EG&G ROCKY FLATS

Programmatic Preliminary Remediation Goals

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PROGRAMMATIC PRELIMINARY REMEDIATION GOALS

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LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS/FS	Corrective Measures Study/Feasibility Study
COC	Contaminant of Concern
C/RAO	Corrective and Remedial Action Objective
DOE	U.S. Department of Energy
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site
LHSU	Lower Hydrostratigraphic Unit
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NRC	Nuclear Regulatory Commission
OU	Operable Unit
PAH	Polyaromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PPRG	Programmatic Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
RI/FS	Remedial Investigation/Feasibility Study
SVOC	Semi-Volatile Organic Carbon
TAL	Target Analyte List
TBC	To-Be-Considered
TCL	Target Compound List
UHSU	Upper Hydrostratigraphic Unit
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound

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1.0 INTRODUCTION

Various areas at the Rocky Flats Plant (RFP) are being closed and/or remediated in accordance with the provisions of the 1991 Interagency Agreement (IAG) signed between the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (USEPA), and the State of Colorado (IAG 1991) to ensure protection of human health and the environment. The IAG integrates the closure and corrective action provisions of the Resource Conservation and Recovery Act (RCRA) with the remediation requirements contained in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The various areas to be closed or remediated, called Individual Hazardous Substance Sites (IHSSs), are divided into 16 Operable Units.

DOE is in the process of conducting a RCRA Facility Investigation/Remedial Investigation (RFI/RI) and Corrective Measures Study/Feasibility Study (CMS/FS) for each OU to select the most appropriate remedy for each OU. In order to identify, evaluate, and select a remedial alternative, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) states that "Alternatives shall be developed that protect human health and the environment by recycling waste or by eliminating, reducing, and/or controlling risks posed through each pathway by a site." The number and type of alternatives to be analyzed shall be determined at each site, taking into account the scope, characteristics, and complexity of the site problem that is being addressed. In developing and, as appropriate, screening the alternatives, the lead agency shall establish remedial action objectives specifying contaminants and media of concern, potential exposure pathways, and remediation goals." [See 40 CFR 300.430(e)(2).]

Remediation goals established are contaminant- and medium-specific levels of exposure that are protective of human health and the environment. The combination of the Baseline Risk Assessment (BRA) results, Applicable or Relevant and Appropriate Requirements (ARARs), and To-Be-Considered documents (TBCs) are used as the basis to establish the remediation goals approved by the regulatory agencies in the Record of Decision (ROD). CERCLA Section 121 and 40 CFR 300.430 allow the following factors to be considered when establishing remediation goals.

- Chemical specific standards established pursuant to a Federal environmental law or any promulgated State standard which is more stringent than a Federal standard are to be used to establish remediation goals. These environmental laws include, but are not limited to, the Toxic Substances Control Act; the Safe Drinking Water Act; the Clean Air Act; the Clean Water Act; the Marine Protection, Research and Sanctuaries Act; and the Solid Waste Disposal Act. In addition to the promulgated standards, the following items should be considered:

    - For systemic toxicants, remediation goals are to be established so that the human population, including sensitive subgroups, may be exposed without adverse effect through a given lifetime. Remediation goals are to incorporate an adequate margin of safety.

- For known or suspected carcinogens, remediation goals are to be established to represent an excess upper-bound lifetime cancer risk to an individual ranging from 10^{-4} to 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives where specific ARARs are not available or protective due to multiple contaminants or exposure pathways. [NOTE: In cases where the chemical-specific ARARs result in a cumulative risk in excess of 10^{-4}, more restrictive remediation goals may be established in accordance with this provision.]

- Factors related to uncertainties, technical limitations (i.e., detection limits), and other pertinent information.

- Non-zero Maximum Contaminant Level Goals (MCLGs), where determined to be relevant and appropriate, are to be attained by remedial actions for ground or surface waters that are current or potential drinking water sources. For MCLGs set at zero, the corresponding Maximum Contaminant Level (MCL) is to be attained when determined to be relevant and appropriate.

- An Alternative Concentration Limit (ACL) can be established pursuant to CERCLA Section 121.

- Water quality standards established under the Clean Water Act Sections 303 and 304 are to be attained for releases to surface waters to be protective of aquatic life where determined to be relevant and appropriate.

- Fauna, flora, and aquatic habitats are to be considered during the establishment of the remediation goals. Environmental evaluations are to be conducted to assess threats to the environment, especially sensitive and critical habitats protected under the Endangered Species Act.

To the extent possible, chemical-specific ARARs are used to determine remediation goals. However, ARARs may not adequately consider the site-specific contamination or the cumulative effects associated with multiple contaminants and/or pathways. As such, chemical-specific ARARs are not always the sole determinant of protectiveness and are supplemented with risk assessments and consideration of other non-promulgated health-based criteria. The risk assessment process includes the evaluation of site-specific factors such as potential for exposure (e.g., future land use), the hazardous substances present, and the presence of sensitive populations and habitats. These factors will be considered during the development of the OU-specific BRA. However, site-wide issues regarding the methodology used for developing the BRAs have impeded the progress of developing and evaluating remedial alternatives.

To overcome this obstacle, DOE is proposing to develop Programmatic Preliminary Remediation Goals (PPRGs) which will establish initial site-wide clean up targets for each environmental media. The PPRGs will form the basis to identify and screen remedial technologies and alternatives in parallel with completing the BRAs. This report presents the purpose for PPRGs and methods used to calculate them. Section 2 provides information regarding the intended current and potential future uses of the PPRGs. Section 3.0 describes the exposure pathways and methodology used to calculate the PPRGs. Section 4.0 provides references for the toxicological information used for each specific contaminant. Section 5.0 gives a comprehensive list of PPRGs that are proposed to be used to development and screen remedial technologies and alternatives.

2.0 PURPOSE OF PROGRAMMATIC PRELIMINARY REMEDIATION GOALS

As stated in Section 1.0, the intended purpose for calculating PPRGs is to establish site-wide clean up targets for environmental contaminants. The PPRG approach will expedite the overall remedial schedule by allowing the CMS/FS process (e.g., identification and screening of remedial technologies and alternatives) to proceed in parallel with completing the BRA. The benefits associated with developing PPRGs include:

- Allowing consistency between OUs by standardizing exposure pathways and methodology for proceeding with the development of remedial technologies and alternatives;

- Permitting the CMS/FS to proceed while issues associated with completing the BRAs are resolved;

- Enabling a means to quickly compare RFI/RI site characterization information with target clean up levels to assess the nature of contamination and to estimate contamination volumes to ascertain remediation cost and evaluate the implementability of certain technologies; and

- Facilitating early identification of data needs to support more detailed evaluation of potential remedial alternatives.

Although there is a certain level of risk associated with developing remedial technologies and alternatives prior to fully characterizing the risks associated with the OU contamination, the programmatic approach is consistent with the NCP. Specifically, 40 CFR 300.430(e)(2)(i) states that, "Initially, preliminary remediation goals are developed based on readily available information, such as chemical-specific ARARs or other reliable information. Preliminary remediation goals should be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected."

The "off-the-shelf" PPRGs will form the initial basis for identifying, screening, and evaluating potential remedial technologies and alternatives. However, the PPRGs are not

intended to be the final justification for selecting a particular remedial alternative. Should the final BRA indicate that the PPRGs are not representative of the actual risk posed by the contamination at the OU, the required changes will be incorporated during the Detailed Analysis of Alternatives phase CMS/FS for that particular OU.

3.0 EXPOSURE PATHWAYS

In order to standardize the PPRGs across all of the OUs, programmatic exposure pathways and future receptors have been established. Table 1 identifies the receptors and exposure pathways selected for each environmental media.

NOTE: ES asks that information pertaining to the selection of these receptors and pathways be provided for inclusion here.

4.0 METHODOLOGY, EQUATIONS, AND ASSUMPTIONS

This section presents the methodology, equations, and assumptions that were used to calculate the PPRGs. In general, the following USEPA guidance documents were used as the basis to derive the risk-based equations and exposure default values to calculate the PPRGs.

- *Human Health Evaluation Manual, Part B: Development of Risk-Based Preliminary Remediation Goals,* (USEPA 1991);
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A),* (USEPA 1989);
- *Changes to Equations in the Part B Guidance,* (Dinan 1992); and
- *Revisions to Chapter 4: Risk-based PRGs for Radioactive Contaminants,* (USEPA 1993b).

To ensure that all of the contaminants that may be encountered at the RFP, PPRGs were developed for all Target Analyte List (TAL) metals, Target Compound List (TCL) organics and 12 radionuclides for each future receptor (i.e., resident, office worker, construction worker, and ecological researcher) and environmental media (i.e., surface soil, subsurface soil, ground water, and surface water) combination identified on Table 1. Separate risk-based equations were developed to account for the carcinogenic, noncarcinogenic, and/or radiological effects of the contaminant. Risk-based PPRGs for carcinogens (including radionuclides) were calculated by setting the carcinogenic target risk level at 10^{-6}. A target risk level of 10^{-6} means an individual has a one-in-one-million probability of developing cancer over a lifetime as a result of exposure to a specific contaminant. This risk is in addition to the probability of an individual developing cancer from other factors such as those associated with heredity or lifestyle. Similarly, PPRGs for toxicants (non-carcinogens) were calculated by setting the hazard index equal to 1 for each contaminant. A hazard index is the ratio between the contaminant concentration and a reference

TABLE 1
PROGRAMMATIC ENVIRONMENTAL MEDIA AND EXPOSURE PATHWAYS

Environmental Media Exposure Scenario	Residential	Commercial\Industrial	Ecological Researcher
Surface Soil	Direct Ingestion of Soils [a/] Inhalation of Particulates [b/] External Radiation Exposure [c/]	<u>Office Worker Scenario</u> Direct Ingestion of Soils [a/] Inhalation of Particulates [b/] External Radiation Exposure [c/]	Direct Ingestion of Soils [a/] Inhalation of Particulates [b/] External Radiation Exposure [c/]
Subsurface Soil	Not Applicable	<u>Construction Worker Scenario</u> Direct Ingestion of Soils [a/] Inhalation of Particulates [b/] External Radiation Exposure [c/] Inhalation of Volatiles	Not Applicable
Ground Water	Direct Ingestion of Ground Water [a/] Inhalation During Domestic Use [d/]	Not Applicable	Not Applicable
Surface Water	Direct Ingestion While Swimming [e/]	Not Applicable	Direct Ingestion While Wading [e/]

<u>NOTES:</u>

[a/] Includes assessment of organics and inorganics.
[b/] Includes assessment of non-volatile organics and inorganics.
[c/] Includes assessment of radionuclides.
[d/] Includes assessment of volatile organics.
[e/] Includes assessment of organics and tritium.

dose. The reference dose represents the exposure level to the contaminant below which adverse effects are not expected. For some of the contaminants both carcinogenic and noncarcinogenic toxicity information was available. For these contaminants, both a carcinogenic and noncarcinogenic risk-based concentration was calculated and the more restrictive value was used as the PPRG. The risk-based equations for radiological effects was used to calculate the PPRGs for the 12 radionuclides.

The risk-based PPRG equations include all of the exposure pathways (e.g., Direct Ingestion of Soils) listed in Table 1 for each exposure scenario/environmental media combination; separate PPRGs were not be calculated for each exposure pathway. When available, USEPA-specified default values were used to calculate the risk-based PPRGs. In the absence of USEPA guidance on specific parameters, site-wide specific default values were established based on previous DOE reports on specific operable units.

4.1 Surface Soils

Exposure pathways, equations, assumptions, and default values used to calculate the surface soil PPRGs for each future receptor scenario are presented in this section. The future receptors considered include residential use, office worker, and ecological researcher. The risk-based equations for all future receptors included the following exposure pathways:

- Direct ingestion of soils contaminated with organic and inorganic (including radionuclides) contaminants;
- Inhalation of non-volatile organic and inorganic (including radionuclides) particulates; and
- External radiation exposure due to radionuclide contaminants.

4.1.1 Residential Exposure

For the residential exposure to surface soil, a combined adult and child exposure was assessed for the soil ingestion pathway. All other pathways were based on an adult exposure only.

The equations and assumptions used to derive risk-based PPRGs for surface soils with carcinogenic COCs is shown on Table 2, and the corresponding equation for COCs with noncarcinogenic effects is shown on Table 3. Table 4 shows the equation used to calculate PPRGs for radionuclides. All default values were based on USEPA guidance.

4.1.2 Commercial\Industrial Exposure

For the commercial/industrial exposure to surface soils, an office worker receptor was assessed. The equations and assumptions used to derive the risk-based PPRGs for surface soils

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TABLE 2
SURFACE SOIL - RESIDENTIAL USE
CARCINOGENIC EFFECTS

$$PPRG_1 = \frac{TR \times AT \times 365\ days/year}{EF \times \left[(SFi \times IRa \times ED \times \frac{1}{BW} \times \frac{1}{PEF}) + (SFo \times 10^{-6}\ kg/mg \times IF) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_1$	Programmatic PRG for surface soil based on residential use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	350 days/year
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRa	daily inhalation rate (m^3/day)	20 m^3/day
ED	exposure duration (years)	30 years
BW	adult body weight (kg)	70 kg
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IF	age-adjusted soil ingestion factor (mg-yr/kg-day)	114 mg-yr/kg-day

Source: USEPA, 1991.

TABLE 3
SURFACE SOIL - RESIDENTIAL USE
NONCARCINOGENIC EFFECTS

$$PPRG_2 = \frac{THI \times AT \times 365\ days/year}{EF \times \left[(ED \times IRa \times \frac{1}{RfDi} \times \frac{1}{BW} \times \frac{1}{PEF}) + (\frac{1}{RfDo} \times 10^{-6}\ kg/mg \times IF) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_2$	Programmatic PRG for surface soil based on residential use (mg/kg)	-
THI	target hazard index (unitless)	1
AT	averaging time (years)	30 years
EF	exposure frequency (days/year)	350 days/year
ED	exposure duration (years)	30 years
IRa	daily inhalation rate (m^3/day)	20 m^3/day
RfDi	inhalation chronic reference dose (mg/kg-day)	COC-Specific
BW	adult body weight (kg)	70 kg
PEF	particulate emission factor (m^3/kg)	4.63 x 10^9 m^3/kg
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IF	age-adjusted soil ingestion rate (mg-yr/kg-day)	114 mg-yr/kg-day

Source: USEPA, 1991.

TABLE 4
SURFACE SOIL - RESIDENTIAL USE
RADIOLOGICAL EFFECTS

$$PPRG_3 = \frac{TR}{\left[(EF \times IRa \times ED \times SFi \times 10^3\ g/kg \times \frac{1}{PEF}) + (EF \times SFo \times 10^{-3}\ g/mg \times IF) + (SFe \times ED \times (1 - Se) \times Te) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_3$	Programmatic PRG for surface soil based on residential use (pCi/g)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
EF	exposure frequency (days/year)	350 days/year
IRa	daily indoor inhalation rate (m^3/day)	20 m^3/day
ED	exposure duration (years)	30 years
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IF	age-adjusted soil ingestion factor (mg-yr/day)	3600 mg-yr/day
SFe	external exposure slope factor (risk/yr per pCi/g)	COC-Specific
Se	gamma shielding factor (unitless)	0.2
Te	gamma exposure factor (unitless)	1

Source: USEPA, 1991; USEPA, 1993b.

is shown on Table 5 for COCs with carcinogenic effects, on Table 6 for COCs with noncarcinogenic effects, and on Table 7 for radionuclides. All default values were based on USEPA guidance.

4.1.3 Ecological Researcher Exposure

The risk-based PPRG equations and assumptions for exposure of an ecological researcher to surface soils are shown on Tables 8, 9, and 10 for potential carcinogens, noncarcinogens, and radionuclides, respectively. Because the ecological researcher is a site-specific receptor, site-specific exposure assumptions were developed. Specifically, the exposure frequency was based on site-specific information. Other exposure assumptions were based on USEPA guidance pertaining to a commercial/industrial land use scenario.

4.2 Subsurface Soils

This section presents the exposure pathways, equations, assumptions, and default values used to calculate the subsurface soil PPRGs. Only a construction worker scenario was considered for this environmental media and the PPRGs were based on the following exposure pathways:

- Direct ingestion of soils contaminated with organic and inorganic (including radionuclides) contaminants;
- Inhalation of non-volatile organic and inorganic (including radionuclides) particulates;
- External radiation exposure due to radionuclide contaminants; and
- Inhalation of volatiles.

4.2.1 Residential Exposure

A scenario involving residential exposure to subsurface soils was not considered to be credible and was therefore not included in the calculation of PPRGs.

4.2.2 Commercial\Industrial Exposure

The risk-based PPRG equations and assumptions are shown on Tables 11, 12, and 13 for potential carcinogens, noncarcinogens, and radionuclides, respectively. USEPA guidance does not specify exposure assumptions specific to a construction worker receptor. Therefore, site-specific information was used to develop assumptions for exposure frequency and exposure duration. All other exposure assumptions were based on USEPA guidance for a commercial/industrial land use scenario.

TABLE 5
SURFACE SOIL - OFFICE WORKER
CARCINOGENIC EFFECTS

$$PPRG_4 = \frac{TR \times BW \times AT \times 365\ days/year}{EF \times ED \times \left[(SFi \times IRa \times \frac{1}{PEF}) + (SFo \times 10^{-6}\ kg/mg \times IRs) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_4$	Programmatic PRG for surface soil based on office worker use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	250 days/year
ED	exposure duration (years)	25 years
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source: USEPA, 1989; USEPA, 1991.
[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

Note: Inhalation of particulates does not apply to volatile organics (i.e., Henry's Law Constant greater than $1x10^{-5}$ atm-m^3/mole and a molecular weight less than 200 g/mole).

TABLE 6
SURFACE SOIL - OFFICE WORKER
NONCARCINOGENIC EFFECTS

$$PPRG_5 = \frac{THI \times BW \times AT \times 365\ days/year}{EF \times ED \times \left[\left(IRa \times \frac{1}{RfDi} \times \frac{1}{PEF} \right) + \left(\frac{1}{RfDo} \times 10^{-6}\ kg/mg \times IRs \right) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_5$	Programmatic PRG for surface soil based on office worker use (mg/kg)	-
THI	target hazard index (unitless)	1
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	25 years
EF	exposure frequency (days/year)	250 days/year
ED	exposure duration (years)	25 years
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
RfDi	inhalation chronic reference dose (mg/kg-day)	COC-Specific
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source: USEPA, 1989; USEPA, 1991.
[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

Note: Inhalation of particulates does not apply to volatile organics (i.e., Henry's Law Constant greater than $1x10^{-5}$ atm-m^3/mole and molecular weight less than 200 g/mole.)

TABLE 7
SURFACE SOIL - OFFICE WORKER
RADIOLOGICAL EFFECTS

$$PPRG_6 = \frac{TR}{ED \times \left[(EF \times IRa \times SFi \times 10^3\ g/kg \times \frac{1}{PEF}) + (EF \times SFo \times 10^{-3}\ g/mg \times IRs) + (SFe \times (1 - Se) \times Te) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_6$	Programmatic PRG for surface soil based on office worker use (pCi/g)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
ED	exposure duration (years)	25 years
EF	exposure frequency (days/year)	250 days/year
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day
SFe	external exposure slope factor (risk/yr per pCi/g)	COC-Specific
Se	gamma shielding factor (unitless)	0.2
Te	gamma exposure factor (unitless)	0.3

Source: USEPA, 1989; USEPA, 1991.

[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

TABLE 8
SURFACE SOIL - ECOLOGICAL RESEARCHER
CARCINOGENIC EFFECTS

$$PPRG_7 = \frac{TR \times BW \times AT \times 365\ days/year}{EF \times ED \times \left[(SFi \times IRa \times \frac{1}{PEF}) + (SFo \times 10^{-6}\ kg/mg \times IRs) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_7$	Programmatic PRG for surface soil based on ecological researcher use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	207 days/year
ED	exposure duration (years)	25 years
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source: USEPA, 1991; DOE, 1993b, DOE, 1993c, DOE, 1993d.

[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

TABLE 9
SURFACE SOIL - ECOLOGICAL RESEARCHER
NONCARCINOGENIC EFFECTS

$$PPRG_8 = \frac{THI \times BW \times AT \times 365\ days/year}{EF \times ED \times \left[\left(IRa \times \frac{1}{RfDi} \times \frac{1}{PEF} \right) + \left(\frac{1}{RfDo} \times 10^{-6}\ kg/mg \times IRs \right) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_8$	Programmatic PRG for surface soil based on ecological researcher use (mg/kg)	-
THI	target hazard index (unitless)	1
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	25 years
EF	exposure frequency (days/year)	207 days/year
ED	exposure duration (years)	25 years
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
RfDi	inhalation chronic reference dose (mg/kg-day)	COC-Specific
PEF	particulate emission factor (m^3/kg)	4.63 x 10^9 m^3/kg
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source: USEPA, 1991; DOE, 1993b; DOE, 1993c; DOE, 1993d.

[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

TABLE 10
SURFACE SOIL - ECOLOGICAL RESEARCHER
RADIOLOGICAL EFFECTS

$$PPRG_9 = \frac{TR}{ED \times \left[(EF \times IRa \times SFi \times 10^3\ g/kg \times \frac{1}{PEF}) + (EF \times SFo \times 10^{-3}\ g/mg \times IRs) + (SFe \times (1 - Se) \times Te) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_9$	Programmatic PRG for surface soil based on ecological researcher use (pCi/g)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
ED	exposure duration (years)	25 years
EF	exposure frequency (days/year)	207 days/year
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day
SFe	external exposure slope factor (risk/yr per pCi/g)	COC-Specific
Se	gamma shielding factor (unitless)	0.2
Te	gamma exposure factor (unitless)	0.3

Source: USEPA, 1991; USEPA, 1993b; DOE, 1993b; DOE, 1993c; DOE, 1993d.

[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

TABLE 11
SUBSURFACE SOIL - CONSTRUCTION WORKER
CARCINOGENIC EFFECTS

$$PPRG_{10} = \frac{TR \times BW \times AT \times 365\ days/year}{EF \times ED \times \left[(SFi \times IRa \times \frac{1}{PEF} \times \frac{1}{VF}) + (SFo \times 10^{-6}\ kg/mg \times IRs) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{10}$	Programmatic PRG for subsurface soil based on construction worker use (mg/kg)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	30 days/year
ED	exposure duration (years)	1 year
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
VF	soil-to-air volatilization factor (m^3/kg)	COC-Specific (See Table 14)
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source: USEPA, 1991; DOE, 1991; DOE, 1993a; DOE, 1993b; DOE, 1993c; DOE, 1993d.
[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

TABLE 12
SUBSURFACE SOIL - CONSTRUCTION WORKER
NONCARCINOGENIC EFFECTS

$$PPRG_{11} = \frac{THI \times BW \times AT \times 365\ days/year}{EF \times ED \times \left[\left(IRa \times \frac{1}{RfDi} \times \frac{1}{PEF} \times \frac{1}{VF} \right) + \left(\frac{1}{RfDo} \times 10^{-6}\ kg/mg \times IRs \right) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{11}$	Programmatic PRG for subsurface soil based on construction worker use (mg/kg)	-
THI	target hazard index (unitless)	1
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	1 year
EF	exposure frequency (days/year)	30 days/year
ED	exposure duration (years)	1 year
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
RfDi	inhalation chronic reference dose (mg/kg-day)	COC-Specific
PEF	particulate emission factor (m^3/kg)	4.63 x 10^9 m^3/kg
VF	soil-to-air volatilization factor (m^3/kg)	COC-Specific (See Table 14)
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day

Source: USEPA, 1991; DOE, 1991; DOE, 1993a; DOE, 1993b; DOE, 1993c; DOE, 1993d.

[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

TABLE 13
SUBSURFACE SOIL - CONSTRUCTION WORKER
RADIOLOGICAL EFFECTS

$$PPRG_{12} = \frac{TR}{ED \times \left[(EF \times IRa \times SFi \times 10^{3}\ g/kg \times \frac{1}{PEF}) + (EF \times SFo \times 10^{-3}\ g/mg \times IRs) + (SFe \times (1-Se) \times Te) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{12}$	Programmatic PRG for subsurface soil based on construction worker use (pCi/g)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
ED	exposure duration (years)	1 year
EF	exposure frequency (days/year)	30 days/year
IRa	workday inhalation rate (m^3/day)	6.64 m^3/day [a/]
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
PEF	particulate emission factor (m^3/kg)	4.63×10^9 m^3/kg
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRs	workday ingestion rate (mg/day)	50 mg/day
SFe	external exposure slope factor (risk/yr per pCi/g)	COC-Specific
Se	gamma shielding factor (unitless)	0.2
Te	gamma exposure factor (unitless)	0.3

Source: USEPA, 1991; DOE, 1991; DOE, 1993a; DOE, 1993b; DOE, 1993c; DOE, 1993d.

[a/] Based on a total inhalation rate of 20 m^3/day adjusted for an 8-hour workday.

For the pathway involving inhalation of volatiles, a volatilization factor was calculated according to USEPA guidance as shown in Table 14. The volatilization model is applicable only if the soil concentration is at or below soil saturation. Thus, for those compounds for which the PPRG exceeds the soil saturation limit, the PPRG is set at the soil saturation limit. The soil saturation was calculated as shown on Table 15.

4.2.3 Ecological Researcher Exposure

The likelihood of having an ecological researcher exposed to subsurface soils was not considered to be credible and was therefore not included in the calculation of PPRGs.

4.3 Ground Water

This section presents the exposure pathways, equations, assumptions, and default values used to calculate the ground water PPRGs. Residential use of the ground water was the only receptor considered. The risk-based equations included the following exposure pathways:

- Direct ingestion of ground water contaminated with organic and inorganic (including radionuclides) contaminants; and
- Inhalation of volatile organics during domestic use.

4.3.1 Residential Exposure

The equations and assumptions used to derive risk-based PPRGs for residential use of ground water is shown on Table 16 for carcinogens, Table 17 for noncarcinogens, and Table 18 for radionuclides. All default exposure assumptions were based on USEPA guidance.

4.3.2 Commercial\Industrial Exposure

A scenario involving commercial/industrial exposure to ground water was not considered to be credible and was therefore not included in the calculation of PPRGs.

4.3.3 Ecological Researcher Exposure

A scenario involving exposure of an ecological researcher to ground water was not considered to be credible and was therefore not included in the calculation of PPRGs.

4.4 Surface Water

This section presents the exposure pathways, equations, assumptions, and default values used to calculate the surface water PPRGs for each future receptor scenario. The future receptors considered include residential use and ecological researcher. The risk-based equations for the residential receptor were based on exposure via swimming, while the risk-based equations for the ecological researcher were based on exposure via wading. For both receptors, the exposure pathways included direct ingestion of surface water.

TABLE 14
SUBSURFACE SOIL - CONSTRUCTION WORKER
VOLATILIZATION FACTOR

$$VF = \frac{\frac{(LS \times V \times DH)}{A} \times (3.14 \times \alpha \times T)^{1/2}}{2 \times D_{ei} \times P_a \times K_{as}}$$

where,

$$\alpha = \frac{D_{ei} \times P_a}{P_a + \frac{(\rho_s)(1 - P_a)}{K_{as}}}$$

Variable	Explanation (Units)	Default Value
VF	volatilization factor (m^3/kg)	--
LS	length of side area (m)	45
V	wind speed in mixing zone (m/s)	2
DH	diffusion height (m)	2
A	area of contamination (cm^2)	20,250,000
D_{ei}	effective diffusivity (cm^2/s)	$D_i \times (P_a^{3.33}/P_t^2)$
P_a	air-filled soil porosity (unitless)	$P_t - \Theta ß$
P_t	total soil porosity (unitless)	$1-(ß/\rho_s)$
Θ	soil moisture content (cm^3/water/g-soil)	10% or 0.1
ß	soil bulk density (g/cm^3)	1.5
ρ_s	true soil density or particle density (g/cm^3)	2.65
K_{as}	soil-air partition coefficient (g-soil/cm^3-air)	(H/K_d) x 41, (41 is a conversion factor)
T	exposure interval (s)	7.9×10^8
D_i	diffusivity in air (cm^2/s)	COC-specific
H	Henry's Law constant (atm-m^3/mole)	COC-specific
K_d	soil-water partition coefficient (cm^3/g)	K_{oc} x OC
K_{oc}	organic carbon partition coefficient (cm^3)	COC-specific
OC	organic carbon content of soil (fraction)	2% or 0.02

Source: Dinan, 1992.

TABLE 15
SUBSURFACE SOIL - CONSTRUCTION WORKER
VOLATILIZATION FACTOR - SATURATED CONDITIONS

$$C_{sat} = \frac{(K_d \times C_w \times \beta) + (C_w \times P_w) + (C_w \times H^1 \times P_a)}{\beta}$$

where:

Variable	Explanation (Units)	Default Value
C_{sat}	soil saturation concentration (mg/kg)	--
K_d	soil-water partition coefficient (L/kg)	K_{oc} x OC
K_{oc}	organic carbon partition coefficient (L/kg)	2% or 0.02
OC	organic carbon content of soil fraction	COC-specific
C_w	upper-limit of free moisture in soil (mg/L water)	S x Θ_m
Θ_m	soil moisture content (kg-water/kg-soil)	10% or 0.1
S	solubility in water (mg/L water)	COC-specific
ß	soil bulk density (kg/L)	1.5
P_w	water filled soil porosity (unitless)	P_t - P_a
P_a	air-filled soil porosity (unitless)	P_t -Θß
Θ	soil moisture content (L water/kg soil)	10% or 0.1
P_t	total soil porosity (unitless)	1 - (ß/ρ_s)
ρ_s	true soil density or particle density (kg/L)	2.65
H^1	Henry's Law constant (unitless)	H x 41, (41 is a conversion factor)
H	Henry's Law constant (atm-m^3/mole)	COC-specific

Source: Dinan, 1992.

TABLE 16
GROUND WATER - RESIDENTIAL USE
CARCINOGENIC EFFECTS

$$PPRG_{13} = \frac{TR \times BW \times AT \times 365\ days/year}{EF \times ED \times [\ (SFi \times IRa \times K) + (SFo \times IRw)\ ]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{13}$	Programmatic PRG for ground water based on residential use (mg/L)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	350 days/year
ED	exposure duration (years)	30 years
SFi	inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRa	daily indoor inhalation rate (m^3/day)	15 m^3/day
K	volatilization factor (L/m^3)	0.0005 x 1000 L/m^3
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRw	daily water ingestion rate (L/day)	2 L/day

Source: USEPA, 1991.

Note: Inhalation component applies only to volatile organics (i.e., Henry's Law Constant greater than $1x10^{-5}$ atm-m^3/mole and molecular weight less than 200 g/mole.)

TABLE 17
GROUND WATER - RESIDENTIAL USE
NONCARCINOGENIC EFFECTS

$$PPRG_{14} = \frac{THI \times BW \times AT \times 365\ days/year}{EF \times ED \times \left[(IRa \times \frac{1}{RfDi} \times K) + (\frac{1}{RfDo} \times IRw) \right]}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{14}$	Programmatic PRG for ground water based on residential use (mg/L)	-
THI	target hazard index (unitless)	1
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	30 years
EF	exposure frequency (days/year)	350 days/year
ED	exposure duration (years)	30 years
IRa	daily indoor inhalation rate (m^3/day)	15 m^3/day
RfDi	inhalation chronic reference dose (mg/kg-day)	COC-Specific
K	volatilization factor (L/m^3)	0.0005 x 1000 L/m^3
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
IRw	daily water ingestion rate (L/day)	2 L/day

Source: USEPA, 1991.

Note: Inhalation component applies only to volatile organics (i.e., Henry's Law Constant greater than $1x10^{-5}$ atm-m^3/mole and molecular weight less than 200 g/mole.)

TABLE 18
GROUND WATER - RESIDENTIAL USE
RADIOLOGICAL EFFECTS

$$PPRG_{15} = \frac{TR}{EF \times ED \times (SFo \times IRw)}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{15}$	Programmatic PRG for ground water based on residential use (pCi/L)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
EF	exposure frequency (days/year)	350 days/year
ED	exposure duration (years)	30 years
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
IRw	daily water ingestion rate (L/day)	2 L/day

Source: USEPA, 1991.

4.4.1 Residential Exposure

The equations and assumptions used to derive PPRGs for residential exposure to surface water while swimming are shown on Tables 19 through 21 for carcinogens, noncarcinogens, and radionuclides, respectively. All assumptions were based on USEPA guidance.

4.4.2 Commercial\Industrial Exposure

The likelihood of having a commercial/industrial exposure to surface water was not considered to be credible and was therefore not included in the calculation of PPRGs.

4.4.3 Ecological Researcher Exposure

The risk-based PPRG equations and assumptions for exposure of an ecological researcher to surface water while wading are shown on Tables 22 through 24 for carcinogens, noncarcinogens, and radionuclides, respectively. USEPA guidance does not provide default values specific to this receptor. Therefore, site-specific information was used to determine exposure duration. All other exposure assumptions were based on USEPA guidance for swimming.

5.0 CONTAMINANT TOXICITY INFORMATION

The COC-specific toxicology values used for the calculation of the PPRGs is presented in Table 25. The toxicity information used to calculate the PPRGs included the slope factor and unit risk for evaluating carcinogenic effects and the reference dose (RfD) and the reference concentration (RfC) for evaluating noncarcinogenic effects. Toxicity values were obtained from the latest information contained on the Integrated Risk Information System (IRIS). If values were not available from IRIS, the *Health Effects Assessment Summary Tables Annual Update,* (USEPA 1993a) was consulted. Values for polycyclic aromatic hydrocarbons were calculated using USEPA guidance entitled *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (USEPA 1993c).

6.0 PROGRAMMATIC PRELIMINARY REMEDIATION GOALS

For each potential COC, the calculated PPRGs for the exposure scenario (i.e., future receptor and environmental media combination identified on Table 1) are given on Table 26. Where a chemical has both carcinogenic and noncarcinogenic effects, the more stringent of the calculated risk-based levels was selected
as the PPRG. The calculated PPRGs are generally pertinent to all of the OUs should the contaminant be identified as an OU-specific COC. However, OU-specific factors may disqualify some or all of the PPRGs should these factors preclude one or more of the exposure pathways which formed the basis of the risk-based equations. For example, the PPRGs for the ground water media may not be applicable at OUs where the ground water is not of sufficient quantity or quality to support domestic residential use. Also, residential use PPRGs may not be appropriate for areas where the future land use will solely be devoted to commercial and/or industrial facilities.

TABLE 19
SURFACE WATER - RESIDENTIAL USE
CARCINOGENIC EFFECTS

$$PPRG_{16} = \frac{TR \times BW \times AT}{CRw \times ET \times EF \times ED \times SFo}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{16}$	Programmatic PRG for surface water based on residential use (mg/L)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (days/year)	7 days/year
ED	exposure duration (years)	70 years
CRw	contact rate (L/hour)	0.05 L/hour
ET	exposure time (hours/day)	2.6 hours/day

Source: USEPA, 1989.

TABLE 20
SURFACE WATER - RESIDENTIAL USE
NONCARCINOGENIC EFFECTS

$$PPRG_{17} = \frac{THI \times BW \times AT \times RfDo}{CRw \times ET \times EF \times ED}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{17}$	Programmatic PRG for surface water based on residential use (mg/L)	-
THI	target hazard index (unitless)	1
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	30 years
EF	exposure frequency (days/year)	7 days/year
ED	exposure duration (years)	30 years
CRw	contact rate (L/hour)	0.05 L/hour
ET	exposure time (hours/day)	2.6 hours/day

Source: USEPA, 1989.

TABLE 21
SURFACE WATER - RESIDENTIAL USE
RADIOLOGICAL EFFECTS

$$PPRG_{18} = \frac{TR}{SFo \times EF \times ED \times CRw \times ET}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{18}$	Programmatic PRG for surface water based on residential use (pCi/L)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
EF	exposure frequency (days/year)	7 days/year
ED	exposure duration (years)	30 years
CRw	contact rate (L/hour)	0.05 L/hour
ET	exposure time (hours/day)	2.6 hours/day

Source: USEPA, 1989; USEPA, 1991.

TABLE 22
SURFACE WATER - ECOLOGICAL RESEARCHER
CARCINOGENIC EFFECTS

$$PPRG_{19} = \frac{TR \times BW \times AT \times 365\ days/year}{IRw \times EF \times ED \times SFo}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{19}$	Programmatic PRG for surface water based on ecological researcher use (mg/L)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	70 years
EF	exposure frequency (events/year)	7 events/year
ED	exposure duration (years)	2.5 years
IRw	ingestion rate (L/event)	0.05 L/event

Source: USEPA, 1989; DOE, 1993c; DOE, 1993d.

TABLE 23
SURFACE WATER - ECOLOGICAL RESEARCHER
NONCARCINOGENIC EFFECTS

$$PPRG_{20} = \frac{THI \times BW \times AT \times 365\ days/year \times RfDo}{IRw \times EF \times ED}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{20}$	Programmatic PRG for surface water based on ecological researcher use (mg/L)	-
THI	target hazard index (unitless)	1
RfDo	oral chronic reference dose (mg/kg-day)	COC-Specific
BW	adult body weight (kg)	70 kg
AT	averaging time (years)	2.5 years
EF	exposure frequency (events/year)	7 events/year
ED	exposure duration (years)	2.5 years
IRw	ingestion rate (L/event)	0.05 L/event

Source: USEPA, 1989; DOE, 1993c; DOE, 1993d.

TABLE 24
SURFACE WATER - ECOLOGICAL RESEARCHER
RADIOLOGICAL EFFECTS

$$PPRG_{21} = \frac{TR}{SFo \times EF \times ED \times IRw}$$

where:

Variable	Explanation (Units)	Default Value
$PPRG_{21}$	Programmatic PRG for surface water based on ecological researcher use (pCi/L)	-
TR	target excess lifetime cancer risk (unitless)	10^{-6}
SFo	oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	COC-Specific
EF	exposure frequency (events/year)	7 events/year
ED	exposure duration (years)	2.5 years
IRw	ingestion rate (L/event)	0.05 L/event

Source: USEPA, 1991; DOE, 1993c; DOE, 1993d.

TABLE 25
COC–Specific Toxicity Values

Target Analyte List Chemical	Oral RfD (mg/kg–day)	Oral Slope Factor $(mg/kg–day)^{-1}$	Inhalation RfD (mg/kg–day)	Inhalation Slope Factor $(mg/kg–day)^{-1}$	External Slope Factor (risk/yr per pCi/g)	Henry's Law Constant $(atm–m^3/mol)$	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
Acenaphthene#	6.00E–02	–	–	–	–	9.20E–05 m	4600 m	3.42E+00 m	
Acenaphthylene#	–	–	–	–	–	1.48E–03 m	2500 m	3.93E+00 m	
Acetone#	1.00E–01	–	–	–	–	2.06E–05 m	2.2 m	1.00E+06 m	0.1093 n
Aldrin	3.00E–05	1.70E+01	–	1.72E+01 b	–	1.60E–05 m	96000 m		
Aluminum	–	–	–	–	–	–			
Anthracene#	3.00E–01	–	–	–	–	1.02E–03 m	14000 m	4.50E–02 m	
Antimony	4.00E–04	–	–	–	–	–			
Aroclor–1016	7.00E–05 c	7.70E+00 c	–	–	–	1.07E–03 m	530000 m		0.05571
Aroclor–1221	7.00E–05 c	7.70E+00 c	–	–	–	1.07E–03 m	530000 m		0.05571
Aroclor–1232	7.00E–05 c	7.70E+00 c	–	–	–	1.07E–03 m	530000 m		0.05571
Aroclor–1242	7.00E–05 c	7.70E+00 c	–	–	–	1.07E–03 m	530000 m		0.05571
Aroclor–1248	7.00E–05 c	7.70E+00 c	–	–	–	1.07E–03 m	530000 m		0.05571
Aroclor–1254	7.00E–05 c	7.70E+00 c	–	–	–	1.07E–03 m	530000 m		0.05571
Aroclor–1260	7.00E–05 c	7.70E+00 c	–	–	–	1.07E–03 m	530000 m		0.05571
Arsenic	3.00E–04	1.75E+00 i	–	1.51E+01	–	–			
Barium	7.00E–02	–	1.43E–04	–	–	–			
Benzene#	–	2.90E–02	–	2.91E–02 b	–	5.59E–03 m	83 m	1.75E+03 m	0.09234 n
alpha–BHC	–	6.30E+00	–	6.30E+00 j	–	5.87E–06 m	3800 m		
beta–BHC	–	1.80E+00	–	1.86E+00 j	–	4.47E–07 m	3800 m		
delta–BHC	–	–	–	–	–	2.07E–07 m	6600 m		
gamma–BHC (Lindane)	3.00E–04	1.30E+00 b	–	–	–	7.85E–06 m	1080 m		
Benzo(a)anthracene	–	7.30E–01 k	–	–	–	1.16E–06 m	1380000 m		
Benzo(a)pyrene	–	7.30E+00	–	–	–	1.55E–06 m	5500000 m		
Benzo(b)fluoranthene	–	7.30E–01 k	–	–	–	1.19E–05 m	550000 m		
Benzo(g,h,i)perylene	–	–	–	–	–	5.34E–08 m	1600000 m		
Benzo(k)fluoranthene	–	7.30E–02 k	–	–	–	3.94E–05 m	550000 m		
Benzoic Acid	4.00E+00	–	–	–	–				
Benzyl Alcohol	3.00E–01 b	–	–	–	–				
Beryllium	5.00E–03	4.30E+00	–	8.40E+00 b	–	–			
bis(2–Chloroethoxy)methane#	–	–	–	–	–	1.70E–07	7		
bis(2–Chloroethyl)ether#	–	1.10E+00	–	1.16E+00 b	–	1.31E–05 m	13.9 m	1.02E+04 m	
bis(2–Chloroisopropyl)ether#	4.00E–02	7.00E–02 b	–	3.50E–02 b	–	1.13E–04 m	61 m	1.70E+03 m	
bis(2–Ethylhexyl)phthalate	2.00E–02	1.40E–02	–	–	–	1.00E–04	10000		
Bromodichloromethane#	2.00E–02	6.20E–02	–	–	–	1.60E–03	53		
Bromoform #	2.00E–02	7.90E–03	–	3.85E–03 b	–	6.60E–04	98		0.1088 n
Bromomethane#	1.40E–03	–	1.43E–03	–	–	6.24E–03	126		
4–Bromophenyl phenyl ether	–	–	–	–	–				
2–Butanone#	6.00E–01	–	2.86E–01	–	–				0.09485 n
Butylbenzylphthalate	2.00E–01	–	–	–	–				
Cadmium	5.00E–04	–	–	6.30E+00	–	–			
Calcium	–	–	–	–	–	–			
Carbon disulfide#	1.00E–01	–	2.86E–03 b	–	–	1.23E–02 m	54 m	2.94E+03 m	

TABLE 25
COC–Specific Toxicity Values

Target Analyte List Chemical	Oral RfD (mg/kg–day)	Oral Slope Factor $(mg/kg–day)^{-1}$	Inhalation RfD (mg/kg–day)	Inhalation Slope Factor $(mg/kg–day)^{-1}$	External Slope Factor (risk/yr per pCi/g)	Henry's Law Constant $(atm–m^3/mol)$	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
Carbon tetrachloride#	7.00E–04	1.30E–01	–	5.25E–02	–	2.41E–02 m	110 m	7.57E+02 m	0.08451 n
Cesium	–	–	–	–	–				
alpha–Chlordane	6.00E–05 d	1.30E+00 d	–	1.30E+00 d	–	9.63E–06 m	140000 m		
beta–Chlordane	6.00E–05 d	1.30E+00 d	–	1.30E+00 d	–	9.63E–06 m	140000 m		
gamma–Chlordane	6.00E–05 d	1.30E+00 d	–	1.30E+00 d	–	9.63E–06 m	140000 m		
4–Chloroaniline	4.00E–03	–	–	–	–				
Chlorobenzene#	2.00E–02	–	5.71E–03 b	–	–	3.72E–03 m	330 m	4.66E+02 m	0.07627 n
Chloroethane#	–	–	2.86E+00	–	–	8.48E–03	33		0.11031 n
Chloroform#	1.00E–02	6.10E–03	–	8.05E–02	–	2.87E–03 m	31 m	8.20E+03 m	0.09404 n
Chloromethane#	–	1.30E–02	–	6.30E–03	–	8.82E–02			0.11827 n
4–Chloro–3–methylphenol	–	–	–	–	–				
2–Chloronaphthalene#	8.00E–02	–	–	–	–				
2–Chlorophenol#	5.00E–03	–	–	–	–	1.30E–05	15		
4–Chlorophenyl phenyl ether	–	–	–	–	–				
Chromium III	1.00E+00	–	–	–	–	–			
Chromium VI	5.00E–03	–	–	4.10E+01 b	–	–			
Chyrsene	–	7.30E–03 k	–	–	–	1.05E–06 m	200000 m		
Cobalt	–	–	–	–	–	–			
Copper	4.00E–02 b	–	–	–	–	–			
Cyanide	2.00E–02	–	–	–	–	–			
4,4–DDD	–	2.40E–01	–	–	–	7.96E–06 m	770000 m		
4,4–DDE	–	3.40E–01	–	–	–	6.80E–05 m	4400000 m		
4,4–DDT	5.00E–04	3.40E–01	–	3.40E–01 j	–	5.13E–04 m	243000 m		
Dibenz(a,h)anthracene	–	7.30E+00 k	–	–	–	7.33E–08 m	3300000 m		
Dibenzofuran	–	–	–	–	–				
Dibromochloromethane	2.00E–02	8.40E–02	–	–	–				
Di–n–butylphthalate	1.00E–01	–	–	–	–	2.82E–07 m	170000 m		
1,2–Dichlorobenzene#	9.00E–02	–	5.71E–02	–	–	1.93E–03 m	1700 m	1.00E+02 m	
1,3–Dichlorobenzene#	–	–	–	–	–	3.59E–03 m	1700 m	1.23E+02 m	
1,4–Dichlorobenzene#	–	2.40E–02 b	2.29E–01 b	–	–	2.89E–03 m	1700 m	7.90E+01 m	
3,3–Dichlorobenzidine	–	4.50E–01	–	–	–	8.33E–07 m	1553 m		
1,1–Dichloroethane#	1.00E–01 b	–	1.43E–01	–	–	4.31E–03 m	30 m	5.50E+03 m	0.09643 n
1,2–Dichloroethane#	–	9.10E–02	–	9.10E–02	–	9.78E–04 m	14 m	8.52E+03 m	0.09643 n
1,1–Dichloroethene#	9.00E–03	6.00E–01	–	1.20E+00 b	–	3.40E–02 m	65 m	2.25E+03 m	0.08386 n
1,2–Dichloroethene (total)#	9.00E–03 b	–	–	–	–		36		0.08386 n
2,4–Dichlorophenol	3.00E–03	–	–	–	–	2.75E–06 m	380 m		
1,2–Dichloropropane#	–	6.80E–02 b	1.14E–03	–	–	2.31E–03 m	51 m	2.70E+03 m	
cis–1,3–Dichloropropene#	3.00E–04	1.80E–01 b,e	5.71E–03	1.30E–01 b,e	–	2.40E–03	23		
trans–1,3–Dichloropropene#	3.00E–04	1.80E–01 b,e	5.71E–03	1.30E–01 b,e	–	1.80E–03	26		
Dieldrin	5.00E–05	1.60E+01	–	2.91E–02 b	–	4.58E–07 m	1700 m		
Diethylphthalate	8.00E–01	–	–	–	–	1.14E–06 m	142 m		
2,4–Dimethylphenol#	2.00E–02	–	–	–	–	6.00E–07	425		
Dimethylphthalate	1.00E+01	–	–	–	–				

TABLE 25
COC–Specific Toxicity Values

Target Analyte List Chemical	Oral RfD (mg/kg–day)	Oral Slope Factor $(mg/kg–day)^{-1}$	Inhalation RfD (mg/kg–day)	Inhalation Slope Factor $(mg/kg–day)^{-1}$	External Slope Factor (risk/yr per pCi/g)	Henry's Law Constant $(atm–m^3/mol)$	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
4,6–Dinitro–2–methylphenol#	–	–	–	–	–	4.80E–11	225		
2,4–Dinitrophenol	2.00E–03	–	–	–	–	6.45E–10 m	16.6 m		
2,4–Dinitrotoluene	2.00E–03	–	–	–	–	5.09E–06 m	45 m		
2,6–Dinitrotoluene	1.00E–03 b	–	–	–	–	3.27E–06 m	92 m		
Di–n–octylphthalate	2.00E–02	–	–	–	–				
Endosulfan I	5.00E–05 b,f	–	–	–	–				
Endosulfan II	5.00E–05 b,f	–	–	–	–				
Endosulfan sulfate	5.00E–05 b,f	–	–	–	–				
Endosulfan (technical)	5.00E–05 b	–	–	–	–				
Endrin ketone	–	–	–	–	–				
Endrin (technical)	3.00E–04	–	–	–	–				
Ethylbenzene#	1.00E–01	–	2.86E–01	–	–	6.43E–03 m	1100 m	1.52E+02 m	0.0707 n
Fluoranthene	4.00E–02	–	–	–	–	6.46E–06 m	38000 m		
Fluorene#	4.00E–02	–	–	–	–	6.42E–05 m	7300 m	1.69E+00 m	
Heptachlor	5.00E–04	4.50E+00	–	4.50E+00 b	–	8.19E–04 m	12000 m		
Heptachlor epoxide	1.30E–05	9.10E+00	–	9.10E+00 b	–	4.39E–04 m	220 m		
Hexachlorobenzene	8.00E–04	1.60E+00	–	1.60E+00 b	–	6.81E–04 m	3900 m		
Hexachlorobutadiene	–	–	–	7.70E–02	–	4.57E+00 m	29000 m		
Hexachlorocyclopentadiene	7.00E–03	–	2.00E–05	–	–	1.37E–02 m	4800 m		
Hexachloroethane	1.00E–03	1.40E–02	–	1.40E–02	–	2.49E–03 m	20000 m		
2–Hexanone#	–	–	–	–	–	3.39E–05	134		
Indeno(1,2,3–cd)pyrene	–	7.30E–01 k	–	–	–	6.86E–08 m	1600000 m		
Iron	–	–	–	–	–	–			
Isophorone	2.00E–01	9.50E–04	–	–	–				
Lead	–	–	–	–	–	–			
Lithium	–	–	–	–	–				
Magnesium	–	–	–	–	–	–			
Manganese	5.00E–03	–	1.43E–05	–	–	–			
Mercury	3.00E–04 b	–	8.57E–05	–	–	–			
Methoxychlor	5.00E–03	–	–	–	–				
Methylene chloride#	6.00E–02	7.50E–03	8.57E–01	1.64E–03	–		48		
2–Methylnaphthalene#	–	–	–	–	–	5.18E–04	8500		
4–Methyl–2–pentanone#	5.00E–02	–	2.29E–02	–	–	9.40E–05	19		
2–Methylphenol	5.00E–02	–	–	–	–				
4–Methylphenol	5.00E–03 b	–	–	–	–				
Molybdenum	5.00E–03	–	–	–	–	–			
Naphthalene#	4.00E–02 b	–	–	–	–		594		
Nickel	2.00E–02	–	–	–	–	–			
2–Nitroaniline	–	–	–	–	–				
3–Nitroaniline	–	–	–	–	–				
4–Nitroaniline	–	–	–	–	–				
Nitrobenzene#	5.00E–04	–	5.71E–04	–	–	2.20E–05	36 m	1.90E+03 m	
2–Nitrophenol	–	–	–	–	–				

TABLE 25
COC–Specific Toxicity Values

Target Analyte List Chemical	Oral RfD (mg/kg–day)	Oral Slope Factor $(mg/kg–day)^{-1}$	Inhalation RfD (mg/kg–day)	Inhalation Slope Factor $(mg/kg–day)^{-1}$	External Slope Factor (risk/yr per pCi/g)	Henry's Law Constant (atm–m^3/mol)	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
4–Nitrophenol#	–	–	–	–	–		21		
n–Nitrosodiphenylamine#	–	4.90E–03	–	–	–	6.40E–04	1200		
n–Nitrosodipropylamine	–	7.00E+00	–	–	–	6.92E–06 m	15 m	9.90E+03 m	
Pentachlorophenol	3.00E–02	1.20E–01	–	–	–	2.75E–06 m	53000 m		
Phenanthrene#	–	–	–	–	–	1.59E–04 m	14000 m	1.00E+00 m	
Phenol	6.00E–01	–	–	–	–	4.54E–07 m	14.2 m		0.08924 n
Potassium	–	–	–	–	–	–			
Pyrene	3.00E–02	–	–	–	–	5.04E–06 m	38000 m		
Selenium	5.00E–03	–	–	–	–	–			
Silver	5.00E–03	–	–	–	–	–			
Sodium	–	–	–	–	–	–			
Strontium	6.00E–01	–	–	–	–				
Stryene#	2.00E–01	–	2.86E–01	–	–	5.20E–03	270		0.0746 n
1,1,2,2–Tetrachloroethane#	–	2.00E–01	–	2.00E–01 b	–	3.81E–04 m	118 m	2.90E+03 m	
Tetrachloroethene#	1.00E–02	5.20E–02 l	–	2.03E–03	–	2.59E–02 m	364 m		0.07852 n
Thallium	–	–	–	–	–	–			
Tin	6.00E–01 b	–	–	–	–				
Toluene#	2.00E–01	–	1.14E–01	–	–	6.37E–03 m	300 m	5.35E+02 m	0.08301 n
Toxaphene	–	1.10E+00	–	1.10E+00 b	–	4.36E–01 m	964 m		
1,2,4–Trichlorobenzene#	1.00E–02	–	2.57E–03	–	–	2.31E–03 m	9200 m	3.00E+01 m	
1,1,1–Trichloroethane#	–	–	–	–	–	1.44E–02 m	152 m		
1,1,2–Trichloroethane#	4.00E–03	5.70E–02	–	5.60E–02	–	1.17E–03 m	56 m	4.50E+03 m	
Trichloroethene#	–	1.10E–02	–	5.95E–03	–	9.10E–03 m	126 m	1.10E+03 m	0.08606 n
2,4,5–Trichlorophenol	1.00E–01	–	–	–	–	2.18E–04 m	89 m		
2,4,6–Trichlorophenol	–	1.10E–02	–	1.00E–02 b	–	3.90E–06 m	2000 m		
Vanadium	7.00E–03 b	–	–	–	–	–			
Vinyl acetate	1.00E+00 b	–	5.71E–02	–	–				
Vinyl chloride#	–	1.90E+00 b	–	3.00E–01 b	–	8.19E–02 m	57 m	2.67E+03 m	0.11375 n
Xylene (total)#	2.00E+00	–	–	–	–	7.04E–03 m	240 m	1.98E+02 m	0.07597 n
Zinc	3.00E–01	–	–	–	–	–			
Nitrate	1.60E+00	–	–	–	–				
Nitrite	1.00E–01	–	–	–	–				
pH	–	–	–	–	–				
Sulfide	–	–	–	–	–				
Ammonium	–	–	–	–	–				
Bicarbonate	–	–	–	–	–				
Bromide	–	–	–	–	–				
Carbonate	–	–	–	–	–				
Chloride	–	–	–	–	–				
Cyanide	–	–	–	–	–				
Fluoride	6.00E–02	–	–	–	–				

TABLE 25
COC–Specific Toxicity Values

Target Analyte List Chemical	Oral RfD (mg/kg–day)	Oral Slope Factor $(mg/kg–day)^{-1}$	Inhalation RfD (mg/kg–day)	Inhalation Slope Factor $(mg/kg–day)^{-1}$	External Slope Factor (risk/yr per pCi/g)	Henry's Law Constant $(atm–m^3/mol)$	Koc (ml/g)	Water Solubility (mg/L)	Diffusivity
Orthophosphate	–	–	–	–	–				
Silica (as Si and SiO_2)	–	–	–	–	–				
Sulfate	–	–	–	–	–				
Americium–241	–	2.40E–10 b•	–	3.20E–08 b•	4.90E–09 b				
Cesium–137	–	2.80E–11 b•	–	1.90E–11 b•	0.00E+00 b				
Plutonium–239	–	2.30E–10 b•	–	3.80E–08 b•	1.70E–11 b				
Plutonium–240	–	2.30E–10 b•	–	3.80E–08 b•	2.70E–11 b				
Radium–226	–	1.20E–10 b•	–	3.00E–09 b•	1.20E–08 b				
Radium–228	–	1.00E–10 b•	–	6.60E–10 b•	0.00E+00 b				
Strontium–89	–	3.00E–12 b•	–	2.90E–12 b•	4.70E–10 b				
Strontium–90	–	3.30E–11 b•	–	5.60E–11 b•	0.00E+00 b				
Tritium	–	5.40E–14 b•	–	7.80E–14 b•	0.00E+00 b				
Uranium–233	–	1.60E–11 b•	–	2.70E–08 b•	4.20E–11 b				
Uranium–234	–	1.60E–11 b•	–	2.60E–08 b•	3.00E–11 b				
Uranium–235	–	1.60E–11 b•	–	2.50E–08 b•	2.40E–07 b				
Uranium–238	–	1.60E–11 b•	–	2.40E–08 b•	2.10E–11 b				

= Chemicals listed are volatile.

• = Values given are in units of risk/yr per pCi/g.

•• = Values given are in units of pCi/L.

••• = Values given are in units of pCi/g.

a = All toxicity values are from IRIS, February 1994 unless otherwise noted.

b = Value from HEAST, 1993.

c = Values given are for PCBs.

d = Values given are for chlordane.

e = Values given are for 1,3–dichloropropene.

f = Values given are for endosulfan.

g = Value given is for a 2,4–DNT/2,6–DNT mixture.

h = Value given is for nickel refinery dust.

i = Value given for arsenic is calculated from an oral unit risk of 5E–5 ($L/\mu g$).

j = Values given for chemicals were calculated from HEAST.

k = Values given for PAHs were found in the EPA guidance document "Research and Development–Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons."

l = Values given for tetrachloroethene are from a U.S. EPA memo from the Office of Research and Development Environmental Criteria and Assessment Office.

m = Values given are found in the Superfund Public Health Evaluation Manual, 1986.

n = Values given are found in the Superfund Exposure Assessment Manual, 1988.

TABLE 26
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT[a]

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Acenaphthene#	2.19E+00	1.68E+03	1.65E+04	1.23E+05	1.02E+06	4.38E+03	1.48E+05
Acenaphthylene#	–	–	–	–	–	–	–
Acetone#	3.65E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
Aldrin	5.00E−06	3.85E−03	3.77E−02	3.36E−01	7.01E+01	1.20E−01	4.07E−01
Aluminum	–	–	–	–	–	–	–
Anthracene#	1.09E+01	8.42E+03	8.23E+04	6.13E+05	5.11E+06	2.19E+04	7.41E+05
Antimony	1.46E−02	1.12E+01	1.10E+02	8.18E+02	6.81E+03	2.92E+01	9.87E+02
Aroclor−1016	1.10E−05	8.51E−03	8.32E−02	7.43E−01	1.55E+02	2.65E−01	8.98E−01
Aroclor−1221	1.10E−05	8.51E−03	8.32E−02	7.43E−01	1.55E+02	2.65E−01	8.98E−01
Aroclor−1232	1.10E−05	8.51E−03	8.32E−02	7.43E−01	1.55E+02	2.65E−01	8.98E−01
Aroclor−1242	1.10E−05	8.51E−03	8.32E−02	7.43E−01	1.55E+02	2.65E−01	8.98E−01
Aroclor−1248	1.10E−05	8.51E−03	8.32E−02	7.43E−01	1.55E+02	2.65E−01	8.98E−01
Aroclor−1254	1.10E−05	8.51E−03	8.32E−02	7.43E−01	1.55E+02	2.65E−01	8.98E−01
Aroclor−1260	1.10E−05	8.51E−03	8.32E−02	7.43E−01	1.55E+02	2.65E−01	8.98E−01
Arsenic	4.86E−05	3.74E−02	3.66E−01	3.27E+00	6.81E+02	1.17E+00	3.95E+00
Barium	2.56E+00	1.97E+03	1.92E+04	1.14E+05	3.32E+05	5.11E+03	1.73E+05
Benzene#	6.15E−04	2.26E+00	2.21E+01	1.66E−01	4.11E+04	7.05E+01	2.38E+02
alpha−BHC	1.35E−05	1.04E−02	1.02E−01	9.08E−01	1.89E+02	3.24E−01	1.10E+00
beta−BHC	4.72E−05	3.64E−02	3.56E−01	3.18E+00	6.62E+02	1.14E+00	3.84E+00
delta−BHC	–	–	–	–	–	–	–
gamma−BHC (Lindane)	6.54E−05	5.04E−02	4.93E−01	4.40E+00	9.17E+02	1.57E+00	5.32E+00
Benzo(a)anthracene	1.16E−04	8.97E−02	8.77E−01	7.84E+00	1.63E+03	2.80E+00	9.47E+00
Benzo(a)pyrene	1.16E−05	8.97E−03	8.77E−02	7.84E−01	1.63E+02	2.80E−01	9.47E−01
Benzo(b)fluoranthene	1.16E−04	8.97E−02	8.77E−01	7.84E+00	1.63E+03	2.80E+00	9.47E+00
Benzo(g,h,i)perylene	–	–	–	–	–	–	–
Benzo(k)fluoranthene	1.16E−03	8.97E−01	8.77E+00	7.84E+01	1.63E+04	2.80E+01	9.47E+01
Benzoic Acid	1.46E+02	1.12E+05	1.10E+06	8.18E+06	6.81E+07	2.92E+05	9.87E+06
Benzyl Alcohol	1.09E+01	8.42E+03	8.23E+04	6.13E+05	5.11E+06	2.19E+04	7.41E+05
Beryllium	1.98E−05	1.52E−02	1.49E−01	1.33E+00	2.77E+02	4.75E−01	1.61E+00
bis(2−Chloroethoxy)methane#	–	–	–	–	–	–	–
bis(2−Chloroethyl)ether#	1.56E−05	5.95E−02	5.82E−01	6.29E+00	1.08E+03	1.86E+00	6.28E+00
bis(2−Chloroisopropyl)ether#	4.22E−04	9.36E−01	9.15E+00	4.00E−01	1.70E+04	2.92E+01	9.87E+01
bis(2−Ethylhexyl)phthalate	6.07E−03	4.68E+00	4.57E+01	4.09E+02	8.51E+04	1.46E+02	4.94E+02
Bromodichloromethane#	1.37E−03	1.06E+00	1.03E+01	3.55E−01	1.92E+04	3.30E+01	1.11E+02
Bromoform#	3.81E−03	8.29E+00	8.11E+01	4.52E−02	1.51E+05	2.59E+02	8.75E+02
Bromomethane#	1.09E−02	3.93E+01	3.84E+02	2.86E+03	2.38E+04	1.02E+02	3.46E+03

TABLE 26
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT*

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
4-Bromophenyl phenyl ether	–	–	–	–	–	–	–
2-Butanone#	2.47E+00	1.68E+04	1.65E+05	1.23E+06	1.02E+07	4.38E+04	1.48E+06
Butylbenzylphthalate	7.30E+00	5.62E+03	5.49E+04	4.09E+05	3.41E+06	1.46E+04	4.94E+05
Cadmium	1.82E-02	1.40E+01	1.37E+02	1.02E+03	8.52E+03	3.65E+01	1.23E+03
Calcium	–	–	–	–	–	–	–
Carbon disulfide#	2.76E-02	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
Carbon tetrachloride#	2.60E-04	5.04E-01	4.93E+00	4.40E+01	9.17E+03	1.57E+01	5.32E+01
Cesium	–	–	–	–	–	–	–
alpha-Chlordane	6.54E-05	5.04E-02	4.93E-01	4.40E+00	9.17E+02	1.57E+00	5.32E+00
beta-Chlordane	6.54E-05	5.04E-02	4.93E-01	4.40E+00	9.17E+02	1.57E+00	5.32E+00
gamma-Chlordane	6.54E-05	5.04E-02	4.93E-01	4.40E+00	9.17E+02	1.57E+00	5.32E+00
4-Chloroaniline	1.46E-01	1.12E+02	1.10E+03	8.18E+03	6.81E+04	2.92E+02	9.87E+03
Chlorobenzene#	5.16E-02	5.62E+02	5.49E+03	4.09E+04	3.41E+05	1.46E+03	4.94E+04
Chloroethane#	2.78E+01	–	–	–	–	–	–
Chloroform#	2.76E-04	1.07E+01	1.05E+02	3.49E-02	1.70E+05	3.35E+02	1.13E+03
Chloromethane#	2.32E-03	5.04E+00	4.93E+01	7.44E-02	9.17E+04	1.57E+02	5.32E+02
4-Chloro-3-methylphenol	–	–	–	–	–	–	–
2-Chloronaphthalene#	2.92E+00	2.25E+03	2.20E+04	1.64E+05	1.36E+06	5.84E+03	1.97E+05
2-Chlorophenol#	1.82E-01	1.40E+02	1.37E+03	1.02E+04	8.52E+04	3.65E+02	1.23E+04
4-Chlorophenyl phenyl ether	–	–	–	–	–	–	–
Chromium III	3.65E+01	2.81E+04	2.74E+05	2.04E+06	1.70E+07	7.30E+04	2.47E+06
Chromium VI	1.82E-01	1.40E+02	1.37E+03	4.88E+03	8.52E+04	3.65E+02	1.23E+04
Chyrsene	1.16E-02	8.97E+00	8.77E+01	7.84E+02	1.63E+05	2.80E+02	9.47E+02
Cobalt	–	–	–	–	–	–	–
Copper	1.46E+00	1.12E+03	1.10E+04	8.18E+04	6.81E+05	2.92E+03	9.87E+04
Cyanide	7.30E-01	5.62E+02	5.49E+03	4.09E+04	3.41E+05	1.46E+03	4.94E+04
4,4-DDD	3.54E-04	2.73E-01	2.67E+00	2.38E+01	4.97E+03	8.52E+00	2.88E+01
4,4-DDE	2.50E-04	1.93E-01	1.88E+00	1.68E+01	3.51E+03	6.01E+00	2.03E+01
4,4-DDT	2.50E-04	1.93E-01	1.88E+00	1.68E+01	3.51E+03	6.01E+00	2.03E+01
Dibenz(a,h)anthracene	1.16E-05	8.97E-03	8.77E-02	7.84E-01	1.63E+02	2.80E-01	9.47E-01
Dibenzofuran	–	–	–	–	–	–	–
Dibromochloromethane	1.01E-03	7.80E-01	7.62E+00	6.81E+01	1.42E+04	2.43E+01	8.23E+01
Di-n-butylphthalate	3.65E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
1,2-Dichlorobenzene#	4.76E-01	2.53E+03	2.47E+04	1.84E+05	1.53E+06	6.57E+03	2.22E+05
1,3-Dichlorobenzene#	–	–	–	–	–	–	–
1,4-Dichlorobenzene#	3.54E-03	2.73E+00	2.67E+01	1.37E-01	4.97E+04	8.52E+01	2.88E+02
3,3-Dichlorobenzidine	1.89E-04	1.46E-01	1.42E+00	1.27E+01	2.65E+03	4.54E+00	1.54E+01

TABLE 26
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT[a]

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
1,1-Dichloroethane#	1.01E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
1,2-Dichloroethane#	1.97E-04	7.20E-01	7.04E+00	5.21E-01	1.31E+04	2.25E+01	7.60E+01
1,1-Dichloroethene#	1.67E-05	1.09E-01	1.07E+00	3.43E+00	1.99E+03	3.41E+00	1.15E+01
1,2-Dichloroethene (total)#	3.28E-01	2.53E+02	2.47E+03	1.84E+04	1.53E+05	6.57E+02	2.22E+04
2,4-Dichlorophenol	1.10E-01	8.42E+01	8.23E+02	6.13E+03	5.11E+04	2.19E+02	7.41E+03
1,2-Dichloropropane#	1.25E-03	9.63E-01	9.42E+00	3.89E-01	1.75E+04	3.01E+01	1.02E+02
cis-1,3-Dichloropropene#	1.27E-04	3.64E-01	3.56E+00	1.03E+00	5.11E+03	1.14E+01	3.84E+01
trans-1,3-Dichloropropene#	1.27E-04	3.64E-01	3.56E+00	1.03E+00	5.11E+03	1.14E+01	3.84E+01
Dieldrin	5.31E-06	4.09E-03	4.00E-02	3.57E-01	7.45E+01	1.28E-01	4.32E-01
Diethylphthalate	2.92E+01	2.25E+04	2.20E+05	1.64E+06	1.36E+07	5.84E+04	1.97E+06
2,4-Dimethylphenol#	7.30E-01	5.62E+02	5.49E+03	4.09E+04	3.41E+05	1.46E+03	4.94E+04
Dimethylphthalate	3.65E+02	2.81E+05	2.74E+06	2.04E+07	1.70E+08	7.30E+05	2.47E+07
4,6-Dinitro-2-methylphenol#	–	–	–	–	–	–	–
2,4-Dinitrophenol	7.30E-02	5.62E+01	5.49E+02	4.09E+03	3.41E+04	1.46E+02	4.94E+03
2,4-Dinitrotoluene	7.30E-02	5.62E+01	5.49E+02	4.09E+03	3.41E+04	1.46E+02	4.94E+03
2,6-Dinitrotoluene	3.65E-02	2.81E+01	2.74E+02	2.04E+03	1.70E+04	7.30E+01	2.47E+03
Di-n-octylphthalate	7.30E-01	5.62E+02	5.49E+03	4.09E+04	3.41E+05	1.46E+03	4.94E+04
Endosulfan I	1.83E-03	1.40E+00	1.37E+01	1.02E+02	8.52E+02	3.65E+00	1.23E+02
Endosulfan II	1.83E-03	1.40E+00	1.37E+01	1.02E+02	8.52E+02	3.65E+00	1.23E+02
Endosulfan sulfate	1.83E-03	1.40E+00	1.37E+01	1.02E+02	8.52E+02	3.65E+00	1.23E+02
Endosulfan (technical)	1.83E-03	1.40E+00	1.37E+01	1.02E+02	8.52E+02	3.65E+00	1.23E+02
Endrin ketone	–	–	–	–	–	–	–
Endrin (technical)	1.09E-02	8.42E+00	8.23E+01	6.13E+02	5.11E+03	2.19E+01	7.41E+02
Ethylbenzene#	1.58E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
Fluoranthene	1.46E+00	1.12E+03	1.10E+04	8.18E+04	6.81E+05	2.92E+03	9.87E+04
Fluorene#	1.46E+00	1.12E+03	1.10E+04	8.18E+04	6.81E+05	2.92E+03	9.87E+04
Heptachlor	1.89E-05	1.46E-02	1.42E-01	1.27E+00	2.65E+02	4.54E-01	1.54E+00
Heptachlor epoxide	9.34E-06	7.20E-03	7.04E-02	6.29E-01	1.31E+02	2.25E-01	7.60E-01
Hexachlorobenzene	5.31E-05	4.09E-02	4.00E-01	3.57E+00	7.45E+02	1.28E+00	4.32E+00
Hexachlorobutadiene	–	–	–	2.60E+06	5.53E+08	–	–
Hexachlorocyclopentadiene	2.56E-01	1.97E+02	1.92E+03	1.42E+04	4.19E+04	5.11E+02	1.73E+04
Hexachloroethane	6.07E-03	4.68E+00	4.57E+01	4.09E+02	1.70E+04	7.30E+01	4.94E+02
2-Hexanone#	–	–	–	–	–	–	–
Indeno(1,2,3-cd)pyrene	1.16E-04	8.97E-02	8.77E-01	7.84E+00	1.63E+03	2.80E+00	9.47E+00
Iron	–	–	–	–	–	–	–
Isophorone	8.95E-02	6.89E+01	6.74E+02	6.02E+03	1.25E+06	2.15E+03	7.28E+03
Lead	–	–	–	–	–	–	–

TABLE 26
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT[a]

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Lithium	–	–	–	–	–	–	–
Magnesium	–	–	–	–	–	–	–
Manganese	1.82E−01	1.40E+02	1.37E+03	1.01E+04	2.99E+04	3.65E+02	1.23E+04
Mercury	1.09E−02	8.42E+00	8.23E+01	6.13E+02	5.02E+03	2.19E+01	7.41E+02
Methoxychlor	1.82E−01	1.40E+02	1.37E+03	1.02E+04	8.52E+04	3.65E+02	1.23E+04
Methylene chloride#	6.22E−03	8.73E+00	8.54E+01	4.29E−02	1.59E+05	2.73E+02	9.22E+02
2−Methylnaphthalene#	–	–	–	–	–	–	–
4−Methyl−2−pentanone#	1.98E−01	1.40E+03	1.37E+04	1.02E+05	8.52E+05	3.65E+03	1.23E+05
2−Methylphenol	1.83E+00	1.40E+03	1.37E+04	1.02E+05	8.52E+05	3.65E+03	1.23E+05
4−Methylphenol	1.82E−01	1.40E+02	1.37E+03	1.02E+04	8.52E+04	3.65E+02	1.23E+04
Molybdenum	1.82E−01	1.40E+02	1.37E+03	1.02E+04	8.52E+04	3.65E+02	1.23E+04
Naphthalene#	1.46E+00	1.12E+03	1.10E+04	8.18E+04	6.81E+05	2.92E+03	9.87E+04
Nickel	7.30E−01	5.62E+02	5.49E+03	4.09E+04	3.41E+05	1.46E+03	4.94E+04
2−Nitroaniline	–	–	–	–	–	–	–
3−Nitroaniline	–	–	–	–	–	–	–
4−Nitroaniline	–	–	–	–	–	–	–
Nitrobenzene#	4.26E−03	1.40E+01	1.37E+02	1.02E+03	8.52E+03	3.65E+01	1.23E+03
2−Nitrophenol	–	–	–	–	–	–	–
4−Nitrophenol#	–	–	–	–	–	–	–
n−Nitrosodiphenylamine#	1.73E−02	1.34E+01	1.31E+02	2.80E−02	2.43E+05	4.17E+02	1.41E+03
n−Nitrosodipropylamine	1.21E−05	9.36E−03	9.15E−02	8.17E−01	1.70E+02	2.92E−01	9.87E+01
Pentachlorophenol	7.08E−04	5.46E−01	5.34E+00	4.77E+01	9.93E+03	1.70E+01	5.76E+01
Phenanthrene#	–	–	–	–	–	–	–
Phenol	2.19E+01	1.68E+04	1.65E+05	1.23E+06	1.02E+07	4.38E+04	1.48E+06
Potassium	–	–	–	–	–	–	–
Pyrene	1.09E+00	8.42E+02	8.23E+03	6.13E+04	5.11E+05	2.19E+03	7.41E+04
Selenium	1.82E−01	1.40E+02	1.37E+03	1.02E+04	8.52E+04	3.65E+02	1.23E+04
Silver	1.82E−01	1.40E+02	1.37E+03	1.02E+04	8.52E+04	3.65E+02	1.23E+04
Sodium	–	–	–	–	–	–	–
Strontium	2.19E+01	1.68E+04	1.65E+05	1.23E+06	1.02E+07	4.38E+04	1.48E+06
Stryene#	2.01E+00	5.62E+03	5.49E+04	4.09E+05	3.41E+06	1.46E+04	4.94E+05
1,1,2,2−Tetrachloroethane#	8.95E−05	3.28E−01	3.20E+00	1.14E+00	5.96E+03	1.02E+01	3.46E+01
Tetrachloroethene#	1.43E−03	1.26E+00	1.23E+01	2.97E−01	2.29E+04	3.93E+01	1.33E+02
Thallium	–	–	–	–	–	–	–
Tin	2.19E+01	1.68E+04	–	1.23E+06	1.02E+07	4.38E+04	1.48E+06
Toluene#	9.65E−01	5.62E+03	5.49E+04	4.09E+05	3.41E+06	1.46E+04	4.94E+05
Toxaphene	7.73E−05	5.95E−02	5.82E−01	5.20E+00	1.08E+03	1.86E+00	6.28E+00

TABLE 26
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT*

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
1,2,4-Trichlorobenzene#	2.34E-02	2.81E+02	2.74E+03	2.04E+04	1.70E+05	7.30E+02	2.47E+04
1,1,1-Trichloroethane#	–	–	–	–	–	–	–
1,1,2-Trichloroethane#	3.18E-04	1.15E+00	1.12E+01	3.26E-01	2.09E+04	3.59E+01	1.21E+02
Trichloroethene#	2.55E-03	5.95E+00	5.82E+01	6.29E-02	1.08E+05	1.86E+02	6.28E+02
2,4,5-Trichlorophenol	3.65E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
2,4,6-Trichlorophenol	1.75E-03	5.95E+00	5.82E+01	5.20E+02	1.08E+05	1.86E+02	6.28E+02
Vanadium	2.56E-01	1.97E+02	1.92E+03	1.43E+04	1.19E+05	5.11E+02	1.73E+04
Vinyl acetate	3.65E+01	2.81E+04	2.74E+05	2.04E+06	1.56E+07	7.30E+04	2.47E+06
Vinyl chloride#	2.81E-05	3.45E-02	3.37E-01	1.09E+01	6.27E+02	1.08E+00	3.64E+00
Xylene (total)#	7.30E+01	5.62E+04	5.49E+05	4.09E+06	3.41E+07	1.46E+05	4.94E+06
Zinc	1.09E+01	8.42E+03	8.23E+04	6.13E+05	5.11E+06	2.19E+04	7.41E+05
Nitrate	5.84E+01	4.49E+04	4.39E+05	3.27E+06	2.73E+07	1.17E+05	3.95E+06
Nitrite	3.65E+00	2.81E+03	2.74E+04	2.04E+05	1.70E+06	7.30E+03	2.47E+05
pH	–	–	–	–	–	–	–
Sulfide	–	–	–	–	–	–	–
Ammonium	–	–	–	–	–	–	–
Bicarbonate	–	–	–	–	–	–	–
Bromide	–	–	–	–	–	–	–
Carbonate	–	–	–	–	–	–	–
Chloride	–	–	–	–	–	–	–
Cyanide	–	–	–	–	–	–	–
Fluoride	2.19E+00	1.68E+03	1.65E+04	1.23E+05	1.02E+06	4.38E+03	1.48E+05
Orthophosphate	–	–	–	–	–	–	–
Silica (as Si and SiO_2)	–	–	–	–	–	–	–
Sulfate	–	–	–	–	–	–	–
Americium-241	1.98E-01	2.16E+01	2.37E+00	9.55E+00	6.50E+02	4.76E+03	1.09E+01
Cesium-137	1.70E+00	8.94E+02	2.83E+01	1.14E+02	2.38E+04	4.08E+04	1.38E+02
Plutonium-239	2.07E-01	9.07E+01	3.43E+00	1.38E+01	2.85E+03	4.97E+03	1.67E+01
Plutonium-240	2.07E-01	9.01E+01	3.42E+00	1.38E+01	2.83E+03	4.97E+03	1.67E+01
Radium-226	3.97E-01	1.10E+01	2.28E+00	9.13E+00	3.27E+02	9.52E+03	9.70E+00
Radium-228	4.76E-01	2.49E+02	7.93E+00	3.20E+01	6.67E+03	1.14E+04	3.86E+01
Strontium-89	1.59E+01	2.85E+02	6.64E+01	2.66E+02	8.53E+03	3.81E+05	2.78E+02
Strontium-90	1.44E+00	7.58E+02	2.40E+01	9.70E+01	2.02E+04	3.46E+04	1.17E+02

TABLE 26
PROGRAMMATIC PRGs FOR ROCKY FLATS PLANT*

Target Analyte List Chemical	Residential Groundwater (mg/L)	Residential Surface Water Swimming (mg/L)	Residential Soil (mg/kg)	Office Worker Soil (mg/kg)	Construction Worker Subsurface Soil (mg/kg)	Wading Ecological Worker (mg/L)	Soil Ecological Worker (mg/kg)
Tritium	8.82E+02	4.63E+05	1.47E+04	5.93E+04	1.23E+07	2.12E+07	7.16E+04
Uranium-233	2.98E+00	4.62E+02	4.47E+01	1.82E+02	2.84E+04	7.14E+04	2.18E+02
Uranium-234	2.98E+00	4.92E+02	4.53E+01	1.85E+02	3.09E+04	7.14E+04	2.22E+02
Uranium-235	2.98E+00	5.78E-01	1.73E-01	6.92E-01	1.74E+01	7.14E+04	6.92E-01
Uranium-238	2.98E+00	5.32E+02	4.60E+01	1.87E+02	3.33E+04	7.14E+04	2.25E+02

= Chemicals listed are volatile.

* = Values given are in units of risk/yr per pCi/g.

** = Values given are in units of pCi/L.

*** = Values given are in units of pCi/g.

a = All toxicity values are from IRIS, February 1994 unless otherwise noted.

b = Value from HEAST, 1993.

c = Values given are for PCBs.

d = Values given are for chlordane.

e = Values given are for 1,3-dichloropropene.

f = Values given are for endosulfan.

g = Value given is for a 2,4-DNT/2,6-DNT mixture.

h = Value given is for nickel refinery dust.

i = Value given for arsenic is calculated from an oral unit risk of 5E-5 (L/μg).

j = Values given for chemicals were calculated from HEAST.

k = Values given for PAHs were found in the EPA guidance document "Research and Development-Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons."

l = Values given for tetrachloroethene are from a U.S. EPA memo from the Office of Research and Development Environmental Criteria and Assessment Office.

m = Values given are found in the Superfund Public Health Evaluation Manual, 1986.

n = Values given are found in the Superfund Exposure Assessment Manual, 1988.

As stated early, the PPRGs presented in Table 26 are not intended to be the final clean-up standards listed in the Record of Decision. Other factors such as, but not limited to, background contaminant concentrations, results of the OU-specific BRA, technology limitations, detection methods, chemical-specific ARARs, cost-benefit evaluations, and worker safety will need to be considered when establishing the final clean up standards. The PPRGs are to be used as a standardized set of limits to enable screening of potential remedial technologies and alternatives. As additional information is obtained through the RFI/RI and CMS/FS processes, it may be determined that the PPRGs are not representative of the actual risk posed by the contamination at the OU. If this situation occurs, the required changes will be incorporated during the Detailed Analysis of Alternatives phase CMS/FS for that particular OU.

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