CA	=	Contaminant concentration in air (mg/m ³)
IhR	=	Inhalation rate (m ³ /day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (period over which exposure is averaged - days)
SF _i	=	Inhalation slope factor (mg/kg/day) ⁻¹

These three equations may be combined and algebraically solved for the concentration:

$$\text{CW} = \frac{\text{BW} \times \text{AT} \times 1\text{E}-06}{(\text{ED} \times \text{EF}) \times [(\text{IR} \times \text{SF}_i) + (\text{SA} \times \text{PC} \times \text{CF} \times \text{ET} \times \text{SF}_o) + (\text{VF} \times \text{IhR} \times \text{SF}_i)]} \quad (4)$$

where:

VF = volatilization factor (0.065 mg/m³ in air per mg/l in water)

For example, values pertinent to 1,1-dichloroethene were substituted into this expression, yielding a PRG of 1.50 x 10⁻¹ ug/L (the parameters used below are valid for the future on-site resident scenario):

$$CW = \frac{70 \text{ kg} \times 25,550 \text{ day} \times 1E-06}{350 \frac{\text{day}}{\text{yr}} \times 24 \text{ yr}} \times \quad (5)$$

$$\left[\left(2 \frac{\ell}{\text{day}} \times 0.6 \left(\frac{\text{mg}}{\text{kg}} \right)^{-1} + \left(22,800 \text{ cm}^2 \times 1.6E-02 \frac{\text{cm}}{\text{hr}} \times 0.001 \frac{\ell}{\text{cm}^3} \times 0.2 \text{ hr} \times 0.6 \left(\frac{\text{mg}}{\text{kg}} \right)^{-1} \right) + \left(0.065 \frac{\text{mg}}{\text{m}^3} \text{ per } \frac{\text{mg}}{\ell} \times 15 \frac{\text{m}^3}{\text{day}} \times 0.18 \left(\frac{\text{mg}}{\text{kg}} \right)^{-1} \right) \right]$$

$$= 1.50E-04 \text{ mg/L} = 1.50E-01 \text{ } \mu\text{g/L}$$

Groundwater PRGs which resulted from these calculations are presented in Table 2-4. Using similar methodology, soil PRGs were calculated with the following pathways:

- Inhalation of Particulates
- Soil Ingestion
- Ingestion of Homegrown Vegetables/Fruit

The risk equations for these exposure routes are shown for radionuclides. Note that radionuclide slope factors are not a function of body weight and averaging time.

Inhalation of Particulates:

$$\text{Risk} = CS \times RD \times IR \times EF \times ED \times SF_i \quad (6)$$

**Table 2-4.
Groundwater
Risk-Based Preliminary Remediation Goals (PRGs)**

Chemical ^a	Preliminary Remediation Goal by Scenario ^{b,c} ($\mu\text{g/L}$)		Generic PRGs from EPA Region IX Guidance, January 1994 ($\mu\text{g/L}$)
	Future On-Site Resident	Commercial/ Industrial Worker	
Volatile Organic Compounds			
Carbon Tetrachloride	0.658	13.8	0.26
Chloroform	2.33	N/A	0.28
1,1-Dichloroethane	2670	N/A	1000
1,2-Dichloroethane	0.780	N/A	0.20
1,1-Dichloroethene	0.150	1.99	0.068
1,2-Dichloroethene	218	N/A	69
cis-1,2-Dichloroethene	225	N/A	77
Tetrachloroethene	1.85	683	1.4
Toluene	3670	N/A	930
Total Xylenes	1210	N/A	1900
1,1,1-Trichloroethane	3120	293684	1500
1,1,2-Trichloroethane	125	N/A	0.32
Trichloroethene	7.43	N/A	2.5
Metals			
Selenium	183	N/A	180
Vanadium	256	N/A	260
Semi-Volatile Organic Compounds			
Naphthalene	888	N/A	310

^a Shaded contaminants were not designated as COCs by the BRA portion of the RFI/RI.

^b The ecological reserve researcher scenario does not apply to this medium.

^c Cells listed as "N/A" represent chemicals which either did not have an associated toxicity constant available, were not designated as COCs in the BRA and thus did not have a calculated risk value available for estimating a PRG, or were not applicable to the volatilization transport mechanism for the commercial/industrial scenario (i.e., metals).

where:

CS = Contaminant concentration in soil (pCi/kg)
RD = Respirable dust concentration (4.2×10^{-8} kg/m³)
IhR = Inhalation rate (m³/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
SF_i = Inhalation slope factor (pCi)⁻¹

Soil Ingestion:

$$\text{Risk} = \text{CS} \times \text{IR} \times \text{CF} \times \text{EF} \times \text{ED} \times \text{SF}_i$$

(7)

where:

CS = Contaminant concentration in soil (pCi/kg)
IR = Ingestion rate (mg/day)
CF = Conversion factor (1×10^{-6} kg/mg)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
SF_o = Oral slope factor (pCi)⁻¹

Ingestion of Homegrown Vegetables/Fruit:

$$\text{Risk} = \text{CS} \times \text{UF} \times \text{IR}_p \times \text{EF} \times \text{ED} \times \text{SF}_o$$

(8)

where:

CS = Contaminant concentration in soil (pCi/kg)
UF = Plant uptake factor
IR_p = Ingestion rate (kg/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
SF_o = Oral slope factor (pCi)⁻¹

These three equations may be combined and algebraically solved for soil concentration:

$$CS = \frac{1E-06}{(ED \times EF) \times [(IR \times CF \times SF_1) + (IRp \times UF \times SF_2) + (RD \times IHR \times SF_3)]} \quad (9)$$

As a specific example, values pertinent to Pu-239,-240 are substituted into this expression, yielding a PRG of $1.25 \times 10^{+3}$ pCi/kg:

$$CS = \frac{1E-06}{24 \text{ yr} \times 350 \frac{\text{day}}{\text{yr}}} \times \quad (10)$$

$$\frac{1}{[(100 \frac{\text{mg}}{\text{day}} \times 1E-06 \frac{\text{kg}}{\text{mg}} \times 2.3E-10 \frac{1}{\text{pCi}}) + (0.078 \frac{\text{kg}}{\text{day}} \times 2.23E-03 \times 2.3E-10 \frac{1}{\text{pCi}}) + (4.2E-08 \frac{\text{kg}}{\text{m}^3} \times 20 \frac{\text{m}^3}{\text{day}} \times 3.8E-08 \frac{1}{\text{pCi}})]}$$

$$= 1.25E+03 \text{ pCi/kg}$$

Risks for PAHs or Aroclor-1254 in surface soil for the primary pathway, soil ingestion, did not exceed 1×10^{-6} . For some of these contaminants, risks for a secondary pathway, plant ingestion, were estimated to be in the 10^{-5} range. However, these risks were not based on measured plant concentrations, but on plant concentrations estimated from soil concentrations. Furthermore, benzo(a)pyrene is the only PAH with a slope factor (EPA 1993), while slope factors for other PAHs are derived from benzo(a)pyrene based on estimated toxicity equivalence. In summary, the risk estimates for the plant ingestion pathway are based indirectly on soil concentrations and limited toxicity information, and are subject to greater uncertainty.

The PRGs for PAHs or Aroclor-1254 in surface soil were estimated using the plant ingestion portion of equation 10. Since these compounds are not radionuclides, body weight and averaging time were included in the numerator, similar to the way they appear in the equations for groundwater. Surface soil PRGs resulting from these calculations are presented in Table 2-5.

**Table 2-5.
Surface Soil
Risk-Based Preliminary Remediation Goals (PRGs)**

Chemical ^a	Preliminary Remediation Goal by Scenario ^{b,c} (mg/kg)	
	Future On-Site Resident	Commercial/Industrial Worker ^d
Polynuclear Aromatic Hydrocarbons		
Acenaphthene	326	2658
Acenaphthylene	199	N/A
Anthracene	1630	N/A
Benzo(a)anthracene	0.168	1.378
Benzo(a)pyrene	0.156	0.137
Benzo(b)fluoranthene	0.307	0.070
Benzo(ghi)perylene	N/A	N/A
Benzo(k)fluoranthene	1.98	1.33
Chrysene	56	N/A
Dibenzo(a,h)anthracene	0.017	0.134
Fluoranthene	1010	1771
Fluorene	251	1745
Indeno(1,2,3-cd)pyrene	0.552	N/A
Naphthalene	94.3	N/A
Phenanthrene	N/A	N/A
Pyrene	634	1342
Polychlorinated Biphenyls		
AROCLOR-1248	0.050	0.125
AROCLOR-1254	0.050	0.125
Radionuclides^e		
Americium-241	1.80	4.12
Uranium-233,-234	4.34	6.81
Uranium-235	4.63	7.34
Uranium-238	2.29	3.55
Plutonium-239,-240	1.25	3.68

^a Shaded contaminants were not designated as COCs by the BRA portion of the RFI/RI.

^b The ecological reserve researcher scenario results in the same PRGs as the commercial/industrial worker scenario.

^c Cells listed as "N/A" represent chemicals which either did not have an associated toxicity constant available, or were not designated as COCs in the BRA and thus did not have a calculated risk value available for estimating a PRG.

^d These values were estimated by linearly reducing the contaminant concentrations presented in the BRA until the appropriate risk value was reached (i.e., 1×10^{-6} or 1, depending on the contaminant effects); therefore PRGs for contaminants not originally included in the BRA could not be estimated for this scenario.

^e Radionuclides are reported in pCi/g.

With regard to the commercial/industrial and ecological reserve researcher scenarios, PRGs were calculated for radionuclides, VOCs, PAHs, and PCBs in a similar manner (for the appropriate media). The key differences between calculating PRGs for residential and occupational scenarios is that occupational scenarios use an exposure duration of 25 years, an exposure frequency of 250 days/year, and a soil ingestion rate of 50 mg/day.

For radionuclides, the inhalation of particulates and ingestion of soil exposure routes were used to find surface soil PRGs. Equation 10 was used with the terms involving plant ingestion deleted. Inhalation of soil gas through the foundation was used to estimate groundwater PRGs for VOCs. PRGs were estimated by linearly reducing risk and groundwater concentrations until a concentration corresponding to a 1×10^{-6} level (or 1 where appropriate) was reached. Since the soil-gas model may respond non-linearly in this region, the groundwater concentrations were checked by using them as input to the model and checking the resulting inhalation risks. The dermal contact pathway was used to derive PRGs for PAHs and PCBs. PRGs were estimated by linearly reducing risk and surface soil concentrations until a concentration corresponding to a 1×10^{-6} level (or 1 where appropriate) was reached. These PRGs are also presented in Table 2-5. Note that wherever this linear extrapolation approach was used, results must first have been available from the BRA to use as a starting point. When results were not available from the BRA, the tables indicate that the PRG for that contaminant is "N/A".

2.4.3 Recommended Preliminary Remediation Goals

Based on the fact that groundwater MCLs are generally considered protective, and are chemical-specific ARARs for OU-1, these concentrations should be designated as initial PRGs for groundwater. If, at some point in the CERCLA process, it is determined that these goals cannot be achieved, then revised PRGs should be developed that will still provide an adequate level of protection, taking into account an appropriate future land use scenario for the RFP. For the purposes of the CMS/FS it is assumed that the future on-site resident scenario will be the scenario selected for PRGs.

Similarly, if it is determined that surface soils PRGs are technically impossible to achieve, then revision of these PRGs may be in order. Revised PRGs for surface soil would also be developed based on an appropriate future land use scenario. For both media, an administrative agreement would have to be achieved as to the level of protection considered acceptable for the revised PRGs. Table 2-6 presents a comparison of the risk-based PRGs, related ARARs (where appropriate), and existing contaminant concentrations for the COCs in the groundwater medium. Surface soil PRGs presented earlier in this document are relevant to the hot spots which are being addressed in OU-1. Note that remedial action evaluation of the low-level plutonium contamination found in OU-1 (from the 903 Pad in OU-2) will intrinsically address the low-level PAH and PCB contamination found in the same area.

Table 2-6
Comparison of Risk-Based PRGs, ARARs, and Existing Concentrations
 (µg/L)

Chemical ¹	Existing Concentration (mean)	Risk-Based PRG ²	Federal MCL	Federal MCLG	State Standard ^a	PQL ³	
						RFP	CDH
Volatile Organic Compounds							
Carbon Tetrachloride	81.20	0.658	5	0	0.3	5	1.0
Chloroform	4.68	2.33	<100	—	6/0.19 ^e	5	1.0
1,1-Dichloroethane	2.10	2670	—	—	—	5	—
1,2-Dichloroethane	6.10	0.780	5	0	0.4	5	1.0
1,1-Dichloroethene	283.23	0.150	7	7	7	5	1.0
1,2-Dichloroethene	106.66	218	—	—	—	5	1.0
cis-1,2-Dichloroethene	0.52	225	70	70	70 ^b	—	1.0
Tetrachloroethene	103.48	1.85	5	0	5/0.8 ^c	10	1.0
Toluene	4.68	3670	1000	1000	1000	5	1.0
Total Xylenes	3.23	1210	10000	10000	10000 ^b	5	1
1,1,1-Trichloroethane	363.29	3120	200	200	200	5	1.0
1,1,2-Trichloroethane	2.69	125	5	3	3/0.6 ^c	5	1.0
Trichloroethene	371.65	7.43	5	0	5	5	1.0
Metals							
Selenium	26.02	183	50	50	10 ^d /20 ^e	5	—
Vanadium	132.16	256	—	—	100 ^c	50	—
Semi-Volatile Organic Compounds							
Naphthalene	0.13	888	—	—	—	10	—

¹ Shaded contaminants were not designated as COCs by the BRA portion of the RFI/RI.

² Based on the future on-site residential scenario.

³ Practical Quantitation Limits (PQLs) are reported for both the Rocky Flats Plant (RFP) and the Colorado Department of Health (CDH).

^a CDH/Water Quality Control Commission, Basic Standards for Groundwater, 3.11.0, effective 3/30/94.

^b Listed as drinking water MCL in State groundwater standards Table A.

^c CDH/Water Quality Control Commission, Classification and Water Quality Standards for Ground Water, 3.12.0; effective 1/31/94.

^d Measured as a dissolved concentration.

^e Agricultural standard.

3.0 REFERENCES

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APPENDIX A

PRG CALCULATION SPREADSHEETS

Groundwater PRGs – VOCs and Metals
Future on-site resident
(ingestion + dermal absorption + volatiles from indoor use)

EXPOSURE CONSTANTS AND PARAMETERS

Abbreviation	Value	Units	Comments
TR	1E-06	Target Risk	
AT	25550	days	8760 (for noncarcs.)
BW	70	kg	
ED	24	years	
EF	350	days/year	
IR	2	L/day	
IhR	15	m ³ /day	indoors
SA	22800	cm ²	entire body area
VF	0.065	mg/m ³ per mg/L	volatization factor indoor use
CF	0.001	l/cm ³	
ET	0.2	hr/day	shower time

PRELIMINARY REMEDIATION GOALS

Chemical	1E-06 PRGs (1) (mg/L)	HI=1 PRGs (2) (mg/L)	Region IX PRG (3) (mg/L)
1,1-Dichloroethane	-	2.67E+00	1.0E+00
1,1-Dichloroethene	1.50E-04	2.16E-01	6.8E-05
1,1,1-Trichloroethane	-	3.12E+00	1.5E+00
1,1,2-Trichloroethane	1.25E-03	9.69E-02	3.2E-04
1,2-Dichloroethane (EDC)	7.80E-04	-	2.0E-04
1,2-Dichloroethene (mixture)	-	2.18E-01	6.9E-02
Carbon Tetrachloride	6.58E-04	1.55E-02	2.6E-04
Chloroform	2.33E-03	2.42E-01	2.8E-04
cis-1,2 Dichloroethene	-	2.25E-01	7.7E-02
Naphthalene	-	8.88E-01	3.1E-01
Tetrachloroethene	1.85E-03	2.29E-01	1.4E-03
Toluene	-	3.67E+00	9.3E-01
Total Xylenes	-	1.21E+01	1.9E+00
Trichloroethene (TCE)	7.43E-03	1.44E-01	2.5E-03
Selenium	-	1.83E-01	1.8E-01
Vanadium	-	2.58E-01	2.6E-01

CHEMICAL/ISOTOPE SPECIFIC CONSTANTS

Chemical	Permeability Constant (4) (cm/hr)	SFo Ingestion (3)	SFi Inhalation (3)	RfDo Ingestion (3)	RfDi Inhalation (3)
1,1-Dichloroethane	8.9E-03	-	-	1.0E-01	1.4E-01
1,1-Dichloroethene	1.6E-02	6.0E-01	1.8E-01	9.0E-03	9.0E-03
1,1,1-Trichloroethane	1.7E-02	-	-	9.0E-02	3.0E+00
1,1,2-Trichloroethane	8.4E-03	5.7E-02	5.6E-02	4.0E-03	4.0E-03
1,2-Dichloroethane (EDC)	5.3E-03	9.1E-02	9.1E-02	-	-
1,2-Dichloroethene (mixture)	1.0E-02	-	-	9.0E-03	9.0E-03
Carbon Tetrachloride	2.2E-02	1.3E-01	5.2E-02	7.0E-04	5.7E-04
Chloroform	8.9E-03	6.1E-03	8.1E-02	1.0E-02	1.0E-02
cis-1,2 Dichloroethene	1.0E-02	-	-	9.0E-03	1.0E-02
Naphthalene	6.9E-02	-	-	4.0E-02	4.0E-02
Tetrachloroethene	4.8E-02	5.1E-02	2.0E-03	1.0E-02	1.0E-02
Toluene	4.5E-02	-	-	2.0E-01	1.1E-01
Total Xylenes	8.0E-02	-	-	2.0E+00	2.0E-01
Trichloroethene (TCE)	1.6E-02	1.1E-02	6.0E-03	6.0E-03	6.0E-03
Selenium	-	-	-	5.0E-03	-
Vanadium	-	-	-	7.0E-03	-

- $1E-06 \times [(BW \times AT) / (ED \times EF)] / [(IR \times SFo) + (SA \times PC \times CF \times ET \times SFo) + (VF \times IhR \times SFi)]$
- $[(BW \times AT) / (ED \times EF)] / [(IR \times 1/RfDo) + (SA \times PC \times CF \times ET \times 1/RfDo) + (VF \times IhR \times 1/RfDi)]$
- From EPA Region IX PRG Tables.
- From EPA/600/8-91/011B - Dermal Exposure Assessment: Principles and Applications.
- Metals equations only include groundwater ingestion.

Surface Soil PRGs – PAHs/PCBs
 Future on-site resident
 (plant ingestion)

EXPOSURE CONSTANTS AND PARAMETERS

Abbreviation	Value	Units	Comments
TR	1E-06	Target Risk	8760 (for noncarcs.)
AT	25550	days	
BW	70	kg	
ED	24	years	
EF	350	days/year	
IR	100	mg/day	
IRp	0.078	kg/day	

PRELIMINARY REMEDIATION GOALS

Chemical	1E-06 PRGs (1) (mg/kg)	HI=1 PRGs (2) (mg/kg)	Region IX PRG (3) (mg/kg)
Acenaphthene	-	3.26E+02	3.60E+01
Acenaphthylene	-	1.99E+02	3.60E+01
Anthracene	-	1.63E+03	1.90E+00
Aroclor-1248	5.03E-02	-	1.10E-01
Aroclor-1254	5.03E-02	-	1.10E-01
Benzo(a)anthracene	1.68E-01	-	1.20E+00
Benzo(a)pyrene	1.56E-01	-	1.20E-01
Benzo(b)fluoranthene	3.07E-01	-	1.20E+00
Benzo(ghi)perylene	N/A	N/A	N/A
Benzo(k)fluoranthene	1.98E+00	-	1.20E+00
Chrysene	5.60E+01	-	1.20E+02
Dibenzo(a,h)anthracene	1.69E-02	-	1.20E-01
Fluoranthene	-	1.01E+03	1.60E+03
Fluorene	-	2.51E+02	2.80E+01
Indeno(1,2,3-cd)pyrene	5.52E-01	-	1.20E+00
Naphthalene	-	9.43E+01	8.00E+01
Phenanthrene	N/A	N/A	N/A
Pyrene	-	6.34E+02	1.20E+03

CHEMICAL/ISOTOPE SPECIFIC CONSTANTS

Chemical	SFo Ingestion (3)	RfDo Ingestion (3)	Plant Uptake (4) (Bv)
Acenaphthene	-	6.00E-02	1.72E-01
Acenaphthylene	-	6.00E-02	2.82E-01
Anthracene	-	3.00E-01	1.72E-01
Aroclor-1248	7.70E+00	-	7.05E-03
Aroclor-1254	7.70E+00	-	7.05E-03
Benzo(a)anthracene	7.30E-01	-	2.22E-02
Benzo(a)pyrene	7.30E+00	-	2.40E-03
Benzo(b)fluoranthene	7.30E-01	-	1.22E-02
Benzo(ghi)perylene	-	-	2.22E-02
Benzo(k)fluoranthene	7.30E-01	-	1.89E-03
Chrysene	7.30E-03	-	6.68E-03
Dibenzo(a,h)anthracene	7.30E+00	-	2.22E-02
Fluoranthene	-	4.00E-02	3.72E-02
Fluorene	-	4.00E-02	1.49E-01
Indeno(1,2,3-cd)pyrene	7.30E-01	-	6.78E-03
Naphthalene	-	4.00E-02	3.97E-01
Phenanthrene	-	-	1.02E-01
Pyrene	-	3.00E-02	4.43E-02

- (1) $1E-06 \times [(AT \times BW) / (ED \times EF)] / (UF \times IRp \times SFo)$
- (2) $[(AT \times BW) / (ED \times EF)] / (UF \times IRp \times 1/RfDo)$
- (3) From EPA Region IX PRG Tables, 1994
- (4) From Travis and Arms, 1988

Surface Soil PRGs – Radionuclides
 Future on-site resident
 (soil ingestion + inhalation of particulates + plant ingestion)

EXPOSURE CONSTANTS AND PARAMETERS

Abbreviation	Value	Units	Comments
TR	1E-06	Target Risk	
ED	24	years	
EF	350	days/year	
IR	100	mg/day	
IhR	20	m ³ /day	
RD	4.2E-08	kg/m ³	respirable dust concentration (3)
CF	1.0E-06	kg/mg	
IRp	0.078	kg/day	

PRELIMINARY REMEDIATION GOALS

Chemical	1E-06 PRGs (1) (pCi/kg)
Americium-241	1.80E+03
Plutonium-239,-240	1.25E+03
Uranium-233,234	4.34E+03
Uranium-235	4.63E+03
Uranium-238	2.29E+03

CHEMICAL/ISOTOPE SPECIFIC CONSTANTS

Chemical	SFo Ingestion (2)	SFi Inhalation (2)	Uptake Factor (2) (Bv)
Americium-241	2.40E-10	3.20E-08	8.19E-04
Plutonium-239,-240	2.30E-10	3.80E-08	2.23E-03
Uranium-233,234	1.60E-11	2.70E-08	2.51E-03
Uranium-235	1.60E-11	2.50E-08	2.51E-03
Uranium-238	2.80E-11	5.20E-08	2.51E-03

- (1) $1E-06 / [(ED \times EF) \times ((IR \times CF \times SFo) + (UF \times IRp \times SFo) + (IhR \times RD \times SFi))]$
 (2) Taken from OU-1 Baseline Risk Assessment
 (3) Taken from Rocky Flats Plant Site Environmental Report, 1992

Surface Soil PRGs – Radionuclides
Future on-site ecological researcher or commercial/industrial worker
(soil ingestion + inhalation of particulates)

EXPOSURE CONSTANTS AND PARAMETERS

Abbreviation	Value	Units	Comments
TR	1E-06	Target Risk	
ED	25	years	
EF	250	days/year	
IR	50	mg/day	
IhR	20	m ³ /day	
RD	4.2E-08	kg/m ³	respirable dust concentration (3)
CF	1.0E-06	kg/mg	

PRELIMINARY REMEDIATION GOALS

Chemical	1E-06 PRGs (1) (pCi/kg)
Americium-241	4.12E+03
Plutonium-239, -240	3.68E+03
Uranium-233,234	6.81E+03
Uranium-235	7.34E+03
Uranium-238	3.55E+03

CHEMICAL/ISOTOPE SPECIFIC CONSTANTS

Chemical	SFo Ingestion (2)	SFi Inhalation (2)
Americium-241	2.40E-10	3.20E-08
Plutonium-239, -240	2.30E-10	3.80E-08
Uranium-233,234	1.60E-11	2.70E-08
Uranium-235	1.60E-11	2.50E-08
Uranium-238	2.80E-11	5.20E-08

- (1) $(1E-06 / (ED \times EF)) / ((IR \times CF \times SFo) + (IhR \times RD \times SFi))$
 (2) Taken from OU-1 Baseline Risk Assessment
 (3) Taken from Rocky Flats Plant Site Environmental Report, 1992

APPENDIX B
POTENTIAL SURFACE WATER ARARs

Runoff from contaminated soils and sediments was identified as a potential concern at OU-1. Woman Creek is a surface water body which could have been impacted by OU-1 contaminants, and was thus evaluated for risk in the OU-1 BRA. Because there was no significant risk associated with this medium (i.e., above 10^{-6}), and because it will be examined as part of OU-5, the medium of surface water is not subject to evaluation under OU-1. However, this attachment presents potential surface water ARARs for the contaminants found in OU-1, in order to assist the OU-5 ARARs assessment.

Sediment toxicity values are usually compared to water quality criteria established for specific basins and streams within water quality basins. This document identifies the State water quality criteria for human health (drinking water and fish ingestion) specific to the Woman Creek classification under the State's rules for Basic Standards and Methodologies for Surface Water 3.1.0 of 5 CCR 1002-8 and Classifications and Numeric Standards South Platte River Basin 3.8.0 of 5 CCR 1002-8. The State's water quality criteria established pursuant to both the Clean Water Act and State statutes are approved by EPA and are more stringent than Federal Water Quality Criteria. Accordingly, the attached table contains a list of the potential numeric surface water ARARs.

Potential Surface Water ARARs^a
Water Quality Criteria
Human Health
(µg/L)

Chemical	Federal	Colorado State-Wide Standards		
	Water and Fish Ingestion	Water Supply ^d	Water and Fish ^e	Domestic Water Supply Numeric Levels from Tables I, II, III ^b
1,1-Dichloroethane	—	—	—	—
1,2-Dichloroethane	0.94 ^c	0.4	0.4	—
1,1-Dichloroethene	—	7	0.057	—
1,2-Dichloroethene	—	—	—	—
Tetrachloroethene	0.80 ^c	5	0.8	—
Toluene	14,300	1,000	1,000	—
Total Xylenes	—	—	—	—
1,1,1-Trichloroethane	18,400	200	200	—
Trichloroethene	2.7 ^c	5	2.7	—
Americium (total)	—	—	—	—
Americium -241	—	—	—	—
Plutonium (total)	—	—	—	—
Plutonium-238/239/240	—	15 pCi/L	—	—

^a Surface water and sediment remediation issues dealt with administratively under Operable Unit 5. These values are for information purposes only.

^b Numeric levels used by Water Quality Commission to establish site-specific numeric standards when determined appropriate to protect the classified uses.

^c Human health criteria for carcinogens reported for three risk levels. Value presented is the 10⁻⁵ risk level.

^d Only applicable to segments classified for water supply.

^e Applicable to all Class 1 aquatic life segments or Class 2 aquatic life segments designated by the commission after rulemaking hearing.

Potential Surface Water ARARs^a
Water Quality Criteria
Aquatic Life
($\mu\text{g/L}$)

Chemical	Federal		Colorado State-Wide Standards			
	Aquatic Life		Aquatic Life		Aquatic Life Numeric Levels from Tables I, II, III ^b	
	Chronic	Acute	Chronic	Acute	Chronic	Acute
1,1-Dichloroethane	—	—	—	—	—	—
1,2-Dichloroethane	20,000 ^c	118,000 ^c	20,000	118,000	—	—
1,1-Dichloroethene	—	—	—	—	—	—
1,2-Dichloroethene	—	—	—	—	—	—
Tetrachloroethene	840 ^c	5,280 ^c	840	5,280	—	—
Toluene	—	17,500 ^c	—	17,500	—	—
Total Xylenes	—	—	—	—	—	—
1,1,1-Trichloroethane	—	—	—	—	—	—
Trichloroethene	21,900 ^c	45,000 ^c	21,900	45,000	—	—
Americium (total)	—	—	—	—	—	—
Americium-241	—	—	—	—	—	—
Plutonium (total)	—	—	—	—	—	—
Plutonium-238/239/240	—	—	—	—	—	—

^a Surface water and sediment remediation issues will be addressed under Operable Unit 5. These values are for information purposes only.

^b Numeric levels used by Water Quality Commission to establish site-specific numeric standards when determined appropriate to protect the classified uses.

^c Criteria not developed; value presented is lowest observed effects level (LOEL).

Potential Surface Water ARARs^a
Water Quality Criteria
Colorado Stream Segment
($\mu\text{g/L}$)

Chemical	Stream Segment Table 1A ^b Big Dry Creek		Table 2 ^c Radionuclides Woman Creek	Table 3 ^e Temporary Modifications Big Creek, Segment 5
	Standard	PQL ^d		
1,1-Dichloroethane	—	—	—	—
1,2-Dichloroethane	—	—	—	—
1,1-Dichloroethene	—	—	—	—
1,2-Dichloroethene	—	—	—	—
Tetrachloroethene	0.8	1.0	—	—
Toluene	—	—	—	—
Total Xylenes	—	—	—	—
1,1,1-Trichloroethane	—	—	—	—
Trichloroethene	—	—	—	66
Americium (total)	—	—	0.05 pCi/L	—
Americium-241	—	—	—	—
Plutonium (total)	—	—	0.05 pCi/L	—
Plutonium-238/239/240	—	—	0.5 pCi/L	—

^a Surface water and sediment remediation issues will be addressed under Operable Unit 5. These values are for information purposes only.

^b Table 1A site-specific organic chemical standards Segments 2, 3, 4, and 5, Big Dry Creek in CDH WQCC Classifications and Numeric Standards 3.8.0. In the absence of specific numeric standards for non-naturally occurring organics, the narrative standard "free from toxics" [Section 3.1.11(1)(d)] shall be interpreted and applied in accordance with the provisions of Section 3.1.2.7(1)(c)(iv), so that the standard is interpreted consistently for surface and groundwaters.

^c Table 2 site-specific radionuclide standards in CDH WQCC Classifications and Numeric Standards 3.8.0.

^d State gas chromatography (GC) practical quantitation limit (PQL).

^e All temporary modifications apply until April 1, 1996.