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EXECUTIVE SUMMARY

A human health risk assessment (HHRA) was performed for Operable Unit No. 3 (OU 3) at the Rocky Flats Environmental Technology Site (RFETS) as part of the Phase I RCRA Facility Investigation/Remedial Investigation (RFI/RI) Report, as required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

OU 3 is the only OU located outside of Site boundaries. Its location is given in Figure 1-2 of the RFI/RI Report. Four Individual Hazardous Substance Sites (IHSSs) are located within OU 3, including Great Western Reservoir (IHSS 200), Standley Lake (IHSS 201), and Mower Reservoir (IHSS 202). Uncontrolled releases of contaminants on site have resulted in the movement of some materials off site by wind and water erosion and by direct release to the atmosphere due to building fires in 1957 and 1969.

The HHRA is intended to estimate the level of current or potential human health risk from exposure to chemicals at or released from contaminant sources within OU 3. The risk (carcinogenic) and hazard (noncarcinogenic) estimates are used to support risk management decisions, in keeping with current and future land uses.

The Environmental Protection Agency (EPA) guidance for risk assessment, as modified by specific agreements between the EPA, the Colorado Department of Public Health and the Environment (CDPHE), and the Department of Energy (DOE), was used for the preparation of this HHRA. The procedures are documented in various technical memoranda and correspondence cited in the HHRA.

The RFI/RI data collected to characterize the nature and extent of contamination at OU 3, augmented historical data collected by others at Rocky Flats over the last decade (see Sections A2.4 and A2.5). Potentially affected media in OU 3, evaluated as part of the RFI/RI and HHRA, included soil, sediment, surface water, groundwater, and air. The sampling results were used to characterize chemical constituents, select chemicals of concern (COCs) for risk assessment, and characterize risks in OU 3.

The CDPHE conservative screen is performed concurrently with the selection of COCs. The screen was designed to determine if a risk assessment was necessary and to aggregate sources of contamination into areas of concern (AOCs) for evaluation in the risk assessment (see Section A3.0). The conservative screen found no significant contamination in IHSSs 201 (Standley Lake) and 202 (Mower Reservoir). The IHSSs 199 (OU 3 soils) and 200 (Great Western Reservoir) did not pass the conservative screen and were evaluated in this HHRA.

The COCs were identified by a six step process, developed in discussions among the EPA, CDPHE, and DOE, that varied from that used for on site OUs (see Section A4.0). Chemicals with concentrations in soil, water, or sediments in IHSSs in OU 3 that were found to be significantly higher than background and that had concentrations above the site-specific Programmatic Preliminary Remediation Goals (PPRGs, DOE 1994c) were designated as COCs.

The COC selection process identified americium-241 and plutonium-239, -240 in surface soil (IHSS 199) and plutonium-239, -240 in surface sediments in Great Western Reservoir (IHSS 200). These chemicals were evaluated in the quantitative risk assessment and will be the focus of a remedial action, if found to be necessary. Risks were calculated and compared to background , for arsenic and beryllium in surface sediments of IHSSs 200, 201, and 202.

The HHRA quantifies risks and hazards from the current and possible future exposure of individuals to COCs present in the AOCs. The assessment of these exposures is discussed in detail in Section A5. There are no current exposures, with the possible exception of an occasional trespasser. Potential future exposed individuals (receptors) were determined to be recreational users, including children and, although unlikely in the near future, residents. Recreational receptors were evaluated for exposures via ingestion of surface soil/sediments, inhalation of soil/sediment particulates suspended in air, dermal contact, and external radiation exposure. Residential receptors were evaluated for the exposures mentioned and also, ingestion of homegrown produce, and ingestion of local beef/milk.

For the recreational scenario, the 95% upper confidence limit of the mean of the concentration or activity for a 50-acre exposure area were used for exposure concentrations . Average values for ten acre plots were used for the residential scenario. Air concentrations were estimated based on the results of the OU 3 wind tunnel study.

Health risks and hazards were characterized by combining estimates of chemical intake, chemical concentrations at the exposure points and toxicity factors. The toxicity factors are EPA calculated reference doses (RfDs) for noncarcinogens and cancer slope factors (SFs) for carcinogens. Noncarcinogenic hazard indices (HIs) can not be calculated for radionuclides and therefore, were only calculated for arsenic and beryllium in the uncertainty section (A7.4). Cancer risk estimates were calculated using site-specific exposure assumptions approved by the EPA and CDPHE for both central tendency (CT) or average exposures, and reasonable maximum exposures (RME). Annual radiation doses due to ingestion inhalation and external exposures were also estimated for comparison to national standards for protection of the general public and no radiation workers (100 mrem/year).

The results of the risk assessment are summarized in Table ES-1 and described briefly below. Results are explained in full in Section A6.

For the residential setting in, direct contact exposure is assumed to occur as a result of ingestion and inhalation. Indirect contact is limited to vegetable, beef, and milk consumption and external radiation exposure. The results indicate the following:

- IHSS 199-Residential: The estimated RME excess cancer risks were 3 x 10-6 (3 in 1 million) or less for residential exposures. For the CT exposures, the estimated excess lifetime cancer risk were less than 2 in 10 million (2 x 10-7). For an adult, the RME annual radiation dose is estimated at 0.12 mrem/year or less for the locations sampled in the IHSS. The CT radiation dose is estimated at 0.025 mrem/yea or less. These values are all below the DOE annual dose limit for the general public of 100 mrem/year. For a child, the RME radiation dose for ingestion exposures is estimated at 0.14 mrem/year or less. The corresponding CT values are 0.039 mrem/year or less.

- IHSS 199-Recreational: For an adult, the RME estimated excess lifetime cancer risk was 5 x 10-8 due to plutonium and americium. The corresponding CT risk was estimated at 3 x 10-9. These risk estimates are well below the level of concern (1 x 10-6). The RME was estimated at 0.003 mrem/year; the corresponding CT value was estimated at 0.00057 mrem/year. For a child, the RME radiation dose for soil ingestion is estimated at 0.0052 mrem/year. The corresponding CT value is estimated at 0.001 mrem/year. These estimates are below the DOE annual dose limit for the general public of 100 mrem/year.

Exposure to sediments located in assumes that Great Western Reservoir is drained and subsequent residential or recreational development occurs in the reservoir basin.

- Residential: The RME estimated excess lifetime cancer risk for a future resident was 9 x 10-7 from all pathways. The corresponding CT estimated excess lifetime cancer risk was estimated at 6 x 10-8. These risks are below the level of concern. The RME for an adult was estimated at 0.0065 mrem/year; the corresponding CT value was estimated at 0.0015 mrem/year., the RME for a child for sediment ingestion was estimated at 0.008 mrem/year. The corresponding CT value was estimated at 0.0022 mrem/year. These values are below the DOE annual dose limit of 100 mrem/year for the general public.

Exposure to Great Western Reservoir sediments is assumed to occur in the future if the reservoir is drained and subsequent recreational use of the area occurs. Under recreational conditions, exposure is assumed to occur to sediments by ingestion, inhalation, and external radiation exposure.

- IHSS 200-Recreational: The estimated RME excess lifetime cancer risk for an adult, is estimated to be 1 x 10-8 . The corresponding estimated CT excess lifetime cancer risk for the exposure setting is 8 x 10-10. Both of these estimates are orders of magnitude below the level of concern. The RME is estimated at 0.00014 mrem/year for an adult exposed to Great Western Reservoir sediment. The CT value is estimated at 0.000014 mrem/year. The RME radiation dose for a child for sediment ingestion is estimated at 0.0001 mrem/year. The corresponding CT value is estimated at 0.00002 mrem/year. These values include exposure to internal and external sources of radiation and are well below the DOE annual dose limit for the general public of 100 mrem/year

The baseline risk assessment recognizes the potential for receptors to experience dermal contact with surface soils located in IHSS 199 and surficial sediments associated with IHSS 200. Appropriate dose-response data do not exist to quantitatively describe the impact of dermal exposure to plutonium and americium.

All of the radiation dose estimates are well below the DOE annual radiation dose limit for members of the general public, it is important to understand the contribution of radiation dose from background conditions as a point of comparison. The radiation dose values estimated in this risk characterization represent the annual amount of radiation received by an individual and does not include that received from background sources including, cosmic radiation from the sun or medical x-rays. Background levels of radiation in the Denver area are estimated to be as high as 350 to 700 mrem/year. These levels are higher than the national average (300 mrem/year) because of high naturally occurring levels of radium, thorium, and radon and because radiation exposure increases with increased altitude.

The baseline risk assessment assumes that, sometime in the future, Great Western Reservoir is drained, and subsequently developed for residential land use. Under these circumstances, residential receptors could be exposed to the IHSS COCs in addition to constituents present at background levels, which includes arsenic and beryllium. Comparing the estimated excess lifetime cancer risk as a result of exposure to arsenic and beryllium to the risk associated with exposure to plutonium under the same exposure conditions, shows that the risks due to background exceed those attributable to site-related contamination. The estimated excess lifetime cancer risk for arsenic, based on the maximum detected background concentration in sediments were 6 x 10-5. For beryllium, the comparable value is about 4 x 10-5. The highest anticipated risk due to exposure to plutonium in IHSS 200 sediments is 1 x 10-7, or about 2 orders of magnitude lower than that for background, arsenic and beryllium. Consequently,

populations that contact the soil or sediments associated with these areas are not expected to experience an excess lifetime cancer risk that exceeds the contribution expected from background sources. This is expressed quantitatively in Table ES-1.

Table ES-1 Summary of Risks and Radiation Doses for OU 3

	Risk		Dose	
	RME	**CT**	**RME**	**CT**
IHSS 199 Residential				
PT14192	1E-06	1E-07	1.2E-01	2.5E-02
U1A	3E-06	2E-07	2.6E-02	7E-03
U2A	1E-06	1E-07	2.3E-02	3.9E-03
Recreational	5E-08	3E-09	3E-03	5.7E-04
IHSS 200				
Residential	9E-07	6E-08	6.5E-03	1.5E-03
Recreational	1E-08	8E-10	1.4E-04	1.4E-05

A1.0 INTRODUCTION

Rocky Flats is a former nuclear weapons production facility located approximately 16 miles northwest of Denver, Colorado. It is a 6,500-acre site with several hundred buildings on about 300 centrally located acres, known as the industrial area. The production mission was suspended in 1992 and Rocky Flats is in a long-term closure mode. In 1995, Kaiser-Hill was selected as the lead contractor in the cleanup and closure of Rocky Flats.

Industrial facilities at Rocky Flats were used to manufacture components of nuclear weapons. The final step in manufacturing was performed at Rocky Flats before the finished weapon was assembled at the DOE-Pantex facility in Texas.

The processes at Rocky Flats included purification and alloying of radioactive metal; machining, cleaning and inspecting the plutonium weapon parts; plus, the manufacture of related weapons components from uranium, beryllium, and stainless steel. The purification and waste recovery process included waste incineration, acid dissolution, and re-precipitation.

OU 3 is unique among Rocky Flats OUs in that it is located outside of site boundaries. Based on historical data, recent sampling events, and the need for a manageable study area, a working definition for the OU 3 study area was developed as shown in Figure 1-2 of the RFI/RI Report. The designated OU 3 study area in Figure 1-2 was not intended to be a legal definition or defined boundary, but rather a practical way to evaluate OU 3. The locations of each of the four Individual Hazardous Substance Sites (IHSSs) (IHSS 199 [Contamination of the Land Surface], IHSS 200 [Great Western Reservoir], IHSS 201 [Standley Lake], and IHSS 202 [Mower Reservoir]) in OU 3 relative to Rocky Flats are shown in Figure 1-2.

In 1992, ChemRisk prepared a report titled "Reconstruction of Historical Rocky Flats Operations and Identification of Release Points for the Colorado Department of Public Health and Environment" (CDPHE, 1992). One of the objectives of the report was to document the history of Rocky Flats relative to offsite releases. A second objective was to identify release points for the materials of concern from routine and nonroutine (accidental) operations. The report concludes that "extensive reviews failed to identify any historical evidence of significant intentional uncontrolled routine releases of radionuclides from the plant to the offsite environment (page 257)." The report further concludes that:

"The review of historical accidents and incidents at the plant site led to the identification of voluminous amounts of information documenting numerous small fires, spills, injuries, and property damage. However, none of the documentation indicated the occurrence of any previously unreported major events potentially impacting the offsite public. Major events of potential interest are those that were studied and publicized following the 1969 fire."

A1.1 PURPOSE OF REPORT

The purpose of the Human Health Risk Assessment (HHRA) is to assess the potential human health risks associated with OU 3 and to provide a basis for determining whether or not remedial actions are necessary. The HHRA addresses the potential risks to public health. The current and potential (future) risks associated with OU 3 under the no-action alternative (no remedial action taken) are assessed based on the data collected.

These objectives have been met and the results are summarized in this report. The work has been performed in accordance with the Environmental Protection Agency (EPA)-approved OU 3 Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Work Plan and addenda (Department of Energy [DOE], 1992).

A1.2 RISK ASSESSMENT APPROACH

Section 300.430(d) of the National Contingency Plan (55FR8709) states that as part of the remedial investigation, a HHRA is to be conducted to determine whether or not contaminants of concern identified at Rocky Flats pose a potential risk to human health and the environment in the absence of remedial action. Figure A1-1 illustrates the basic HHRA process and components. The HHRA identifies and estimates potential human health risks resulting from exposure to site contaminants present in various environmental media. The HHRA considers risks from both radiological and nonradiological contaminants. The EPA and DOE recommend a two-phase evaluation for the radiological portion of the assessment. The HHRA incorporates the two-phase analysis, which includes:

- Procedures established by the International Commission on Radiological Protection (ICRP) and adopted by the EPA used to estimate the radiation dose equivalent to humans from potential exposure to radionuclides through all pertinent exposure pathways.

- Estimates of health risk based on the age-averaged lifetime excess cancer incidence per unit intake (and per unit external exposure) for radionuclides of concern.

HHRA results will be used to determine if remedial actions are warranted at OU 3, and if so, what associated cleanup levels will be necessary to protect human health.

A1.3 RISK GUIDANCE

A number of guidance and informational documents were used to provide direction for developing the HHRA. These include:

- *Risk Assessment Guidance for Superfund, Human Health Evaluation Manual.* Volume 1, (Part A), Interim Final, 1989. EPA/540/1-89/002 (EPA, 1989a) including OSWER Directive 9285.6-03 Human Health Evaluation, Supplemental Guidance: "Standard Default Exposure Factors."

- *Guidance for Data Useability in Risk Assessment,* Interim Final, 1990. EPA/540/G-90/008 (EPA, 1990b).

- *Superfund Exposure Assessment Manual,* 1988, EPA/540/1-88/001 (EPA, 1988a).

- *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,* Federal Guidance Report No. 11, EPA/520/1-88-020 (EPA, 1988b).

- *Radiation Protection of the Public and Environment,* DOE Order 5400.5, (DOE, 1990).

- *Risk Assessment in the Federal Government: Managing the Process,* 1983, National Academy Press, Washington, D.C., (National Academy Press, 1983).

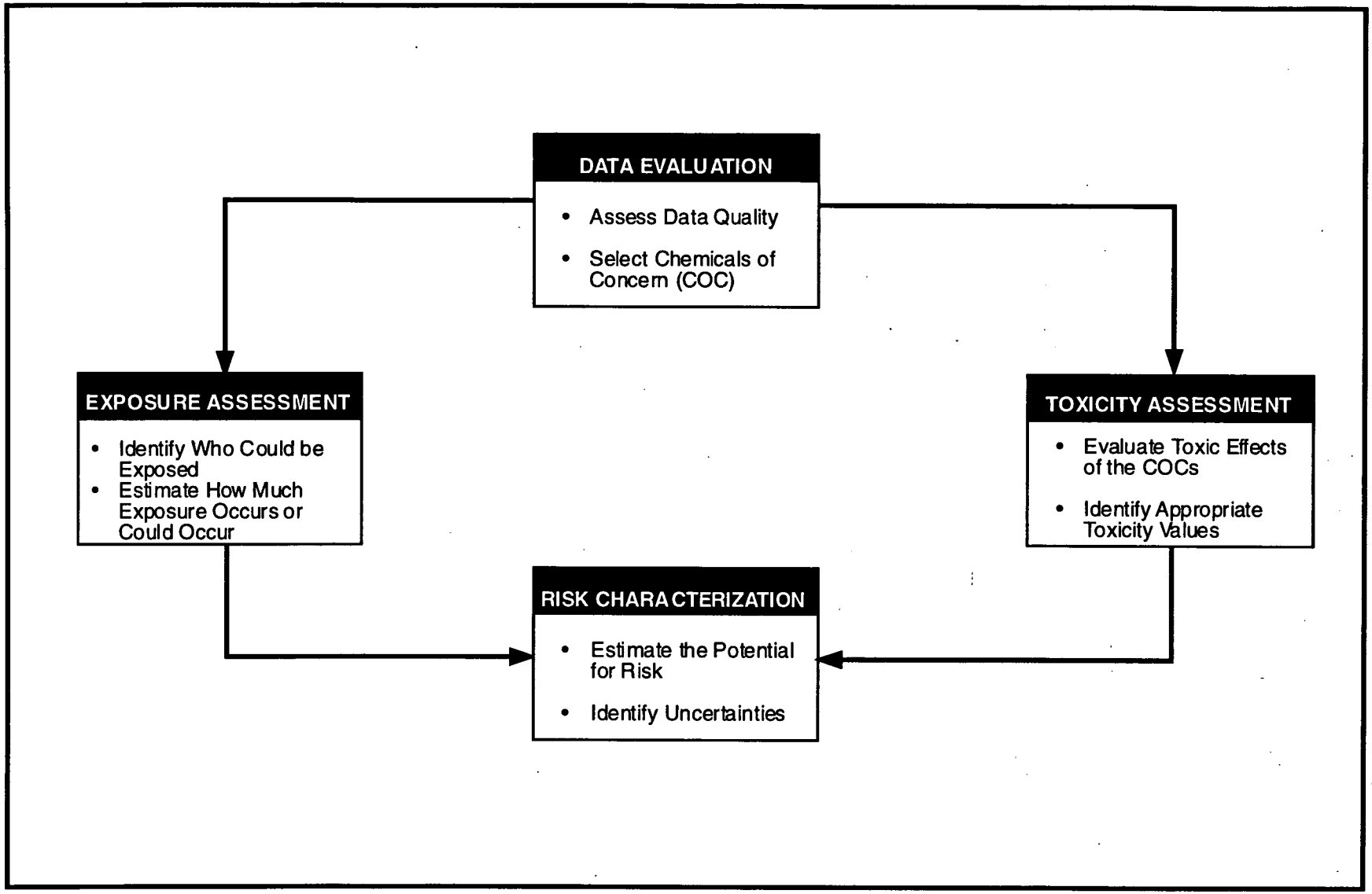

Figure A1-1
Human Health Risk Assessment Process

- *External Exposure to Radionuclides in Air, Water, and Soil,* Federal Report No. 12, 402-R-93-081, (EPA, 1993).

- Publications of the National Council of Radiation Protection, International Council on Radiological Protection, United Nations Scientific Committee on the Effects of Atomic Radiation, as appropriate.

In addition, site-specific risk assessment guidance provided by EPA and CDPHE was followed (CDPHE/EPA/DOE, 1994; DOE, 1994a; DOE, 1993a; and EPA, 1994a).

A1.4 TECHNICAL MEMORANDA

The following Technical Memoranda were prepared as part of the HHRA process for OU 3:

- Technical Memorandum No. 2, Human Health Risk Assessment for Operable Unit No. 3, Rocky Flats Plant, Exposure Scenarios; April 23, 1993.

- Addendum to Technical Memorandum No. 2, Human Health Risk Assessment, Exposure Scenarios, Operable Unit 3; April 11, 1995.

- Technical Memorandum No. 3, Human Health Risk Assessment Model Description, Operable Unit 3; March 6, 1995.

- Technical Memorandum No. 4, Human Health Risk Assessment, Chemicals of Concern Identification, Operable Unit 3; September 23, 1994.

- Technical Memorandum No. 5, Human Health Risk Assessment, Toxicity Assessment, Operable Unit 3; September 2, 1994.

In addition, the CDPHE Conservative Screen Letter Report was prepared for OU 3 (DOE, 1994b). Information summarized in Sections A3.0 through A6.0 of this appendix has been presented to EPA and CDPHE in the Technical Memoranda and CDPHE Conservative Screen Letter Report.

A1.5 HHRA OVERVIEW

Section A2.0 provides an overview of the history of Rocky Flats as it affects environmental media in OU 3, a description of the historical data used in the HHRA, and a general description of the field investigation conducted at OU 3.

Section A3.0 presents the identification of the areas of concern.

Section A4.0 summarizes the chemicals of concern.

Section A5.0 presents the exposure assessment.

Section A6.0 presents the toxicity assessment.

Section A7.0 is the risk characterization.

Section A8.0 is the uncertainty analysis.

Section A9.0 provides the references.

Attachment 1 includes exposure parameters.

Attachment 2 includes RBC ratios.

Attachment 3 includes risk and dose calculations.

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A2.0 ENVIRONMENTAL MEDIA IN OU3

This section provides an overview of the history of Rocky Flats as it affects environmental media in OU 3, a description of the historical data used in the HHRA, and a general description of the field investigation conducted at OU 3 for the RFI/RI process.

A2.1 THE HISTORY OF OU 3

OU 3 is unique among Rocky Flats OUs in that it is located outside of site boundaries. The designated OU 3 study area as shown on Figure 1-2 of the RFI/RI Report is not intended to be a legal definition or defined boundary, but rather a practical way to evaluate OU 3. The locations of the four IHSSs in OU 3 are shown in Figure 1-2.

A2.1.1 Potential Sources of Contamination

Most of the plutonium contamination in OU 3 originated as wind-blown particulates from the 903 Pad. Contamination of soils on the 903 Pad resulted when 55-gallon drums of plutonium-contaminated coolant corroded and released contaminated coolant into the soils over a 10-year period. Upon removal of these drums, the soils were exposed to wind erosion, resuspension, and deposition into OU 3. Minor amounts of contaminants were released during the 1957 fire in Building 771 and the 1969 fire in Building 776. Other sources of potential contamination include early operation practices that resulted in surface water releases and reconstruction of the holding ponds, which released contaminated sediments into Great Western Reservoir.

A2.2 POTENTIALLY AFFECTED ENVIRONMENTAL MEDIA

The potentially affected media in OU 3 include the following:

- Soil
- Sediment
- Surface water
- Groundwater
- Air

During the RFI/RI field investigation discussed in Section A2.4, samples were collected from each of the five media to evaluate the impact of Rocky Flats on the OU 3 media. Details of the field investigation can be found in Section 2.0.

A2.3 LAND USE AND DEMOGRAPHICS

A 1994 demographic study shows that approximately 2.2 million people live within a 52-mile radius of Rocky Flats (DOE, 1995a). Between 1989 and 1994, the population of the eight-county Denver metropolitan area increased by 73,508. Between 1985 and 1989, a 1.0 percent annual increase in population matched the national average. In 1989, only a 0.1 percent increase in population was recorded (DOE, 1993b).

Most residential use within 5 miles (8 kilometers [km]) of Rocky Flats is located to the east, in the city of Broomfield subdivision and to the southeast, just south of Standley Lake (IHSS 201). Single-family dwellings are located in unincorporated areas immediately east and south of Rocky Flats. Figure A2-1 portrays the 1994 population estimates and household numbers within a 10-mile radius of Rocky Flats. The area of Figure A2-1, including Sectors 2 through 5 and the pie sections P through J, present a general estimate of the population in the OU 3 study area. Sector 1 is not considered part of the OU 3 study area because this sector lies within the site boundaries. Table A2-1 is a summary of the sectors and the associated sections that are pertinent to the OU 3 study area for 1994, 2005, and 2015.

Population increases with increasing distance from Rocky Flats. Commercial development is concentrated near the residential developments southeast of Rocky Flats and generally east and south of Standley Lake, and around the Jefferson County Airport. Industrial land use within 5 miles (8 km) of the plant is limited to quarrying and mining operations. Open-space lands are located northeast of Rocky Flats near the City of Broomfield, and in small parcels adjoining major drainages and small neighborhood parks in the cities of Westminster and Arvada (e.g., Standley Lake is surrounded by Standley Lake Park). Irrigated and nonirrigated croplands, producing primarily wheat and barley, are located northeast of Rocky Flats near the cities of Broomfield, Lafayette, and Louisville; north of Rocky Flats near Louisville and Boulder; and in scattered parcels adjacent to the eastern boundary of the site. Several horse operations and small hay fields are located south of Rocky Flats. The presence of cattle have been noted east and southeast of the site. The demographics report characterizes much of the vacant land adjacent to Rocky Flats and the reservoirs as rangeland (DOE, 1995a).

Table A2-1
Summary of Population Sectors in the OU 3 Study Area

Sector	1994 Pop.	1994 Household No.	2005 Pop.	2005 Household No.	2015 Pop.	2015 Household No.
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	182	75	1,957	739	3,318	1,308
4	2,683	868	6,852	2,444	10,059	3,801
5	10,757	3,591	17,667	6,357	23,625	8,940

(DOE 1995a)

Future land use in the vicinity of Rocky Flats will most likely involve continued suburban expansion, with increases in the density of residential, commercial, and perhaps industrial land use in the area. A large area of future residential growth is projected around the perimeter of the Standley Lake Park, where a trend of building to closeout densities is predicted. The primary growth in residential development is projected for the land west of Standley Lake and east of Indiana Street, which is an area that is currently vacant and undeveloped rangeland (DOE, 1992).

The largest anticipated change in land surface regarding recreational/open-space use is the addition of more open space to Standley Lake. The Standley Lake task force is considering the transformation of the Standley Lake area into a state park that would be managed by the Colorado Division of Parks and Outdoor Recreation (DOE, 1992).

A reduction in open space between Great Western Reservoir and Standley Lake is predicted because of the proposed residential and commercial/industrial development in that area (Broomfield, 1991).

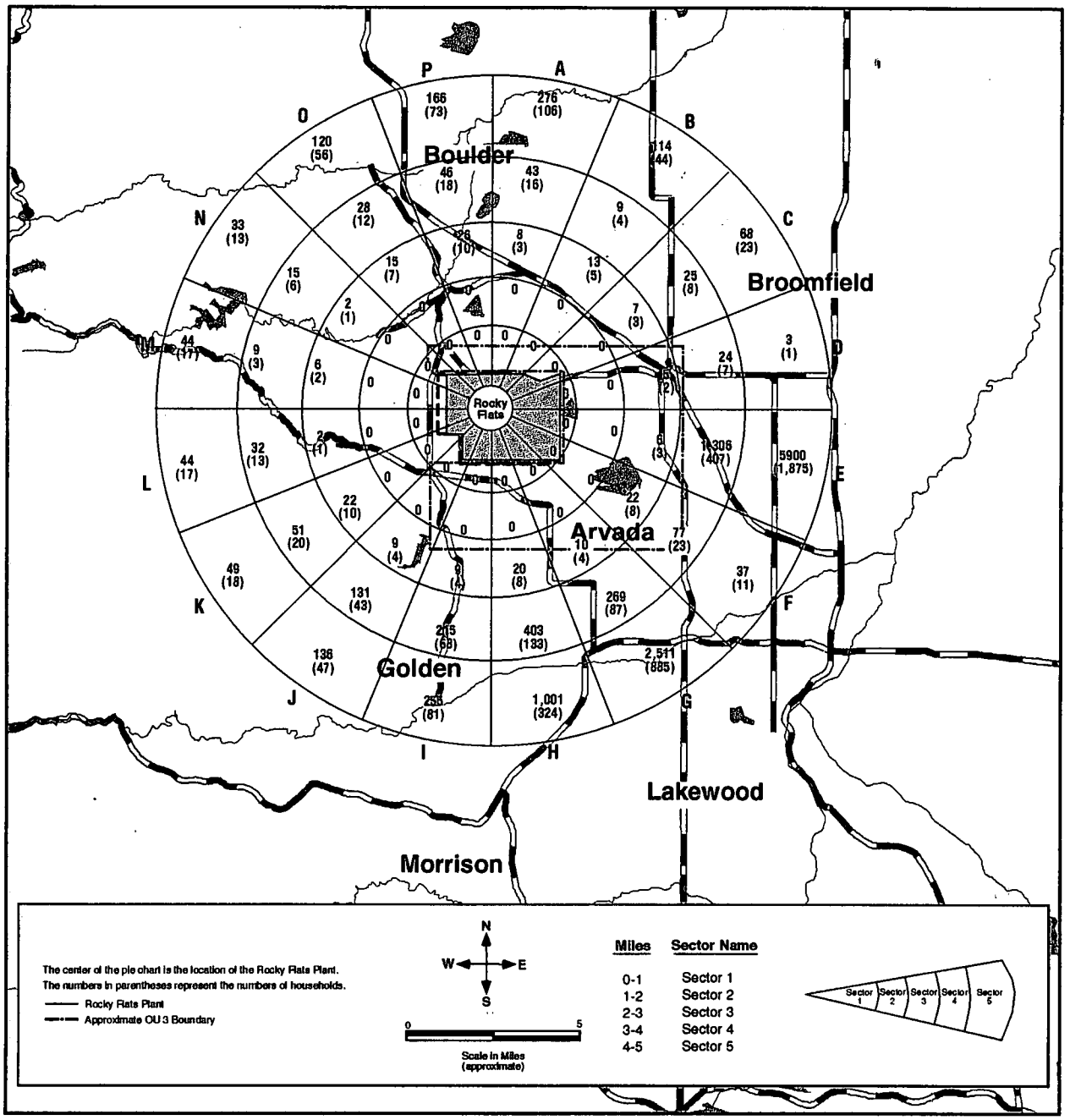

Figure A2-1 1994 Population and (Households)
Sectors 1-5

However, the open space area in the immediate vicinity of Great Western Reservoir is projected to remain as open space, with less restricted access to the area for recreational/open space purposes.

Available land use and development documents indicate a decline in large-scale parcels of land zoned for agricultural use. Agricultural-based activities are expected to decline over time.

Further details on land use and demographics can be found in Volume 1, Subsection 3.2.

A2.4 DESCRIPTION OF HISTORICAL DATA

Historical data for the IHSSs included in OU 3 were reviewed during development of the RFI/RI Work Plan (DOE, 1992). These data are summarized in the *Final Past Remedy Report Operable Unit No. 3-IHSS 199* (DOE, 1991a) and in the *Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3-IHSS 200, 201, and 202* (DOE, 1991b). The useability of the previous data collected was reviewed in accordance with the procedures found in *Guidance for Data Useability in Risk Assessment (Part A)* (EPA, 1990b). The conclusions indicated that, although useful for evaluating the general nature of the hazards, much of the data do not meet data quality objectives (DQOs) to perform a rigorous quantitative risk assessment (DOE, 1992).

Site-specific background data are available for surface soil, stream sediments, stream surface water, and groundwater from the following sources:

- Rock Creek Background Soil Samples (surface soil) (DOE, 1993b)
- Background Geochemical Characterization Report (surface sediments and surface water collected from streams, and groundwater) (DOE, 1993c)

These data sets include results from samples collected at stations located in buffer zone areas west, north, and south of the industrial areas of Rocky Flats (DOE, 1993c). These buffer areas have remained undisturbed by plant operations. Therefore, results of the analyses for these samples represent "background" conditions for Rocky Flats. No samples were collected from nearshore sediments, water, or subsurface sediments from background reservoirs or lakes in areas near Rocky Flats.

A2.5 OU 3 FIELD INVESTIGATION

Field investigations were performed at OU 3 to meet the RFI/RI objectives specified in the OU 3 Work Plan, which was approved by EPA and CDPHE (DOE, 1992). Based on the objectives, OU 3-specific DQOs and data needs were identified in the OU 3 RFI/RI Work Plan. Soil, surface water, sediment, groundwater, air quality, meteorological, and ecological data collection comprised the field work to help achieve the DQOs. More specific sample information and the results and data can be found in the RFI/RI Report, Section 2.0 and Appendixes C, D, and E, for all of the media discussed in the following subsections. The ecological data are presented and discussed in the Ecological Risk Assessment in Appendix B.

A2.5.1 Surface and Subsurface Soil

The purpose of the surface soil sampling program was to characterize the lateral extent of plutonium, americium, and uranium contamination in OU 3 and to confirm results obtained from previous soil investigations. The surface-soil investigation consisted of sampling from 61 locations located north,

east, and south of Rocky Flats. The samples were collected from the study area from June 1992 through June 1993. The samples were analyzed for plutonium-239, -240, americium-241, uranium-233, -234, uranium-235, and uranium-238.

The RFI/RI trench data set consists of 549 radionuclide measurements taken from 11 trenches in OU 3. In each trench, 10 samples were collected from ground surface to a depth of 96 cm. The purpose of the sampling was to evaluate the presence, activities, and vertical distribution of radionuclides in subsurface soils. The trench soil samples were analyzed for plutonium-239, -240, americium-241, uranium-233, -234, uranium-235, and uranium-238.

A2.5.2 Sediment

The purpose of the sediment sample collection was to evaluate the presence, concentrations, and distribution of potential contaminants associated with sediments. The sediment investigation consisted of sampling the reservoirs and drainages through sediment grab and sediment core samples. The drainages that were sampled for sediment include: Woman Creek, Walnut Creek, and Big Dry Creek; and the reservoirs sampled included: Great Western Reservoir (IHSS 200), Standley Lake (IHSS 201), and Mower Reservoir (IHSS 202).

Samples were collected from July to October 1992 and analyzed for radionuclides (including tritium, cesium-137, and strontium-89, -90 at several locations) and Target Analyte List (TAL) metals. Additionally, some samples were analyzed for total organic carbon (TOC), specific gravity, grain size, and volatile organic compounds (VOCs).

A2.5.3 Surface Water

The purpose of the surface-water sample collection was to characterize radionuclides and metals residing within the OU 3 drainages and reservoirs. Although one objective was to evaluate seasonal fluctuations, insufficient flows prevented useful measurements for this purpose. The drainages that were sampled for surface water include Walnut Creek, Woman Creek, Dry Creek Valley Ditch, Church Ditch, Coal Creek, and Big Dry Creek. The reservoirs that were sampled included Great Western Reservoir, Standley Lake, and Mower Reservoir.

Samples were collected at different locations in May, June, July, and October 1992 and analyzed for both dissolved and total radionuclides and metals. At Mower Reservoir, VOCs were also analyzed. The surface-water samples were also analyzed for other parameters, including atrazine, simazine, oil and grease, nitrate and nitrite, orthophosphate, ammonia, hydrogen sulfide, sulfate, bicarbonate, carbonate, chloride, fluoride, total dissolved solids, and total suspended solids. Water quality analyses were performed to obtain *in situ* measurements of pH, temperature, alkalinity, hardness, turbidity, dissolved oxygen, and conductivity.

A2.5.4 Groundwater

The purpose of the groundwater sampling was to obtain site-specific hydrogeologic information in the vicinity of Great Western Reservoir and Standley Lake and to assess impacts on groundwater from potential contamination that has been dispersed offsite to OU 3 through the reservoirs. Groundwater sampling was also used to identify potential contamination from sediment/groundwater interactions and surface water/groundwater interactions. In December 1992, two wells were installed and one at the base of the dam on the east side of Standley Reservoir; one at the base of the dam on the east side of Great

Western Reservoir. Beginning in January 1993, groundwater samples were collected monthly from the two monitoring wells. The samples were analyzed for the following in situ parameters: water level, pH, temperature, specific conductance, turbidity, and dissolved oxygen. The samples were analyzed for plutonium, americium, uranium, nitrates and other major anions, total metals, and dissolved metals.

A2.5.5 Air

Ambient-air monitoring in OU 3 began in May 1995 using three ultra high-volume air monitoring stations situated in the vicinity of Standley Lake. No air monitoring data are available at this writing. It is anticipated that approximately six months of air monitoring data will be available for use in the HHRA in time for the final RFI/RI report.

Wind-tunnel studies were conducted to measure resuspension of particulates from soil. The studies were designed to address particle size distributions relative to wind speed, and activities of suspended radionuclides by particle size (DOE, 1992). The analytes selected as COCs for soil are also considered COCs for airborne particulates through resuspension of soil. Data from wind-tunnel studies, in combination with surface-soil data, are used in the HHRA to evaluate exposure by the inhalation (air) pathway. Air monitoring data collected through the Rocky Flats Radionuclide Ambient Air Monitoring Program (RAAMP) are used in the HHRA to verify estimated ambient radionuclide activities, based on the data from wind-tunnel studies.

A2.5.6 Results

Summary statistics for each analyte are presented by environmental medium in Appendix D of the RFI/RI report.

The data evaluations performed under the RFI/RI Work Plan and described in detail in the RFI/RI Report indicate that most of the analytes detected within OU 3 are found at concentrations/activities within background levels. The exceptions to this statement are as follows:

- Plutonium-239, -240 was found to be elevated above background levels in surface soils and sediments within three 10-acre plots.
- Americium-241 was found to be elevated above background levels in surface soils.
- Copper was found to be elevated above background levels in Great Western Reservoir subsurface sediments.
- Arsenic, cadmium, copper, lead, nickel, potassium, and zinc were elevated above background levels in subsurface sediments in Standley Lake. However, results of spatial analysis indicate the presence of these metals is not related to Rocky Flats.
- Potassium was found to be elevated above background levels in Mower Reservoir subsurface sediments and to be slightly elevated in groundwater. However, because potassium is an essential human nutrient, it was not evaluated quantitatively in the HHRA.
- Strontium was found to be slightly elevated above background levels in groundwater.

Further details on the nature and extent of contamination in OU 3 can be found in Section 4.0.

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A3.0 IDENTIFICATION OF AREAS OF CONCERN

This section and the section that follows describe the process and results associated with two separate but related data evaluations used to identify Areas of Concern (AOCs) and COCs specific to OU 3. The objective of the AOCs identification process is to first identify source areas (as defined by CDPHE) that, due to the nature and extent of contamination, warrant detailed evaluation. Source areas may then be aggregated into AOCs. The objective of the COC selection process is to identify potentially site-related chemicals (i.e., potentially related to historical releases from Rocky Flats and subsequent transport to OU 3) whose concentrations/activities exceed background levels and whose presence may represent a significant impact on human health. The conservative nature of both the AOC and COC processes ensures that the areas of OU 3 associated with risk are identified and evaluated in the HHRA.

Each of the data evaluation processes presented in this section and Section A4.0 are applied on an IHSS-specific basis. Consequently, each IHSS is associated with specific AOCs and COCs. The IHSSs are evaluated individually because each is associated with unique characteristics:

- IHSS 199 delineates the area associated with surface soil contamination from deposition of wind-blown particulates from Rocky Flats.

- IHSS 200, IHSS 201, and IHSS 202 include the three reservoirs and their associated drainages that received runoff or discharges from different drainages associated with various areas within and surrounding Rocky Flats.

This section summarily describes the processes and results of the AOC data evaluation. Complete details and results are presented in two reports: (1) the CDPHE Conservative Screen Letter Report (DOE, 1994b) and (2) the Responses to CDPHE Comments on the CDPHE Conservative Screen Letter Report for OU 3 (DOE, 1995b,c).

A3.1 SUMMARY OF AOC IDENTIFICATION PROCESS

AOCs for OU 3 were identified using the CDPHE Conservative Screen. The CDPHE Conservative Screen was also used to determine if a HHRA was necessary. The CDPHE Conservative Screen (Figure A3-1) includes the following six steps:

- STEP 1: Define Potential Chemicals of Concern (PCOCs). PCOCs are defined as either inorganic analytes with concentrations or activities detected in OU 3 that are significantly elevated over background levels, or as organic analytes detected in OU 3 at concentrations greater than the detection limits reported in the Rocky Flats Environmental Database System (RFEDS). Section A3.2 describes the data sets used in this step.

- STEP 2: Identify "Source Areas." Source Areas are defined for the CDPHE Conservative Screen as those areas of each IHSS within the OU where concentrations or activities of each PCOC exceed an upper-bound background value (i.e., background mean plus two standard deviations).

- STEP 3: Calculate a risk-based concentration (RBC) for each PCOC.

- STEP 4: Calculate an RBC Ratio Sum for each Source Area by summing the PCOC-specific RBC ratios for each medium within each Source Area.

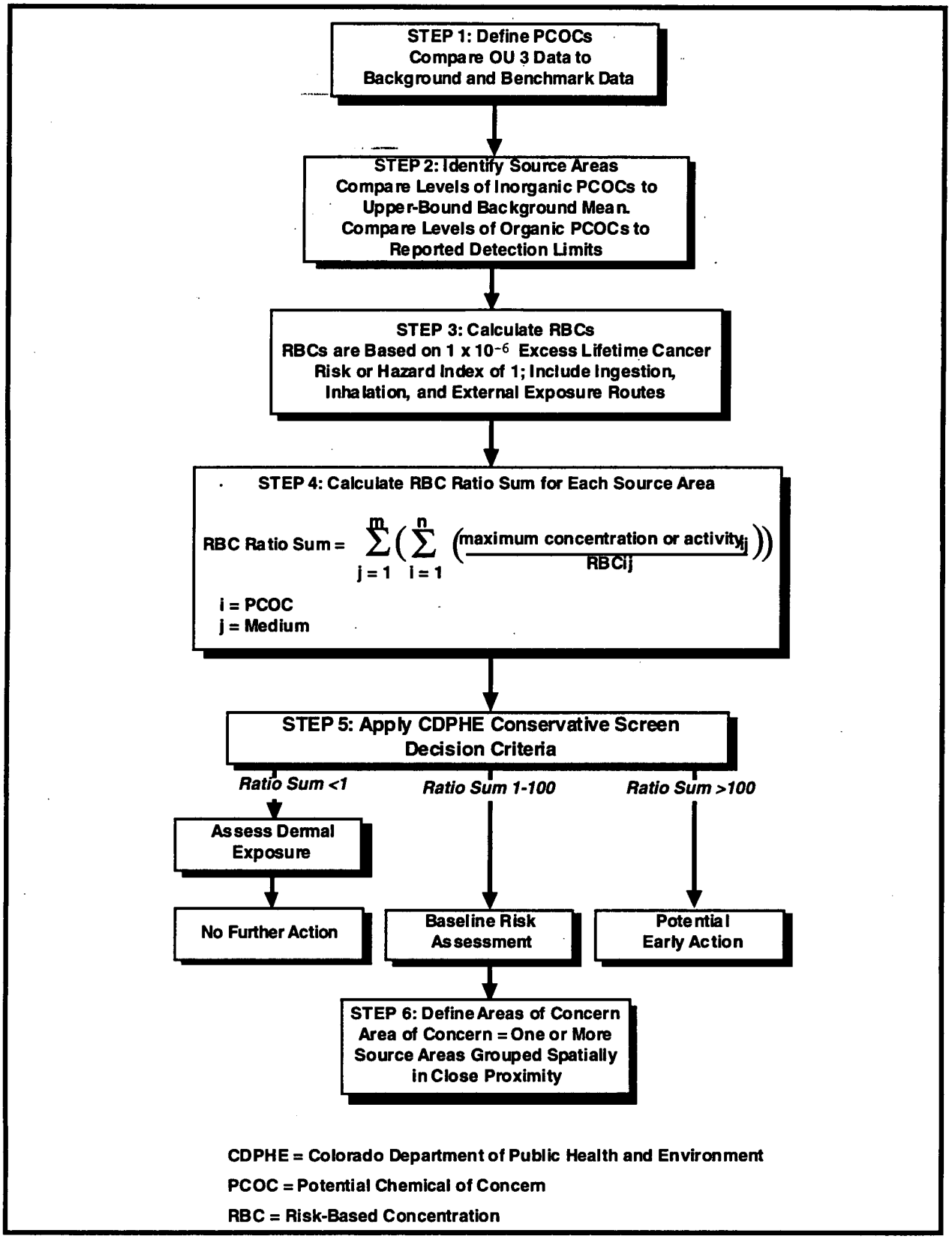

Figure A3-1
CDPHE Conservative Screen Process

- STEP 5: Apply the CDPHE Conservative Screen decision criteria to each Source Area (Figure A3-1).

- STEP 6: Define AOCs.

A3.2 DATA SETS USED IN THE CDPHE CONSERVATIVE SCREEN

In Step 1 of the CDPHE Conservative Screen process, soil data were compared to available background data, using statistical comparison tests and methodologies developed for Rocky Flats (Gilbert, 1993), to identify PCOCs for soil. In addition, for OU 3, mean and maximum values for sediment, surface water, and groundwater data were compared to literature benchmark data and data in the Background Geochemical Characterization Report (BGCR) (DOE, 1993c). Finally, data for these media were also analyzed using various semi-quantitative statistical methods.

Data collected during the OU 3 RFI/RI field investigation program were prepared for quantitative data analysis tasks, including the CDPHE Conservative Screen following standard and Rocky Flats-specific data-treatment protocols. A detailed description of the preparation process is included in Appendix F of the RFI/RI report. In addition, surface-soil data from the Remedy Lands (DOE, 1991a) and sediment data from the 1983/1984 Sediment Investigations in Great Western Reservoir and Standley Lake (DOE, 1991b) were used in the CDPHE Conservative Screen.

The OU 3 sample data sets used in the CDPHE Conservative Screen are summarized in Table A3-1 by IHSS and medium. Surface soil is the only OU 3 medium that has a background data set suitable for rigorous statistical comparisons. A "weight-of-evidence evaluation" was used to evaluate data sets for which no background data were available. This weight-of-evidence evaluation involves the application of a variety of data analysis techniques in lieu of rigorous statistical tests. The results of the evaluations are considered together to assess if levels of chemicals in OU 3 represent background conditions or contamination. A detailed description of the weight-of-evidence approach is provided in Section A4.1.6.

Further details on how the CDPHE Conservative Screen was applied to the OU 3 IHSSs and media, can be found in the CDPHE Conservative Screen Letter Report (DOE, 1994b). Figure A3-2 is a flowchart that shows the weight-of-evidence process used to compare OU 3 data to background.

Table A3-2 summarizes the PCOCs identified as a result of Step 1 of the CDPHE Conservative Screen. The following describes the results in more detail.

A3.2.1 Surface-Soil Results

The results of the background statistical comparison indicate americium-241 and plutonium-239, -240 are PCOCs for surface soil in OU 3. These two radionuclides were identified as PCOCs by more than one statistical test (hot-measurement test, Slippage test, Quantile test, Gehan test for americium-241 and plutonium-239, -240, and t-test for plutonium-239, -240), and the pattern of americium-241 and plutonium-239, -240 activities in surface soil suggests that the reported levels are not attributable to background conditions, but rather represent wind-blown deposition.

A3.2.2 Subsurface-Soil (Trench Data) Results

More than one of the statistical tests indicates that activities of americium-241 and plutonium-239, -240 in OU 3 subsurface soil are significantly different than background. Because the maximum values for

Table A3-1
OU 3 Data Sets Used in the CDPHE Conservative Screen
Rocky Flats Environmental Technology Site

IHSS	Medium	Description
199	Surface Soil	61 RFI/RI plots, average of CDPHE (O - 0.25 in.) and RFP (0 - 2 in.) sample collection methods; 47 Jefferson County Remedy Acre locations (Remedy Lands)
	Subsurface Soil	11 trenches were sampled at 10 depth intervals down to 96 cm
200	Surface Water	13 sample locations in reservoir and streams/ditches
	Surface Sediment	41 RFI/RI sample locations in reservoir and streams/ditches sampled from 0 to 6 in.; 51, 1983/84 sample locations
	Subsurface Sediments	8 sample locations in reservoir samples at 1 in. and 2 in. depth intervals down to approximately 36 in.
	Groundwater	1 sample location
201	Surface Water	12 sample locations in reservoir and streams/ditches
	Surface Sediment	48 sample locations in reservoir and streams/ditches sampled from 0 to 6 in.; 1983/84 sample locations
	Subsurface Sediments	8 sample locations in reservoir sampled at 1 in. and 2 in. depth intervals down to approximately 36 in.
	Groundwater	1 sample location
202	Surface Water	8 sample locations in reservoir and streams/ditches
	Surface Sediment	14 sample locations in reservoir and streams/ditches sampled from 0 to 6 in.
	Subsurface Sediments	4 sample locations in reservoir sampled at 1 in. and 2 in. depth intervals down to approximately 36 in.

these two analytes were found in surface soil samples, the surface soil data were used to define the AOCs in the CDPHE Conservative Screen Letter Report (DOE, 1994b).

A3.2.3 Surface-Sediment Results

Because background data were not available for rigorous statistical evaluation of surface sediment data, weight-of-evidence evaluations were performed for radionuclides, metals, and organic compounds (IHSS

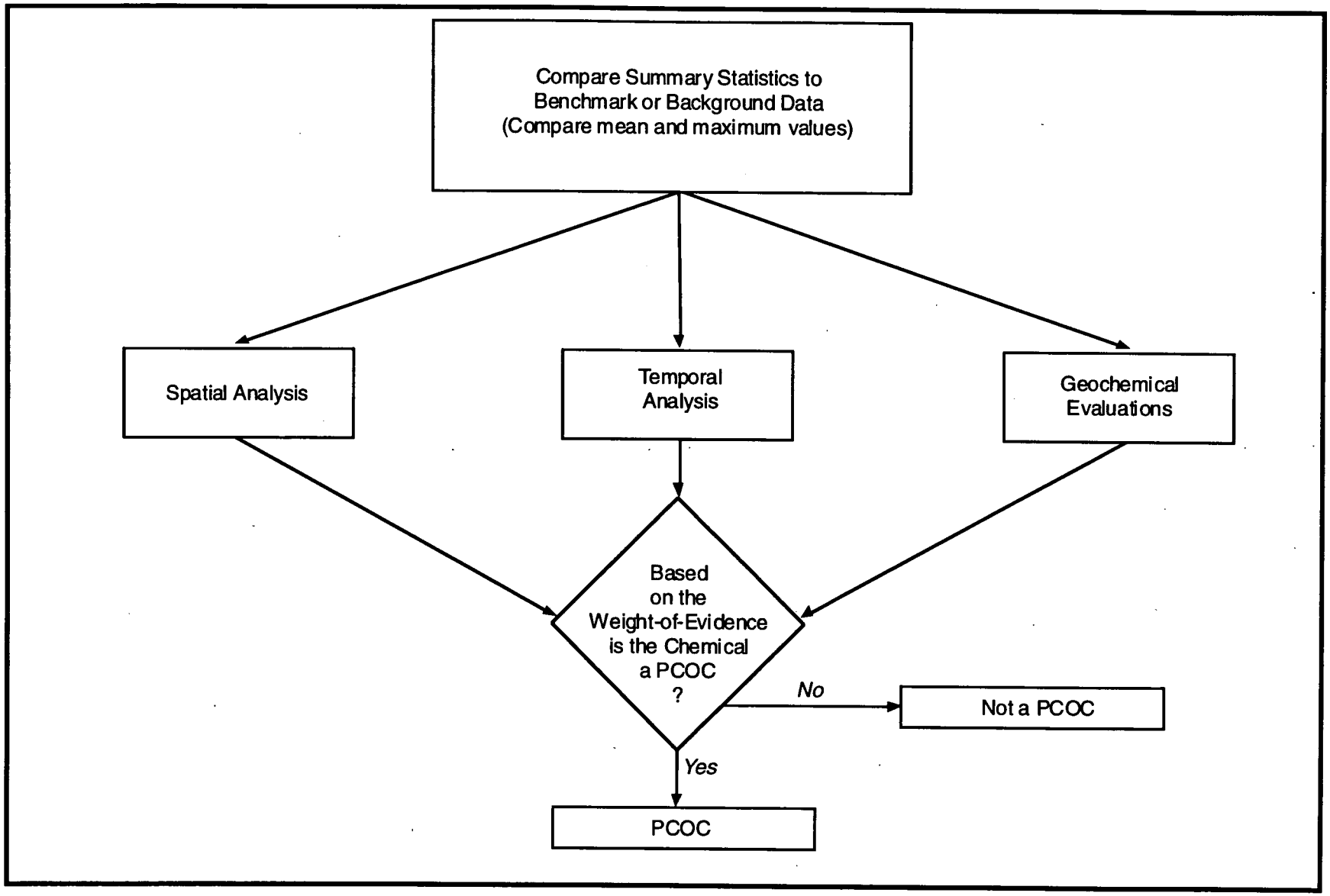

Figure A3-2
Weight-of-Evidence Evaluations

Table A3-2
OU 3 Potential Chemicals of Concern for
Rocky Flats Environmental Technology Site

Media	IHSS	PCOCs
Surface Soil	199	Americium-241 Plutonium-239, -240
Subsurface Soil	199	Americium-241 Plutonium-239, -240
Surface Sediment (Grab Samples)	200 (Great Western Reservoir) 201 (Standley Lake) 202 (Mower Reservoir)	Plutonium-239, -240 None None
Subsurface Sediments (Core Samples)	200 (Great Western Reservoir) 201 (Standley Lake) 202 (Mower Reservoir)	Plutonium-239, -240 Copper None None
Surface Water	200 (Great Western Reservoir) 201 (Standley Lake) 202 (Mower Reservoir)	None None None
Groundwater	200 (Great Western Reservoir) 201 (Standley Lake)	Strontium None

Note: PCOCs are inorganic chemicals with detected concentrations above background levels or organic chemicals detected above reported detection limits.

200 only) in surface sediments. The weight-of-evidence approach, as applied to surface sediments, is described in detail in the CDPHE Conservative Screen Letter Report (DOE, 1994b). The results indicated that only plutonium-239, -240 in Great Western Reservoir (IHSS 200) was a PCOC for surface sediments. The mean and maximum values for plutonium-239, -240 in IHSS 200 reservoir sediment samples exceeded corresponding benchmark values.

No surface sediment constituents detected in IHSSs 201 or 202 were retained as PCOCs as a result of the weight-of-evidence evaluation. Plutonium-239, -240 was not a PCOC in IHSSs 201 and 202 for the following reasons:

- For IHSS 201, the mean value of plutonium-239, -240 in OU 3 reservoir-sediment samples was less than the benchmark values, and the mean and maximum values for OU 3 stream-sediment samples were less than corresponding mean and maximum BGCR stream-sediment values.
- For IHSS 202, the mean and maximum values for plutonium-239, -240 in OU 3 stream-sediment samples were less than the corresponding mean and maximum BGCR stream-sediment values.

A3.2.4 Subsurface-Sediment Results

The results of the weight-of-evidence evaluations indicate plutonium-239, -240 and copper are PCOCs for subsurface sediments in Great Western Reservoir, based on the following:

- The mean and maximum copper concentrations exceed the BGCR mean and maximum values; the maximum copper concentration exceeds the maximum benchmark value.

- The mean and maximum values for plutonium-239, -240 in subsurface sediment samples exceed corresponding benchmark values and BGCR stream-sediment values.

The results of the weight-of-evidence evaluations for americium-241 and plutonium-239, -240 for IHSS 201 and IHSS 202, based on the background comparisons, indicate that they are not PCOCs for IHSS 201 and IHSS 202. However, these analytes were retained for further analysis in the Conservative Screen, as requested by CDPHE, because they are associated with Rocky Flats activities.

The results of the background and benchmark comparisons for metals in IHSS 201 and IHSS 202 eliminated all metals, except arsenic, cadmium, copper, lead, nickel, potassium, and zinc for Standley Lake (IHSS 201) and potassium for Mower Reservoir (IHSS 202). Based on results of spatial analysis, the analytes in IHSS 201 were eliminated as PCOCs. Potassium was not retained as a PCOC for Mower Reservoir because it is an essential human nutrient.

A3.2.5 Surface-Water Results

No VOCs were detected in surface-water samples from IHSS 202 and, therefore, no organic PCOCs were identified for surface water. Based on the weight-of-evidence evaluations, no inorganic PCOCs were identified for surface water in IHSSs 200, 201, or 202.

A3.2.6 Groundwater Results

The results of the weight-of-evidence evaluations indicate strontium is a PCOC for groundwater (IHSS 200 only) for the following reasons:

- The mean and maximum values for strontium in OU 3 groundwater exceed corresponding mean and maximum values for BGCR groundwater samples.

- The maximum value for strontium in OU 3 groundwater exceeds the maximum benchmark value.

A3.3 IDENTIFICATION OF SOURCE AREAS

The purpose of Step 2 of the CDPHE Conservative Screen is to delineate areas of each IHSS within OU 3 where concentrations or activities of each PCOC exceed an upper-bound background value (i.e., background mean plus two standard deviations); these areas are then designated as "Source Areas" that are further evaluated in the Conservative Screen. The Source Areas identified by this step can represent potential contamination associated with primary sources located within the OU, or as is the case for OU 3, secondary sources resulting from deposition of chemicals that have migrated from primary sources on Rocky Flats. For Great Western Reservoir, the entire IHSS was considered as a Source Area for

subsequent steps in the CDPHE Conservative Screen because the IHSS is a spatially discrete water body. Individual drainages associated with the reservoir are also included.

Surface soil is the only OU 3 medium associated with a background data set suitable for rigorous statistical comparisons. For IHSS 199, americium-241 and plutonium-239, -240 activities at each surface-soil sampling location, including the RFI/RI and Remedy Lands sampling plots, were compared to their respective upper-bound background values (i.e., 0.04 picocuries per gram [pCi/g] for americium-241 and 0.09 pCi/g for plutonium-239, -240). Nineteen out of 61 RFI/RI sample locations (see Figure 3-3 of Volume 1) and all 47 Remedy Lands locations (see Figure 3-4 of Volume 1) have americium-241 or plutonium-239, -240 activities that exceed the upper-bound background values and, therefore, were identified as Source Areas for OU 3. Figures 3-3 and 3-4 also show all RFI/RI and Remedy Lands sampling locations, respectively. Figure 3-4 shows two locations for T8, which is a composited sample. The left half of the symbols on the figures show the results of the comparison of the americium-241 activity at each location to the upper-bound americium-241 background value. The right half of the symbols show the results of the comparison of the plutonium-239, -240 activity at each location to the upper-bound plutonium-239 ,-240 background value. Blue symbols indicate a sample location with an activity greater than the upper-bound background value. Green symbols represent sample locations that do not exceed upper-bound background values; 42 of the 61 RFI/RI locations have americium-241 and plutonium-239 ,-240 activities that do not exceed upper-bound background values. Table A3-3 summarizes americium-241 and plutonium-239, -240 activities for each surface-soil sampling location.

A3.4 CALCULATIONS OF RISK-BASED CONCENTRATIONS

The RBCs presented in the Final Rocky Flats Programmatic Risk-Based Preliminary Remediation Goals (DOE, 1994c) were used for Step 3 of the CDPHE Conservative Screen for OU 3. The purpose of the Programmatic Preliminary Remediation Goals (PPRGs) document was to develop initial sitewide cleanup goals (chemical- and medium-specific) for Rocky Flats that are protective of human health and the environment (DOE, 1994c). The PPRGs also were developed to be used as RBCs in the data aggregation process for HHRAs.

The RBCs used in the CDPHE Conservative Screen for OU 3 are based on a residential exposure scenario for soil, sediment, and groundwater. To calculate the RBCs, a target risk of 1×10^{-6} was used for carcinogenic chemicals and a target Hazard Index of 1 was used for noncarcinogenic chemicals. The RBCs are based on exposure via the ingestion, inhalation, and external exposure (radionuclides only) pathways. Table A3-4 summarizes the RBCs for each PCOC in surface soil, surface sediment, subsurface sediment, and groundwater. RBCs were not calculated for surface water because no PCOCs were identified.

A3.5 RATIO OF MAXIMUM CONCENTRATIONS TO RISK-BASED CONCENTRATIONS

For Step 4 of the CDPHE Conservative Screen, the following ratio was calculated for each PCOC per medium in each Source Area identified in Step 2.

$$\text{RBC Ratio} = \frac{\text{Maximum detected concentration or activity of PCOC}}{\text{RBC for PCOC}} \qquad \text{(A-1)}$$

The PCOC-specific ratios were then summed for each medium within a Source Area. Ratios for carcinogenic PCOC and noncarcinogenic PCOCs were summed separately because exposures to these two types of PCOCs result in different adverse health effects. Finally, the medium-specific ratios were

Table A3-3
Americium-241 and Plutonium-239, -240 Activities for OU 3 Surface-Soil Sampling Locations

Location Code	Americium-241	Plutonium-239, -240
PT12592	0.012	0.029
PT12692	0.012	0.023
PT12792	0.029	0.132
PT12892	0.030	0.036
PT12992	R	0.020
PT13092	0.021	0.047
PT13192	0.028	0.069
PT13292	0.008	0.017
PT13392	0.011	0.041
PT13492	0.003	0.030
PT13592	0.062	0.205
PT13792	0.011	0.034
PT14092	0.010	0.021
PT14192	0.520	2.950
PT14292	0.013	0.280
PT14392	0.020	0.270
PT14492	0.033	0.015
PT14592	0.030	0.068
PT14692	0.013	0.035
PT14792	0.006	0.013
PT14892	0.001	0.008
PT14992	0.023	0.095
PT15092	0.036	0.160
PT15192	0.081	0.745
PT15292	0.095	0.511
PT15392	0.034	0.215
PT15492	0.026	0.055
PT15592	0.013	0.041
PT15692	0.019	0.036
PT15792	-0.002	0.012
PT15892	0.004	0.042
PT15992	0.006	0.282
PT16092	0.004	0.041
PT16192	0.016	0.052
PT16292	0.068	0.089
PT16392	0.054	0.115
PT16492	0.008	0.024
PT16592	0.013	0.034
PT16692	0.027	0.040
PT16792	0.001	0.020
PT16992	0.003	0.028
PT17092	0.011	0.031
PT17192	0.026	0.016

Table A3-3 (continued)

Location Code	Americium-241	Plutonium-239, -240
PT17292	R	0.085
PT17392	0.005	0.034
PT17492	0.002	0.017
PT17692	0.004	0.012
PT17792	0.008	0.074
PT17992	0.014	0.059
PT18592	0.099	0.665
PT18692	0.036	0.735
PT18792	0.011	0.051
PT18892	0.013	0.021
PT18992	R	0.019
PT19092	0.009	0.032
PT19192	0.038	0.148
PT19292	0.166	0.321
PT19392	R	0.014
PT19492	0.077	0.087
PT19592	0.052	0.250
PT19692	0.006	0.009
T1A	R	0.952
T1B	R	1.475
T2A	R	0.757
T2B	R	0.681
T2C	R	1.600
T3A	R	0.923
T3B	R	0.734
T3C	R	0.656
T4A	0.161	0.808
T4B	0.078	0.365
T5	0.128	0.566
T6	0.060	0.476
T7	0.056	0.162
T8	0.041	0.225
T9	0.114	0.592
T10	0.053	0.249
T11	0.065	0.480
T12A	0.049	0.288
T12B	0.048	0.356
T13A	0.200	0.891
T13B	0.095	0.686
T14A	0.100	0.608
T14B	0.088	0.432
T15A	0.213	1.336
T15B	0.140	1.084

Table A3-3 (continued)

Location Code	Americium-241	Plutonium-239, -240
U1A	R	6.468
U1B	R	2.672
U2A	R	3.590
U2B	R	1.219
U3A	0.279	1.696
U3B	0.260	1.190
U4	0.099	0.178
U5	0.118	0.412
U6	0.101	0.423
U7	0.268	1.151
U8	0.150	0.201
U9	0.306	1.857
U10A	0.363	1.739
U10B	0.229	1.089
U11A	0.112	0.718
U11B	0.141	0.771
U12A	0.195	0.972
U12B	0.122	0.742
U13A	0.197	1.272
U13B	0.159	0.762
U14A	0.138	0.683
U14B	0.161	0.989

Notes:

pCi/g = picocuries per gram.
R = Analytical result was rejected by data validators.
T = tilled.
U = untilled.

summed for each Source Area to produce RBC Ratio Sums (i.e., RBC Ratio Sum-C = RBC Ratio Sum for carcinogenic PCOCs; RBC Ratio Sum-NC = RBC Ratio Sum for noncarcinogenic PCOCs) for the Source Areas according to the following formula:

$$\text{RBC Ratio Sum} = \sum_{j=1}^{m} \left(\sum_{i=1}^{n} \left(\text{maximum concentration or activity}_{i,j} / \text{RBC}_{i,j} \right) \right) \quad \text{(A-2)}$$

where

RBC = risk-based concentration
i = PCOC
j = medium

maximum concentration or activity = maximum concentration or activity in the Source Area

Table A3-4
Risk-Based Concentrations for OU 3 PCOCs
Rocky Flats Environmental Technology Site

Medium	IHSS	PCOCs	Risk Based Concentrations
Surface Soil and Subsurface Soil	199	Americium-241 Plutonium-239, -240	2.37 pCi/g 3.43 pCi/g (assumes Plutonium-239)
Surface Sediment (Grab Samples)	200	Plutonium-239, -240	3.43 pCi/g (assumes Plutonium-239)
	201	None	
	202	None	
Subsurface Sediment (Core Samples)	200	Copper Plutonium-239, -240	11,000 mg/kg 3.43 pCi/g (assumes Plutonium-239)
	201	None	
	202	None	
Surface Water	200	None	NA
	202	None	NA
Groundwater	200	Strontium	21.9 mg/L
	201	None	NA

Notes:
PCOCs = Inorganic chemicals with detected levels above background levels or organic chemicals detected above detection limits.
NA = Not applicable.

Three of the surface-soil Source Areas identified in Step 2 have RBC Ratio Sums greater than 1 (sample locations PT14192, U1A, and U2A). The RBC Ratio Sums for these areas range from 1 to 2. Figure A3-3 shows RBC Ratio Sums for all RFI/RI surface-soil sampling locations. Blue symbols indicate that a surface-soil location has an RBC Ratio Sum greater than 1. Green symbols indicate surface-soil locations with Ratio Sums less than 1; 18 of the 19 RFI/RI surface soil Source Areas have RBC Ratio Sums less than 1. Figure A3-4 shows Ratio Sums for the Remedy Lands surface-soil locations. Forty-five of the 47 Remedy Lands Source Areas have RBC Ratio Sums less than 1. Table A3-5 summarizes the RBC Ratio Sums for the 19 RFI/RI and 47 Remedy Lands surface-soil Source Areas. Attachment 2 contains a table that shows PCOC-specific ratios, RBCs, and toxicity values for all surface-soil Source Areas.

RBC Ratio Sums for Great Western Reservoir (IHSS 200) were calculated using maximum values of PCOCs from all sediment data (surface and subsurface samples). The RBC Ratio Sum-C for Great Western Reservoir is greater than 1 and the RBC Ratio Sum-NC is less than 1.

Table A3-6 summarizes the Ratio Sums for Great Western Reservoir. Attachment 2 contains a table that shows PCOC-specific RBC ratios and toxicity values for IHSS 200. As discussed in Subsection A3.2.4, americium-241 and plutonium-239, -240 in sediments for IHSS 201 and IHSS 202 were retained for further analysis after Step 1 as requested by CDPHE. RBC ratios were calculated for these analytes for

IHSSs 201 and 202 using maximum values from subsurface sediments. Maximum values for these analytes in subsurface sediments were greater than maximum values in surface sediments. PCOC-specific RBC ratios or RBC Ratio Sums for IHSSs 201 or 202 (subsurface sediments) indicate that none of the chemical-specific RBC ratios or RBC Ratio Sums exceed 1 (Table A3-7). Therefore, there are no AOCs associated with IHSS 201 or IHSS 202.

A3.6 CDPHE CONSERVATIVE SCREEN DECISION CRITERIA

Further actions for Source Areas are determined by the following decision criteria (CDPHE/EPA/DOE, 1994):

- If the RBC Ratio Sum for a Source Area is greater than or equal to 100, DOE may conduct a Voluntary Corrective Action for that portion of the OU.
- If the RBC Ratio Sum for a Source Area is between 1 and 100, DOE must conduct an HHRA for that Source Area, in accordance with Risk Assessment Guidance for Superfund (EPA, 1989a).
- If the RBC Ratio Sum for a Source Area is less than or equal to 1, no further action is required (i.e., a HHRA is not required) pending an evaluation of potential dermal exposure.

All RBC Ratio Sums for surface-soil Source Areas in OU 3 are either less than 1 (i.e., no further action is required pending dermal exposure evaluation) or in the 1 to 100 range (i.e., further evaluation in a HHRA is required). For those surface-soil Source Areas with RBC Ratio Sums less than 1, the CDPHE Conservative Screen decision criteria include an evaluation of dermal exposure. Dermal contact with surface soil in OU 3 is not considered to be a significant exposure pathway because radionuclides are not expected to be significantly absorbed through the skin (EPA, 1989a; EPA, 1989b). As a screening step to verify the assumption that dermal contact is not a significant exposure pathway, maximum activities of americium-241 and plutonium-239, -240 for surface-soil samples in each Source Area with a RBC Ratio Sum less than 1 were compared to a Dermal RBC (i.e., RBC based on exposure via dermal absorption). No activities for surface-soil samples in the OU 3 data set exceed the Dermal RBCs. The methods used to calculate the Dermal RBCs are presented in the CDPHE Conservative Screen Letter Report (DOE, 1994b) along with the results of the comparison.

The RBC Ratio Sum-C for the Great Western Reservoir Source Area is slightly greater than 1. Therefore, further evaluation in the HHRA is required for Great Western Reservoir.

Based on the conservative screening process specified by CDPHE and the decision criteria described above, three surface-soil Source Areas (sample locations PT14192, U1A, and U2A) and the Great Western Reservoir Source Area, require further evaluation in the HHRA. No further action is required for all other surface-soil Source Areas (18 RFI/RI soil-sampling locations and 45 Remedy locations). In addition, no further action is required for Standley Lake or Mower Reservoir because no PCOCs were identified for those IHSSs and the RBC Ratio Sums for Standley Lake and Mower Reservoir, based on americium-241 and plutonium-239, -240, are less than 1.

A3.7 RESULTS OF CDPHE CONSERVATIVE SCREEN

Based on the results of the CDPHE Conservative Screen process, Great Western Reservoir (IHSS200) and three surface-soil sample plots located within IHSS 199 (PT14192, U1A, and U2A - See Figure A3-4) were identified as areas of concern in OU 3. No other areas of concern were identified in OU 3.

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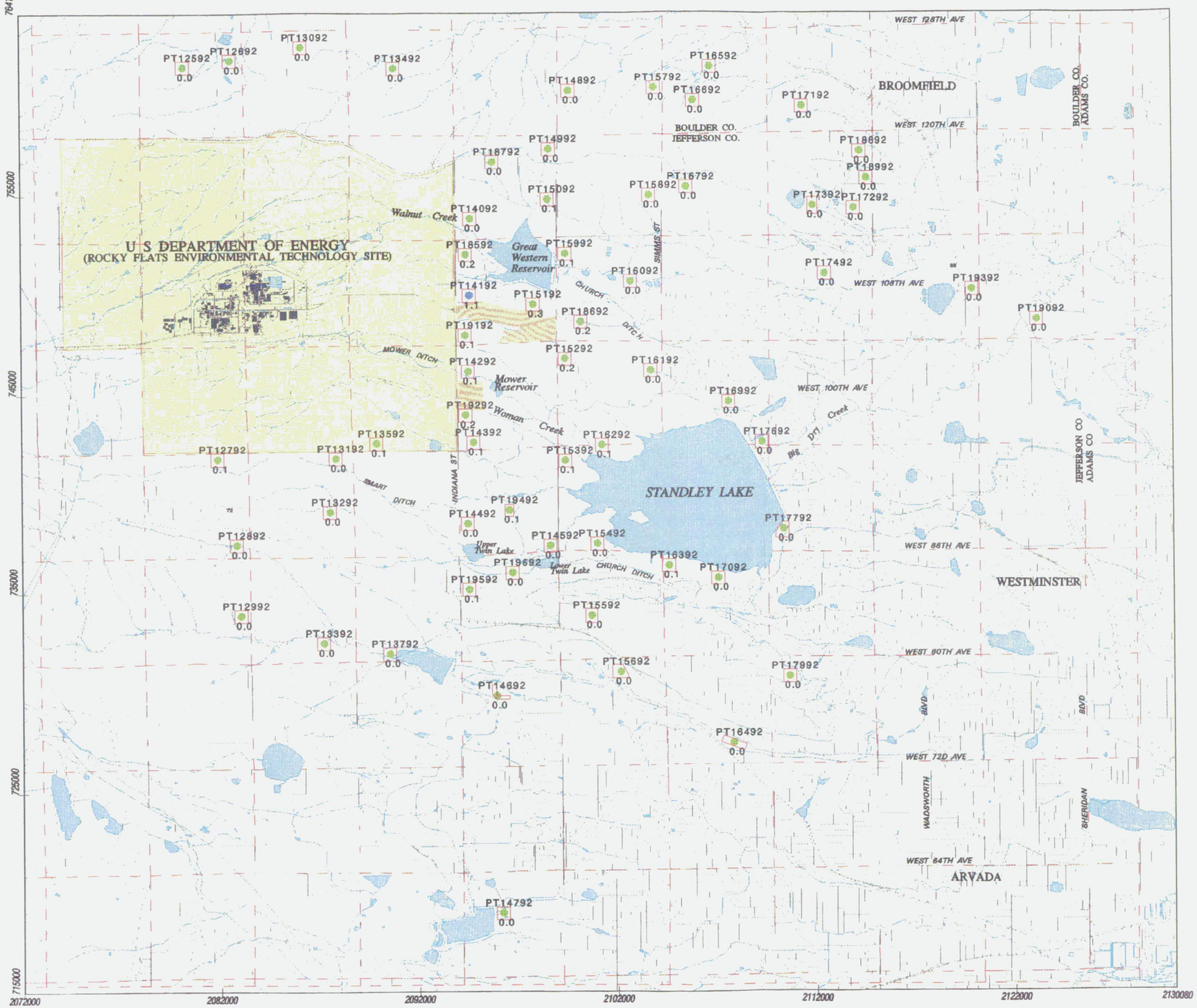


Figure A3-3

RFI/RI Surface Soil Plots
Surface Soils / Radionuclides

Ratios of 241Am and 239/240Pu to RBC Levels

Operable Unit 3
IHSS 199 - Surface Soil Sampling Area

ROCKY FLATS
ENVIRONMENTAL TECHNOLOGY SITE
U.S. Department of Energy

Key to Symbols

○ 0.1← RBC Ratio Sum

Key to Symbol Colors

- Ratio Sum < 1
- Ratio Sum = 1 - 100
- Ratio Sum > 100
- Rejected Data
- RFI/RI soil sample plot
- untilled / tilled — Remedy Lands Area

The symbols show the ratio sums (sums of ratios of detected activities of each radionuclide to corresponding RBCs). (RBC = Risk-based concentration.)

Ratios are calculated using average values of CDH and RFP soil-sampling methods for RFI/RI plots, and maximum values for Remedy Lands. The circular symbols represent data collected within the soil sample plots; however, the placement of the symbol does not indicate the exact location of where a sample was taken.

The reference levels (in pCi/g) used to calculate ratios are as follows:

REFERENCE LEVEL	241 Am	239/240 Pu
RBC	2.37	3.43

Mapping Sources:
Jefferson County Mapping Dept.
EG&G Rocky Flats, Inc.
U.S. Geological Survey

N

Scale 1:63360
1 inch = 1 mile

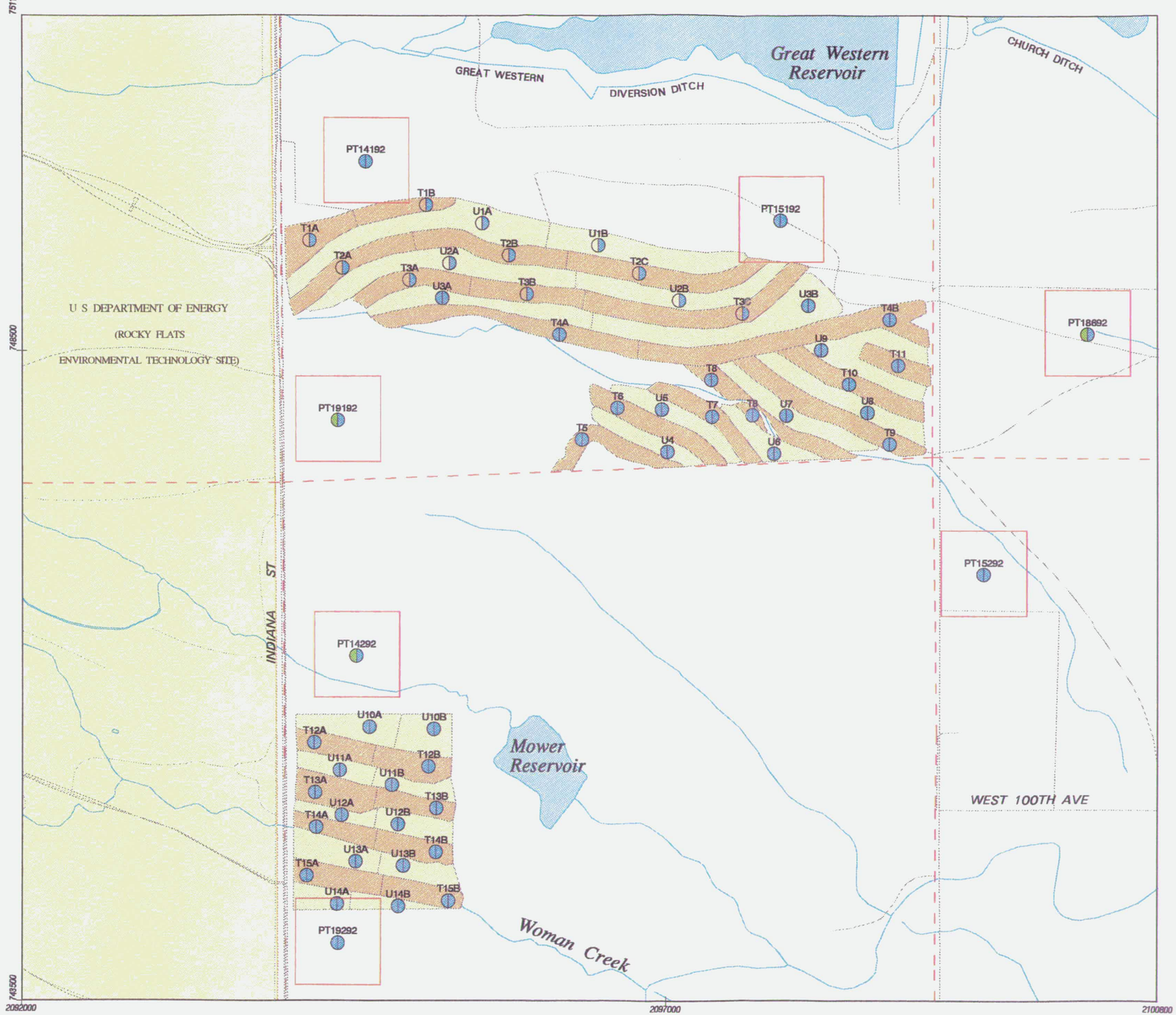
0 0.5 1 2
MILES

Polyconic projection. 1927 North American datum.
Colorado central zone state plane coordinate system.

Figure A3-4
Remedy Lands
Surface Soils / Radionuclides

Ratios of 241Am and 239/240Pu to Background Levels
Operable Unit 3
IHSS 199 - Surface Soil Sampling Area

ROCKY FLATS
ENVIRONMENTAL TECHNOLOGY SITE
U.S. Department of Energy



Key to Symbols
241Am 239/240Pu

Key to Symbol Colors
Background Ratio (Comparison to background)
- < 1 (Does not exceed background)
- > 1 (Exceeds background)
- Rejected Data

RFI/RI soil sample plot

untilled / tilled — Remedy Lands Area

The symbols show the ratios of each radionuclide (241Am and 239/240Pu) to the upper-bound background values (mean + 2 std dev).

Ratios are calculated using average values of CDH and RFP soil-sampling methods for RFI/RI plots, and maximum values for Remedy Lands. The circular symbols represent data collected within the soil sample plots; however, the placement of the symbol does not indicate the exact location of where a sample was taken.

The reference levels (in pCi/g) used to calculate ratios are as follows:

	241 Am	239/240 Pu
MEAN+2 STD DEV	0.04	0.09
REFERENCE LEVEL		

Mapping Sources:
Jefferson County Mapping Dept.
EG&G Rocky Flats, Inc.
U.S. Geological Survey

Scale 1:9600
1 in = 800 ft

0 250 500 1000
SCALE IN FEET

N

Polyconic projection. 1927 North American datum.
Colorado central zone state plane coordinate system.

Table A3-5
RBC Ratio Sums for OU 3 Surface Soil Source Areas for Rocky Flats Environmental Technology Site

Location Code	Ratio Sum	Location Code	Ratio Sum
PT12792	0.05	T2C	0.5
PT13592	0.09	T3A	0.3
PT14192	1	T3B	0.2
PT14292	0.1	T3C	0.2
PT14392	0.1	T4A	0.3
PT14992	0.04	T4B	0.1
PT15092	0.06	T5	0.2
PT15192	0.3	T6	0.2
PT15292	0.2	T7	0.07
PT15392	0.08	T8	0.08
PT15992	0.08	T9	0.2
PT16292	0.05	U10A	0.7
PT16392	0.06	U10B	0.4
PT18592	0.2	U11A	0.3
PT18692	0.2	U11B	0.3
PT19192	0.06	U12A	0.4
PT19292	0.2	U12B	0.3
PT19492	0.06	U13A	0.5
PT19592	0.09	U13B	0.3
T10	0.1	U14A	0.3
T11	0.2	U14B	0.4
T12A	0.1	U1A	2
T12B	0.1	U1B	0.8
T13A	0.3	U2A	1
T13B	0.2	U2B	0.4
T14A	0.2	U3A	0.6
T14B	0.2	U3B	0.5
T15A	0.5	U4	0.1
T15B	0.4	U5	0.2
T1A	0.3	U6	0.2
T1B	0.4	U7	0.4
T2A	0.2	U8	0.1
T2B	0.2	U9	0.7

Notes:
RBC = Risk Based Concentration.
RBC Ratio Sum = $\frac{\text{Americium-241 activity}}{\text{RBC}} + \frac{\text{Plutonium-239,-240 activity}}{\text{RBC}}$

The AOCs discussed here were determined based on the sampling results at discrete sampling locations. The AOCs were derived by examining the results of each sample location separately. This is consistent with the human health risk assessment methodology approved for use by EPA and CDPHE. The

Table A3-6
Source Area RBC Ratio Sums for IHSS 200 Sediments and Groundwater
Rocky Flats Environmental Technology Site

Source Area	Medium	RBC Ratio Sum - C	RBC Ratio Sum - NC
IHSS 200	Sediments	1.2[a]	0.03[b]
IHSS 200	Groundwater		0.3[c]
TOTAL		1.2	0.3

Notes:

C = Carcinogenic potential contaminants.
NC = Noncarcinogenic potential contaminants.
IHSS = Individual Hazardous Substance Site.
mg/L = milligrams per liter.
pCi/g = picocuries per gram.

[a]For Plutonium-239, -240: $\frac{4.04 \text{ pCi/g}}{3.43 \text{ pCi/g}} = 1.2$

[b]For Cu: $\frac{311 \text{ mg/kg}}{11{,}000 \text{ mg/kg}} = 0.03$

[c]For Sr: $\frac{5.59 \text{ mg/L}}{21.9 \text{ mg/L}} = 0.3$

plutonium-239, -240 and americium-241 isoconcentration lines shown in Figures 4-6A and 4-6B, respectively, were derived using the results from each discrete sampling location. Therefore, the analytical basis of the human health risk assessment and the isoconcentration lines found in Figures 4-6A and 4-6B are the same. Otherwise, they do not explicitly relate to one another.

Table A3-7
Source Area RBC Ratio Sums for IHSS 201 and IHSS 202 Subsurface Sediments
Rocky Flats Environmental Technology Site

	IHSS 201			IHSS 202		
Analyte	**Maximum Detected Activity (pCi/g)**	**RBC (pCi/g)**	**RBC Ratio**	**Maximum Detected Activity (pCi/g)**	**RBC (pCi/g)**	**RBC Ratio**
Americium-241	0.180	2.37	0.08	0.1748	2.37	0.074
Plutonium-239, -240	0.380	3.43	0.11	1.1120	3.43	0.320
		Ratio Sum--C	0.19		Ratio Sum--C	0.394

Notes: Ratio Sum--C = Ratio sum for carcinogenic analytes.

A4.0 SELECTION OF CHEMICALS OF CONCERN

The COC selection process was developed as part of the Data Aggregation process used for Rocky Flats HHRAs by EPA, CDPHE, and DOE. Guidance for the Data Aggregation process was provided in a memorandum (DOE, 1994a), and during a presentation by CDPHE, EPA, and DOE on June 3, 1994 (CDPHE/EPA/DOE, 1994). The COC selection process is used in conjunction with the CDPHE Conservative Screen (DOE, 1994b) to aggregate the OU 3 data for the characterization of potential OU 3 risks (Figure A4-1). The CDPHE Conservative Screen is used to identify the areas of the OUs that may be impacted by contaminants. The COCs identified in this section are used in the HHRA to quantify potential risk to exposed receptors in the AOCs identified for OU 3. Complete details and results of the COC selection process are available in *Technical Memorandum No. 4 Human Health Risk Assessment Chemicals of Concern Identification, Operable Unit 3*, (TM4), (DOE, 1994d).

A4.1 SUMMARY OF COC SELECTION PROCESS

The COC selection process was applied to concentration/activity data for each of the following IHSSs and media:

- IHSS 199, Contamination of Soils
  - Surface soils
- IHSS 200, Great Western Reservoir
  - Surface sediments
  - Subsurface sediments
  - Surface water
  - Groundwater
- IHSS 201, Standley Lake
  - Surface sediments
  - Surface water
  - Groundwater
- IHSS 202, Mower Reservoir
  - Surface sediments
  - Surface water

Exposure to subsurface sediments located in Standley Lake and Mower Reservoir was not evaluated for the following reasons:

- Current information indicates it is highly unlikely that these water sources will be drained and subsequently developed for residential or recreational purposes.
- Under current conditions, no plausible or reasonable exposure pathway exists under which a receptor would contact subsurface sediments located in Standley Lake or Mower Reservoir. Developing a quantitative model, or a qualitative discussion, to estimate intake or exposure to

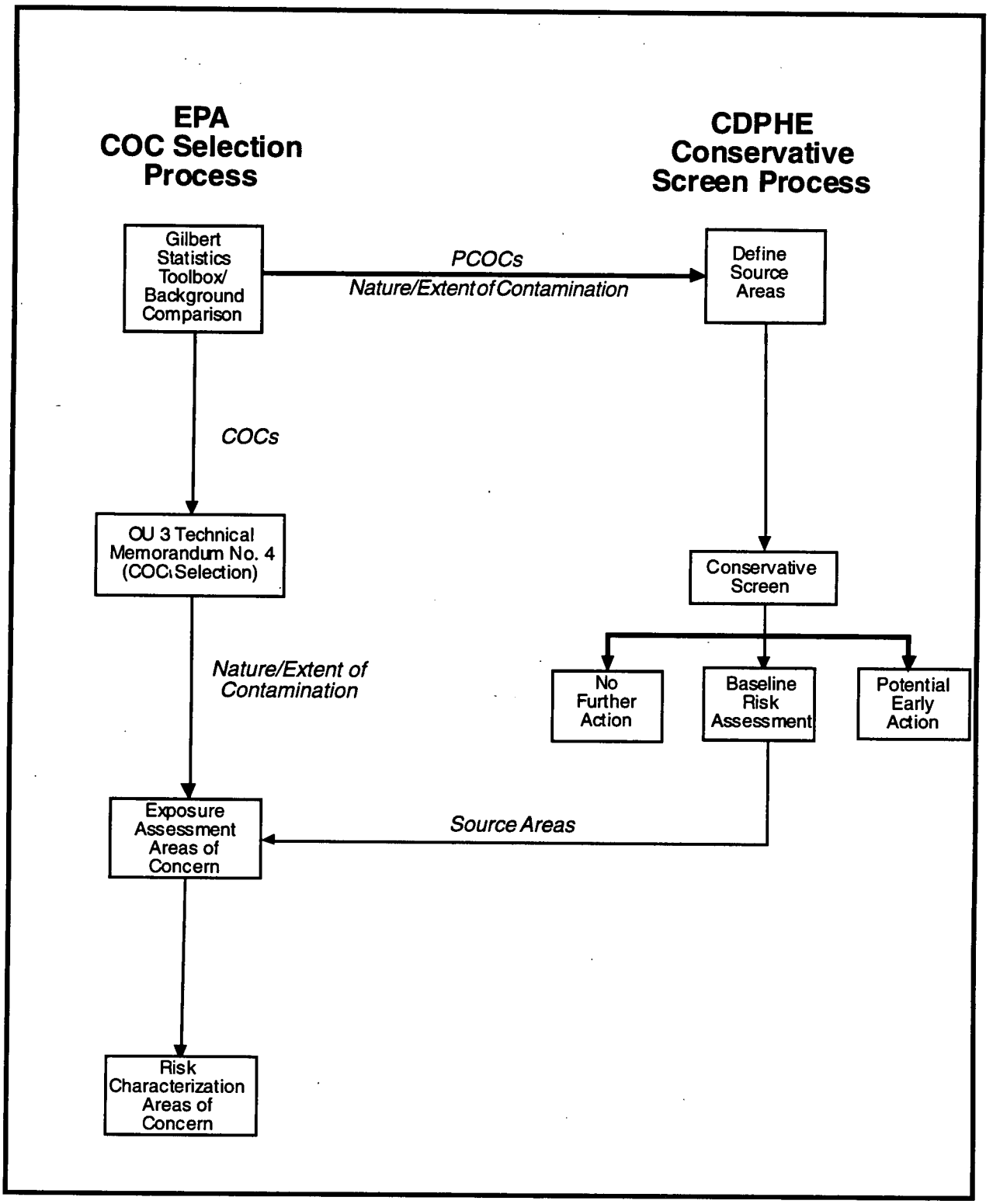


Figure A4-1
COC/Area of Concern Identification Process

COCs present in subsurface sediments would require consideration of inappropriate and technically unsupportable receptor activities.

The objective of the COC process is to identify those chemicals in a particular medium that, based on concentration and toxicity, contribute significantly to risks calculated for exposure scenarios involving that medium (EPA, 1989a). The COCs are used in the HHRA to quantify risks associated with exposure to OU 3 media. The COC selection process was agreed upon by EPA, CDPHE, and DOE and is based on *Risk Assessment Guidance for Superfund* (EPA, 1989a), the Interagency Agreement (IAG) (EPA, 1991a), and site-specific guidance (CDPHE/EPA, 1993; DOE, 1993a; CDPHE/EPA/DOE, 1994; and EPA, 1994a).

The COC selection process for OU 3 includes an application of the following steps (Figure A4-2):

1. Statistical background comparison tests
2. An essential nutrient screen
3. A frequency of positive detection screen
4. A concentration-toxicity screen
5. A comparison to PRGs (DOE, 1994b)
6. Weight-of-evidence evaluation

The following provides more detail on how each step of the COC selection process was applied to OU 3.

A4.1.1 Statistical Background Comparison Tests

The purpose of this step of the COC selection process is to identify chemicals with concentration/activities in OU 3 that are significantly greater than corresponding concentrations/activities in background. Background data suitable for rigorous statistical comparisons are limited to surface soils; no background data were available for statistical comparisons for other media under consideration in OU 3. For surface soils, five different statistical tests (hot-measurement test, Gehan test, quantile test, slippage test, and t-test) were performed for each analyte. If any one of the statistical tests performed for a given comparison indicated a significant difference between OU 3 and background data, then the analyte was considered to be a PCOC and professional judgement was applied to determine if the statistical results were plausible (Gilbert, 1993).

A4.1.2 Essential Nutrients Screen

Calcium, iron, magnesium, potassium, and sodium were eliminated from consideration as PCOCs in all environmental media, because these metals are considered essential nutrients in the human diet (EPA, 1989a).

A4.1.3 Frequency of Detection Screen

Chemicals that are infrequently detected may be artifacts in the data because of sampling or analytical problems and therefore may not be Rocky Flats-related chemicals (EPA, 1989a). Detected chemicals not

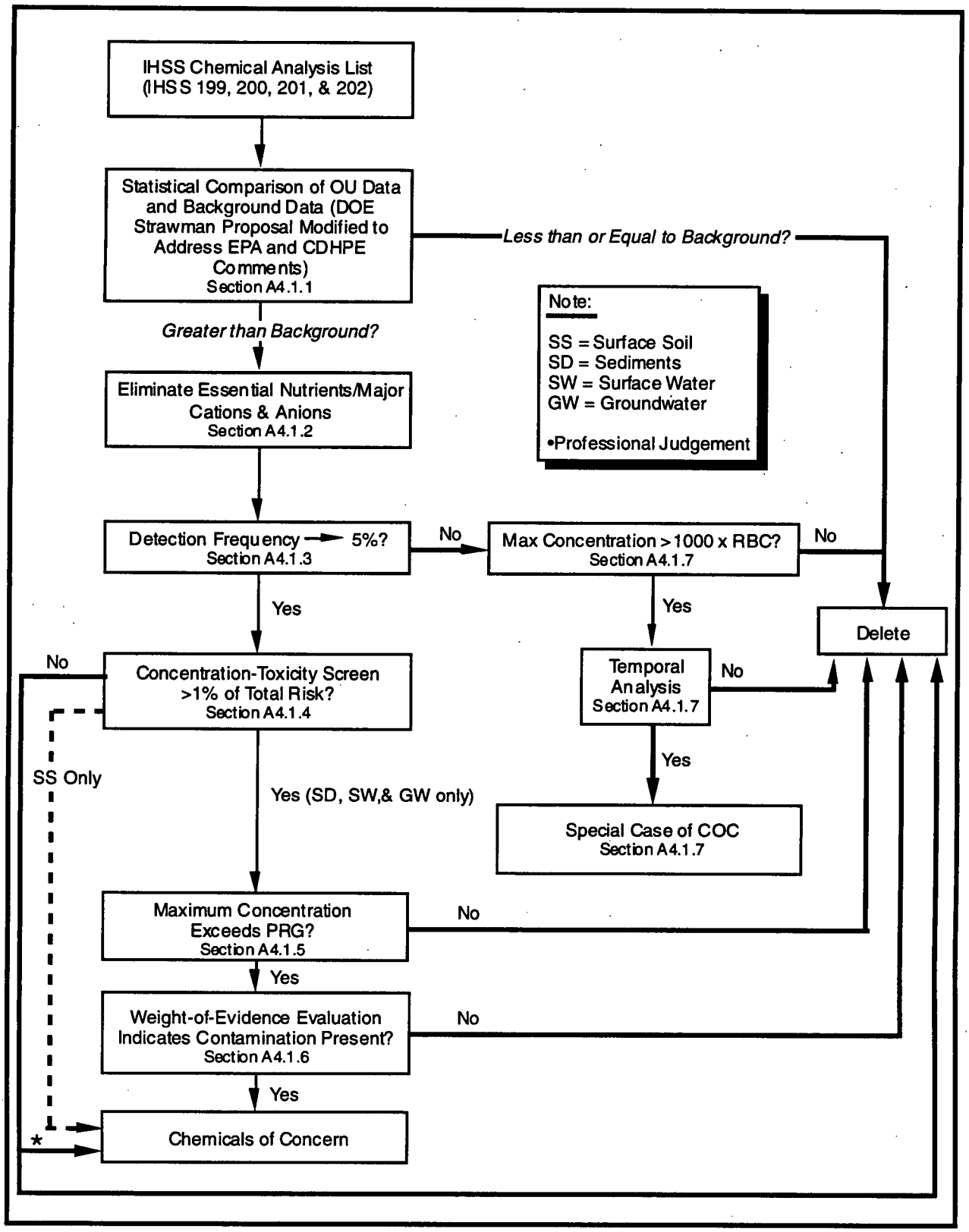


Figure A4-2
Human Health Risk Assessment Chemicals of Concern Selection Process

eliminated by the first two steps of the COC selection process were evaluated by medium and IHSS. Chemicals that were not detected in any samples within a medium and IHSS were eliminated as COCs for that medium and IHSS. Chemicals detected in greater than 5 percent of the samples for a medium within an IHSS were identified and further evaluated by the concentration-toxicity screen.

A4.1.4 Concentration-Toxicity Screen

The concentration-toxicity screen was used to identify the chemicals within each medium and IHSS that were most likely to contribute to 99 percent total risks calculated for exposure scenarios involving the medium and IHSS. This screen was performed following EPA guidance (EPA, 1989a). The first part of the screen involved calculating an individual risk factor for each chemical not eliminated as a COC based on prior steps. The chemical risk factor was calculated either by multiplying the maximum chemical concentration by the corresponding slope factor for carcinogens, or by dividing the maximum chemical concentration by the corresponding reference dose for chemicals that elicit adverse noncarcinogenic effects. For chemicals with both oral and inhalation toxicity values, the more conservative toxicity factors (i.e., greater slope factor for carcinogens and lower reference doses for chemicals that elicit adverse noncarcinogenic effects) were used to calculate the chemical risk factors.

The individual risk factors were then summed by medium and IHSS to obtain a total risk factor, according to the end point of toxicity (carcinogenic or noncarcinogenic effects). Radionuclide and nonradionuclide chemicals were summed separately because units for slope factors and concentrations/activities in environmental media are different for these classes of chemicals. The ratio of each individual chemical risk factor to the total risk factor gives an indication of the relative risk for that medium and IHSS due to each chemical. The chemicals whose combined ratios sum to 0.99 (99 percent) of the total risk were considered likely to contribute significantly to the overall risk. All other chemicals were eliminated as COCs.

Chemicals without oral or inhalation toxicity values cannot be evaluated in the concentration-toxicity screen step. The chemicals without toxicity values that were detected in OU 3 were assessed further using a weight-of-evidence evaluation (Section A4.1.6) to determine if levels of the chemicals in OU 3 were elevated over background conditions.

A4.1.5 PRG Screen

The chemicals remaining at this point in the COC selection process were evaluated further using the PRG screen. The PRGs were calculated based on the methods presented in *Programmatic Preliminary Remediation Goals* (DOE, 1994c). The maximum detected values for the chemicals whose combined risk factor ratios summed to 0.99 for each medium and IHSS in the concentration-toxicity screen were compared to the corresponding PRGs. Any chemicals with maximum detected values less than the corresponding PRG were eliminated as COCs. Maximum detected values greater than a PRG were retained and evaluated under the weight-of-evidence process.

A4.1.6 Weight-of-Evidence Screen

The weight-of-evidence evaluation involves the application of a variety of data analysis techniques in lieu of a rigorous, quantitative statistical testing scheme as proposed by Gilbert (1993) (Figure A3-2). The results of the evaluations are considered together to assess if levels of chemicals detected in OU 3

represent background conditions or contamination. The following analyses are included in the weight-of-evidence evaluation:

- Comparisons of means, standard deviations, and ranges of OU 3 data to the Background Geochemical Characterization Report (DOE, 1993c) data, and the Background Soil Characterization Report (DOE, 1995d).
- Comparisons of means, standard deviations, and ranges of OU 3 data to literature data.
- Probability plot analysis evaluating data populations.
- Temporal analysis of data to identify seasonal variations or sampling anomalies.
- Spatial analysis combined with the evaluation of physical processes affecting deposition and the evaluation of contribution of various water sources to OU 3 reservoirs.

Each of these evaluations was performed as appropriate for each environmental medium within an IHSS. The results of the evaluations were considered together to assess if a chemical should be retained as a COC. For those chemicals eliminated as COCs by this step, reasonable evidence supported the conclusion that detected concentrations of the chemical in OU 3 were representative of background conditions.

A4.1.7 Supplemental Screening Processes

The COC selection process presented in Figure A4-2 includes three additional screening steps: maximum concentration greater than 1,000 times the PRG, temporal analysis, and special-case chemical of concern. The results of the COC selection process for OU 3 did not warrant application of these specific screening components; they are discussed in detail in TM 4 (DOE, 1994d). The specific reasons these steps were not applied to data for OU 3 are described in TM 4.

A4.2 DESCRIPTION OF DATA SETS USED IN COC SELECTION PROCESS

The COCs were selected using the OU 3 database, which comprises data extracted from the RFEDS as of February 15, 1994. These raw data were processed for use in the OU 3 RFI/RI and the resulting database (called the OU 3 database) is used in all subsequent RFI/RI, HHRA and ERA data analysis tasks. The data-processing protocols were applied before any analyses were performed. These protocols are described in TM 4 (DOE, 1994d) and Appendix F of the RFI/RI report and include removal of duplicated records, segregation of quality assurance/quality control (QA/QC) information, and general preparation of the database for analysis. These protocols do not include adjustment or other operations that affect or alter the analytical results.

The OU 3 database consists of data from the following sources:

- Historical data
- The RFI/RI sampling program
- Background data

The following subsections provide more details on these sources.

A4.2.1 Historical Data

Historical data for the IHSSs included in OU 3 were reviewed during development of the RFI/RI Work Plan. These data are summarized in the *Final Past Remedy Report Operable Unit No. 3-IHSS 199* (DOE, 1991a) and in the *Historical Information Summary and Preliminary Health Risk Assessment Operable Unit No. 3-IHSS 200, 201, and 202* (DOE, 1991b). The usability of the previous data collected was reviewed in accordance with the procedures found in *Guidance for Data Useability in Risk Assessment (Part A)* (EPA, 1990b). The conclusions indicated that much of the data do not meet data quality objectives (DQOs) to perform a rigorous quantitative risk assessment (DOE, 1992).

However, two data sets from pre-RFI/RI investigations were included in the OU 3 database after meeting the data usability evaluation criteria. The two data sets are:

1. The 1983/1984 sediment sampling investigations data (referred to as the Setlock data in the OU 3 RFI/RI Work Plan)(DOE, 1992).

   In 1983, a series of surficial sediment grab and sediment core samples were collected from Great Western Reservoir (IHSS 200) and analyzed for plutonium-239, -240. In 1984, sediment grab, surface water, and sediment core samples were collected from Standley Lake (IHSS 201) and analyzed for plutonium-239, -240. Based on the results of statistical comparison tests and the statistical requirements identified in the OU 3 Work Plan, the 1983/1984 grab data for each reservoir were combined with the corresponding OU 3 RFI/RI data for the COC selection process and subsequent data analyses reference TM 4 appendix.

2. The Remedy Lands surface soil data (DOE, 1991a).

   Surface soil samples were collected in 1991 (DOE, 1991a) from two parcels of land located directly east of the eastern boundary of the site. The samples were collected from tilled and untilled strips of land within the two parcels and analyzed for americium-241, plutonium-238, and plutonium-239, -240. The decision was made to include these data in the OU 3 database because it provides additional information for characterizing the area located adjacent to site boundary. Also, combining the data would result in a conservative estimate of risk for that area because the highest values for radionuclides in the soil are found in the Remedy Lands data set. These data also provide an assessment of the area within OU 3 with the most significant contamination.

A4.2.2 The RFI/RI Sampling Program

Based on the existing data review, a sampling program was designed to collect information necessary to perform an RFI/RI (DOE, 1992). The sampling was performed during 1992 and 1993 and entered into the RFEDS. Data from this sampling program are the foundation of the OU 3 database.

During the RFI/RI sampling program, the following environmental media were sampled:

- Surface soil
- Subsurface soil
- Surface sediment
- Subsurface sediment

- Surface water
- Groundwater

Details of the OU 3 RFI/RI sampling program can be found in Section 2.0.

A4.2.3 Background Data

Site-specific background data are available for surface soil, stream sediments, surface water, and groundwater from the following sources:

- *Rock Creek Background Soil Samples* (surface soil) (DOE, 1993b)

- *Background Geochemical Characterization Report* (surface sediments and surface water collected from streams and groundwater) (DOE, 1993c)

These data sets include results from samples collected at stations located in buffer zone areas west, north, and south of Rocky Flats (DOE, 1993c). These buffer areas are near site boundaries and have remained undisturbed by plant operations. Therefore, results of the analyses for these samples represent "background" conditions for Rocky Flats. No samples were collected from surface sediments, surface water, or subsurface sediments in background reservoirs or lakes near Rocky Flats.

A4.3 SUMMARY OF RESULTS OF COC SELECTION PROCESS

The chemicals that were eliminated during each step in the COC selection process for each medium are listed in Tables A4-1 through A4-4. The steps followed for the COC selection for surface soils (Table A4-1) included statistical comparisons of OU 3 and background data (Gilbert's methodology), detection frequency, concentration-toxicity screen, and comparison to PRGs. The steps followed for the COC selection for sediments (Table A4-2) included elimination of essential nutrients, elimination of chemicals detected infrequently, concentration-toxicity screen, comparison to PRGs, and weight-of-evidence evaluations. The steps followed for COC selection for surface water (Table A4-3) included elimination of essential nutrients, elimination of chemicals infrequently detected, concentration toxicity screen, comparison to PRGs, and weight-of-evidence evaluations. The steps followed for COC selection for groundwater (Table A4-4) included elimination of essential nutrients, elimination of chemicals detected infrequently, concentration toxicity screen, comparison to PRGs, and weight-of-evidence evaluations.

The results of the COC selection process are shown in Table A4-5 for each medium and each IHSS. Americium-241 and plutonium-239, -240 in surface soil (IHSS 199) and plutonium-239, -240 in surface sediment in Great Western Reservoir (IHSS 200) are the only COCs identified for OU 3. These COCs will be evaluated within the AOCs delineated in the previous section for the human health risk assessment.

Table A4-1
COC Selection Process Results for Surface Soils
(Chemicals are shown below the step by which they were eliminated as a COC)

Zero Detections	Statistical Comparison Tests	Essential Nutrients Screen	Detection Frequency Screen	Concentration-Toxicity Screen	PRG Screen	Chemicals Without A Toxicity Factor	Weight-of-Evidence Evaluation
None eliminated	$^{233/234}$U ^{235}U ^{238}U	None eliminated	NA[a]	^{238}Pu	NA[b]	None	NA[b]

[a]NA = Not applicable. No radionuclides eliminated by this step. All radionuclides samples were assumed detections for purpose of data analysis.

[b]NA = Not applicable. PRG screen and weight-of-evidence evaluation were not performed for surface soil.

Table A4-2
COC Selection Process Results for Sediments
(Chemicals are shown below the test step by which they were eliminated as a COC)

Zero Detections	Statistical Comparison Tests	Essential Nutrients Screen	Detection Frequency Screen	Concentration-Toxicity Screen	PRG Screen	Weight-of-Evidence Evaluation	Chemicals Without a Toxicity Factor [a]	COCs
IHSS 200 - Great Western Reservoir - Surface Sediments (Grab Samples)								
Cyanide	NA [b]	Calcium Magnesium Iron Sodium Potassium	Thallium [c]	Antimony Copper Mercury Molybdenum Nickel Selenium Silver Strontium Tin Vanadium Zinc ^{228}Ra Tritium $^{89/90}$Sr ^{137}Cs	Barium Chromium Cadmium $^{233/234}$U ^{238}U ^{226}Ra ^{241}Am	Arsenic Beryllium Manganese ^{235}U	Aluminum Cesium Cobalt Lead Lithium Silicon	$^{239/240}$Pu
IHSS 200 - Great Western Reservoir - Subsurface Sediments (Core Samples)								
Thallium	NA	Calcium Iron Magnesium Sodium Potassium	None	Copper Mercury Molybdenum Nickel Selenium Silver Strontium Tin Vanadium Zinc	^{241}Am $^{239/240}$Pu ^{210}Po $^{233/234}$U ^{238}U ^{235}U Arsenic Barium Beryllium Cadmium Chromium Manganese	None	Aluminum Cesium Cobalt Lead Lithium	None

Table A4-2 (Continued)

IHSS 201 - Standley Lake - Surface Sediments (Grab Samples)								
Cesium Thallium	NA [a]	Calcium Magnesium Iron Sodium Potassium		Antimony Barium Beryllium Copper Mercury Molybdenum Nickel Selenium Silver Strontium Tin Vanadium Zinc 228 Ra 89/90 Sr Tritium 137 Cs	Chromium Cadmium 233/234 U 238 U 239/240 Pu 226 Ra 241 Am	Arsenic Manganese 235 U	Aluminum Cobalt Lead Lithium Silicon	None
IHSS 202 - Mower Reservoir - Surface Sediments (Grab Samples)								
Cadmium Cyanide Molybdenum 1,1,1-Trichloroethane 1,1,2,2,-Tetrachloroethane 1,1,2-Trichloroethane 1,1-Dichloroethane 1,1-Dichloroethene 1,2-Dichloroethane 1,2-Dichloroethene 1,2-Dichloropropane 2-Hexanone 4-Methyl-2-pentanone Benzene Bromodichloromethane Bromoform Bromomethane Carbon Disulfide Carbon Tetrachloride Chlorobenzene Chloroethane Chloroform Chloromethane Cis-1,3-Dichloropropene Dibromochloromethane Ethylbenzene Styrene Tetrachloroethene Thallium Trans-1,3-Dichloropropene Trichloroethene Total Xylenes Vinyl Acetate Vinyl Chloride	NA	Calcium Magnesium Iron Sodium Potassium	None	Antimony Copper Mercury Nickel Selenium Silver Strontium Tin Vanadium Zinc Acetone 2-Butanone Methylene chloride Toluene Total xylenes Trichlorotrifluoroethane	Barium Chromium Manganese 233/234 U 235 U 238 U 239/240 Pu 241 Am	Arsenic Beryllium	Aluminum Cesium Cobalt Lead Lithium Silicon Thallium	None

[a] Chemicals without toxicity factors are evaluated using the weight-of-evidence evaluation.

[b] NA = Not applicable; statistical tests were not performed because of lack of appropriate background data set.

[c] Thallium will be discussed in the weight-of-evidence section. PRGs were unavailable for comparison.

Table A4-3
COC Selection Process Results for Surface Water
(Chemicals are shown below the step by which they were eliminated as a COC)

Zero Detections	Statistical Comparison Tests	Essential Nutrients Screen	Detection Frequency Screen	Concentration-Toxicity Screen	PRG Screen	Weight-of-Evidence Evaluation	Chemicals Without Toxicity Factor [b]	COCs
IHSS 200 - Great Western Reservoir								
Antimony Cyanide Mercury Selenium Silver Thallium Atrazine Simazine Tripesticides [a]	NA	Calcium Magnesium Iron Sodium Potassium	None	Nickel Tin	Arsenic Beryllium Manganese Cadmium Molybdenum Barium Vanadium Chromium Zinc Copper Strontium Tritium $^{239/240}$Pu $^{233/234}$U ^{235}U ^{238}U ^{241}Am	None	Lead Lithium Aluminum Cobalt Silicon	None
IHSS 201 - Standley Lake								
Antimony Arsenic Beryllium Cadmium Cesium Silver Thallium Tin Vanadium Atrazine Simazine	NA	Calcium Magnesium Iron Sodium Potassium	None	Barium Zinc Chromium Copper Strontium	Manganese Mercury Nickel Molybdenum Cyanide Selenium $^{233/234}$U ^{235}U ^{238}U ^{241}Am $^{239/240}$Pu	None	Lead Lithium Silicon Cobalt Aluminum	None

[a] Tripesticides--Ametryn, atraton, prometon, prometryn, propazine, simetryn, terbuthylazine, and terbutryn.
[b] Chemicals without toxicity factors are evaluated using the weight-of-evidence evaluation.
[c] VOAs = Volatile Organic Analyses
NA = Not applicable.

Table A4-3 (Continued)
COC Selection Process Results for Surface Water
(Chemicals are shown below the step by which they were eliminated as a COC)

Zero Detections	Statistical Comparison Tests	Essential Nutrients Screen	Detection Frequency Screen	Concentration-Toxicity Screen	PRG Screen	Weight-of-Evidence Evaluation	Chemicals Without Toxicity Factor [b]	COCs
IHSS 202 - Mower Reservoir								
Antimony Beryllium Cobalt Selenium Silver Thallium Cyanide Atrazine Simazine VOAs[c]	NA	Calcium Magnesium Iron Sodium Potassium	None	Strontium Copper Zinc Tin	Arsenic Manganese Cadmium Molybdenum Barium Vanadium Chromium Mercury Nickel $^{239/240}$Pu $^{233/234}$U ^{235}U ^{238}U ^{241}Am	None	Aluminum Cesium Lead Lithium Silicon	None

[a] Tripesticides--Ametryn, atraton, prometon, prometryn, propazine, simetryn, terbuthylazine, and terbutryn.
[b] Chemicals without toxicity factors are evaluated using the weight-of-evidence evaluation.
[c] VOAs = Volatile Organic Analyses
NA = Not applicable.

Table A4-4
COC Selection Process Results for Groundwater
(Chemicals are shown below the step by which they were eliminated as a COC)

Zero Detections	Statistical Comparison Tests	Essential Nutrients Screen	Detection Frequency Screen	Concentration-Toxicity Screen	PRG Screen	Weight-of-Evidence Evaluation	Chemicals without a Toxicity Factor [b]	COCs
IHSS 200 (Well 49192)								
Mercury Molybdenum Silver Thallium	NA	Calcium Magnesium Iron Sodium Potassium	None	Copper Selenium Tin Zinc	^{241}Am Barium Cadmium Chromium Nickel $^{239/240}$Pu Strontium ^{235}U Vanadium	Arsenic Beryllium Manganese Antimony $^{233/234}$U ^{238}U	Lead Lithium Cesium Aluminium Cobalt Silicon	None
IHSS 201 (Well 49292)								
Antimony Beryllium Cadmium Cesium Cobalt Mercury Nickel Selenium Silver Thallium Tin Vanadium	NA	Calcium Magnesium Iron Sodium Potassium	None	Copper Zinc $^{239/240}$Pu	^{241}Am Barium Chromium Manganese Molybdenum Strontium $^{233/234}$U ^{235}U ^{238}U	Arsenic	Lead Lithium Silicon Aluminium	None

[a] Total metals and total radionuclides (unfiltered).
[b] Chemicals without toxicity factors were subject to the weight-of-evidence evaluation.
NA = Not Applicable

Table A4-5
Results of COC Selection Process

IHSS	Surface Soil	Surface Sediment	Subsurface Sediment	Surface Water	Groundwater
199 Contamination of Soils	Plutonium-239, -240 Americium-241	NA	NA	NA	NA
200 Great Western Reservoir	NA	Plutonium-239, -240	–	–	–
201 Standley Lake	NA	–	–	–	–
202 Mower Reservoir	NA	–	–	–	–

Notes:

NA = Not Applicable
– = No COCs were identified

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A5.0 EXPOSURE ASSESSMENT

An exposure assessment is an assessment of exposure to COCs that are present at or migrating from Rocky Flats. The type of exposure is defined by the available pathways and routes through which receptors may contact COCs. The magnitude of exposure is assessed by estimating the amount of chemical available and the frequency and duration of the contact.

A5.1 POTENTIALLY EXPOSED POPULATIONS AND EXPOSURE PATHWAYS

An exposure pathway is the means by which a person (receptor) may come into contact with (be exposed to) contaminants in environmental media. A complete pathway has five elements:

1. Contamination source
2. Mechanisms for contaminant release
3. Environmental transport medium
4. Feasible route of exposure
5. Exposure point (a point of contact by a receptor with the contaminated medium)

The pathway must be complete for an exposure to occur.

Figure A5-1 is an exposure pathway conceptual model that identifies the potential pathways for all of the media of concern for OU 3. This exposure pathway conceptual model illustrates how contaminated media may interact with each other, potentially resulting in cross-media contamination, and an increased number of exposure routes. Based on results of the COC selection process and CDPHE Conservative Screen Letter Report, soil (IHSS 199) and sediments in Great Western Reservoir (IHSS 200) represent the only potential sources of contaminant exposure in OU 3.

A5.2 EXPOSURE PATHWAY ANALYSIS

The potential receptors and associated exposure pathways (Figure A5-1) have been identified based on the COCs and the AOCs. There are no residents living within the AOCs at this time. Land use for the portions of OU 3 containing the AOCs is controlled through zoning limitations and land use restrictions included in the existing deeds of ownership. All locations identified as AOCs are within areas owned by the City of Broomfield or the City of Westminster and are subject to the City and County zoning requirements (Note: Parcels D, E, and F as shown on Figure A5-2 were purchased by the City of Westminster from Jefferson County in February 1995). In addition, all AOCs are located within areas zoned for open space. The City of Broomfield, through deeds of ownership (Jefferson County, 1964; Jefferson County, 1985a; Jefferson County, 1985b), controls the use of land surrounding Great Western Reservoir (see parcels identified as A, B, and C on Figure A5-2). A small portion of parcel C, located near the northeast portion of Great Western Reservoir, is zoned for Planned Unit Development (PUD) and is not owned by the City of Broomfield. According to the City of Broomfield (Oglesby, 1995), any uses of this land would have to be compatible with the overall open space planning and zoning requirements of the parcel and would require the submittal of development plans, public hearings and approval by the Broomfield City Council. Additionally, as indicated on Figure A5-2, the City of Westminster has similar legal authority over the parcels identified as D and E which includes the Remedy Lands (Jefferson County, 1985c; Jefferson County, 1985d).

The City of Broomfield, City of Westminster, and Jefferson County are closely involved in the current and future land use issues associated with OU 3. This is evidenced by the municipalities' purchase in

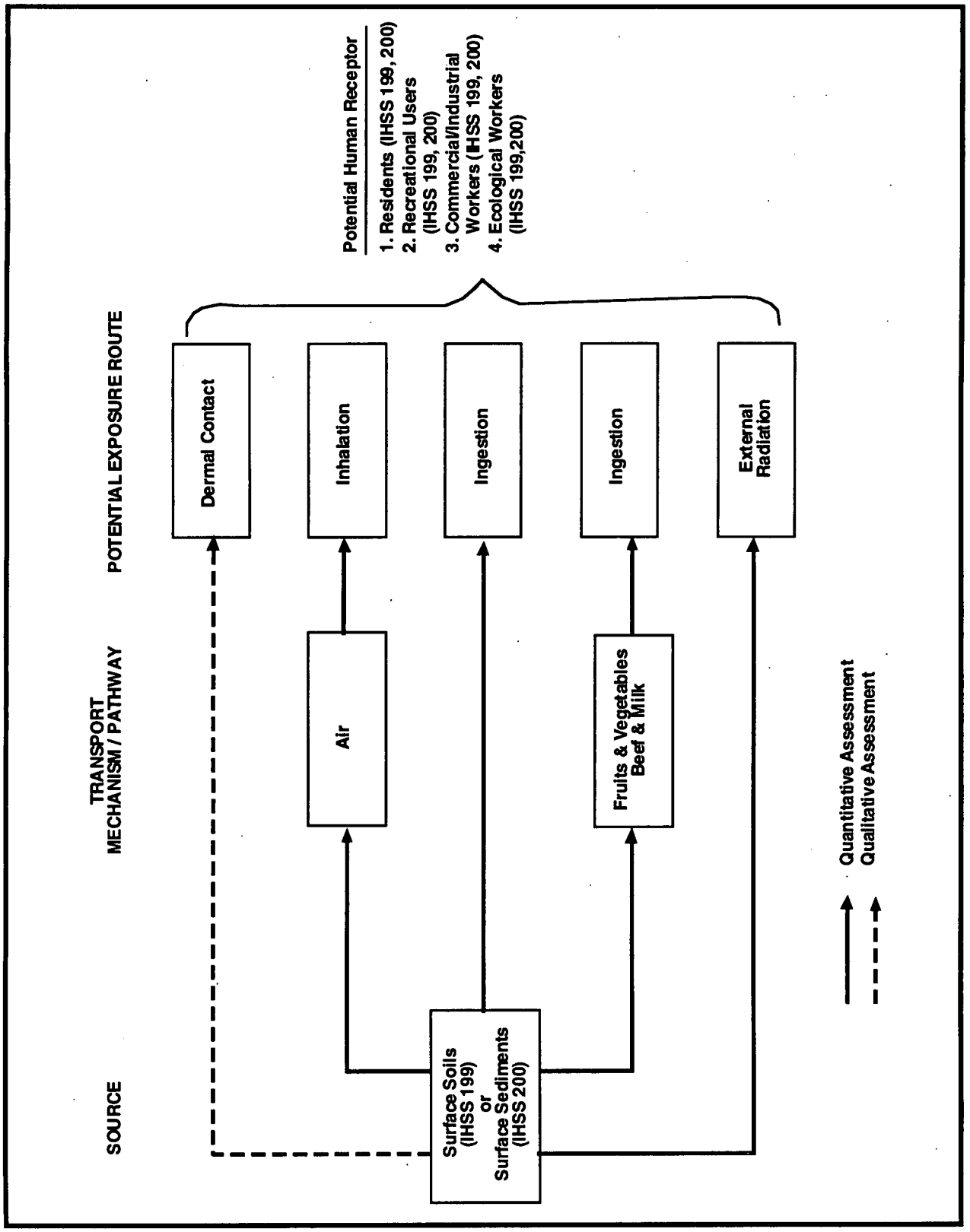


Figure A5-1
Conceptual Site Model of Potential Exposure Pathways in IHSSs 199 and 200

1985 of parcels A, B, D, and E, and their placement of deed restrictions on these lands for the expressed purpose of limiting potential exposure to plutonium (Jefferson County, 1985a; Jefferson County, 1985b; Jefferson County, 1985c; Jefferson County, 1985d). The ownership deeds for Parcels A, B, D, and E state that the zoning limitations and land use restrictions "shall be perpetual and shall run with the land."

Parcel C has been owned by the City of Broomfield since 1964 and, with the exception of the area zoned for PUD, is zoned for open-space use. Parcel C does not have specific deed restrictions because the City of Broomfield: (1) is aware of the existence of plutonium contamination, (2) has had control of the land before knowledge of potential plutonium contamination, and (3) has historically maintained effective control by limiting development and access in that area.

The land use restrictions and zoning limitations, suggest that the most likely land use for IHSSs 199 and 200 is recreational, and therefore, exposure pathways associated with a recreational scenario are quantitatively evaluated in the HHRA. In addition, the land use associated with the most conservative estimates of risk (i.e., residential) is also quantitatively evaluated in the HHRA. The commercial/ industrial worker and ecological researcher scenarios were not quantitatively evaluated in the HHRA, because, it is assumed risks for those two scenarios are less than risks associated with a residential scenario. Exposure pathways and exposure point concentrations are discussed quantitatively in Section A5.3, "Exposure Pathways Selected for Quantitative Analysis."

A5.2.1 Exposure Scenarios for IHSS 199 – Soils Contamination

Plutonium-239, -240 and americium-241 were identified as COCs in IHSS 199 surface soils (DOE, 1994a). Exposure will be assessed at the three AOCs in IHSS 199 identified just east of Indiana Street in or near the Remedy Land (Figure A5-3) (DOE, 1994b). These AOCs comprise one 10-acre soil plot (PT14192) sampled during the 1992 RFI/RI investigation and two untilled Remedy Land plots (U1A and U2A; the area for each plot is approximately 10 acres) sampled in 1991.

The AOCs in IHSS 199 are unused fields which have not been developed for recreational uses. Although it is possible a current trespasser may be exposed to the surface soil within the AOCs, the estimates of risk for future receptors will be much greater than the occasional trespasser who visits the area once or infrequently throughout the year. EPA defines the reasonable maximum exposure as "the highest exposure that is reasonably expected to occur at the site" (EPA, 1989a). In evaluating future land uses for risk assessment, consideration was given to whether future activities are likely to be different than those currently experienced, as well as reasonable potential uses. Pertinent information, including the municipalities' planning and zoning designs discussed in Section A2.1, coupled with census projections from the Denver Regional Council of Governments all support the assessment that the lands identified in Figure A5-2 will be used for open space in the future. On this basis, a recreational land-use scenario is identified as the most likely future-use RME scenario. Residential use is also evaluated in the HHRA for IHSS 199 in an effort to quantify the most conservative risk estimates for the surficial soils.

A5.2.1.1 Future Recreational Exposure Scenario

Health risks are evaluated for a hypothetical recreational receptor within a 50-acre exposure area (CDPHE/EPA/DOE, 1994) in the surface soil AOCs (PT14192, U1A, and U2A). Figure A5-3 shows the exposure area for a recreational scenario. This 50-acre exposure area includes the three soil plots identified as AOCs. Therefore, this 50-acre area represents the exposure area presenting maximum risks to a recreational user of OU 3. The recreational exposure scenario assumes a receptor participates in various recreational activities in the OU 3 area (i.e., hiking, biking, and picnicking) and is exposed to

plutonium-239, -240 and americium-241 in the surface soils in the AOCs. The elements of the recreational exposure scenario for surface soil in IHSS 199 are described below and are also summarized in Table A5-1.

The following pathways for exposure to an adult using the exposure area for recreational purposes are assessed quantitatively in the HHRA:

- Inadvertent ingestion of surface soil (includes adult and child exposure)
- Inhalation of airborne soil particulates suspended in air by wind erosion and recreational activities
- External radiation exposure

Dermal contact with soil COCs is qualitatively addressed in Section A8.0 for this scenario.

A5.2.1.2 Future Residential Exposure Scenario

Health risks are also evaluated for a hypothetical future resident within a 10-acre exposure area (CDPHE/EPA/DOE, 1994) in the surface soil AOCs. Figure A5-3 shows the three exposure areas evaluated for the residential scenario. The HHRA quantitatively assesses the following exposure pathways for a future residential adult:

- Inadvertent ingestion of surface soil (includes child exposure as well)
- Inhalation of soil particulates suspended in air by wind erosion
- External radiation exposure
- Ingestion of home grown produce (fruits and vegetables)
- Ingestion of beef/milk from locally raised livestock

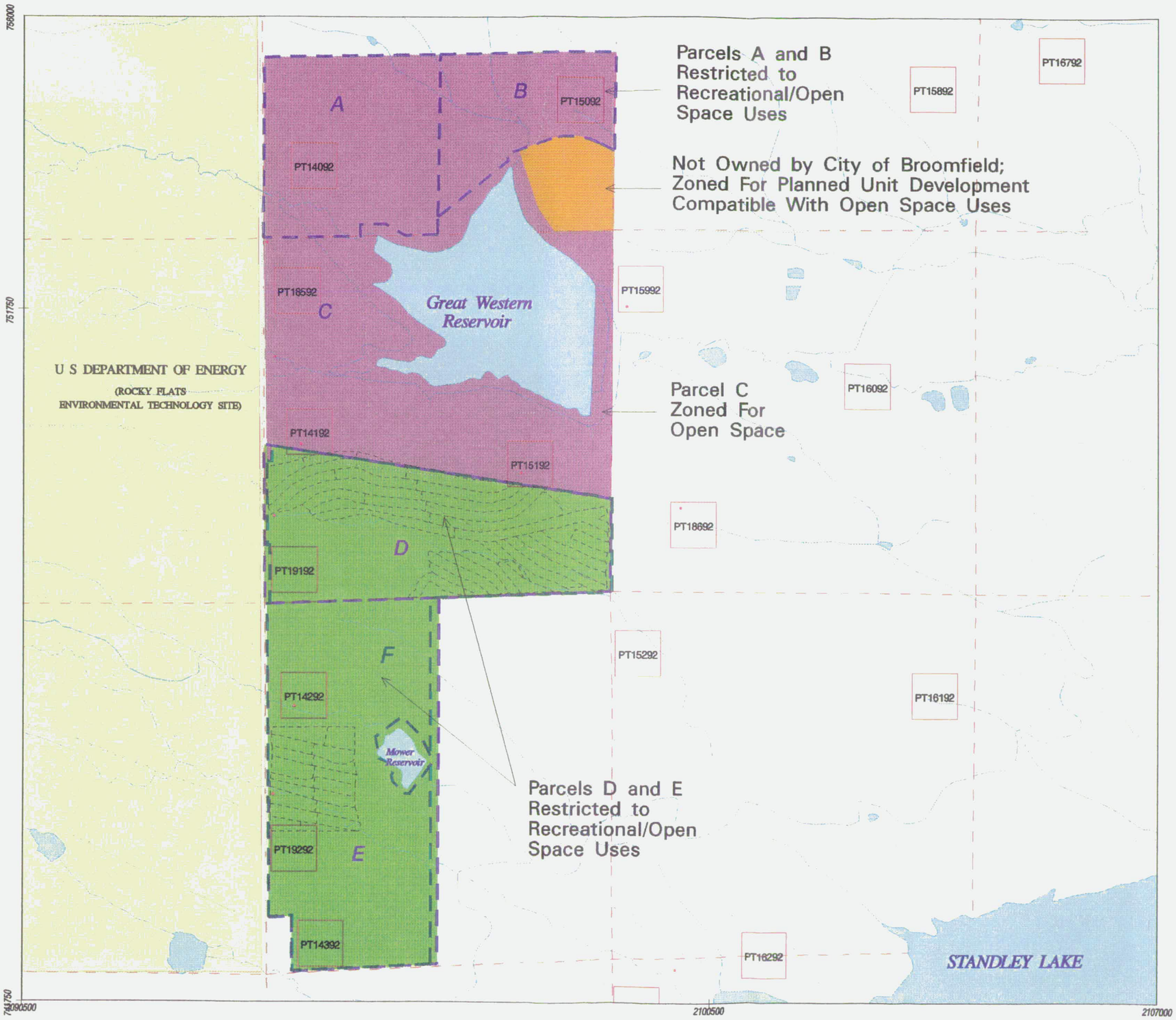
The HHRA qualitatively addresses dermal contact with surface soils and subsequent absorption of COCs in Section A8.0.

The quantitative values of exposure parameters to be assumed for these scenarios and exposure pathways are presented in Attachment 1 (Tables 1 through 5). Exposure parameters are presented for estimating central tendency (CT) and reasonable maximum exposure (RME) intake for each potentially complete exposure pathway. The exposure parameters are reasonable estimates of numerous variables including body weight, daily inhalation volume, daily ingestion rates, body surface area, soil or food matrix effects, and the frequency and duration of exposure. Exposure point concentrations, determined by chemical analytical data and fate and transport modeling (described in Technical Memorandum No. 3, Human Health Risk Assessment, Model Description, Operable Unit 3 [DOE, 1995c]), are used with these exposure parameters and equations to obtain pathway-specific chemical intakes to estimate risks. Risk estimates are presented in Section A7.0 of this HHRA.

Figure A5-2

Lands Controlled Through Zoning and Deed Restrictions
Operable Unit 3

ROCKY FLATS
ENVIRONMENTAL TECHNOLOGY SITE
U.S. Department of Energy



A,B,D,E — — — Deed restriction parcel boundaries
F — — —

Zoning	Current Land Ownership
Recreation / Open Space	City of Broomfield
	City of Westminster
Planned Unit Development	Not owned by municipalities or Jefferson County

RFI/RI soil trench

RFI/RI soil sample plot

Remedy Lands Area

Deed Information

A Owned by the City of Broomfield. Deed July 8, 1985 between the Great Western Venture and the City of Broomfield. Parcel 2. Reception No. 85063451.
B Owned by the City of Broomfield. Deed July 8, 1985 between the Great Western Venture and the City of Broomfield. Parcel 1. Reception No. 85063451.
C Owned by the City of Broomfield. No Explicit Deed Restrictions.
D Owned by Jefferson County. Deed July 8, 1985 between Butler Investments, Ltd., William C. Ackard, and the County of Jefferson, State of Colorado. Reception No. 85063459.
E Owned by Jefferson County. Deed July 9, 1985 between Perry S. McKay, Charles C. McKay, First Interstate Bank of Denver, and the County of Jefferson, State of Colorado. Reception No. 85063464.
F Owned by the City of Westminster. Deed February 23, 1995 between the County of Jefferson, The State of Colorado and The City of Westminster

Mapping Sources:
Jefferson County Mapping Dept
EG&G Rocky Flats
U.S. Geological Survey
CH2M HILL, Inc.

N

Scale 1:18000
1 in = 1500 ft

0 500 1000 2000
SCALE IN FEET

Polyconic projection. 1927 North American datum.
Colorado central zone state plane coordinate system.

Table A5-1
OU 3 Exposure Scenarios

IHSS	Land Use Assumption	Receptor (s)	Environmental Medium	Exposure Parameter Table No. in Attachment 2	Exposure Pathway [a]	Evaluation [b,c]
IHSS 199: Soils Contamination (Chemicals of Concern = $^{239/240}Pu$, and ^{241}Am)						
	Future Recreational	Adult Recreationist	Surface Soil	A-1	Inadvertent ingestion of surface soil (includes child expsoure)	b
				A-2	Inhalation of soil particulates suspended in air by wind erosion & other activities	b
				A-3	External radiation exposure	b
					Dermal contact	c
	Future Residential	Adult Residential	Surface Soil	3	External radiation exposure	b
					Dermal contact	c
				4	Ingestion of homegrown produce	b
				5	Ingestion of beef/milk from locally-raised livestock	
IHSS 200: Great Western Reservoir (drained [d]) (Chemicals of Concern = $^{239/240}Pu$)						
	Future Residential	Adult Resident	Reservoir and Stream Surface Sediments	1	Inadvertent ingestion of surface sediment (includes child exposure)	b
				2	Inhalation of sediment particulates suspended in air by wind erosion & construction activities	b
				3	External radiation exposure	b
				4	Dermal contact	c
				4	Ingestion of homegrown produce	b
				5	Ingestion of beef/milk from locally-raised livestock	
	Future Recreational	Adult Recreationist	Reservoir and Stream Surface Sediments	1	Inadvertent ingestion of surface sediment (includes child exposure)	b
				2	Inhalation of sediment particulates suspended in air by wind erosion & other activities	b
				3	External radiation exposure	b
					Dermal contact	c

[a] **Phase** 2 exposure scenarios were evaluated only if **Phase** 1 scenarios present a 10^{-6} risk or greater. RME and Central Tendency (CT) exposures will be assessed.
[b] Risks were assessed quantitatively for this exposure pathway.
[c] Risks were assessed qualitatively for this exposure pathway.

A5.2.2 Exposure Scenarios for IHSS 200—Great Western Reservoir Surface Sediments

The reservoir, drainages, and ditches in IHSS 200 have not been developed for residential, industrial, or recreational uses. Although it is possible a trespasser may be exposed to the shoreline surface sediments within the IHSS 200 AOC, the estimates of risk for future receptors will be much greater than the occasional trespasser who may visit the area once or infrequently throughout the year. Therefore, the remaining discussion of the exposure scenarios refer to hypothetical future exposures.
By 1997, the City of Broomfield may shift from using the Great Western Reservoir as its water source to using Carter Lake and water purchased from the Denver Water Board. Anticipating this action and the potential that the reservoir may be drained, a scenario for exposure to plutonium-239, -240 in Great Western Reservoir surface sediment was developed. If the reservoir is drained for recreational, residential, or commercial/industrial uses, the surface sediments in the center of the reservoir will be available for exposure. Water acts as a barrier to human contact and currently inhibits exposure to the sediments.

The surface sediments in IHSS 200 include the reservoir surface sediments and the North and South Walnut Creek drainage sediments (from Indiana Street into the reservoir). Graphical representation of the exposure areas for the two scenarios that will be quantitatively evaluated (residential and recreational) is shown on Figure A5-4. The placement of the exposure areas within Great Western Reservoir on Figure A5-4 is based on maximum plutonium concentrations at known locations.

A5.2.2.1 Future Recreational Exposure Scenario

The recreational exposure scenario assumes a receptor participates in various recreational activities in the 50-acre recreational exposure area and is exposed to plutonium-239, -240 in the surface sediments within the exposure area. All plutonium-239, -240 activity data within the exposure area were used to calculate an exposure point concentration (discussed in Section A5.3), including those data points that failed the CDPHE conservative screen. In Section A7.0, the following exposure pathways for an adult receptor are quantitatively assessed:

- Inadvertent ingestion of surface sediment (includes child exposure)
- Inhalation of airborne sediment particulates suspended in air by wind erosion and other recreational activities
- External radiation exposure

The exposure parameters for these exposure pathways are presented in Tables 1 through 3 in Attachment 1. Dermal contact with sediment is qualitatively addressed for this scenario in Section A7.0.

A5.2.2.2 Future Residential Exposure Scenario

The residential exposure scenario assumes a resident lives in the 10-acre residential exposure area of IHSS 200 and is exposed to plutonium-239, -240 in the surface sediments within the exposure area. All plutonium-239, -240 activity data within the exposure area are used to calculate an exposure point concentration (discussed in Section A5.3 below), including those data points that failed the CDPHE

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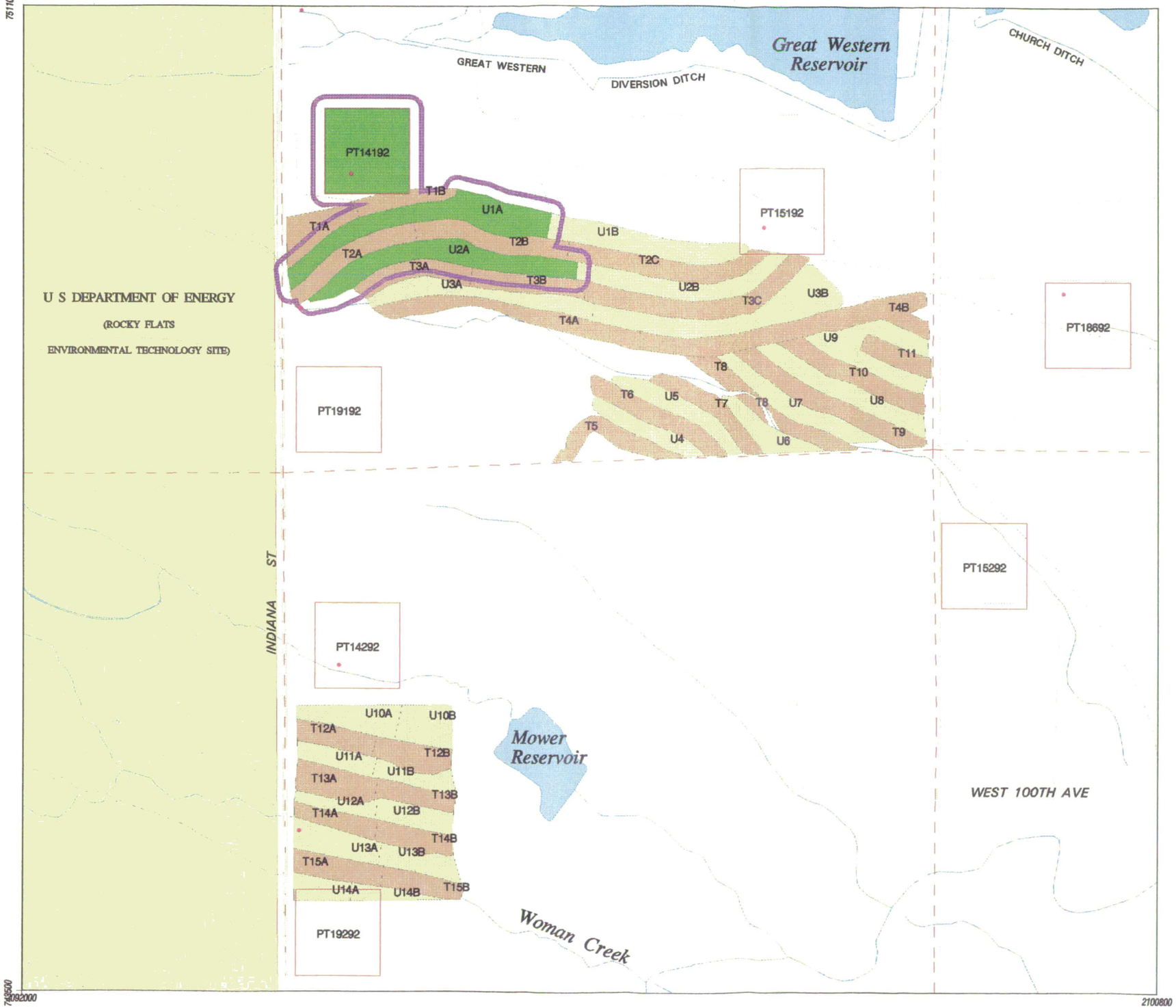


Figure A5-3
Exposure Areas
Operable Unit 3
IHSS 199 - Surface Soil Sampling Area

ROCKY FLATS
ENVIRONMENTAL TECHNOLOGY SITE
U.S. Department of Energy

Exposure Areas

- Recreational Scenario (50 acres)
- Residential Scenario Area of Concern (10 Ac.)
- RFI/RI soil trench
- RFI/RI soil sample plot
- untilled / tilled — Remedy Lands Area

Note: Areas of Concern were identified in the Letter Report, Colorado Department of Public Health and Environment Conservative Screen to define Areas of Concern at Operable Unit 3 (DOE, Sept. 23, 1994). Areas of Concern are defined as one or more Source Areas grouped spatially in close proximity, and exceeding risk-based criteria defined in the CDPHE Conservative Screen. Source Areas are defined as all sample locations where chemical concentrations exceed background levels.

Mapping Sources:
Jefferson County Mapping Dept
EG&G Rocky Flats
U.S. Geological Survey
CH2M HILL, Inc.

N

Scale 1:9600
1 in = 800 ft

0 250 500 1000
SCALE IN FEET

Polyconic projection. 1927 North American datum.
Colorado central zone state plane coordinate system.

conservative screen. In Section A7.0, the following exposure pathways for an adult exposure are quantitatively assessed:

- Inadvertent ingestion of reservoir and stream surface sediment (includes child exposure)
- Inhalation of airborne sediment particulates in air suspended by wind erosion and other activities
- External radiation exposure
- Ingestion of homegrown produce (fruits and vegetables)
- Ingestion of beef/milk from locally raised livestock

The exposure parameters for these exposure pathways are presented in Tables 1 through 5 in Attachment 1. Dermal contact with sediment is addressed qualitatively in Section A7.0 for this scenario.

A5.3 EXPOSURE PATHWAYS SELECTED FOR QUANTITATIVE ANALYSIS

Exposure is quantified by estimating the intake of media and combining it with the concentration of constituents in the media at the exposure point. Intake is estimated by combining the parameters that describe the rate of contact with or intake of the media, the frequency of contact, duration of contact and body weight of the exposed individual. Exposure point concentrations can be estimated by direct measurement at a point of contact or by modeling contaminant release and transport to the point of contact (exposure point).

As summarized on Table A5-1, the following exposure pathways have been selected for quantitative analysis:

- IHSS 199: ingestion, inhalation, and external radiation exposure of surface soil to a future recreationist.
- IHSS 199: ingestion, inhalation, and external radiation exposure of surface soil and ingestion of homegrown produce, beef, and milk to a future resident.
- IHSS 200: ingestion, inhalation, and external radiation exposure of reservoir and stream sediments to a future recreationist.
- IHSS 200: ingestion, inhalation, and external radiation exposure of reservoir and stream surface sediments and ingestion of homegrown produce, beef, and milk to a future resident.

A5.3.1 Chemical Intake Estimation

Using the exposure-point concentrations of the COCs in IHSS 199 soils and IHSS 200 surface sediments, it is possible to estimate the potential human intake via each exposure pathway described in Section A5.2. Intake parameters for CT exposure and RME conditions are presented in Attachment 1, Tables 1 through 5. Intakes are estimated for average CT and RME conditions. The RME is estimated by

selecting values for exposure variables so that the combination of all variables results in the maximum exposure that can reasonably be expected. The CT is estimated by selecting average values for exposure variables.

A5.3.1.1 Internal Exposure to Radionuclides

Ingestion or inhalation of radionuclides and their subsequent deposition in receptor tissues or organs will result in a radiation dose to those systems as well as to surrounding systems. Internal exposure to radionuclide COCs (plutonium-239, -240 and americium-241) is assessed in two ways. First, using conventional "dose assessment" methods, the committed effective dose equivalent (CEDE) based on intake of radionuclides via ingestion or inhalation is calculated and compared to radiation protection standards. The CEDE is the summation, over specified tissues, of the products of the dose equivalent in a tissue or organ and the weighting factor for that tissue over a 50-year period (EPA 1989a). The second method, using conventional "risk assessment" techniques, involves calculating the intake of each radionuclide and multiplying the intake by a EPA-derived carcinogenic slope factor (EPA, 1989a). This calculation results in an estimation of the risk of cancer associated with ingestion or inhalation of a radionuclide. Both methods described above are discussed in EPA guidance (1989a).

Intake of radionuclides by ingestion or inhalation is a function of the radionuclide activity, rate of intake (or the amount of contaminated medium contacted per unit time or event), and exposure frequency and duration. The intake is an estimate of the total intake of a radionuclide, expressed in units of radioactivity (Curies [Ci]).

The intake of radionuclides for both methods is estimated using the following equation

$$\text{Intake} = C \times IR \times EF \times ED \qquad \text{(A-3)}$$

where

Intake = Internal radionuclide intake via inhalation or ingestion (μCi for dose assessment, pCi for risk assessment)

C = Radionuclide activity at the point of exposure (pCi/m^3, μCi/g, pCi/kg)

IR = Medium intake rate (the amount of medium taken into the body per unit time) (m^3/day or g/day)

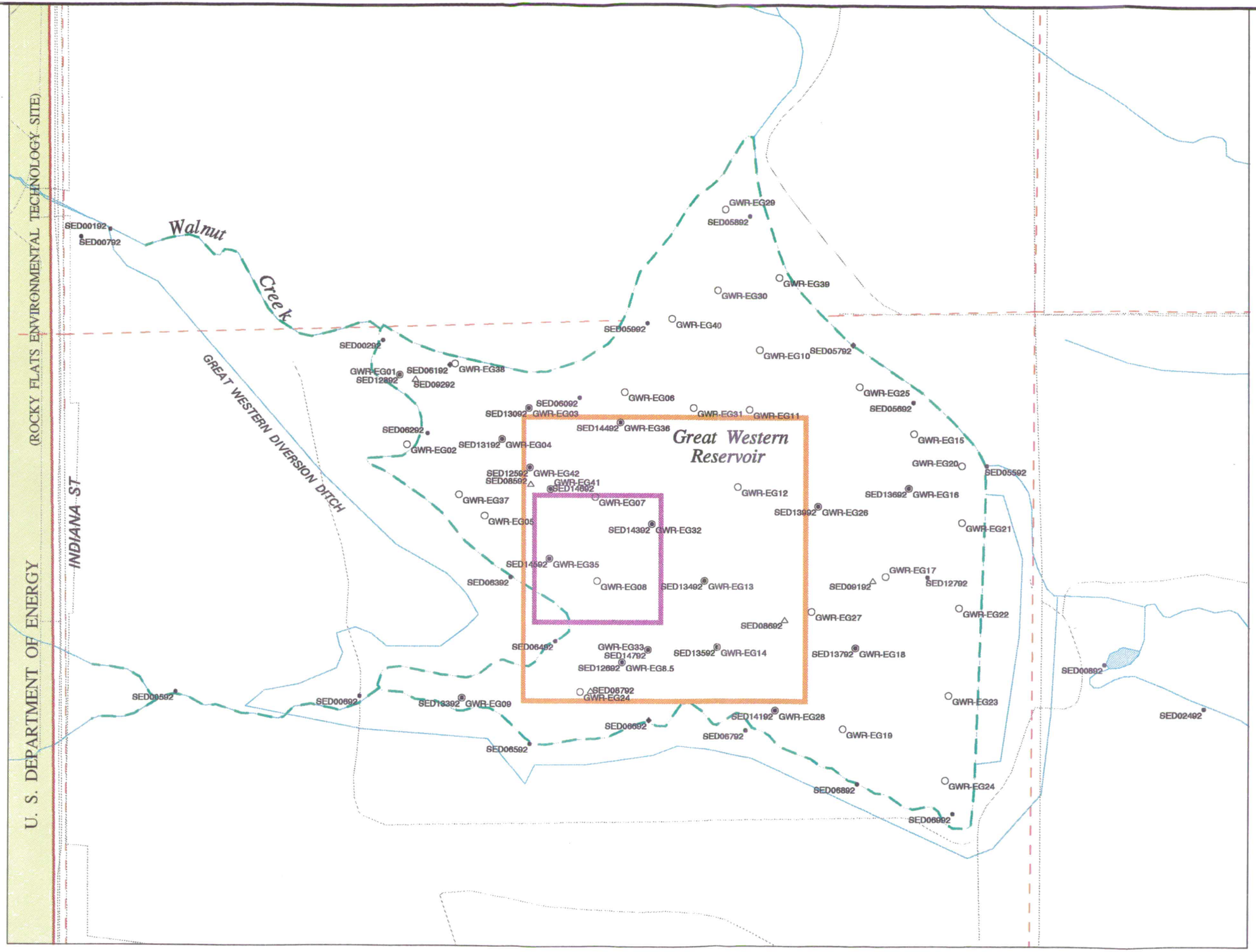
EF = Exposure frequency (number of days of exposure per year) and,

ED = Exposure duration (1 year for dose assessment, 30 years for risk assessment)

The intake value is then multiplied by either a dose conversion factor or a carcinogenic slope factor to estimate CEDE or carcinogenic risk, respectively. The radiation dose is a function of the type of radiation emitted by the radionuclide. The dose equivalent was developed to normalize the unequal biological effects from the different types of radiation. Because radiation doses from systemically incorporated radionuclides may continue long after intake, doses to specific tissues and organs from internal radionuclides are typically reported in terms of the committed dose equivalent. The committed dose equivalent to specific organs is estimated by multiplying the intake of each radionuclide by the

Figure A5-4

Exposure Areas
Operable Unit 3
IHSS 200 Great Western Reservoir



ROCKY FLATS
ENVIRONMENTAL TECHNOLOGY SITE
U.S. Department of Energy

Example Exposure Areas:
- Recreational Scenario (50 acres)
- Residential Scenario (10 acres)
- Area of Concern
- 1992 Sediment Grab/Core Sample Location
- 1992 Sediment Core Sample Location
- 1992 Sediment Grab Sample Location
- 1983/84 Sediment Sample Location

Note: Exposure areas are the approximate areas over which a receptor is exposed, based on land use. These areas are represented by squares centered on the approximate area of maximum plutonium activities in Great Western Reservoir.

The Area of Concern is represented by the reservoir shoreline and includes the IHSS 200 drainages (North Walnut Creek and South Walnut Creek).

Mapping Sources:
Jefferson County Mapping Dept.
EG&G Rocky Flats
U.S. Geological Survey

Scale 1 : 6000
1 inch = 500 ft

0 250 500 1000
SCALE IN FEET

N

Polyconic projection. 1927 North American datum. Colorado central zone state plane coordinate system.

appropriate dose conversion factor (DCF). The committed dose equivalents for each radionuclide are then summed to obtain a total CEDE.

For some radionuclides, committed effective dose coefficients vary based on the chemical species (e.g., oxidation state or mineralized form). Differences in committed effective dose equivalents for the ingestion route reflect differences in fractional uptake (f1) of radionuclide species from the small intestine to blood. According to EPA (1988b), less soluble radionuclide forms have smaller CEDEs than more soluble forms because the less soluble forms are absorbed to a lesser degree from the gastrointestinal tract into the bloodstream.

It is assumed, based on site characteristics, that plutonium in soil at Rocky Flats (and OU 3) is relatively insoluble and exists as Pu IV (solid plutonium dioxide and PuO_2). Consequently, the CEDE for plutonium was selected assuming that the predominant species at RFETS and OU 3 is the less soluble Pu IV.

The dose conversion factor (DCF, expressed in units of millirems [mrem] per μCi) is used to estimate the equivalent dose (in mrem per year), which can then be compared to a radiation protection standard.

The carcinogenic slope factors for radionuclides of concern are multiplied by the estimated radionuclide intake in total pCi (either inhaled or ingested) to estimate risk (EPA, 1989a).

A5.3.1.2 External Irradiation

External exposure to plutonium-239, -240 and americium-241 in IHSS 199 soils and plutonium-239, -240 in IHSS 200 sediments is assessed in a similar manner as internal radionuclide exposure (i.e., dose assessment and risk assessment). External radiation exposure is estimated using the following equation (EPA, 1991b)

$$EDE = DCF \times SC \times ET \times EF \times Te \times (1-Se) \qquad \text{(A-4)}$$

where

DCF = Dose conversion factor (mrem/hr per pCi/g)
SC = Soil activities (pCi/g)
ET = Exposure time (hrs/day)
EF = Exposure frequency (days/yr)
Te = Gamma exposure time factor (fraction of day) (unitless)
Se = Gamma shielding factor (unitless)

This will result in an estimate of the effective dose equivalent, which can then be compared to radiation protection standards. The CEDE for internal exposure is added to the annual external dose for purposes of standards comparison. For the risk assessment method, the following equation was used

$$Risk = C \times (1 - Se) \times Te \times Ed \times EFR \times SF \qquad \text{(A-5)}$$

where

C = Radionuclide activity at the point of exposure (pCi/g soil or sediment)
Se = Gamma shielding factor (unitless)

Te = Gamma exposure time factor (fraction of day) (unitless)
Ed = Exposure duration (years)
EFR = Exposure frequency ratio (ratio of exposure frequency to 365 days/year)
SF = Slope factor (risk/year per pCi/g)

A5.3.2 Exposure-Point Calculations

EPA (1989c) specifies that when estimating exposure-point concentrations, the overall objective is to calculate a value that represents a conservative estimate of the average concentration contacted at the point of exposure. Typically, this is represented by the 95-percent upper confidence limit (95 UCL) on the arithmetic mean concentration. The following sections describe the process for calculating the exposure-point concentrations for exposure scenarios developed for IHSS 199 and IHSS 200. Exposure-point concentrations are provided on the risk calculation spreadsheets in Attachment 3.

A5.3.2.1 Exposure Scenarios for IHSS 199—Soil

Two exposure scenarios are quantitatively evaluated in the HHRA-recreational and residential contact with surface soil. The exposure-point concentrations for all exposure pathways were estimated for these scenarios according to the following:

- For the recreational setting, the 95 UCL on the arithmetic mean, assuming a normal distribution, was calculated using all data points located within the 50-acre exposure area as shown in Figure A5-3. The 95 UCL concentration for plutonium-239 is 3.27 pCi/g, and the 95 UCL concentration for americium-241 is 0.52 pCi/g.

- For the residential setting, the COC activities associated with each of the sample locations that were identified as a result of the CDPHE conservative screen (PT14192; U1A; and U2A) were used to represent individual exposure-point concentrations, each within a 10-acre exposure area. The COC activities for each individual sample location represent the average value of the two sample collection techniques used to characterize the 10-acre plots (see Section 2.2 of the RFI/RI report for a description of the Soil Sampling Techniques). Therefore, the samples represent composite conditions within the 10-acre plots, not single, discrete locations associated with specific COC activities. The sample concentrations for plutonium-239 are 2.95, 6.468, and 3.59 pCi/g for samples PT14192, U1A and U2A, respectively. For americium-241, a concentration of 0.52 pCi/g was used for location PT14192.

The exposure-point concentrations for inhalation exposures were estimated based on data collected as part of the OU 3 wind-tunnel study in combination with a box model. Selection criteria for the box model were presented in Technical Memorandum No. 3, Human Health Risk Assessment, Model Description, Operable Unit 3.

For OU 3, the erosion potential data derived from wind-tunnel tests performed on soils and exposed reservoir sediments are used in the box model to estimate the inhalation exposure-point concentrations. Midwest Research Institute (MRI) conducted portable wind-tunnel tests to quantify resuspended particulate emissions from the soils and sediments associated with OU 3. Erosion potential and threshold velocities were determined over the course of 25 individual trials at four sites (three terrestrial and one sediment site). Threshold velocity is defined as the wind-tunnel air speed at which visible particulate movement occurred in the test area. Erosion potential is the mass of particulate matter resuspended from the test area normalized to a grams per square meter (g/m^2) basis.

As part of the wind-tunnel test, the soil and exposed sediment at the four sites were subjected to various levels of disturbance and these included:

- undisturbed (no modifications)
- moderately disturbed (grass is cut and raked)
- extra-disturbed (grass is cut and raked, and a vehicle is driven over the disturbed area)

According to MRI (1994), the undisturbed and moderately disturbed sites yielded such high threshold velocities that resuspension from these areas was considered highly unlikely. The average 10-meter equivalent threshold velocity for the extra-disturbed sites was 18.6 meters per second. To be conservative, the equivalent threshold value for the extra-disturbed sites was used to model inhalation exposure for the HHRA.

The box model used to estimate exposure-point concentrations was designed to compute the equilibrium concentration of particulates in the boxes corresponding to two exposure areas, one 10-acre area and one 50-acre area. These correspond to the residential and recreational exposure areas, respectively. Both areas were modeled as square areas with wind-speed-dependent emission rates into the "box" of air space above the area.

The governing equation of the box model is

$$LWH\frac{dC}{dt} = q_s LW + WHuC_{in} - WHuC \qquad \text{(A-6)}$$

where

L = Length of airshed (m)
W = Width of airshed (m)
H = Mixing height (m)
C = Airshed pollutant concentration (g/m^3)
C_{in} = Incoming concentration (g/m^3)
u = Average diluting wind speed (m/s)
q_s = emission rate (g/m^2s)

Steady state solutions can be approximated by setting dC/dt = 0 and obtaining

$$C = \frac{q_s L}{uH} + C_{in} \qquad \text{(A-7)}$$

where C_{in} is assumed to be 0 due to clean, incoming air. This equilibrium approximation is neither time nor width dependent. This results in the equation used for the box model:

$$C = \frac{q_s L}{uH} \qquad \text{(A-8)}$$

The following inputs were used to calculate the dust concentrations for the 10 and 50 acre plots:

Variable	10-Acre Plot	50-Acre Plot	Units
q_S	$.0000343 (u-18.6)^{1.5}$	$.0000343 (u-18.6)^{1.5}$	g/m^2s
L	200	450	meters
u	12.01	12.01	m/s
H	2	2	meters

The emission rate, q_S, was calculated from the wind-tunnel study assuming a wind speed of 18.6 m/s at ten meters.

The model was used to estimate particulate concentrations in the box. The particulate concentration was computed by assuming that the soil available for resuspension is replenished after every 15-minute wind-speed event above the threshold wind speed, even in the case of consecutive events. In other words, for all 15-minute intervals in which the windspeed was above 18.6 m/s, the windspeed (u) was used in calculating q_S for input into the box model. This is a conservative approximation given that, according to the MRI study (1994), in the absence of significant air disturbance to the area, the time of replenishment is on the order of one year after a wind-speed event.

The particulate concentration resulting from the box model was combined with the COC-associated activities measured in surface soil or sediment to estimate the exposure-point concentration for the inhalation route, assuming the wind speed exceeds 18.6 m/s. In addition, a resuspension ratio (i.e., ratio of analyte in resuspended particulates [PM-10 fraction] to ratio in soil or sediment) was used to calculate levels of COCs in air. Calculation of the exposure-point concentration in this manner assumes that no inhalation occurs at wind speeds below 18.6 m/s, based on the results of the wind-tunnel studies. Meteorological data for Rocky Flats were used to determine the number of events (on an annual basis) when wind speeds exceed 18.6 m/s to calculate a time-weighted exposure-point concentration. Risk calculation spreadsheets in Attachment 3 show formulas used to calculate air exposure-point concentrations.

A5.3.2.2 Exposure Scenarios for IHSS 200—Surficial Sediments

Exposure to surficial sediments associated with Great Western Reservoir assumes the reservoir is drained sometime in the future and the area developed for recreational or residential purposes. At that time, it is assumed an individual using the area for recreation or a resident would contact the surficial sediments. The exposure-point concentrations for these scenarios were estimated according to the following:

- For the recreational setting, the 95 UCL on the arithmetic mean, assuming a normal distribution, was calculated using all data points located within the 50-acre exposure area as shown in Figure A5-4. The 95 UCL concentration for plutonium-239 is 0.867 pCi/g.

- For the residential setting, the 95 UCL on the arithmetic mean, assuming a normal distribution, was calculated using all data points located within a 10-acre exposure area, as shown on Figure A5-4. The 10-acre exposure area was selected to include those sample locations associated with the highest reported activities of COCs detected in Great Western Reservoir. The 95 UCL concentration for plutonium-239 is 2.19 pCi/g.

In addition, the exposure-point concentrations for both the recreational and residential setting included three data points associated with the 1983/84 sediment data. These historical data represent previous studies to characterize radionuclide deposition in Great Western Reservoir sediments. The three data points were included in the estimation of the exposure-point concentration because they represented the highest detected activities of plutonium reported in the historical data set. However, the locations of these samples are unknown. It was assumed for the HHRA that the locations are within the 10-acre and 50-acre exposure areas. The inhalation-specific, exposure-point concentrations were estimated according to the procedures discussed in Section A5.3.2.1.

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A6.0 TOXICITY ASSESSMENT

Conducting a toxicity assessment involves assessing the potential for the identified COCs to cause adverse effects in exposed individuals. The toxicity assessment also seeks to develop a reasonable appraisal of the associations between the degree of exposure to a contaminant and the possibility of adverse health effects. A chemical agent may not cause adverse effects or toxic effects in biological systems unless the agent, or its metabolic byproducts, reach critical receptor sites in the body at specific levels and for a period of time sufficient to elicit a particular effect. Whether or not a toxic response occurs depends on the chemical and physical properties of the toxic agent, the degree of exposure to the agent, and the susceptibility of an individual to the particular effect. To characterize the toxicity of a particular chemical, the type of effect it can produce and how much is needed to produce that effect must be known.

The toxicity assessment contains two components:

1) Hazard identification, which is the process of evaluating the adverse human health effects, if any, that may result from exposure to the COCs.

2) Dose-response evaluation, which quantitatively examines the relationship between the level of exposure and the occurrence of adverse health effects in the exposed population. Dose-response relationships, which are expressed as quantitative toxicity reference values for the COCs, are also summarized.

A6.1 HAZARD IDENTIFICATION

The COCs identified for OU 3 include plutonium-239, -240 and americium-241 for soil (IHSS 199) and plutonium-239, -240 for surface sediments in Great Western Reservoir (IHSS 200).

EPA classifies all radionuclides as human carcinogens (Group A), based on their property of emitting ionizing radiation and on the extensive weight of evidence provided by epidemiological studies of radiogenic cancers in humans (EPA, 1993; EPA, 1994b). At Superfund radiation sites, EPA generally evaluates potential human health risks based on the radiotoxicity, (i.e., adverse health effects caused by ionizing radiation), rather than on the chemical toxicity, of each radionuclide present (EPA, 1993).

The effects of exposure to ionizing radiation fall into three general categories: (1) carcinogenic, (2) mutagenic (genetic), and (3) teratogenic. In the following subsections, the biological damage mechanisms of ionizing radiation are described as well as the carcinogenic, mutagenic (genetic), and teratogenic effects. Section A6.1.2 presents the rationale for using total cancer incidence as the basis for assessing radiation risks to receptors.

A6.1.1 Biological Damage Mechanisms

Radiation produces damage in biological systems through ionization of molecules. Damage may occur directly, as when a chromosome breaks into smaller pieces after absorption of energy from radiation. Damage may also occur indirectly, through ionization of water molecules to produce highly reactive free radicals. The free radicals may react with other cellular compounds and cause damage through oxidation reactions.

The biological effects of radiation are classified as either nonstochastic or stochastic effects. Nonstochastic effects are effects that occur only after a minimum (threshold) dose has been received. Examples of nonstochastic effects include reddening of the skin (erythema) and cataracts. Nonstochastic effects are principally associated with high levels of radiation exposure (greater than 10 roentgen equivalent man [rem]). A rem is a unit of "dose equivalent" used in radiation protection to measure the amount of damage to human tissue from a dose of ionizing radiation. It is highly unlikely that receptors at OU 3 could ever receive radiation doses that would cause nonstochastic effects.

Stochastic effects are those for which the probability of occurrence increases with the cumulative dose (i.e., it is assumed there is no threshold dose). The stochastic effects associated with low levels of radiation exposure include cancer, genetic effects, and teratogenic effects.

A6.1.2 Carcinogenic Effects

Ionizing radiation has been demonstrated to induce human cancer. A great deal of data exist correlating high exposures of radiation to cancer induction in humans. In general, scientists agree that the probability of cancer increases with dose, but scientists continue to debate which dose-response model most accurately predicts the effects of low-level radiation exposure. Current radiation-protection standards are based on the idea that each increment of radiation exposure causes a linear increase in the risk of cancer (the linear nonthreshold hypothesis).

The Biological Effects of Ionizing Radiation (BEIR) V Committee of the National Academy of Science (NAS) recently completed a study entitled *Health Effects of Exposure to Low Levels of Ionizing Radiation* (otherwise known as the BEIR V Report) (NAS, 1990). The study included information from the continuing epidemiological studies of the Japanese survivors of the atomic bomb and of radiotherapy patients treated for cancer. The BEIR V Committee concluded that the linear nonthreshold dose-response model most accurately predicts the increased risk of most forms of cancer that develop from exposure to low doses of radiation. The BEIR V Committee also increased the cancer risk estimates for radiation exposure from the 1980 BEIR III Report (NAS, 1980) by a factor of 3 to 4, based primarily on results of studies that reevaluated the actual radiation doses received by the Japanese survivors of the atomic bomb. EPA has revised their slope factors for radionuclides incorporating recommendations from BEIRV. The EPA recently finished evaluating the cancer risk from radiation exposure as part of the safety analysis for radionuclide standards for atmospheric releases (known as National Emission Standards for Hazardous Air Pollutants [NESHAP] (EPA, 1989b). These risk estimates are in terms of the excess cancer induction and excess cancer deaths expected in a population of 1 million people, each person exposed to one rad. A rad is defined by the International Commission on Radiation Units and Measurements (ICRUM) as the amount, or dose, of ionizing radiation absorbed by any material, such as human tissue. Radiation absorbed dose is expressed as energy per unit mass. One rad is equivalent to 100 ergs of energy absorbed by one gram of absorbing material. The use of these risk estimates in the risk assessment is explained in Section A7.0 of this Draft HHRA.

A6.1.3 Mutagenic (Genetic) Effects

Radiation can cause damage to cells by changing the number, structure, or genetic content of the genes and chromosomes in the cell nucleus (NAS, 1972, 1980). These heritable radiation effects are classified as either gene mutations or chromosome aberrations. Gene mutations and chromosome aberrations may occur in either somatic (body) or germ (reproductive) cells. When the mutation or aberration occurs in a somatic cell, the damage is expressed in the exposed individual. For somatic-cell mutations, the worst consequence of the damage is cancer induction. When the mutation or aberration occurs in a germ cell,

the resulting damage may be expressed in the descendants of the exposed individual. Followup epidemiological studies of human populations exposed to low doses of radiation have not shown conclusive evidence of heritable effects that are due to radiation exposure. Most scientists agree, however, that these effects may be occurring in numbers so low that they are not detectable in the study populations. Because of the lack of conclusive human data, animal studies are used to determine risk factors for heritable effects in humans.

The results of extensive animal studies have shown that radiation increases the spontaneous, or natural, mutation rate. No new types of mutations have been attributed to radiation exposure. Estimates based on extrapolation from these animal studies are that at least 100 rem of low-dose-rate, low-LET radiation are required to double the spontaneous mutation rate in humans. Current human dose-response models, however, assume that the probability of genetic damage increases linearly with radiation dose, and that there is no evidence of a "threshold" dose for initiating heritable damage to germ cells (EPA, 1989a).

A6.1.4 Teratogenic Effects

Relatively high doses of radiation exposure have been shown to produce abnormalities in animals and humans exposed in utero. The effects of radiation exposure to the fetus vary with the stage of gestation. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has developed quantitative risk estimates for effects of prenatal irradiation (primarily mental retardation) over the different stages of pregnancy. Possible risks of fetal radiation exposure include mental retardation, development of fatal cancer after birth, malformation, and preimplantation loss or spontaneous abortion.

A6.1.5 Summary

Cancer induction through exposure to low levels of radiation constitutes the most significant potential consequence of exposure. The risks of heritable effects from radiation exposure are much lower than cancer induction for the first few generations. Carcinogenic effects can be induced at any point during a lifetime. However, exposures must occur during a specific period during gestation for the risks of effects on the developing fetus to be significant. In most cases, the cumulative risk of cancer is much higher than the risk of fetal effects or genetic effects. For these reasons, cancer induction is used as the basis for assessing the radiation risks to receptors.

A6.2 DOSE-RESPONSE EVALUATION

The method used for this radiological risk assessment conforms to the guidelines outlined in Chapter 10 of *Risk Assessment Guidance for Superfund, Volume I: Health Evaluation Manual, Part A* (EPA, 1989a). In accordance with EPA guidance, the risk associated with radiation exposure is evaluated by using age-averaged slope factors that represent lifetime excess cancer incidence per unit of intake for each radionuclide. These factors are tabulated as part of the Health Effects Assessment Summary Tables (HEAST) documentation (EPA, 1994b). Table A6-1 lists the internal (ingestion and inhalation) and external slope factors for COCs.

EPA's Office of Radiation and Indoor Air (ORIA) calculates radionuclide slope factors using health-effects data, and dose and risk models from a number of national and international scientific advisory commissions and organizations, including BEIRV, the NAS, the National Council on Radiation Protection and Measurement (NCRP), UNSCEAR, and the International Commission on Radiological

Table A6-1

Toxicity Constants Carcinogenic Slope Factors[a] for Americium-241 and Plutonium-239, -240

Radionuclide	Radioactive Half-Life[b]	Ingestion (risk/pCi)[b]	External Ihalation (risk/pCi)[b]	(Risk/Year pe pCi/g soil)[b]
Americium-241	432 years	3.28×10^{-10}	3.85×10^{-8}	4.59×10^{-9}
Plutonium-239[c]	24,100 years	3.16×10^{-10}	2.78×10^{-8}	1.26×10^{-11}

[a]EPA classifies all radionuclides as Group A (known human) carcinogens. Radionuclide slope factors are calculated by EPA's Office of Radiation and Indoor Air. Ingestion and inhalation slope factors are best estimates (i.e., median or 50th percentage values) of the age-averaged, lifetime excess cancer incidence (fatal and nonfatal cancer) risk per unit of activity inhaled or ingested, expressed as risk/picocurie (risk/pCi). External slope factors are best estimates of the lifetime excess cancer incidence risk for each year of exposure to external radiation from photon-emitting radionuclides distributed uniformly in a thick layer of soil and are expressed as risk/year per pCi/gram of soil.

[b]A curie (Ci), the common unit of activity, is equal to 3.7 x 1010 nuclear transformations per second. (1 pCi = 10^{-12}Ci.)

[c]The toxicity constants for Americium-241 will be used for Plutonium-239, -240. While Plutonium-239 and Plutonium-240 have different half-lives and external slope factors (but equal internal slope factors), only Plutonium-239 is listed here since 90 percent of the activity between the two isotopes is from Plutonium-239.

Source: EPA, 1994b.

Protection (ICRP). Radionuclide slope factors are calculated for each radionuclide individually, based on its unique chemical, metabolic, and radioactive properties.

The internal, ingestion and inhalation, slope factors account for:

- The amount of radionuclide transported into the bloodstream from either the gastrointestinal (GI) tract following ingestion, or from the lungs following inhalation.
- The ingrowth and decay of significant radioactive progeny produced within the body subsequent to intake.
- The distribution and retention of each radionuclide (and its associated progeny, if appropriate) in body tissues and organs.
- The radiation dose delivered to body tissues and organs from the radionuclide (and its associated progeny, if appropriate).
- The sex, age, and organ-specific risk factors over the lifetime of exposure.

The slope factors are the average risk per unit intake or exposure for an individual in a stationary population with vital statistics (mortality rates) typical of the United States population in 1970. Radionuclide ingestion and inhalation slope factors are not expressed as a function of body weight and time, and do not require corrections for gastrointestinal absorption or lung-transfer efficiencies (EPA, 1994b).

External slope factors, which account for photon energy flux attenuation and buildup in soil, provide cancer risk estimates per unit exposure to a uniform concentration in soil. Because of the radiation risk models employed, both the internal and external slope factors are characterized as best estimates (i.e., median or 50th percentile values) of the age-averaged lifetime total excess cancer incidence risk per unit intake or exposure.

DCFs used for calculating dose are taken from *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion* (EPA, 1988b) and are shown in Table A6-2. These DCFs are used to determine the CEDE resulting from intake of each radionuclide. The "committed dose" concept was introduced as a means of controlling occupational exposures to radionuclides that remain in the body for long periods of time.

DCFs are listed by solubility class and lung-clearance class for each radionuclide. Solubility classes are characterized by an "F1" value (Table A6-2). The F1 value represents the fraction of the radiological contaminant that is transferred from the gastrointestinal tract to the blood. The F1 and lung-clearance class values for a particular radionuclide are dependent on the chemical form of that radionuclide.

The following subsections discuss important assumptions and procedures used to determine risks related to internal and external exposure OU 3.

A6.2.1 Internal Exposure

Internal exposure to radiation may occur through inhalation or ingestion of radioactive contaminants. Determination of risk due to internal exposure involves calculating the total amount of radioactive material taken into the body, and then multiplying this by the oral slope factor. The risk of cancer incidence from internal exposure to radiological contaminants was calculated using slope factors published in the annual 1994 HEAST (EPA, 1994b).

The risk of cancer incidence from ingesting or inhaling radioactive contaminants is calculated by multiplying the total lifetime intake by the slope factor for ingestion or inhalation. These slope factors relate risk of cancer incidence to intake of each radionuclide. The cancer-incidence risk factors are taken from HEAST (EPA, 1994b).

A6.2.2 External Exposure

Radionuclides can have deleterious effects on humans without being taken into or brought in contact with the body. This is because high-energy beta particles and photons from radionuclides in contaminated air, water, or soil can travel long distances with only minimum attenuation in these media before depositing their energy in human tissues. External radiation exposures can result from either exposure to radionuclides at Rocky Flats or to radionuclides that have been transported from Rocky Flats to other locations in the environment. Gamma and X-rays are the most penetrating of the emitted radiations, and comprise the primary contribution to the radiation dose from external exposures. Alpha particles are not sufficiently energetic to penetrate the outer layer of skin and do not contribute significantly to the

Table A6-2

Dose Conversion Factors (DCFs) for Inhalation and Ingestion Used in the Dose Assessment

Radionuclide	f_1[a]	Inhalation Class[b]	DCF for Inhalation (Sv/Bq)[c]	DCF for Ingestion (Sv/Bq)[c]
Americium-241	1×10^{-3}	W	1.2×10^{-4}	9.84×10^{-7}
Plutonium-239, -240[d]	1×10^{-3}	W	1.16×10^{-4}	9.56×10^{-7}
	1×10^{-4}	—	—	9.96×10^{-8}
	1×10^{-5}	Y	8.33×10^{-5}	1.4×10^{-8}

Source: EPA, 1988b.

Notes:
— = Not applicable.

[a]Fractional amounts of radionuclide absorbed across the gastrointestinal tract into the bloodstream.
[b]Lung clearance classification recommended by the International Commission on Radiological Protection (ICRP): Y = year, W = week.
[c]Sv/Bq = sieverts per becquerel.
[d]The toxicity constants for Plutonium-239 and Plutonium-239, -240 are equivalent.

external dose. External exposure to beta particles imparts a dose primarily to the outer layer skin cells, although high-energy beta radiation can penetrate into the human body.

The HEAST risk factors (Table A6-1) (slope factors) for surface-soil contamination were used to calculate increased cancer incidence risks from external exposure. These factors assume uniform deposition of contaminants over a large area, which increases the uncertainty of such calculated risks.

A7.0 RISK CHARACTERIZATION

This section describes the radiological risk estimation methods and the results of the risk characterization for receptors exposed under recreational and residential settings in IHSS 199 and IHSS 200 based on the assumed exposure conditions.

A7.1 RISK ESTIMATION METHODS

RME and CT risks are estimated for each COC and each exposure pathway. The exposure estimates are compared or combined with toxicity values for the COCs to generate a quantitative risk estimate, as described in the following sections.

A7.1.1 Dose Estimation Methods—Internal and External Radiation

Sections A5.3.2.1 and A5.3.2.2 discussed the methods used to estimate the CEDEs for internal radiation exposure and effective dose equivalents (EDEs) for external exposure to radiation sources. The CEDE and EDE values are summed to estimate the total effective dose equivalents (TEDEs) which are calculated for all radionuclides and all pathways. For example, the TEDE accounts for radiation exposure resulting from ingestion, inhalation, and external exposures. Total annual radiation dose is equal to the TEDE for one year of exposure and can be compared to annual radiation protection standards.

For this assessment, the TEDEs are compared to the DOE annual radiation dose limit for members of the public, including residents and recreationalists. This value is equal to 100 mrem/year for all routes of exposure. TEDEs that exceed 100 mrem/year indicate that the exposure to the radioactive sources exceeds regulatory limits.

A7.1.2 Cancer Risk Estimation Methods—Intake-Based

The potential for carcinogenic effects is evaluated by estimating excess lifetime cancer risk. Excess lifetime cancer risk is the incremental increase in the probability of developing cancer during one's lifetime over the background probability of developing cancer (i.e., if no exposure to Rocky Flats-related COCs occurred). For example, a 2×10^{-6} excess lifetime cancer risk means that for every one million people exposed to the carcinogen at the defined exposure conditions averaged over a lifetime, the average incidence of cancer is increased by two occurrences. The NCP states a point of departure for remediation goals of 1×10^{-6} and an acceptable excess lifetime cancer risk range of 1×10^{-4} to 1×10^{-6} (EPA, 1990a).

The slope factor gives the incremental risk when applied to the lifetime radionuclide intake. Because of the methods followed in estimating slope factors, the excess lifetime cancer risks should be regarded as upper bounds on the potential cancer risks rather than an accurate representation of true cancer risk. The actual risk could be as low as zero.

Where the risks are less than 1×10^{-2}, it can generally be assumed that the dose-response relationship will be linear in the low-dose portion of the dose-response curve. Under this assumption, the slope factor is a constant and risk is related directly to intake. This relationship can be described as Risk = Slope Factor x Intake.

The exposure scenarios evaluated for IHSS 199 involve potential exposure to more than one carcinogen. Although synergistic or antagonistic interaction might occur among chemicals at IHSS 199, there is insufficient information in the toxicological literature to predict quantitatively the effect of such interaction. Therefore, to be consistent with EPA guidelines on chemical mixtures (EPA, 1986), the carcinogenic risks are treated as additive. For estimating intake-based cancer risks from exposure to multiple carcinogens from a single exposure route, the following equation will be used

$$Risk_T = \sum_{i=1}^{N} Risk_i \qquad \text{(A-9)}$$

where

$Risk_T$ =total cancer risk from route of exposure
$Risk_i$ =cancer risk for the i-th chemical
N =number of chemicals

A7.2 SUMMARY OF ESTIMATED RISKS

Tables A7-1 through A7-5 present summaries of the total risks, both for the TEDE and cancer risk estimates for adults. All of the estimated risks are within the EPA's acceptable excess lifetime cancer risk range of 1×10^{-4} to 1×10^{-6}. All of the estimated doses are well below the DOE annual dose limit for the general public of 100 mrem/year. It is also important to note that the risk calculations were performed for areas of OU 3 with the highest activities of COCs (plutonium and americium). This means that for all other areas of OU 3, risks are even lower than those reported for the AOCs. Attachment 3 presents the detailed calculation spreadsheets for all risk estimates discussed in this section.

Table A7-1
Risk Summary for IHSS 199

RME Residential
Adult

	Cancer Risk			CEDE/EDE		
Pathway	**PT14192**	**U1A**	**U2A**	**PT14192**	**U1A**	**U2A**
Soil ingestion	1E-06	3E-06	1E-06	0.072	0.012	0.007
Soil inhalation	2E-08	3E-08	2E-08	0.0086	0.013	0.0071
Soil external	6E-08	2E-09	1E-09	0.018	0.001	0.008
Vegetable consumption	7E-08	7E-08	4E-08	1.6E-2	3.7E-4	2.1E-4
Beef consumption	1E-08	2E-10	9E-11	3.7E-3	9E-7	7.4E-3
Milk consumption	1E-11	2E-11	1E-11	5.6E-6	2.3E-7	1.3E-7
Total	1E-06	3E-06	1E-06	1.2E-1	2.6E-2	2.3E-2

Notes:
RME = Reasonable maximum exposure.
CEDE = Committed effective dose equivalent (mrem/yr).
EDE = Effective dose equivalent-1 year exposure-external exposure only mrem/yr.
1E-06 = 1×10^{-6} or 0.000001

Table A7-2
Risk Summary for IHSS 199

CT Residential
Adult

	Cancer Risk			CEDE/EDE		
Pathway	**PT14192**	**U1A**	**U2A**	**PT14192**	**U1A**	**U2A**
Soil ingestion	1E-07	2E-07	1E-07	0.015	0.0025	0.0014
Soil inhalation	2E-09	3E-09	2E-09	0.0027	0.0047	0.0023
Soil external	5E-09	2E-10	9E-11	0.0036	0.0003	0.0002
Vegetable consumption	3E-09	3E-09	2E-09	0.002	5E-5	3E-5
Beef consumption	1E-09	2E-11	1E-11	1.5E-3	2.6E-7	2E-7
Milk consumption	1E-12	1E-12	8E-13	2.3E-6	9.6E-8	5.3E-8
Total	1E-07	2E-07	1E-07	2.5E-2	7E-3	3.9E-3

Notes:

CT = Central tendency exposure.
CEDE = Committed effective dose equivalent (mrem/yr).
EDE = Effective dose equivalent-1 year exposure-external exposure only mrem/yr.
1E-06 = 1 x 10^{-6} or 0.000001

Table A7-3
Risk Summary for IHSS 199

Adult

	RME Recreational		CT Recreational	
Pathway	**Cancer Risk**	**CEDE/EDE**	**Cancer Risk**	**CEDE/EDE**
Soil ingestion	5E-08	0.0026	3E-09	0.00052
Soil inhalation	1E-09	0.00052	3E-11	0.000043
Soil external	1E-09	6.6E-5	5E-11	3.25E-6
Total	5E-08	3E-3	3E-9	5.7E-4

Notes:

RME = Reasonable maximum exposure.
CT = Central tendency exposure.
CEDE = Committed effective dose equivalent (mrem/yr).
EDE = Effective dose equivalent-1 year exposure-external exposure only mrem/yr.
1E-06 = 1 x 10^{-6} or 0.000001

Table A7-4
Risk Summary for IHSS 200

Adult				
	RME Residential		CT Residential	
Pathway	**Cancer Risk**	**CEDE/EDE**	**Cancer Risk**	**CEDE/EDE**
Soil ingestion	9E-07	4E-03	6E-08	8E-04
Soil inhalation	5E-09	1.9E-03	5E-10	6.1E-04
Soil external	7E-10	4.8E-04	6E-11	9E-05
Vegetable consumption	2E-08	1.3E-04	9E-10	2E-05
Beef consumption	2E-11	1.3E-07	2E-12	3.3E-08
Milk consumption	6E-12	3.3E-08	5E-13	8.5E-09
Total	9E-07	6.5E-03	6E-08	1.5E-03

Notes:
RME = Reasonable maximum exposure.
CT = Central tendency exposure.
CEDE = Committed effective dose equivalent (mrem/yr).
EDE = Effective dose equivalent-1 year exposure-external exposure only mrem/yr.
9E-07 = 9×10^{-7} or 0.0000009

Table A7-5
Risk Summary for IHSS 200

Adult				
	RME Recreational		CT Recreational	
Pathway	**Cancer Risk**	**CEDE/EDE**	**Cancer Risk**	**CEDE/EDE**
Sediment ingestion	1E-08	1E-04	8E-10	1E-05
Sediment inhalation	1E-10	4.3E-5	3E-12	3.6E-06
Sediment external	4E-12	7E-07	2E-13	3.4E-08
Total	1E-08	1.4E-04	8E-10	1.4E-05

Notes:
RME = Reasonable maximum exposure.
CT = Central tendency exposure.
CEDE = Committed effective dose equivalent (mrem/yr).
EDE = Effective dose equivalent-1 year exposure-external exposure only mrem/yr.
1E-08 = 1×10^{-8} or 0.00000001

A7.2.1 Risk Results of IHSS 199

Tables A7-1 through A7-3 summarize the estimated excess lifetime cancer risk and TEDE based on the RME and CTE activities of plutonium and americium in soil. The total risk values presented represent the additive risk across all pathways evaluated quantitatively.

A7.2.1.1 Residential Exposure

Tables A7-1 and A7-2 summarize the risks associated with adult residential exposure to plutonium and americium in soil based on RME and CT conditions, respectively. Direct contact exposure is assumed to occur as a result of ingestion and inhalation. Indirect exposure is limited to fruit, vegetable, beef, and milk consumption and external radiation exposure. The results indicate the following:

- For an adult, and based on a time-weighted soil ingestion rate, the estimated excess lifetime cancer risk is 1×10^{-6} for locations PT14192 and U2A, and 3×10^{-6} for location U1A, based on the reasonable maximum exposure point concentration. For the CT concentration combined with the time-weighted soil ingestion rate, the estimated excess lifetime cancer risk is 1×10^{-7} for locations PT14192 and U2A, and 2×10^{-7} for location U1A.

- For an adult, the TEDE is about 0.012 mrem/year, 0.026 mrem/year, and 0.023 mrem/year for locations PT14192, U1A, and U2A, respectively, based on the RME exposure point concentration. The TEDE based on the CT concentration is about 0.025 mrem/year, 0.007 mrem/year, and 0.0039 mrem/year for PT14192, U1A, and U2A, respectively. These values are all below the DOE annual dose limit for the general public of 100 mrem/year.

- For a child, the CEDE for ingestion exposures under RME conditions is about 0.14 mrem/year for PT14192 and U1A, and 0.013 mrem/year for U2A. The corresponding CT values are 0.039 mrem/year, 0.0064 mrem/year, and 0.0036 mrem/year for PT14192, U1A and U2A, respectively.

For adults, the main contribution to risk and dose estimates is the soil ingestion exposure route. Excess lifetime cancer risks for children are not calculated because the intake equation includes a time weighted soil ingestion rate based on a lifetime exposure.

A7.2.1.2 Recreational Exposure

Table A7-3 summarizes the risks associated with exposure to soil under recreational use of a 50-acre plot of IHSS 199 that includes the individual 10-acre plots where the presence of COCs were identified. Exposure is assumed to be limited to soil ingestion, inhalation, and external radiation exposure. The results indicate the following:

- For an adult, the RME activity of plutonium and americium result in an estimated excess lifetime cancer risk of 5×10^{-8}. The corresponding CT risk is estimated at 3×10^{-9}.

- For an adult, the RME TEDE is estimated at 0.003 mrem/year; the corresponding CT TEDE is estimated at 0.00057 mrem/year. Both estimates are below the DOE annual dose limit for the general public of 100 mrem/year.

- For a child, the RME CEDE for soil ingestion is estimated at 0.0052 mrem/year. The corresponding CT CEDE is estimated at 0.001 mrem/year. Both estimates are below the DOE annual dose limit for the general public of 100 mrem/year.

- For adults, the main contributor to risk and dose estimates is the soil ingestion route.

A7.2.2 Risk Results of IHSS 200

Exposure to sediments located in IHSS 200 is assumed to occur in the future if Great Western Reservoir is drained and subsequent residential or recreational development occurs in the reservoir basin.

A7.2.2.1 Residential Exposure

Tables A7-4 and A7-5 summarize the risks associated with exposure to sediment based on adult residential and recreational exposure conditions. Exposure is assumed to include: ingestion, inhalation, external radiation exposure, fruit, vegetable, beef and milk consumption. The results indicate the following:

- The RME estimated total excess lifetime cancer risk resulting from adult exposure associated with the above pathways is 9×10^{-7}; this includes risk from all pathways. The corresponding CT estimated excess lifetime cancer risk is about 6×10^{-8}. These risks are based on adult exposure and associated intake assumptions.

- For an adult, the RME TEDE is estimated at 0.0065 mrem/year; the corresponding CT TEDE is estimated at 0.0015 mrem/year. These values include exposure to internal and external radiation sources and are below the DOE annual dose limit for the general public of 100 mrem/year.

- For a child, the RME CEDE for sediment ingestion is estimated at 0.008 mrem/year. The corresponding CT CEDE is estimated at 0.0022 mrem/year. Both estimates are below the DOE annual dose limit for the general public of 100 mrem/year.

- For adults, the main contributor to risk and dose estimates is the sediment ingestion route.

A7.2.2.2 Recreational Exposure

Exposure to Great Western Reservoir sediments is assumed to occur in the future if the reservoir is drained and subsequent recreational use of the area occurs. Under recreational conditions, exposure is assumed to occur to sediments by ingestion, inhalation, and external radiation exposures.

- The total excess lifetime cancer risk, based on adult exposure, is estimated to be 1×10^{-8} assuming RME exposure conditions. The corresponding excess lifetime cancer risk for the CT exposure setting is estimated to be 8×10^{-10}.

- The RME TEDE is estimated at about 0.00014 mrem/year for an adult exposed to Great Western Reservoir sediment. The CE TEDE is about 0.000014 mrem/year. These values include exposure to internal and external sources of radiation and are below the DOE annual dose limit for the general public of 100 mrem/year.

- For a child, the RME CEDE for sediment ingestion is estimated at 0.0001 mrem/year. The corresponding CE CEDE is estimated at 0.00002 mrem/year. Both estimates are below the DOE annual dose limit for the general public of 100 mrem/year.

- For adults, the main contributor to the risk and dose estimates is the sediment ingestion route.

A7.3 DERMAL EXPOSURES

The baseline risk assessment recognizes the potential for receptors to experience dermal contact with surface soils located in IHSS 199 and surficial sediments associated with IHSS 200. Appropriate dose-response data have not been collected with which to quantitatively describe the impact of dermal exposure to plutonium and americium. Dermal exposure is discussed in the Uncertainty Analysis, Section A8.0.

A7.4 COMPARISON OF COC-RELATED RISK TO RISK FROM BACKGROUND

Even though none of the TEDE estimates exceeded the DOE annual radiation dose limit for members of the general public, it is important to understand the contribution of radiation dose from background conditions as a point of comparison (Table A7-6). The TEDE values estimated in this risk characterization represent the amount of radiation received over and above the contribution from background sources of radiation.

The U.S. average background radiation is about 300 mrem/year, including exposure to radon (Table A7-6). Radiation received from routine medical treatment averages about 50 mrem/year in the U.S. More specifically, background levels of radiation in the Denver area are estimated to be as high as 350 to 700 mrem/year (NCRP, 1987). These levels are higher than the national average because of the high natural levels of radium, thorium, and radon and because radiation exposure increases with increased altitude. The CEDEs for the residential and recreational scenarios for IHSSs 199 and 200 were all below 1 mrem/year.

The risks were calculated for arsenic and beryllium in surface sediments so that a comparison could be made with background concentrations of these metals. Table A7-7, "Risks Due to Maximum Concentrations of Beryllium in Surface Sediments," derives carcinogenic and noncarcinogenic risks from maximum beryllium concentrations in surface sediments at IHSS 200, 201, and 202. For comparison purposes, the risks from maximum beryllium concentrations in surface sediments from the Background Geochemical Characterization Report (DOE, 1993c) are also calculated. Also, for conservatism, the non-carcinogenic risks are calculated separately for an adult resident and a child resident. Table A7-8, "Risks Due to Maximum Concentrations of Arsenic in Surface Sediments," shows the same calculations for maximum arsenic concentrations.

The carcinogenic risks from the maximum background beryllium concentration in Table A7-7 is 8.8×10^{-6}. The carcinogenic risk from IHSSs 200, 201, and 202 are 1.1×10^{-5}, 1.1×10^{-5}, and 1.0×10^{-5}, respectively. All of these risks are essentially equal and are within the EPA target risk range of 1×10^{-4} to 1×10^{-6}. The non-carcinogenic risks from beryllium for the child and adult are well below the EPA threshold criteria of 1.0.

Table A7-6
Average Annual EDEs from Ionizing Radiation for a Member of the U.S. Population

Source	Effective Dose Equivalent (mrem)[a]	(Percent)
Natural		
Radon	200	55
Cosmic	27	8
Terrestrial	28	8
Internal	39	11
Total Natural	294	82
Artificially Induced		
Medical		
X-ray diagnosis	39	11
Nuclear medicine	14	4
Consumer products	10	3
Other		
Occupational	< 1	< 0.3
Nuclear fuel cycle	< 1	< 0.03
Fallout	< 1	< 0.03
Miscellaneous[b]		
Total Artificial	63	18
Total Natural and Artificially Induced Sources of Ionizing Radiation =	357	100

Sources: NAS, 1990; NCRP, 1987.
[a]mrem = millirem or 1/1,000 rem or 0.001 rem.
[b]DOE facilities, smelters, transportation, and other sources.

The carcinogenic risk from the maximum background arsenic concentration in Table A7-8 is 4.7×10^{-5}. The carcinogenic risk from IHSSs 200, 201, and 202 are 2.6×10^{-5}, 4.8×10^{-5}, and 2.8×10^{-5}, respectively. All of these risks are essentially equal and are within the EPA target risk range of 1×10^{-4} to 1×10^{-6}. The non-carcinogenics risks from arsenic for the child and adult are below the EPA threshold criteria of 1.0.

The baseline risk assessment assumes that, sometime in the future, Great Western Reservoir is drained, and subsequently developed for residential land use. Under these circumstances, residential receptors could be exposed to the IHSS COCs in addition to those constituents present at background levels that were not identified as COCs. Constituents detected in IHSS 200 sediments at background concentrations include arsenic and beryllium. Comparing the estimated excess lifetime cancer risk as a result of exposure to arsenic and beryllium, which were detected at background-level concentrations, to the risk associated with exposure to plutonium under the same exposure conditions, shows that the risks due to background exceed those attributable to Rocky Flats-related contamination. The excess lifetime cancer risk for arsenic, based on the maximum detected concentration in sediments is estimated to be 6×10^{-5}.

Table A7-7
Risks Due to Maximum Concentrations of Beryllium in Surface Sediments Residential Exposure Scenario – Direct Sediment Ingestion

REASONABLE MAXIMUM EXPOSURE PARAMETERS

Exposure Factors Description	Units	Parameter Value
Age Adjusted Ingestion Rate (IRAA)	mg-yr/kg-day	114.3
Ingestion Rate, Adult (IRA)	mg/day	100
Ingestion Rate, Child (IRC)	mg/day	200
Exposure Frequency (EF)	days/year	350
Exposure Duration, Adult (EDA)	years	24
Exposure Duration, Child (EDC)	years	6
Conversion Factor (CF)	kg/mg	1.00E-06
Body Weight, Adult (BWA)	kg	70
Body Weight, Child (BWC)	kg	15
Carcinogenic Averaging Time (AT)	days	25550
Adult Non-Carcinogenic Averaging Time (NATA)	days	8760
Child Non-Carcinogenic Averaging Time (NATC)	days	2190

IRAA = [((IRA)(EDA)/(BWA)) + ((IRC)(EDC)/(BWC))]

CARCINOGENIC RISK

Chemical	Maximum Concentration (mg\kg)	Intake Factor (1) (kg/kg-day)	Intake (mg\kg\day)	Oral Slope Factor (mg\kg\day)-01	Carcinogenic Risk
BACKGROUND BERYLLIUM	1.30E+00	1.57E-06	1.93E-06	4.30E+00	8.8E-06
IHSS 200 BERYLLIUM	1.60E+00	1.57E-06	2.08E-06	4.30E+00	1.1E-05
IHSS 201 BERYLLIUM	1.60E+00	1.57E-06	2.38E-06	4.30E+00	1.1E-05
IHSS 202 BERYLLIUM	1.50E+00	1.57E-06	2.23E-06	4.30E+00	1.0E-05

(1) - Intake Factor = ((IRAA)(EF)(CF)/(AT))

Table A7-7 (continued)

NON-CARCINOGENIC RISK (ADULT)

Chemical	Maximum Concentration (mg\kg)	Intake Factor (2) (kg/kg-day)	Intake (mg\kg\day)	Oral Reference Dose (mg\kg\day)	Hazard Quotient
BACKGROUND BERYLLIUM	1.30E+00	1.37E-06	1.78E-06	5.00E-03	3.6E-04
IHSS 200 BERYLLIUM	1.60E+00	1.37E-06	1.92E-06	5.00E-03	4.4E-04
IHSS 201 BERYLLIUM	1.60E+00	1.37E-06	2.19E-06	5.00E-03	4.4E-04
IHSS 202 BERYLLIUM	1.50E+00	1.37E-06	2.05E-06	5.00E-03	4.1E-04

(2) - Intake Factor = ((IRA)(EF)(EDA)(CF)/(BWA)(NATA))

NON-CARCINOGENIC RISK (CHILD)

Chemical	Maximum Concentration (mg\kg)	Intake Factor (3) (kg/kg-day)	Intake (mg\kg\day)	Oral Reference Dose (mg\kg\day)	Hazard Quotient
BACKGROUND BERYLLIUM	1.30E+00	1.28E-05	1.66E-05	5.00E-03	3.3E-03
IHSS 200 BERYLLIUM	1.60E+00	1.28E-05	1.79E-05	5.00E-03	4.1E-03
IHSS 201 BERYLLIUM	1.60E+00	1.28E-05	2.05E-05	5.00E-03	4.1E-03
IHSS 202 BERYLLIUM	1.50E+00	1.28E-05	1.92E-05	5.00E-03	3.8E-03

(3) - Intake Factor = ((IRC)(EF)(EDC)(CF)/(BWC)(NATC))

Table A7-8
Risks Due to Maximum Concentrations of Arsenic in Surface Sediments Residential Exposure Scenario – Direct Sediment Ingestion

REASONABLE MAXIMUM EXPOSURE PARAMETERS

Exposure Factors Description	Units	Parameter Value
Age Adjusted Ingestion Rate (IRAA)	mg-yr/kg-day	114.3
Ingestion Rate, Adult (IRA)	mg/day	100
Ingestion Rate, Child (IRC)	mg/day	200
Exposure Frequency (EF)	days/year	350
Exposure Duration, Adult (EDA)	years	24
Exposure Duration, Child (EDC)	years	6
Conversion Factor (CF)	kg/mg	1.00E-06
Body Weight, Adult (BWA)	kg	70
Body Weight, Child (BWC)	kg	15
Carcinogenic Averaging Time (AT)	days	25550
Adult Non-Carcinogenic Averaging Time (NATA)	days	8760
Child Non-Carcinogenic Averaging Time (NATC)	days	2190

IRAA = [((IRA)(EDA)/(BWA)) + ((IRC)(EDC)/(BWC))]

CARCINOGENIC RISK

Chemical	Maximum Concentration (mg\kg)	Intake Factor (1) (kg/kg-day)	Intake (mg\kg\day)	Oral Slope Factor (mg\kg\day)-01	Carcinogenic Risk
BACKGROUND ARSENIC	1.73E+01	1.57E-06	2.57E-05	1.75E+00	4.7E-05
IHSS 200 ARSENIC	9.40E+00	1.57E-06	1.40E-05	1.75E+00	2.6E-05
IHSS 201 ARSENIC	1.77E+01	1.57E-06	2.63E-05	1.75E+00	4.8E-05
IHSS 202 ARSENIC	1.04E+01	1.57E-06	1.55E-05	1.75E+00	2.8E-05

(1) - Intake Factor = ((IRAA)(EF)(CF)/(AT))

Table A7-8 (continued)

NON-CARCINOGENIC RISK (ADULT)

Chemical	Maximum Concentration (mg\kg)	Intake Factor (2) (kg/kg-day)	Intake (mg\kg\day)	Oral Reference Dose (mg\kg\day)	Hazard Quotient
BACKGROUND ARSENIC	1.73E+01	1.37E-06	2.37E-05	3.00E-04	7.9E-02
IHSS 200 ARSENIC	9.40E+00	1.37E-06	1.29E-05	3.00E-04	4.3E-02
IHSS 201 ARSENIC	1.77E+01	1.37E-06	2.42E-05	3.00E-04	8.1E-02
IHSS 202 ARSENIC	1.04E+01	1.37E-06	1.42E-05	3.00E-04	4.7E-02

(2) - Intake Factor = ((IRA)(EF)(EDA)(CF)/(BWA)(NATA))

NON-CARCINOGENIC RISK (CHILD)

Chemical	Maximum Concentration (mg\kg)	Intake Factor (3) (kg/kg-day)	Intake (mg\kg\day)	Oral Reference Dose (mg\kg\day)	Hazard Quotient
BACKGROUND ARSENIC	1.73E+01	1.28E-05	2.21E-04	3.00E-04	7.4E-01
IHSS 200 ARSENIC	9.40E+00	1.28E-05	1.20E-04	3.00E-04	4.0E-01
IHSS 201 ARSENIC	1.77E+01	1.28E-05	2.26E-04	3.00E-04	7.5E-01
IHSS 202 ARSENIC	1.04E+01	1.28E-05	1.33E-04	3.00E-04	4.4E-01

(3) - Intake Factor = ((IRC)(EF)(EDC)(CF)/(BWC)(NATC))

For beryllium, the comparable risk is estimated to be 4×10^{-5}. The highest anticipated risk due to exposure to plutonium in IHSS 200 sediments could be as much as 1×10^{-7}, or about 2 orders of magnitude lower. Consequently, persons that contact the soil or sediments associated with these areas are not expected to experience an excess lifetime cancer risk that exceeds contribution expected from background sources. Quantitatively, these risks can be expressed as follows:

- Background risk from arsenic and beryllium combined is 1×10^{-4} (0.0001) or about 1 in 10,000
- The maximum risk estimated based on exposure to plutonium and americium detected in IHSS 199 at location (U1A) is 3×10^{-6} (0.000003), or about 3 in 1,000,000.
- Using the additive risk values for IHSS 199, the total background and OU 3-related risk is about 0.000103. About three percent is attributed to Rocky Flats-related sources of contamination.

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A8.0 UNCERTAINTY ANALYSIS

Uncertainties in the baseline risk assessment are assessed qualitatively in the following sections. A qualitative analysis is appropriate given that the Reasonable Maximum Exposure (RME) risks are well within the EPA's excess lifetime cancer risk range of 1×10^{-4} to 1×10^{-6}. Since RME risks represent upper bound risks, a quantitative uncertainty analysis would only serve to better define the distribution of risks below the RME level. A quantitative uncertainty analysis is not warranted since it would merely better define the distribution of already acceptable risks.

A8.1 UNCERTAINTIES ASSOCIATED WITH DATA EVALUATION AND COC SELECTION

Uncertainties are associated with the collection, analysis, and evaluation of environmental data. Environmental sampling may not have accurately characterized chemical concentrations or radionuclide activities. Two sampling methodologies were used to collect soil samples in OU 3 for radionuclide analysis. The two data sets were found to be statistically comparable and were used in the risk assessment.

Statistical background comparison tests were performed only for surface soil because background data sets were not considered comparable to the RI data for the purposes of rigorous quantitative, statistical tests. Consequently, an alternative " weight of evidence" approach for comparing site to background data was used for sediment, surface water, and groundwater.

The weight of evidence approach relies on a series of evaluations involving the application of a variety of data analysis techniques in lieu of a rigorous, quantitative statistical testing scheme as proposed by Gilbert (1993). The results of the evaluations are considered together to assess if levels of chemicals detected in OU 3 represent background conditions or contamination. Analyses performed in the weight of evidence evaluation included: comparisons of means, standard deviations, and ranges of OU 3 data to BGCR data; comparisons of means, standard deviations, and ranges of OU 3 data to benchmark data; probability plot analysis evaluation of data populations; temporal analysis, and spatial analysis. Because the weight of evidence evaluation is a qualitative comparison, it was designed to be conservative to reduce the potential for inappropriately eliminating a PCOC. Additional discussion of the weight of evidence methodology may be found in TM 4.

Metals and VOCs were not analyzed for in soil samples because no source for a metals or VOC release from Rocky Flats to OU 3 via the air pathway has been identified,. Therefore the risk estimates for soils in OU 3 do not include risk associated with VOCs or naturally occurring concentrations of metals. Additional information regarding soils analysis can be found in section 4.3.1 of this report.

A8.2 UNCERTAINTY IN THE EXPOSURE ASSESSMENT

Quantitative estimates of intake derived for the exposure assessment are conditional estimates that include numerous assumptions on the type of exposures that may occur, the frequency and duration of those exposures, and the concentration of PCOCs at the point of exposure. Potential future exposures are based on assumptions of potential land use and estimates of potential future exposure point concentrations based on current monitoring data. The standard approach is intended to provide a conservative estimate of risk (in this case, more likely to overestimate risk than to underestimate risk). Conservative exposure assumptions are used for many of the exposure parameters, resulting in a compounding effect. No attempt is made in this assessment to quantify the compounding effect on the cumulative risk estimates.

A8.2.1 Exposure Assumptions

One major area of uncertainty in the exposure assessment is the prediction of human activities that may lead to contact with PCOCs in environmental media. The degree to which exposure models fully reflect the activities and processes that may lead to contact with constituents in environmental media cannot be estimated.

Activities that differ from the assumptions made for a particular exposure pathway could lead to exposure different from those quantified. The probability of occurrence was not included in the quantification of risk. If a land-use assumed for a scenario does not occur, the risk as calculated will not occur. Because it is unlikely that the assumed residential development will occur sometime in the future, specific land-use assumptions that may lead to an overestimate of exposure include:

- Future development of the area currently occupied by Great Western Reservoir (IHSS 200) for residential or recreational uses and subsequent exposure to sediments currently 80 feet beneath the reservoir surface

- Future residential development of the Remedy Lands

- Future reliance on homegrown vegetables, beef, or dairy products cultivated or raised on land within IHSS 199 or land currently occupied by Great Western Reservoir (IHSS 200)

The assumptions that adults ingest 100mg of soil per day and children ingest 200mg of soil per day are likely conservative. In addition, the assumption that 100-percent of soil ingested per day comes from the contaminated source is conservative. Soil ingestion rates and the fraction from the contaminated source tend to overestimate risk.

The assessment does not quantify risks associated with a commercial/industrial setting or for a potential ecological research receptor scenario. Exposure to receptors under these scenarios is assumed to be less than for the assumed residential scenarios. Individual worker exposure may vary, and in some cases may be more or less than the exposure assumed for OU 3 residents.

Quantification of the deposition of radionuclides onto plants from surface soil or sediments through wind entrainment and dispersion, or by cattle with subsequent deposition in muscle tissue or milk, introduces uncertainty due to data limitations associated with modeling these pathways.

The model used to estimate deposition of particulate onto plant material does not account for plant uptake through the root system. All contaminant contribution to plant material is assumed to occur through atmospheric deposition. This may lead to an under- or overestimate of risk.

The model used to estimate uptake of radionuclides by beef, and subsequent transfer to dairy milk, did not account for animal intake of food sources other than grass; intake of silage or other grains was not considered. This could lead to an over- or underestimate of risk depending on the food sources available to the animal population in question.

In addition, no contaminant loss due to leaching, erosion, or runoff was considered. This could lead to an overestimate of risk as these processes would lead to a reduction in the concentration of a contaminant over time.

A8.2.2 Exposure-Point Concentrations

For future recreational or residential exposures, the exposure point concentration was estimated by combining all plutonium-239, -240 data within the exposure areas. For recreational land-uses, the exposure area was 50 acres, and for the residential setting, the exposure area was assumed to be 10 acres. The 95 UCL concentrations calculated for the exposure areas may not represent risks at an individual location. The estimate assumes the plutonium-239, -240 activity is the same over the entire exposure area. This may lead to an under- or overestimate of risk.

The method for estimating dust concentrations in air based on wind-tunnel studies conducted on OU 3 may lead to an under- or overestimation of risk. The wind-tunnel studies were performed on vegetated areas as they currently exist in OU 3. Assuming IHSS 199 or IHSS 200 are developed sometime in the future for residential or recreational uses, the vegetation currently in place that inhibits dust generation at lower wind speeds may be compromised, leading to dust generation over and above that estimated in the baseline risk assessment.

Additional uncertainty is inherent in the wind-tunnel study. The majority of OU 3 remains vegetated and relatively undisturbed. However, the threshold velocities associated with these areas are so high that resuspension rarely occurs. Exposure modeling used the threshold velocities for the extra disturbed case to generate usable results from the box model. These results are conservative because the extra disturbed state does not exist over most of OU 3 and the areas of concern.

The threshold wind speed associated with dust generation was based on visual observation made while conducting the wind-tunnel studies at IHSS 199 (DOE, 1995d). This may lead to an underestimate of the true particulate concentration.

A8.2.3 Exposure (Dose) Assessment

Internal radiation doses are calculated by multiplying a given intake of radioactivity by the DCF, which relates intake to dose. The DCF incorporates a set of standard biological factors that are based on what is expected from the average or "standard" man under conditions of occupational exposure. These biological factors include body weight, critical-organ weights, and assumptions about intake and retention for both inhalation and ingestion models. In addition, the DCF incorporates information on physical decay, such as types and energies for each major radioactive emission for each radionuclide.

The primary source of error in the DCF is in the biological information. In particular, the parameters used in the transport model will vary depending to a large extent on the chemical form of the radionuclide, how soluble it is in the body, and the individual's metabolism. If the intake is known, the transport parameters can be approximated for a particular individual, using bioassay data for that individual. For most general risk assessments, this information must be approximated for the "average" individual. If the most likely chemical form for the radionuclide is known, the DCF for that chemical solubility can be chosen. For consistency, the plutonium-239 DCF from EPA (EPA, 1994b) was chosen to account for the relatively insoluble form of plutonium (Pu IV) anticipated to be present at OU 3. This may lead to an underestimate of risk if the form of plutonium-239 actually present is more soluble than assumed.

A8.3 UNCERTAINTIES IN THE TOXICITY ASSESSMENT

The risk of increased incidence of cancer or of fatal cancer from exposure to low-level radiation is determined by applying a risk factor to either the radiation dose or the radionuclide intake. Regardless of the type of risk factor used, the same basic uncertainties remain. The uncertainties are related to the model used for determining the health effects of radiation exposure, which are based on the average risk per unit intake for an individual.

The model most frequently used for determining risk of radiation exposure is the linear nonthreshold model. This model assumes that there is some increased risk for any increment of radiation exposure, there being no threshold below which effects are not seen. This is the most conservative model for evaluating radiation risk. The model uses data from high-dose radiation exposures (such as the survivors of the atomic bomb) and extrapolates risk from these high exposures to the low-level environmental or occupational dose range. There is a great deal of scientific debate about whether such high-dose-rate data are applicable for comparison with doses at or near natural background levels. Federal agencies, however, currently use the linear nonthreshold model to govern exposure.

Use of carcinogenic slope factors is subject to several types of uncertainties. The studies from which these values are derived typically involve conditions that are not identical to the type of exposures of interest involving radionuclides in the environment. For exposure to ionizing radiation, data to establish dose-response estimates are taken primarily from studies of human populations exposed to high levels of radiation. These include atomic bomb survivors, underground miners, radium dial painters, patients injected with thorotrast or radium, and patients who received high x-ray doses during various treatment programs. EPA (1989a) notes that the major source of uncertainty in determining low-level radiation risks is extrapolation of these data to much lower doses.

The dose conversion factor applied to plutonium assumes that the form of plutonium present at OU 3 exhibits low solubility. Physical and chemical information collected for OU 3 supports this assumption; however, if plutonium solubility is affected sometime in the future, the resulting risks may change.

Risks related to dermal exposure to radionuclides was not quantified due to the lack of dermal toxicity values. The assessment assumes that radionuclides exhibit similar dermal activity as metals. Metals are typically associated with little to no dermal effects following direct exposure. It is anticipated that plutonium and americium behave similarly to other inorganics.

Dermal absorption of inorganics through water and soil is thought to be negligible. Metals in water do not penetrate the skin to any large degree (Clement, 1988). Metals in soil may have an absorption fraction of less than 1 percent; dermal contact with soil appears to be a concern relative to ingestion only when the percent absorbed exceeds 10 percent (EPA, 1992).

A8.4 UNCERTAINITES ASSOCIATED WITH RISK CHARACTERIZATION

During risk characterization the carcinogenic risks and noncarcinogenic effects of plutonium and americium were added in each assessed medium for each assessed pathway. The potential synergistic, antagonistic, or additive effects due to simultaneous exposure to several contaminants was not considered. This could result in an overestimation, or an underestimation of risk.

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ATTACHMENT 1

EXPOSURE PARAMETERS

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Table 1
Rocky Flats OU 3 Exposure Parameters for Quantitative Risk Assessment Soil or Sediment Ingestion

Factors for Potentially Complete Routes of Exposure		Exposure Scenarios: Future Residential	Exposure Scenarios: Future Recreational
Ingestion Rate - Child (mg/day)	RME[1]	200[1],[3]	100[5]
	CT[2]	100[2],[4]	50[5]
Ingestion Rate - Adult (mg/day)	RME	100[6]	50[5]
	CT	50[7]	25[5]
Fraction Ingested from Contaminated Source - Child	RME	1.0[8]	1.0
	CT	0.82[8]	1.0
Fraction Ingested from Contaminated Source - Adult	RME	1.0[8]	1.0
	CT	0.64[8]	1.0
Matrix Effect in GI Tract (Absorption Factor)	RME	Chemical-Specific[9]	Chemical-Specific[9]
	CT	Chemical-Specific[9]	Chemical-Specific[9]
Exposure Frequency - Child and Adult (days/year)	RME	350[10]	25[12]
	CT	234[11]	10[12]
Exposure Duration - Child (years)	RME	6[10]	6[10]
	CT	2[13]	2[13]
Exposure Duration - Adult (years)	RME	24[10]	24[10]
	CT	7[14]	7[14]

Notes:

(1) = Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum risks in a baseline or remediation risk assessment. RME Risks are derived using professional judgement to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others in combination with others set at Central Tendency (CT) values in order to characterize the HE risks to a very small proportion of an exposed population.

(2) = Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst case" when used in combination with selected high-end values). Average risks are derived using professional judgement to set all exposure parameters at 50th percentile or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) = EPA RAGS, HHEM, Standard Default Exposure Factors (1991a). A defensible alternative HE value for the child is 110 mg/day, the approximate 95th percentile using Zr tracer study of Calabrese and others (1989, 1991) (median = 16 mg/day, 95% CI = 8-24 mg/day, n=128, AIHC, 1994). An alternative HE assumption for the adult is 55 mg/day (0.5 times the child rate).

(4) = Preliminary CT default values (EPA, 1993).

(5) = Assumes standard default residential rates as specified for open-space recreational users at DOE's Fernald Site and Hanford Site (RME=200 mg/day for children and 100 mg/day for adults) and the Denver's Lowry Landfill Superfund Site (CT=100 mg/day for children and 50 mg/day for adults). Assumes that Exposure Time is 1.5 hours per day (CT);

5.0 hours per day (RME) and that total soil ingestion occurs over 10 daylight hours (1.5/10 = 0.15; 5.0/10 = 0.5). Using the default daily ingestion rates soil ingestion per visit for children is calculated as RME=0.5x200=100 mg/visit; CT=0.15x100=51 mg/visit. For adults the ingestion rates are RME=50 and CT=8. Actual open-space recreational intakes would vary, depending on the activity, possibly with dirt biking at one extreme and photographing wildlife at the other.

(6) = EPA, 1991a.

(7) = Assumed to one-half equal residential exposure. See (6).

(8) = Based on the average time spent at home (0.64 for an adult and 0.82 for a child) (AIHC, 1994). EPA, 1989a recognizes the need for a soil "fraction ingested" from a contaminated source to reflect "population activity patterns."

(9) = In the absence of a chemical-specific value, consult methods to estimate maximum oral bioavailability (absorption in the gastrointestinal tract) such as reported by EPA, 1994b, for lead in soil and by Finley and Paustenbach, 1994, for TCDD in soil. Assuming chemical toxicity values are based on absorption from drinking water, absorption adjustments are indicated because toxic chemicals only partially desorb from soil particles (EPA, 1989a).

(10) = EPA, 1991a.

(11) = EPA, 1991a.

(12) = Exposure frequency based upon Boulder County's Park and Open Space Visitor Interviews of 1985 (est. 7 days/yr, CT; 25 days/yr, RME). DOE's Hanford Site recreational user (7 days/yr, CT), and Department of the Interior's (DOI) National Survey of Fishing, Hunting, and Nonconsumptive Wildlife Recreation of 1985 for Colorado (9.4 days/yr for nonconsumptive use, CT; 15.4 days/yr for fishing and hunting, CT).

(13,14) = Preliminary CT default values, summing to 9 years (2 years + 7 years) total exposure duration (EPA, 1993). Preliminary CT value (EPA, 1993). A current alternative value is EPA's CT Residential Occupancy Period (ROP) of 8.1 years of total population (EPA, 1992; AIHC, 1994).

Table 2
Rocky Flats OU 3 Exposure Parameters for Quantitative Risk Assessment Soil or Sediment Particulate Inhalation

Factors for Potentially Complete Routes of Exposure		Exposure Scenarios: Future Residential	Exposure Scenarios: Future Recreational
Inhalation Rate - Adult (m^3/day)	RME[1]	0.83[1],[3]	1.4[5]
	CT[2]	0.63[2],[4]	0.83[5]
Exposure Time Adult (hr/day)	RME	24[3]	5[6]
	CT	15[7]	1.5[6]
Exposure Frequency - Adult (days/year)	RME	350[3]	25[10]
	CT	234[9]	10[10]
Exposure Duration - Adult (years)	RME	30[3]	30[3]
	CT	9[11]	9[11]

Notes:

(1) = Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum risks in a baseline or remediation risk assessment. RME Risks are derived using professional judgment to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others in combination with others set at Central Tendency (CT) values in order to characterize the HE risks to a very small proportion of an exposed population.

(2) = Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline remediation risk assessment (or a "reasonable worst case" when used in combination with selected high-end values). Average risks are derived using professional judgment to set all exposure parameters at 50th percentile or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) = EPA, 1991a.

(4) = CT residential inhalation rate for an adult based on EPA, 1991b.

(5) = Inhalation Rate based upon DOE's Fernald Site and Hanford Site recreational users (0.83 m^3/hr, CT) and on EPA's Exposure Factors Handbook (1.4 m^3/hr, RME), which assumes 7% heavy activity, 37% moderate activity, 28% light activity, and 28% resting for an adult.

(6) = Based on the five-year (1988-1992) mean annual ratio of PM10 soil or dust particles to total suspended particulates (TSP) as reported in 1992 RFP Site Environmental Report; EPA Exposure Factors Handbook (1989c) recognizes that need for a "respirable fraction of particulates" to indicate the total respirable fraction assumed deposited in the lung (i.e., 100% of the PM-10 value).

(7) = Based on the average time spent at home (0.64 for an adult) (AIHC, 1994; Gephart, Tell, and Trieme, 1994).

(8) = Exposure Time based upon Boulder County's Park and Open Space Visit Interviews of 1992 (est.

1.6 hr/day, CT; 5.0 hr/day, RME), DOD's Rocky Mountain Arsenal Site recreations user (1.6 hr/day, CT; 5.0 hr/day, RME), and City of Boulder's Open Space Visitation Study for 1993 (1.0 hr/day, CT; 2.0 hr/day, RME).

(9) = Preliminary CT default values (EPA, 1993).

(10) = Exposure frequency based on Boulder County's Park and Open Space Visitor interviews of 1985 (estimated 7 days/year, CT; 25 days/year, RME), DOE's Handford Site recreational user (7 days/year, CT), and DOI's National Survey of Fishing, Hunting, and Nonconsumptive Wildlife Recreation of 1985 for Colorado (9.4 days/year for nonconsumptive use, CT; 15.4 days/year for fishing and hunting, CT).

(11) = Preliminary CT value (EPA, 1993). A current alternative value is EPA's CT Residential Occupancy Period (ROP) of 8.1 years of total population (EPA, 1992; AIHC, 1994).

Table 3
Rocky Flats OU 3 Exposure Parameters for Quantitative Risk Assessment External Irradiation

Factors for Potentially Complete Routes of Exposure		Exposure Scenarios: Future Residential	Exposure Scenarios: Future Recreational
Gama Exposure Time Factor	RME[1]	1[1],[3]	0.2[5]
Te	CT[2]	0.75[2],[4]	0.1[5]
Gamma Shielding Factor	RME	0.8[6]	1[8]
1 - Se	CT	0.5[7]	0.8[9]
Exposure Frequency -	RME	350[3]	25[11]
Adult (days/year)	CT	234[10]	10[11]
Exposure Duration -	RME	30[3]	30[3]
Adult (years)	CT	9[12]	9[12]

Notes:
(1) = Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum risks in a baseline or remediation risk assessment. RME Risks are derived using professional judgement to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others in combination with others set at Central Tendency (CT) values in order to characterize the HE risks to a very small proportion of an exposed population.

(2) = Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst case" when used in combination with selected high-end values). Average risks are derived using professional judgement to set all exposure parameters at 50th percentile or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) = EPA, 1991b.

(4) = Assuming the CT fraction of time spent at home (average of adult = 0.64 and child = 0.82) (AIHC, 1994; Gephart, Tell, and Triemer, 1994).

(5) = Assuming the HE fraction of time exposed (1.5 out of 24 hours), CT; 5.0 out of 24 hours, RME).

(6) = Standard default screening value specified in EPA, 1991b (1 - 0.2 = 0.8), assuming substantial time of exposure is shielded by structures.

(7) = Estimated typical value for residents and indoor workers shielded by buidlings (DOE documents for RFETS, such as "Mining Exposure Scenario for Baseline Risk Assessment at the Rocky Flats Environmental Technology Site" (DOE, 1994e).

(8) = Standard default screening value specified in EPA, 1991b, assuming limited exposure time shielded by structures.

(9) = Assumed typical value for outdoor workers with only limited shielding indoors.

(10) = Preliminary CT default value (EPA, 1993).

(11) = Exposure Frequency based upon Boulder County's Park and Open Space Vistor Interviews of 1985 (est. 7 days/yr, CT; 25 days/hr, RME). DOE's Hanford Site recreational user (7 day/yr, CT), and Department of the Interior's (DOI) National Survey of Fishing, Hunting, and Nonconsumptive Wildlife Recreation of 1985 for Colorado (9.4 days/yr for nonconsumptive use, CT; 15.4 day/yr for fishing and hunting, CT).

12) = Preliminary CT value (EPA, 1993). A current alternative value is EPA's CT Residential Occupancy Period (ROP) of 8.1 years of total population (EPA, 1992; AIHC, 1994).

Table 4
Rocky Flats OU 3 Exposure Parameters for Quantitative Risk Assessment Homegrown Produce Ingestion

Factors for Potentially Complete Routes of Exposure		Exposure Scenarios: Future Residential	Exposure Scenarios: Future Recreational
Ingestion Rate - Vegetables	RME[1]	200[1],[3]	(NA)
Adult (mg/day)	CT[2]	200[2],[3]	(NA)
Ingestion Rate - Fruits	RME	140[3]	(NA)
Adult (mg/day)	CT	140[3]	(NA)
Fraction Vegetables Ingested	RME	0.4[4]	(NA)
from Contaminated Source	CT	0.25[4]	(NA)
Fraction Fruits Ingested	RME	0.3[4]	(NA)
from Contaminated Source	CT	0.2[4]	(NA)
Washoff Factor	RME	1.0[5]	(NA)
	CT	0.5[5]	(NA)
Exposure Frequency -	RME	350[6]	(NA)
Adult (days/year)	CT	150[7]	(NA)
Exposure Duration -	RME	30[8]	(NA)
Adult (years)	CT	9[9]	(NA)

Notes:
(1) = Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum risks in a baseline or remediation risk assessment. RME Risks are derived using professional judgement to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others in combination with others set at Central Tendency (CT) values in order to characterize the HE risks to a very small proportion of an exposed population.

(2) = Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst case" when used in combination with selected high-end values). Average risks are derived using professional judgement to set all exposure parameters at 50th percentile or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) = Average adult vegetable intake and average adult fruit intake (EPA, 1989b).

(4) = The HE and CT fraction ingested (FI) is based on the fraction of fruits and vegetables consumed daily that is home-grown (EPA, 1989b).

(5) = It assumed that residents consuming their own howegrown fruits and vegetables also wash off at least one-half of all contaminated soil and dust particles adhering to root and leaf vegetables and to fruits.

(6) = EPA, 1991. A conservative exposure frequency would be 215 days (first harvest May 1; last harvest December 1) (Cox, 1994). The default exposure frequency of 350 days/year assumes and additional 135 days consuming preserved home-grown produce.

(7) = Based on the typical fraction of the year home-grown produce is harvested on Colorado's Eastern Plains (first harvest May 15; last harvest October 15) (Cox, 1994).

(8) = EPA, 1991a.

(9) = Preliminary CT value (EPA, 1993). A current alternative value is EPA's CT Residential Occupancy Period (ROP) of 8.1 years of total population (EPA, 1992; AIHC, 1994).

(10) = Preliminary CT default value (EPA, 1993).

(11) = Exposure Frequency based upon Boulder County's Park and Open Space Vistor Interviews of 1985 (est. 7 days/yr, CT; 25 days/hr, RME). DOE's Hanford Site recreational user (7 day/yr, CT), and Department of the Interior's (DOI) National Survey of Fishing, Hunting, and Nonconsumptive Wildlife Recreation of 1985 for Colorado (9.4 days/yr for nonconsumptive use, CT; 15.4 day/yr for fishing and hunting, CT).

12) = Preliminary CT value (EPA, 1993). A current alternative value is EPA's CT Residential Occupancy Period (ROP) of 8.1 years of total population (EPA, 1992; AIHC, 1994).

Table 5

Rocky Flats OU 3 Exposure Parameters for Quantitative Risk Assessment Beef/Milk Ingestion

Factors for Potentially Complete Routes of Exposure		Exposure Scenarios: Future Residential	Exposure Scenarios: Future Recreational
Ingestion Rate - Beef Adult (mg/day)	RME[1]	40[1,3]	(NA)
	CT[2]	38[2,3]	(NA)
Ingestion Rate - Milk Adult (mg/day)	RME	52[3]	(NA)
	CT	50[3]	(NA)
Fraction Ingested from Contaminated Source	RME	0.4[4]	(NA)
	CT	0.25[4]	(NA)
Exposure Frequency - Adult (days/year)	RME	350	(NA)
	CT	150	(NA)
Exposure Duration - Adult (years)	RME	30[5]	(NA)
	CT	9[6]	(NA)

Notes:

(1) = Top entry is based on High-End (HE) exposure used to characterize the Reasonable Maximum risks in a baseline or remediation risk assessment. RME Risks are derived using professional judgement to set one or more sensitive exposure parameters at HE (90-98th percentile) values in combination with others in combination with others set at Central Tendency (CT) values in order to characterize the HE risks to a very small proportion of an exposed population.

(2) = Bottom entry is based on Central Tendency (CT) used to characterize the typical case in a baseline or remediation risk assessment (or a "reasonable worst case" when used in combination with selected high end values). Average risks are derived using professional judgement to set all exposure parameters at 50th percentile or mean values in order to characterize the mid-range risk to the largest proportion of an exposed population.

(3) = Average adult milk intake and average adult beef intake EPA/600/6-9/003.

(4) = The HE and CT fraction ingestion (FI) is based on the fraction of milk and beef consumed daily that is *home-grown* (EPA, 1989b).

(5) = EPA, 1991a.

(6) = Preliminary CT value (EPA, 1993). a current alternative value is EPA's CT Residential Occupancy Period (ROP) of 8.1 years of total population (EPA, 1992; AIHC, 1994).

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ATTACHMENT 2

RBC RATIOS

Page 1 of 14

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Attachment 2: RBC Ratios

Attachment 2 contains the following tables:

Table 1. Ratios of PCOC Concentrations/Activities to RBCs, OU 3 Surface Soil (Maximum detected result for each sample location, RBCs, PCOC-specific RBC ratios, and toxicity values used for RBCs).

Table 2. Ratios of PCOC Concentrations/Activities to RBCs OU 3 IHSS 200 Sediments and Groundwater (Maximum detected result for each PCOC per medium, RBCs, PCOC-specific RBC ratios, and toxicity values used for RBCs).

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Table D-1
Ratios of PCOC Concentration/Activities to RBCs
OU3 Surface Soil
Rocky Flats Plant

Location Code	Chemical Name	Unit	Max Result	RBC	PCOC Ratio	Oral SF	Inhal SF	Ext SF
PT12592	AMERICIUM-241	PCI/G	.0120	2.3728	.0051	2.400e-010	3.200e-008	4.900e-009
PT12592	PLUTONIUM-239/240	PCI/G	.0285	3.4255	.0083	2.300e-010	3.800e-008	1.700e-011
PT12692	AMERICIUM-241	PCI/G	.0120	2.3728	.0051	2.400e-010	3.200e-008	4.900e-009
PT12692	PLUTONIUM-239/240	PCI/G	.0230	3.4255	.0067	2.300e-010	3.800e-008	1.700e-011
PT12792	AMERICIUM-241	PCI/G	.0292	2.3728	.0123	2.400e-010	3.200e-008	4.900e-009
PT12792	PLUTONIUM-239/240	PCI/G	.1324	3.4255	.0387	2.300e-010	3.800e-008	1.700e-011
PT12892	AMERICIUM-241	PCI/G	.0302	2.3728	.0127	2.400e-010	3.200e-008	4.900e-009
PT12892	PLUTONIUM-239/240	PCI/G	.0364	3.4255	.0106	2.300e-010	3.800e-008	1.700e-011
PT12992	PLUTONIUM-239/240	PCI/G	.0205	3.4255	.0060	2.300e-010	3.800e-008	1.700e-011
PT13092	AMERICIUM-241	PCI/G	.0210	2.3728	.0089	2.400e-010	3.200e-008	4.900e-009
PT13092	PLUTONIUM-239/240	PCI/G	.0465	3.4255	.0136	2.300e-010	3.800e-008	1.700e-011
PT13192	AMERICIUM-241	PCI/G	.0275	2.3728	.0116	2.400e-010	3.200e-008	4.900e-009
PT13192	PLUTONIUM-239/240	PCI/G	.0685	3.4255	.0200	2.300e-010	3.800e-008	1.700e-011
PT13292	AMERICIUM-241	PCI/G	.0080	2.3728	.0034	2.400e-010	3.200e-008	4.900e-009
PT13292	PLUTONIUM-239/240	PCI/G	.0170	3.4255	.0050	2.300e-010	3.800e-008	1.700e-011
PT13392	AMERICIUM-241	PCI/G	.0110	2.3728	.0046	2.400e-010	3.200e-008	4.900e-009
PT13392	PLUTONIUM-239/240	PCI/G	.0406	3.4255	.0119	2.300e-010	3.800e-008	1.700e-011
PT13492	AMERICIUM-241	PCI/G	.0030	2.3728	.0013	2.400e-010	3.200e-008	4.900e-009
PT13492	PLUTONIUM-239/240	PCI/G	.0300	3.4255	.0088	2.300e-010	3.800e-008	1.700e-011
PT13592	AMERICIUM-241	PCI/G	.0615	2.3728	.0259	2.400e-010	3.200e-008	4.900e-009
PT13592	PLUTONIUM-239/240	PCI/G	.2050	3.4255	.0598	2.300e-010	3.800e-008	1.700e-011
PT13792	AMERICIUM-241	PCI/G	.0107	2.3728	.0045	2.400e-010	3.200e-008	4.900e-009
PT13792	PLUTONIUM-239/240	PCI/G	.0343	3.4255	.0100	2.300e-010	3.800e-008	1.700e-011
PT14092	AMERICIUM-241	PCI/G	.0095	2.3728	.0040	2.400e-010	3.200e-008	4.900e-009
PT14092	PLUTONIUM-239/240	PCI/G	.0205	3.4255	.0060	2.300e-010	3.800e-008	1.700e-011
PT14192	AMERICIUM-241	PCI/G	.5200	2.3728	.2192	2.400e-010	3.200e-008	4.900e-009
PT14192	PLUTONIUM-239/240	PCI/G	2.9500	3.4255	.8612	2.300e-010	3.800e-008	1.700e-011

t = External
hal = Inhalation
I/G = picocuries per gram
OC = Potential Chemical of Concern
IC = Risk Based Concentration
= slope factor

Table D-1
Ratios of PCOC Concentration/Activities to RBCs
OU3 Surface Soil
Rocky Flats Plant

Location Code	Chemical Name	Unit	Max Result	RBC	PCOC Ratio	Oral SF	Inhal SF	Ext SF
PT14292	AMERICIUM-241	PCI/G	.0130	2.3728	.0055	2.400e-010	3.200e-008	4.900e-009
PT14292	PLUTONIUM-239/240	PCI/G	.2800	3.4255	.0817	2.300e-010	3.800e-008	1.700e-011
PT14392	AMERICIUM-241	PCI/G	.0200	2.3728	.0084	2.400e-010	3.200e-008	4.900e-009
PT14392	PLUTONIUM-239/240	PCI/G	.2700	3.4255	.0788	2.300e-010	3.800e-008	1.700e-011
PT14492	AMERICIUM-241	PCI/G	.0330	2.3728	.0139	2.400e-010	3.200e-008	4.900e-009
PT14492	PLUTONIUM-239/240	PCI/G	.0151	3.4255	.0044	2.300e-010	3.800e-008	1.700e-011
PT14592	AMERICIUM-241	PCI/G	.0295	2.3728	.0124	2.400e-010	3.200e-008	4.900e-009
PT14592	PLUTONIUM-239/240	PCI/G	.0680	3.4255	.0199	2.300e-010	3.800e-008	1.700e-011
PT14692	AMERICIUM-241	PCI/G	.0130	2.3728	.0055	2.400e-010	3.200e-008	4.900e-009
PT14692	PLUTONIUM-239/240	PCI/G	.0345	3.4255	.0101	2.300e-010	3.800e-008	1.700e-011
PT14792	AMERICIUM-241	PCI/G	.0062	2.3728	.0026	2.400e-010	3.200e-008	4.900e-009
PT14792	PLUTONIUM-239/240	PCI/G	.0128	3.4255	.0037	2.300e-010	3.800e-008	1.700e-011
PT14892	AMERICIUM-241	PCI/G	.0010	2.3728	.0004	2.400e-010	3.200e-008	4.900e-009
PT14892	PLUTONIUM-239/240	PCI/G	.0075	3.4255	.0022	2.300e-010	3.800e-008	1.700e-011
PT14992	AMERICIUM-241	PCI/G	.0227	2.3728	.0096	2.400e-010	3.200e-008	4.900e-009
PT14992	PLUTONIUM-239/240	PCI/G	.0946	3.4255	.0276	2.300e-010	3.800e-008	1.700e-011
PT15092	AMERICIUM-241	PCI/G	.0355	2.3728	.0150	2.400e-010	3.200e-008	4.900e-009
PT15092	PLUTONIUM-239/240	PCI/G	.1604	3.4255	.0468	2.300e-010	3.800e-008	1.700e-011
PT15192	AMERICIUM-241	PCI/G	.0805	2.3728	.0339	2.400e-010	3.200e-008	4.900e-009
PT15192	PLUTONIUM-239/240	PCI/G	.7450	3.4255	.2175	2.300e-010	3.800e-008	1.700e-011
PT15292	AMERICIUM-241	PCI/G	.0953	2.3728	.0402	2.400e-010	3.200e-008	4.900e-009
PT15292	PLUTONIUM-239/240	PCI/G	.5107	3.4255	.1491	2.300e-010	3.800e-008	1.700e-011
PT15392	AMERICIUM-241	PCI/G	.0340	2.3728	.0143	2.400e-010	3.200e-008	4.900e-009
PT15392	PLUTONIUM-239/240	PCI/G	.2150	3.4255	.0628	2.300e-010	3.800e-008	1.700e-011
PT15492	AMERICIUM-241	PCI/G	.0255	2.3728	.0107	2.400e-010	3.200e-008	4.900e-009
PT15492	PLUTONIUM-239/240	PCI/G	.0545	3.4255	.0159	2.300e-010	3.800e-008	1.700e-011
PT15592	AMERICIUM-241	PCI/G	.0135	2.3728	.0057	2.400e-010	3.200e-008	4.900e-009
PT15592	PLUTONIUM-239/240	PCI/G	.0413	3.4255	.0121	2.300e-010	3.800e-008	1.700e-011

t = External
nal = Inhalation
I/G = picocuries per gram
OC = Potential Chemical of Concern
C = Risk Based Concentration
= slope

Table D-1
Ratios of PCOC Concentration/Activities to RBCs
OU3 Surface Soil
Rocky Flats Plant

Location Code	Chemical Name	Unit	Max Result	RBC	PCOC Ratio	Oral SF	Inhal SF	Ext SF
PT15692	AMERICIUM-241	PCI/G	.0185	2.3728	.0078	2.400e-010	3.200e-008	4.900e-009
PT15692	PLUTONIUM-239/240	PCI/G	.0360	3.4255	.0105	2.300e-010	3.800e-008	1.700e-011
PT15792	AMERICIUM-241	PCI/G	-.0020	2.3728	-.0008	2.400e-010	3.200e-008	4.900e-009
PT15792	PLUTONIUM-239/240	PCI/G	.0115	3.4255	.0034	2.300e-010	3.800e-008	1.700e-011
PT15892	AMERICIUM-241	PCI/G	.0040	2.3728	.0017	2.400e-010	3.200e-008	4.900e-009
PT15892	PLUTONIUM-239/240	PCI/G	.0415	3.4255	.0121	2.300e-010	3.800e-008	1.700e-011
PT15992	AMERICIUM-241	PCI/G	.0060	2.3728	.0025	2.400e-010	3.200e-008	4.900e-009
PT15992	PLUTONIUM-239/240	PCI/G	.2820	3.4255	.0823	2.300e-010	3.800e-008	1.700e-011
PT16092	AMERICIUM-241	PCI/G	.0035	2.3728	.0015	2.400e-010	3.200e-008	4.900e-009
PT16092	PLUTONIUM-239/240	PCI/G	.0410	3.4255	.0120	2.300e-010	3.800e-008	1.700e-011
PT16192	AMERICIUM-241	PCI/G	.0158	2.3728	.0066	2.400e-010	3.200e-008	4.900e-009
PT16192	PLUTONIUM-239/240	PCI/G	.0523	3.4255	.0153	2.300e-010	3.800e-008	1.700e-011
PT16292	AMERICIUM-241	PCI/G	.0675	2.3728	.0284	2.400e-010	3.200e-008	4.900e-009
PT16292	PLUTONIUM-239/240	PCI/G	.0890	3.4255	.0260	2.300e-010	3.800e-008	1.700e-011
PT16392	AMERICIUM-241	PCI/G	.0535	2.3728	.0225	2.400e-010	3.200e-008	4.900e-009
PT16392	PLUTONIUM-239/240	PCI/G	.1145	3.4255	.0334	2.300e-010	3.800e-008	1.700e-011
PT16492	AMERICIUM-241	PCI/G	.0079	2.3728	.0033	2.400e-010	3.200e-008	4.900e-009
PT16492	PLUTONIUM-239/240	PCI/G	.0238	3.4255	.0069	2.300e-010	3.800e-008	1.700e-011
PT16592	AMERICIUM-241	PCI/G	.0131	2.3728	.0055	2.400e-010	3.200e-008	4.900e-009
PT16592	PLUTONIUM-239/240	PCI/G	.0340	3.4255	.0099	2.300e-010	3.800e-008	1.700e-011
PT16692	AMERICIUM-241	PCI/G	.0267	2.3728	.0112	2.400e-010	3.200e-008	4.900e-009
PT16692	PLUTONIUM-239/240	PCI/G	.0402	3.4255	.0117	2.300e-010	3.800e-008	1.700e-011
PT16792	AMERICIUM-241	PCI/G	.0005	2.3728	.0002	2.400e-010	3.200e-008	4.900e-009
PT16792	PLUTONIUM-239/240	PCI/G	.0200	3.4255	.0058	2.300e-010	3.800e-008	1.700e-011
PT16992	AMERICIUM-241	PCI/G	.0025	2.3728	.0011	2.400e-010	3.200e-008	4.900e-009
PT16992	PLUTONIUM-239/240	PCI/G	.0280	3.4255	.0082	2.300e-010	3.800e-008	1.700e-011
PT17092	AMERICIUM-241	PCI/G	.0110	2.3728	.0046	2.400e-010	3.200e-008	4.900e-009
PT17092	PLUTONIUM-239/240	PCI/G	.0305	3.4255	.0089	2.300e-010	3.800e-008	1.700e-011

xt = External
nhal = Inhalation
CI/G = picocuries per gram
COC = Potential Chemical of Concern
BC = Risk Based Concentration
f = slope factor

Table D-1
Ratios of PCOC Concentration/Activities to RBCs
OU3 Surface Soil
Rocky Flats Plant

Location Code	Chemical Name	Unit	Max Result	RBC	PCOC Ratio	Oral SF	Inhal SF	Ext SF
PT17192	AMERICIUM-241	PCI/G	.0265	2.3728	.0111	2.400e-010	3.200e-008	4.900e-009
PT17192	PLUTONIUM-239/240	PCI/G	.0165	3.4255	.0048	2.300e-010	3.800e-008	1.700e-011
PT17292	PLUTONIUM-239/240	PCI/G	.0852	3.4255	.0249	2.300e-010	3.800e-008	1.700e-011
PT17392	AMERICIUM-241	PCI/G	.0045	2.3728	.0019	2.400e-010	3.200e-008	4.900e-009
PT17392	PLUTONIUM-239/240	PCI/G	.0340	3.4255	.0099	2.300e-010	3.800e-008	1.700e-011
PT17492	AMERICIUM-241	PCI/G	.0020	2.3728	.0008	2.400e-010	3.200e-008	4.900e-009
PT17492	PLUTONIUM-239/240	PCI/G	.0165	3.4255	.0048	2.300e-010	3.800e-008	1.700e-011
PT17692	AMERICIUM-241	PCI/G	.0035	2.3728	.0015	2.400e-010	3.200e-008	4.900e-009
PT17692	PLUTONIUM-239/240	PCI/G	.0120	3.4255	.0035	2.300e-010	3.800e-008	1.700e-011
PT17792	AMERICIUM-241	PCI/G	.0080	2.3728	.0034	2.400e-010	3.200e-008	4.900e-009
PT17792	PLUTONIUM-239/240	PCI/G	.0740	3.4255	.0216	2.300e-010	3.800e-008	1.700e-011
PT17992	AMERICIUM-241	PCI/G	.0139	2.3728	.0059	2.400e-010	3.200e-008	4.900e-009
PT17992	PLUTONIUM-239/240	PCI/G	.0586	3.4255	.0171	2.300e-010	3.800e-008	1.700e-011
PT18592	AMERICIUM-241	PCI/G	.0985	2.3728	.0415	2.400e-010	3.200e-008	4.900e-009
PT18592	PLUTONIUM-239/240	PCI/G	.6650	3.4255	.1941	2.300e-010	3.800e-008	1.700e-011
PT18692	AMERICIUM-241	PCI/G	.0355	2.3728	.0150	2.400e-010	3.200e-008	4.900e-009
PT18692	PLUTONIUM-239/240	PCI/G	.7350	3.4255	.2146	2.300e-010	3.800e-008	1.700e-011
PT18792	AMERICIUM-241	PCI/G	.0113	2.3728	.0048	2.400e-010	3.200e-008	4.900e-009
PT18792	PLUTONIUM-239/240	PCI/G	.0510	3.4255	.0149	2.300e-010	3.800e-008	1.700e-011
PT18892	AMERICIUM-241	PCI/G	.0125	2.3728	.0053	2.400e-010	3.200e-008	4.900e-009
PT18892	PLUTONIUM-239/240	PCI/G	.0208	3.4255	.0061	2.300e-010	3.800e-008	1.700e-011
PT18992	PLUTONIUM-239/240	PCI/G	.0194	3.4255	.0057	2.300e-010	3.800e-008	1.700e-011
PT19092	AMERICIUM-241	PCI/G	.0088	2.3728	.0037	2.400e-010	3.200e-008	4.900e-009
PT19092	PLUTONIUM-239/240	PCI/G	.0322	3.4255	.0094	2.300e-010	3.800e-008	1.700e-011
PT19192	AMERICIUM-241	PCI/G	.0377	2.3728	.0159	2.400e-010	3.200e-008	4.900e-009
PT19192	PLUTONIUM-239/240	PCI/G	.1480	3.4255	.0432	2.300e-010	3.800e-008	1.700e-011
PT19292	AMERICIUM-241	PCI/G	.1659	2.3728	.0699	2.400e-010	3.200e-008	4.900e-009
PT19292	PLUTONIUM-239/240	PCI/G	.3210	3.4255	.0937	2.300e-010	3.800e-008	1.700e-011

= External
nal = Inhalation
I/G = picocuries per gram
OC = Potential Chemical of Concern
C = Risk Based Concentration
= slope

Table D-1
Ratios of PCOC Concentration/Activities to RBCs
OU3 Surface Soil
Rocky Flats Plant

Location Code	Chemical Name	Unit	Max Result	RBC	PCOC Ratio	Oral SF	Inhal SF	Ext SF
PT19392	PLUTONIUM-239/240	PCI/G	.0140	3.4255	.0041	2.300e-010	3.800e-008	1.700e-011
PT19492	AMERICIUM-241	PCI/G	.0765	2.3728	.0322	2.400e-010	3.200e-008	4.900e-009
PT19492	PLUTONIUM-239/240	PCI/G	.0865	3.4255	.0253	2.300e-010	3.800e-008	1.700e-011
PT19592	AMERICIUM-241	PCI/G	.0515	2.3728	.0217	2.400e-010	3.200e-008	4.900e-009
PT19592	PLUTONIUM-239/240	PCI/G	.2500	3.4255	.0730	2.300e-010	3.800e-008	1.700e-011
PT19692	AMERICIUM-241	PCI/G	.0060	2.3728	.0025	2.400e-010	3.200e-008	4.900e-009
PT19692	PLUTONIUM-239/240	PCI/G	.0090	3.4255	.0026	2.300e-010	3.800e-008	1.700e-011
T10	AMERICIUM-241	PCI/G	.0532	2.3728	.0224	2.400e-010	3.200e-008	4.900e-009
T10	PLUTONIUM-239/240	PCI/G	.2487	3.4255	.0726	2.300e-010	3.800e-008	1.700e-011
T11	AMERICIUM-241	PCI/G	.0647	2.3728	.0273	2.400e-010	3.200e-008	4.900e-009
T11	PLUTONIUM-239/240	PCI/G	.4803	3.4255	.1402	2.300e-010	3.800e-008	1.700e-011
T12A	AMERICIUM-241	PCI/G	.0487	2.3728	.0205	2.400e-010	3.200e-008	4.900e-009
T12A	PLUTONIUM-239/240	PCI/G	.2883	3.4255	.0842	2.300e-010	3.800e-008	1.700e-011
T12B	AMERICIUM-241	PCI/G	.0483	2.3728	.0203	2.400e-010	3.200e-008	4.900e-009
T12B	PLUTONIUM-239/240	PCI/G	.3564	3.4255	.1040	2.300e-010	3.800e-008	1.700e-011
T13A	AMERICIUM-241	PCI/G	.1997	2.3728	.0842	2.400e-010	3.200e-008	4.900e-009
T13A	PLUTONIUM-239/240	PCI/G	.8913	3.4255	.2602	2.300e-010	3.800e-008	1.700e-011
T13B	AMERICIUM-241	PCI/G	.0951	2.3728	.0401	2.400e-010	3.200e-008	4.900e-009
T13B	PLUTONIUM-239/240	PCI/G	.6856	3.4255	.2001	2.300e-010	3.800e-008	1.700e-011
T14A	AMERICIUM-241	PCI/G	.1000	2.3728	.0421	2.400e-010	3.200e-008	4.900e-009
T14A	PLUTONIUM-239/240	PCI/G	.6077	3.4255	.1774	2.300e-010	3.800e-008	1.700e-011
T14B	AMERICIUM-241	PCI/G	.0882	2.3728	.0372	2.400e-010	3.200e-008	4.900e-009
T14B	PLUTONIUM-239/240	PCI/G	.4324	3.4255	.1262	2.300e-010	3.800e-008	1.700e-011
T15A	AMERICIUM-241	PCI/G	.2128	2.3728	.0897	2.400e-010	3.200e-008	4.900e-009
T15A	PLUTONIUM-239/240	PCI/G	1.3360	3.4255	.3900	2.300e-010	3.800e-008	1.700e-011
T15B	AMERICIUM-241	PCI/G	.1403	2.3728	.0591	2.400e-010	3.200e-008	4.900e-009
T15B	PLUTONIUM-239/240	PCI/G	1.0840	3.4255	.3165	2.300e-010	3.800e-008	1.700e-011
T1A	PLUTONIUM-239/240	PCI/G	.9517	3.4255	.2778	2.300e-010	3.800e-008	1.700e-011

xt = External
nhal = Inhalation
CI/G = picocuries per gram
COC = Potential Chemical of Concern
BC = Risk Based Concentration
F = slope factor

Table D-1
Ratios of PCOC Concentration/Activities to RBCs
OU3 Surface Soil
Rocky Flats Plant

Location Code	Chemical Name	Unit	Max Result	RBC	PCOC Ratio	Oral SF	Inhal SF	Ext SF
T1B	PLUTONIUM-239/240	PCI/G	1.4750	3.4255	.4306	2.300e-010	3.800e-008	1.700e-011
T2A	PLUTONIUM-239/240	PCI/G	.7572	3.4255	.2211	2.300e-010	3.800e-008	1.700e-011
T2B	PLUTONIUM-239/240	PCI/G	.6805	3.4255	.1987	2.300e-010	3.800e-008	1.700e-011
T2C	PLUTONIUM-239/240	PCI/G	1.6000	3.4255	.4671	2.300e-010	3.800e-008	1.700e-011
T3A	PLUTONIUM-239/240	PCI/G	.9228	3.4255	.2694	2.300e-010	3.800e-008	1.700e-011
T3B	PLUTONIUM-239/240	PCI/G	.7336	3.4255	.2142	2.300e-010	3.800e-008	1.700e-011
T3C	PLUTONIUM-239/240	PCI/G	.6555	3.4255	.1914	2.300e-010	3.800e-008	1.700e-011
T4A	AMERICIUM-241	PCI/G	.1614	2.3728	.0680	2.400e-010	3.200e-008	4.900e-009
T4A	PLUTONIUM-239/240	PCI/G	.8084	3.4255	.2360	2.300e-010	3.800e-008	1.700e-011
T4B	AMERICIUM-241	PCI/G	.0784	2.3728	.0330	2.400e-010	3.200e-008	4.900e-009
T4B	PLUTONIUM-239/240	PCI/G	.3650	3.4255	.1066	2.300e-010	3.800e-008	1.700e-011
T5	AMERICIUM-241	PCI/G	.1277	2.3728	.0538	2.400e-010	3.200e-008	4.900e-009
T5	PLUTONIUM-239/240	PCI/G	.5661	3.4255	.1653	2.300e-010	3.800e-008	1.700e-011
T6	AMERICIUM-241	PCI/G	.0603	2.3728	.0254	2.400e-010	3.200e-008	4.900e-009
T6	PLUTONIUM-239/240	PCI/G	.4764	3.4255	.1391	2.300e-010	3.800e-008	1.700e-011
T7	AMERICIUM-241	PCI/G	.0564	2.3728	.0238	2.400e-010	3.200e-008	4.900e-009
T7	PLUTONIUM-239/240	PCI/G	.1624	3.4255	.0474	2.300e-010	3.800e-008	1.700e-011
T8	AMERICIUM-241	PCI/G	.0406	2.3728	.0171	2.400e-010	3.200e-008	4.900e-009
T8	PLUTONIUM-239/240	PCI/G	.2252	3.4255	.0657	2.300e-010	3.800e-008	1.700e-011
T9	AMERICIUM-241	PCI/G	.1137	2.3728	.0479	2.400e-010	3.200e-008	4.900e-009
T9	PLUTONIUM-239/240	PCI/G	.5915	3.4255	.1727	2.300e-010	3.800e-008	1.700e-011
U10A	AMERICIUM-241	PCI/G	.3631	2.3728	.1530	2.400e-010	3.200e-008	4.900e-009
U10A	PLUTONIUM-239/240	PCI/G	1.7390	3.4255	.5077	2.300e-010	3.800e-008	1.700e-011
U10B	AMERICIUM-241	PCI/G	.2291	2.3728	.0966	2.400e-010	3.200e-008	4.900e-009
U10B	PLUTONIUM-239/240	PCI/G	1.0890	3.4255	.3179	2.300e-010	3.800e-008	1.700e-011
U11A	AMERICIUM-241	PCI/G	.1119	2.3728	.0472	2.400e-010	3.200e-008	4.900e-009
U11A	PLUTONIUM-239/240	PCI/G	.7180	3.4255	.2096	2.300e-010	3.800e-008	1.700e-011
U11B	AMERICIUM-241	PCI/G	.1406	2.3728	.0593	2.400e-010	3.200e-008	4.900e-009

xt = External
nhal = Inhalation
CI/G = picocuries per gram
COC = Potential Chemical of Concern
BC = Risk Based Concentration
F = slope factor

Table D-1
Ratios of PCOC Concentration/Activities to RBCs
OU3 Surface Soil
Rocky Flats Plant

Location Code	Chemical Name	Unit	Max Result	RBC	PCOC Ratio	Oral SF	Inhal SF	Ext SF
U11B	PLUTONIUM-239/240	PCI/G	.7711	3.4255	.2251	2.300e-010	3.800e-008	1.700e-011
U12A	AMERICIUM-241	PCI/G	.1948	2.3728	.0821	2.400e-010	3.200e-008	4.900e-009
U12A	PLUTONIUM-239/240	PCI/G	.9722	3.4255	.2838	2.300e-010	3.800e-008	1.700e-011
U12B	AMERICIUM-241	PCI/G	.1222	2.3728	.0515	2.400e-010	3.200e-008	4.900e-009
U12B	PLUTONIUM-239/240	PCI/G	.7422	3.4255	.2167	2.300e-010	3.800e-008	1.700e-011
U13A	AMERICIUM-241	PCI/G	.1965	2.3728	.0828	2.400e-010	3.200e-008	4.900e-009
U13A	PLUTONIUM-239/240	PCI/G	1.2720	3.4255	.3713	2.300e-010	3.800e-008	1.700e-011
U13B	AMERICIUM-241	PCI/G	.1585	2.3728	.0668	2.400e-010	3.200e-008	4.900e-009
U13B	PLUTONIUM-239/240	PCI/G	.7617	3.4255	.2224	2.300e-010	3.800e-008	1.700e-011
U14A	AMERICIUM-241	PCI/G	.1379	2.3728	.0581	2.400e-010	3.200e-008	4.900e-009
U14A	PLUTONIUM-239/240	PCI/G	.6831	3.4255	.1994	2.300e-010	3.800e-008	1.700e-011
U14B	AMERICIUM-241	PCI/G	.1613	2.3728	.0680	2.400e-010	3.200e-008	4.900e-009
U14B	PLUTONIUM-239/240	PCI/G	.9893	3.4255	.2888	2.300e-010	3.800e-008	1.700e-011
U1A	PLUTONIUM-239/240	PCI/G	6.4680	3.4255	1.8882	2.300e-010	3.800e-008	1.700e-011
U1B	PLUTONIUM-239/240	PCI/G	2.6720	3.4255	.7800	2.300e-010	3.800e-008	1.700e-011
U2A	PLUTONIUM-239/240	PCI/G	3.5900	3.4255	1.0480	2.300e-010	3.800e-008	1.700e-011
U2B	PLUTONIUM-239/240	PCI/G	1.2190	3.4255	.3559	2.300e-010	3.800e-008	1.700e-011
U3A	AMERICIUM-241	PCI/G	.2792	2.3728	.1177	2.400e-010	3.200e-008	4.900e-009
U3A	PLUTONIUM-239/240	PCI/G	1.6960	3.4255	.4951	2.300e-010	3.800e-008	1.700e-011
U3B	AMERICIUM-241	PCI/G	.2602	2.3728	.1097	2.400e-010	3.200e-008	4.900e-009
U3B	PLUTONIUM-239/240	PCI/G	1.1900	3.4255	.3474	2.300e-010	3.800e-008	1.700e-011
U4	AMERICIUM-241	PCI/G	.0990	2.3728	.0417	2.400e-010	3.200e-008	4.900e-009
U4	PLUTONIUM-239/240	PCI/G	.1777	3.4255	.0519	2.300e-010	3.800e-008	1.700e-011
U5	AMERICIUM-241	PCI/G	.1176	2.3728	.0496	2.400e-010	3.200e-008	4.900e-009
U5	PLUTONIUM-239/240	PCI/G	.4119	3.4255	.1202	2.300e-010	3.800e-008	1.700e-011
U6	AMERICIUM-241	PCI/G	.1008	2.3728	.0425	2.400e-010	3.200e-008	4.900e-009
U6	PLUTONIUM-239/240	PCI/G	.4236	3.4255	.1237	2.300e-010	3.800e-008	1.700e-011
U7	AMERICIUM-241	PCI/G	.2677	2.3728	.1128	2.400e-010	3.200e-008	4.900e-009

t = External
hal = Inhalation
I/G = picocuries per gram
OC = Potential Chemical of Concern
C = Risk Based Concentration
= slope factor

Table D-1
Ratios of PCOC Concentration/Activities to RBCs
OU3 Surface Soil
Rocky Flats Plant

Location Code	Chemical Name	Unit	Max Result	RBC	PCOC Ratio	Oral SF	Inhal SF	Ext SF
U7	PLUTONIUM-239/240	PCI/G	1.1510	3.4255	.3360	2.300e-010	3.800e-008	1.700e-011
U8	AMERICIUM-241	PCI/G	.1500	2.3728	.0632	2.400e-010	3.200e-008	4.900e-009
U8	PLUTONIUM-239/240	PCI/G	.2009	3.4255	.0586	2.300e-010	3.800e-008	1.700e-011
U9	AMERICIUM-241	PCI/G	.3059	2.3728	.1289	2.400e-010	3.200e-008	4.900e-009
U9	PLUTONIUM-239/240	PCI/G	1.8570	3.4255	.5421	2.300e-010	3.800e-008	1.700e-011

= External
al = Inhalation
/G = picocuries per gram
C = Potential Chemical of Concern
= Risk Based Concentration
= slope

Table D-2
Ratios of PCOC Concentration/Activities to RBCs
OU3 - IHSS 200 - Sediments and Groundwater
Rocky Flats Plant

Medium	Chemical Name	Unit	Max Result	RBC - C	RBC - NC	PCOC Ratio - C	PCOC Ratio - NC	Oral SF	Inhal SF	Ext SF	Oral RFD	Inhal RFD
GW	STRONTIUM	MG/L	5.5900		21.9000		.2553				6.000e-001	
SD	PLUTONIUM-239/240	PCI/G	4.0400	3.4255		1.1794		2.300e-010	3.800e-008	1.700e-011		
SD	COPPER	MG/KG	311.0000		11000.0000		.0283				4.000e-002	

= carcinogenic
= External
= Inhalation
= milligrams per liter
= non-carcinogenic
= picocuries per gram
= Potential Chemical of Concern
= Risk Based Concentration
= reference dose
= slope factor

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ATTACHMENT 3

EXPOSURE PARAMENTERS

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Attachment 3: Risk Spreadsheets

This Attachment includes summary tables referenced in the Risk Characterization section of the risk assessment. The summary tables provide the details associated with calculating estimates of risk related to chemical/radionuclide intake and external radiation exposures.

Table of Contents

Each table includes the following information:

- Exposure pathway (i.e., soil ingestion)
- Receptor (i.e., residential)
- Affected population (i.e., adult and child)
- COC
- Sample concentration
- Risk calculation results (CEDE and cancer risk estimates)

In addition, each table identifies the exposure parameters used in the calculation of the above. These include, but are not limited to:

- Ingestion rates
- Exposure frequency
- Exposure duration
- Conversion factors

Tables presenting the results for vegetable, beef, and milk consumption also present the equations used to estimate deposition and plant/animal uptake.

Sufficient information is presented in each table that the values calculated for committed effective dose equivalents or cancer risks can be reproduced. Each table also includes pertinent notes and references.

The following provides a list of Tables included in this Attachment. Tables 1 though 18 correspond to IHSS 199; Tables 19 through 36 correspond to IHSS 200.

List of Tables

Table No.	Risk Value	Exposure	Receptor
1	Committed Effective Dose Equivalent	Ingestion of Soil	Residential
2	Excess Lifetime Cancer Risk	Ingestion of Soil	Residential
3	Committed Effective Dose Equivalent	Ingestion of Soil	Recreational
4	Excess Lifetime Cancer Risk	Ingestion of Soil	Recreational
5	Committed Effective Dose Equivalent	Inhalation of Soil	Adult Residential

List of Tables

Table No.	Risk Value	Exposure	Receptor
6	Excess Lifetime Cancer Risk	Inhalation of Soil	Adult Residential
7	Committed Effective Dose Equivalent	Inhalation of Soil	Adult Recreational
8	Excess Lifetime Cancer Risk	Inhalation of Soil	Adult Recreational
9	Effective Dose Equivalent	External Radiation from Soil	Adult Residential
10	Excess Lifetime Cancer Risk	External Radiation from Soil	Adult Residential
11	Effective Dose Equivalent	External Radiation from Soil	Adult Recreational
12	Excess Lifetime Cancer Risk	External Radiation from Soil	Adult Recreational
13	Effective Dose Equivalent	Ingestion of Vegetables	Residential
14	Excess Lifetime Cancer Risk	Ingestion of Vegetables	Residential
15	Effective Dose Equivalent	Ingestion of Beef	Residential
16	Excess Lifetime Cancer Risk	Ingestion of Beef	Residential
17	Effective Dose Equivalent	Ingestion of Milk	Residential
18	Excess Lifetime Cancer Risk	Ingestion of Milk	Residential
19	Committed Effective Dose Equivalent	Ingestion of Sediment	Residential
20	Excess Lifetime Cancer Risk	Ingestion of Sediment	Residential
21	Committed Effective Dose Equivalent	Ingestion of Sediment	Recreational
22	Excess Lifetime Cancer Risk	Ingestion of Sediment	Recreational
23	Committed Effective Dose Equivalent	Inhalation of Sediment	Adult Residential
24	Excess Lifetime Cancer Risk	Inhalation of Sediment	Adult Residential
25	Committed Effective Dose Equivalent	Inhalation of Sediment	Adult Recreational
26	Excess Lifetime Cancer Risk	Inhalation of Sediment	Adult Recreational
27	Effective Dose Equivalent	External Radiation from Sediment	Adult Residential

List of Tables

Table No.	Risk Value	Exposure	Receptor
28	Excess Lifetime Cancer Risk	External Radiation from Sediment	Adult Residential
29	Effective Dose Equivalent	External Radiation from Sediment	Adult Recreational
30	Excess Lifetime Cancer Risk	External Radiation from Sediment	Adult Recreational
31	Effective Dose Equivalent	Ingestion of Vegetables	Residential
32	Excess Lifetime Cancer Risk	Ingestion of Vegetables	Residential
33	Effective Dose Equivalent	Ingestion of Beef	Residential
34	Excess Lifetime Cancer Risk	Ingestion of Beef	Residential
35	Effective Dose Equivalent	Ingestion of Milk	Residential
36	Excess Lifetime Cancer Risk	Ingestion of Milk	Residential

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Table 1
Committed Effective Dose Equivalent
Ingestion of Soil--Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	ADULT RESIDENT				CHILD RESIDENT			
			RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PT14192										
PU-239	2.95	5.18E-05	103.3	0.005	22.1	0.0011	206.5	0.011	56.6	0.0029
AM-241	0.52	3.64E-03	18.2	0.066	3.9	0.0142	36.4	0.132	10.0	0.0363
TOTAL				0.072		0.0153		0.143		0.0393
U1A										
PU-239	6.468	5.18E-05	226.4	0.012	48.4	0.0025	452.8	0.023	124.1	0.0064
AM-241	R	3.64E-03	--	--	--	--	--	--	--	--
TOTAL				0.012		0.0025		0.023		0.0064
U2A										
PU-239	3.59	5.18E-05	125.7	0.007	26.9	0.0014	251.3	0.013	68.9	0.0036
AM-241	R	3.64E-03	--	--	--	--	--	--	--	--
TOTAL				0.007		0.0014		0.013		0.0036

EXPOSURE ASSUMPTIONS (d)

	RME		CT	
	Adult	Child	Adult	Child
Ingestion rate (IR) (g/day)	0.1	0.2	0.05	0.1
Exposure frequency (EF) (days/year)	350	350	234	234
Fraction ingested from contaminated source (	1	1	0.64	0.82

Annual Intake = SC x IR x EF x FI
EDE = DCF x Intake

NOTES:
(a) Concentrations shown are the average of the RFP and CDH collection method. "R" represents data that were rejected by independent data validators.
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values: "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 2
Excess Lifetime Cancer Risk
Ingestion of Soil
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	AGE-ADJUSTED			
			RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PT14192						
PU-239	2.95	3.16E-10	3717.0	1E-06	267.8	8E-08
AM-241	0.52	3.28E-10	655.2	2E-07	47.2	2E-08
TOTAL				1E-06		1E-07
U1A						
PU-239	6.468	3.16E-10	8149.7	3E-06	587.2	2E-07
AM-241	R	3.28E-10	--	--	--	--
TOTAL				3E-06		2E-07
U2A						
PU-239	3.59	3.16E-10	4523.4	1E-06	325.9	1E-07
AM-241	R	3.28E-10	--	--	--	--
TOTAL				1E-06		1E-07

EXPOSURE ASSUMPTIONS (c)

	RME	CT
Age-adjusted ingestion rate (IRadj) (mg-yr/day)	3600	388
Exposure duration - ages 1-6 (EDc) (years)	6	2
Exposure duration - ages 7-31 (EDa) (years)	24	7
Soil ingestion rate - ages 1-6 (IRc) (mg/day)	200	100
Soil ingestion rate - ages 7-31 (IRa) (mg/day)	100	50
Exposure frequency (EF) (days/year)	350	234
Fraction ingested from contaminated source, adult (Fia)	1	0.64
Fraction ingested from contaminated source, child (Fic)	1	0.82
Conversion factor (CF) (g/mg)	0.001	0.001

IRadj = (IRc x EDc x Fic) + (IRa x EDa x Fia)
Intake = SC x IRadj x EF x CF
Risk = Intake x RF

NOTES:
(a) Concentrations shown are the average of the RFP and CDH collection method.
"R" represents data that were rejected by independent data validators.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values: "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 3
Rocky Flats RFI/RI
Committed Effective Dose Equivalent
Ingestion of Soil
Recreational Exposure Scenario

			ADULT RESIDENT				CHILD RESIDENT			
RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PU-239	3.27	5.18E-05	4.09	2.12E-04	0.82	4.23E-05	8.18	4.23E-04	1.64	8.47E-05
AM-241	0.52	3.64E-03	0.65	2.37E-03	0.13	4.73E-04	1.30	4.73E-03	0.26	9.46E-04
TOTAL				2.58E-03		5.16E-04		5.16E-03		1.03E-03

EXPOSURE ASSUMPTIONS (d)

	RME		CT	
	Adult	Child	Adult	Child
Ingestion rate (IR) (g/day)	0.05	0.1	0.025	0.05
Exposure frequency (EF) (days/yea	25	25	10	10

Annual Intake = SC x IR x EF
EDE = DCF x Intake

NOTES:
(a) PU-239 value represents the RME surface soil concentration calculated from locations PT14192, T1A, T1B, T2A, T2B, T3A, T3B, U1A, and U2A.
Am-241 value represents the RME surface soil concentration that was not rejected by data validators (location PT14192)
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 4
Excess Lifetime Cancer Risk
Ingestion of Soil
Recreational Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	AGE-ADJUSTED			
			RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	3.27	3.16E-10	147.15	5E-08	8.99	3E-09
AM-241	0.52	3.28E-10	23.40	8E-09	1.43	5E-10
TOTAL				5E-08		3E-09

EXPOSURE ASSUMPTIONS (c)

	RME	CT
Age-adjusted ingestion rate (IRadj) (mg-yr/day)	1800	275
Exposure duration - ages 1-6 (EDc) (years)	6	2
Exposure duration - ages 7-31 (EDa) (years)	24	7
Soil ingestion rate - ages 1-6 (IRc) (mg/day)	100	50
Soil ingestion rate - ages 7-31 (IRa) (mg/day)	50	25
Exposure frequency (EF) (days/year)	25	10
Conversion factor (CF) (g/mg)	0.001	0.001

IRadj = (IRc x EDc) + (IRa x EDa)
Intake = SC x IRadj x EF x CF
Risk = Intake x RF

NOTES:
(a) Concentrations shown are the average of the RFP and CDH collection method.
"R" represents data that were rejected by independent data validators.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 5
Rocky Flats RFI/RI
Committed Effective Dose Equivalent
Inhalation of Soil
Adult Residential Exposure Scenario

RADIONUCLIDE (a)	AIRBORNE RADIOACTIVITY CONCENTRATION (ARC) (pCi/m3)	INHALATION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PT14192						
PU-239	3.21E-06	0.31	0.0190	0.0059	0.0060	0.0019
AM-241	1.05E-06	0.44	0.0062	0.0027	0.0020	0.0009
TOTAL				0.0086		0.0027
U1A						
PU-239	7.03E-06	0.31	0.04	0.0128	0.0132	0.0041
AM-241	–	–	–	–	–	–
TOTAL				0.0128		0.0041
U2A						
PU-239	3.90E-06	0.31	0.02	0.0071	0.0073	0.0023
AM-241	–	–	–	–	–	–
TOTAL				0.0071		0.0023

EXPOSURE ASSUMPTIONS (d)

	RME- ADULT	CT-ADULT
Exposure scenario: Resident inhalation of contaminated soil		
Dust Concentration from surface soil (DC) (mg/m3)	0.000265	0.000265
Respirable Fraction (PM10)	1	1
Respiratory Deposition Factor (RD)	0.85	0.85
Resident inhalation rate (IR) (m3/hr)	0.83	0.83
Exposure Time (ET) (hr/day)	24	15
Exposure frequency (EF) (days/year)	350	234
Conversion factor (CF) (1 g/1000 mg)	0.001	0.001
	PU-239	AM-241
Activity in dust/Activity in soil (R)	4.1	7.6

ARC = SC x DC x CF x R
Annual Intake = ARC x PM10 x RD x IR x ET x EF
EDE = DCF x Intake

NOTES:
(a) Concentrations used are the average of the RFP and CDH collection method. "R" represents data that were rejected by independent data validators.
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values of Radionuclide Intake and Air Concnetration and Dose Factors for Inhalation, Submersion, and Ingestion (EPA-520/1-88-020). Dose factors include the contribution to dose from ingrowth of decay products after intake of parent radionuclide.
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 6
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Inhalation of Soil
Adult Residential Exposure Scenario

RADIONUCLIDE	CANCER INCIDENCE RISK FACTOR FOR INHALATION (RF) (pCi)-1 (a)	AIRBORNE RADIOACTIVITY CONCENTRATION (ARC) (pCi/m3)	RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PT14192						
PU-239	2.78E-08	3.21E-06	0.57	2E-08	0.05	2E-09
AM-241	3.85E-08	1.05E-06	0.19	7E-09	0.018	7E-10
TOTAL				2E-08		2E-09
U1A						
PU-239	2.78E-08	7.03E-06	1.25	3E-08	0.12	3E-09
AM-241	3.85E-08	–	–	–	–	–
TOTAL				3E-08		3E-09
U2A						
PU-239	2.78E-08	3.90E-06	0.69	2E-08	0.07	2E-09
AM-241	3.85E-08	–	–	–	–	–
TOTAL				2E-08		2E-09

EXPOSURE ASSUMPTIONS (b)

	RME- ADULT	CT-ADULT
Exposure scenario: Resident inhalation of contaminated soil		
Dust Concentration from surface soil (DC) (mg/m3)	0.000265	0.000265
Respirable Fraction (PM10)	1	1
Respiratory Depostion Factor (RD)	0.85	0.85
Resident inhalation rate (IR) (m3/hr)	0.83	0.63
Exposure Time (ET) (hr/day)	24	15
Exposure frequency (EF) (days/year)	350	234
Conversion factor (CF) (1 g/1000 mg)	0.001	0.001
Exposure duration (ED) (years)	30	9
	PU-329	AM-241
Activity in dust/Activity in soil (R)	4.1	7.6

ARC = SC x DC x CF x R
Intake = ARC x PM10 x RD x IR x ET x EF x ED

Risk = Intake x RF

NOTES:
(a) Cancer risk factors taken from November 1994 HEAST tables.
(b) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 7
Rocky Flats RFI/RI
Committed Effective Dose Equivalent
Inhalation of Soil
Adult Recreational Exposure Scenario

RADIONUCLIDE	AIRBORNE RADIOACTIVITY CONCENTRATION (ARC) (pCi/m3)	INHALATION DOSE CONVERSION FACTOR (DCF) (a) (mrem/pCi)	RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (b)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PU-239	7.91E-06	0.31	0.001	3.62E-04	9.85E-05	3.03E-05
AM-241	2.33E-06	0.44	3.47E-04	1.54E-04	2.90E-05	1.29E-05
TOTAL				5.16E-04		4.32E-05

EXPOSURE ASSUMPTIONS (c)

	RME- ADULT	CT-ADULT
Dust Concentration from surface soil (DC) (mg/m3)	0.00059	0.00059
Respirable Fraction (PM10)	1	1
Respiratory Deposition Factor (RD)	0.85	0.85
Recreational inhalation rate (IR) (m3/hr)	1.4	0.83
Exposure Time (ET) (hr/day)	5	1.5
Exposure frequency (EF) (days/year)	25	10
Conversion factor (CF) (1 g/1000 mg)	0.001	0.001
	PU-239	AM-241
Activity in dust/Activity in soil (R)	4.1	7.6

ARC = SC x DC x CF x R
Annual Intake = ARC xPM10 x RD x IR x ET x EF
EDE = DCF x Intake

NOTES:
(a) Dose factors taken from Federal Guidance Report 11, "Limiting Values of Radionuclide Intake and Air Concnetration and Dose Factors for Inhalation, Submersion, and Ingestion (EPA-520/1-88-020). Dose factors include the contribution to dose from ingrowth of decay products after intake of parent radionuclide.
(b) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(c) Source of values (unless otherwise noted): "Open-Space Exposure Parameters" (5/31/95)

Table 8
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Inhalation of Soil
Adult Recreational Exposure Scenario

RADIONUCLIDE	CANCER INCIDENCE RISK FACTOR FOR INHALATION (RF) (pCi)-1 (a)	AIRBORNE RADIOACTIVITY CONCENTRATION (ARC) (pCi/m3)	RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	2.78E-08	7.91E-06	0.035	1E-09	8.86E-04	2E-11
AM-241	3.85E-08	2.33E-06	0.010	4E-10	2.61E-04	1E-11
TOTAL				1E-09		3E-11

EXPOSURE ASSUMPTIONS (b)

	RME- ADULT	CT-ADULT
Dust Concentration from surface soil (DC) (mg/m3)	0.00059	0.00059
Respirable Fraction (PM10)	1	1
Respiratory Depostion Factor (RD)	0.85	0.85
Recreational Inhalation rate (IR) (m3/hr)	1.4	0.83
Exposure Time (ET) (hr/day)	5	1.5
Exposure frequency (EF) (days/year)	25	10
Conversion factor (CF) (1 g/1000 mg)	0.001	0.001
Exposure duration (ED) (years)	30	9
	PU-239	AM-241
Activity in dust/Activity in soil (R)	4.1	7.6

ARC = SC x DC x CF x R
Intake = ARC x PM10 x RD x IR x ET x EF x ED

Risk = Intake x RF

NOTES:
(a) Cancer risk factors taken from November 1994 HEAST tables.
(b) Source of values (unless otherwise noted): "Open-Space Exposure Parameters" (5/31/95)

Table 9
Rocky Flats RFI/RI
Effective Dose Equivalent
Exposure to External Radiation from Contaminated Soil
Adult Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	SURFACE DOSE CONVERSION FACTOR (DCF) (b) (mrem-g/pCi-hr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR EXPOSURE (mrem/yr) (c)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR EXPOSURE (mrem/yr) (c)
PT14192				
PU-239	2.95	3.24E-08	6.42E-04	1.26E-04
AM-241	0.52	5.00E-06	1.75E-02	3.42E-03
TOTAL			1.81E-02	3.55E-03
U1A				
PU-239	6.468	3.24E-08	1.41E-03	2.76E-04
AM-241	R	5.00E-06	–	–
TOTAL			1.41E-03	2.76E-04
U2A				
PU-239	3.59	3.24E-08	7.82E-04	1.53E-04
AM-241	R	5.00E-06	–	–
TOTAL			7.82E-04	1.53E-04

EXPOSURE ASSUMPTIONS (d)

	ADULT - RME	ADULT - CT
Exposure Time (hrs/day)	24	15
Exposure frequency (EF) (days/year)	350	234
Gamma Exposure Time Factor (Te)	1	0.75
Gamma Shielding Factor (1-Se)	0.8	0.5

EDE = DCF x SC x ET x EF x Te x (1-Se)

NOTES:
(a) Concentrations shown are the average of the RFP and CDH collection method.
"R" represents data that were rejected by independent data validators.
(b) Dose factors from Federal Guidance Report No. 12. "External Exposure to Radionuclides in Air, Water, and Soil" (EPA, 1993).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values: "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 10
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Exposure to External Radiation from Contaminated Soil
Adult Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	CANCER INCIDENCE RISK FACTOR FOR EXT. EXPOSURE (b) (RF) (risk-g/pCi-y)	RME RISK OF CANCER INCIDENCE	CT RISK OF CANCER INCIDENCE
PT14192				
PU-239	2.95	1.26E-11	9E-10	8E-11
AM-241	0.52	4.59E-09	6E-08	5E-09
TOTAL			6E-08	5E-09
U1A				
PU-239	6.468	1.26E-11	2E-09	2E-10
AM-241	R	4.59E-09	-	-
TOTAL			2E-09	2E-10
U2A				
PU-239	3.59	1.26E-11	1E-09	9E-11
AM-241	R	4.59E-09	-	-
TOTAL			1E-09	9E-11

EXPOSURE ASSUMPTIONS (c)

	ADULT - RME	ADULT - CT
Exposure duration (ED) (years)	30	9
Gamma Shielding factor: (1-Se)	0.8	0.5
Gamma Exposure Time Factor (Te)	1	0.75
Exposure frequency ratio (EFR)	1	0.6

Risk = SC x ED x Te x (1 - Se) x EFR x RF

NOTES:
(a) Concentrations shown are the average of the RFP and CDH collection method.
"R" represents data that were rejected by independent data validators.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values: "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 11
Rocky Flats RFI/RI
Effective Dose Equivalent
Exposure to External Radiation from Contaminated Soil
Adult Recreational Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	SURFACE DOSE CONVERSION FACTOR (DCF) (b) (mrem-g/pCi-hr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PU-239	3.27	3.24E-08	2.65E-06	1.27E-07
AM-241	0.52	5.00E-06	6.50E-05	3.12E-06
TOTAL			6.76E-05	3.25E-06

EXPOSURE ASSUMPTIONS (d)

	ADULT - RME	ADULT - CT
Exposure Time (ET) (hrs/day)	5	1.5
Exposure frequency (EF) (days/year)	25	10
Gamma Exposure Time Factor (Te)	0.2	0.1
Gamma Shielding Factor (1-Se)	1	0.8

EDE = DCF x SC x ET x EF x Te x (1-Se)

NOTES:
(a) PU-239 value represents the RME surface soil concentration calculated from locations PT14192, T1A, T1B, T2A, T2B, T3A, T3B, U1A, and U2A. AM-241 value represents the only concentration that was not rejected by data validaters (location PT14192).
(b) Dose factors from Federal Guidance Report No. 12. "External Exposure to Radionuclides in Air, Water, and Soil" (EPA, 1993).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 12
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Exposure to External Radiation from Contaminated Soil
Adult Recreational Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	CANCER INCIDENCE RISK FACTOR FOR EXT. EXPOSURE (b) (RF) (risk-g/pCi-y)	RME RISK OF CANCER INCIDENCE	CT RISK OF CANCER INCIDENCE
PU-239	3.27	1.26E-11	2E-11	8E-13
AM-241	0.52	4.59E-09	1E-09	5E-11
TOTAL			1E-09	5E-11

EXPOSURE ASSUMPTIONS (c)

	ADULT - RME	ADULT - CT
Exposure duration (ED) (years)	30	9
Shielding factor (1-SF)	1	0.8
Gamma Exposure Time Factor (Te)	0.2	0.1
Exposure frequency ratio (EFR)	0.07	0.03

Risk = SC x ED x Te x (1 - SF) x EFR X RF

NOTES:

(a) PU-239 value represents the RME surface soil concentration calculated from locations PT14192, T1A, T1B, T2A, T2B, T3A, T3B, U1A, and U2A. AM-241 value represents the only concentration that was not rejected by data validaters (location PT14192).

(b) Cancer risk factors taken from November 1994 HEAST tables.

(c) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 13
Rocky Flats RFI/RI
Effective Dose Equivalent
INGESTION OF VEGETABLES
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/kg)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/kg)	REPROD./STORAGE VEGETABLES/FRUIT CONCENTRATION FROM ROOT UPTAKE (VC2) (pCi/kg)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	ACCTEPTABLE DOSE LIMIT (mrem/yr)	ADULT RESIDENT							
						RME ANNUAL INTAKE OF LEAFY VEGETABLES (pCi/yr)	RME ANNUAL INTAKE OF REPRO/STORAGE VEGETABLES/FRUIT (pCi/yr)	RME TOTAL PLANT INTAKE (pCi/yr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE OF LEAFY VEGETABLES (pCi/yr)	CT ANNUAL INTAKE OF REPRO/STORAGE VEGETABLES/FRUIT (pCi/yr)	CT TOTAL PLANT INTAKE (pCi/yr)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PT1418													
PU-239	2.85	5.75E-04	5.56E-05	5.18E-05	100	1.0	2.3	3.3	1.71E-04	0.1	0.3	0.4	2E-05
AM-241	0.52	1.27E-03	5.56E-05	3.64E-03	100	2.1	2.3	4.3	1.56E-02	0.3	0.3	0.6	2E-03
TOTAL									1.58E-02				2E-03
U1A													
PU-239	6.480	1.29E-03	1.25E-04	5.18E-05	100	2.1	5.1	7.2	3.74E-04	0.3	0.7	1.0	3E-05
AM-241	R	--	--	--	--	--			--	--	--		--
TOTAL									3.74E-04				3E-05
U2A													
PU-239	3.59	6.98E-04	6.91E-05	5.18E-05	100	1.2	2.8	4.0	2.08E-04	0.2	0.4	0.5	2E-05
AM-241	R	--	--	--	--	--			--	--	--		--
TOTAL									2.08E-04				2E-05

EXPOSURE ASSUMPTIONS (d)

	RME - Adult	CT- Adult
Vegetable ingestion rate (IRV) (g/day)	200	200
Fruit ingestion rate (IRF) (g/day)	140	140
Exposure frequency (EF) (days/yr)	350	150
Fraction veg. ingested from contaminated source (Fl1)	0.4	0.25
Fraction fruit ingested from contaminated source (Fl2)	0.3	0.2
Fraction of leafy vegetables ingested (R1) **	0.06	0.06
Fraction of repro./storage vegetables ingested (R2) **	0.04	0.04
Washoff factor (WF)	1	0.5
Dry weight to wet weight conversion (CF)	0.429	0.429
Time to harvest (T) (yr)	0.12	
Surface area (SA) (m2)	0.05	
Weight of produce (WT) (kg)	0.454	

VC1 = (SC x Br x CF) + (DR x T x SA/WT x .06 l/kg/y)
VC2 = SC x Br x CF

	PU-239	AM-241
Br: Soil-to-plant biotransfer factor (leafy) (e)	0.00045	0.0015
Br: Soil-to-plant biotransfer factor (reproduce/storage areas) (e)	0.000045	0.00025
Deposition rate (DR) (pCi/m2-yr) (PT1418)	0.52	0.17
Deposition rate (pCi/m2-yr) (U1A)	1.14	--
Deposition rate (pCi/m2-yr) (U2A)	0.838	--

Annual Intake of leafy veg. = VC1 X IRL X EF X Fl1 X WF X R1
Annual Intake of repro./storage veg/fruit. = VC2 X EF X WF X [IRF X Fl2 + IRV X R2 X Fl1]

EDE = DCF x Intake

NOTES:
** Of all fruits and vegetables consumed, it is assumed that 6% are leafy and 94 % are repro./storage
(a) Concentrations shown are the average of the RFP and CDH collection method. "R" represents data that were rejected by independent data validators.
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (10/95)
(e) Source of Br and Bt values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 14
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Ingestion of Vegetables
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	REPROD./STORAGE VEGETABLE/FRUIT CONCENTRATION FROM ROOT UPTAKE (VC2) (pCi/g)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	ADULT RESIDENT							
					RME INTAKE OF LEAFY VEGETABLES (pCi)	RME ANNUAL INTAKE OF REPRO/STORAGE VEGETABLES/FRUIT (pCi)	RME TOTAL PLANT INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT INTAKE OF LEAFY VEGETABLES (pCi)	CT ANNUAL INTAKE OF REPRO/STORAGE VEGETABLES/FRUIT (pCi)	CT TOTAL PLANT INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PT14102												
PU-239	2.85	5.75E-04	5.68E-05	3.16E-10	29.0	69.8	69.8	3E-08	1.3	2.8	4.0	1E-08
AM-241	0.52	1.23E-03	5.51E-05	3.29E-10	61.8	68.5	130.3	4E-08	2.6	2.8	5.3	2E-08
TOTAL								7E-08				3E-08
U1A												
PU-239	0.488	1.25E-03	1.25E-04	3.16E-10	63.1	153.9	216.4	7E-08	2.6	6.3	8.8	3E-08
AM-241	R	-	-	3.29E-10	-			-	-	-		-
TOTAL								7E-08				3E-08
U3A												
PU-239	3.89	8.88E-04	8.91E-05	3.16E-10	36.2	85.1	120.3	4E-08	1.4	3.5	4.9	2E-08
AM-241	R	-	-	3.29E-10	-			-	-	-		-
TOTAL								4E-08				2E-08

EXPOSURE ASSUMPTIONS (c)

	RME - Adult	CT - Adult
Vegetable ingestion rate (IRV) (g/day)	200	200
Fruit ingestion rate (IRF) (g/day)	140	140
Exposure frequency (EF) (days/year)	350	180
Exposure duration (ED) (years)	30	9
Fraction veg. ingested from contaminated source (Fl1)	0.4	0.25
Fraction fruit ingested from contaminated source (Fl2)	0.3	0.2
Fraction of leafy vegetables ingested (Fl1) **	0.06	0.06
Fraction of repro./storage vegetables ingested (Fl2) **	0.94	0.94
Washoff factor (WF)	1	0.5
Dry weight to wet weight conversion (CF)	0.429	0.429
Time to harvest (T) (yr)	0.12	
Surface area (SA) (m2)	0.05	
Weight of produce (WT) (kg)	0.454	

VC1 = (SC x Br x CF) + (DR x T x SA/WT x .001 kg/g)
VC2 = SC x Br x CF

	PU-239	AM-241
Br; Soil-to-plant biotransfer factor (leafy) (d)	0.00046	0.0055
Br; Soil-to-plant biotransfer factor (reproduce/storage areas) (d)	0.000045	0.00025
Deposition rate (DR) (pCi/m2-yr) (PT14102)	0.82	0.171
Deposition rate (pCi/m2-yr) (U1A)	1.14	-
Deposition rate (pCi/m2-yr) (U3A)	0.833	-

Intake of leafy veg. = VC1 X IRL X EF X ED X Fl1 X WF X Fl1
Annual intake of repro./storage veg/fruit. = VC2 X EF X ED X WF X (IRF X Fl2 + IRV X Fl2 X Fl1)

RISK = INTAKE X RF

NOTES:
** Of all fruits and vegetables consumed, it is assumed that 6% are leafy and 94% are repro./storage
(a) Concentrations shown are the average of the RFP and CDH collection method. "R" represents data that were rejected by independent data validators.
(b) Cancer risk factors taken from November 1994 HEAST tables
(c) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (8/8/95)
(d) Source of Br values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 15
Rocky Flats RFI/RI
Effective Dose Equivalent
Ingestion of Beef
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g) (a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	BEEF CONCENTRATION (BC) (pCi/g)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	ADULT RESIDENT			
					RME ANNUAL INTAKE (pCi/yr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PT14192								
PU-239	2.95	5.75E-04	5.93E-07	5.18E-05	7.88E-03	4.08E-07	3.21E-03	1.66E-07
AM-241	0.52	1.23E-03	7.66E-05	3.64E-03	1.02E+00	3.71E-03	4.15E-01	1.51E-03
TOTAL						3.71E-03		1.51E-03
U1A								
PU-239	6.468	1.25E-03	1.30E-06	5.18E-05	1.73E-02	8.95E-07	7.03E-03	3.64E-07
AM-241	R	--	--	3.64E-03	--	--	--	--
TOTAL						8.95E-07		3.64E-07
U2A								
PU-239	3.59	6.98E-04	7.21E-07	5.18E-05	9.59E-03	4.97E-07	3.90E-03	2.02E-07
AM-241	R	--	--	3.64E-03	--	--	--	--
TOTAL						7.42E-03		3.02E-03

EXPOSURE ASSUMPTIONS (d)

	RME - Adult	CT- Adult
Beef ingestion rate (IR) (g/day) (e)	40	38
Exposure frequency (EF) (days/year)	350	150
Fraction ingested from contaminated source (FI)	0.95	0.95
Quantity of plant eaten by animal (Qp) (kg/day) (e)	6.8	
Quantity of soil eaten by animal (Qs) (kg/day) (e)	0.4	

BC = (Qp*VC1+Qs*Sc)*FI

	PU-239	AM-241
FI: Ingestion-to-beef biotransfer factor (day/kg) (f)	5.00E-07	3.50E-04

Annual Intake = BC x IR x EF x FI
EDE = DCF x Intake

NOTES:
(a) Concentrations shown are the average of the RFP and CDH collection method. "R" represents data that were rejected by independent data validators.
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)
(e) Source of values: "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/8-90/003)
(f) Source of FI value: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 16
Excess Lifetime Cancer Risk
Ingestion of Beef
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	BEEF CONCENTRATION (BC) (pCi/g)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	ADULT RESIDENT			
					RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PT14192								
PU-239	2.95	5.75E-04	5.93E-07	3.16E-10	0.24	7E-11	0.029	9E-12
AM-241	0.52	1.23E-03	7.66E-05	3.28E-10	30.6	1E-08	3.7	1E-09
TOTAL						1E-08		1E-09
U1A								
PU-239	6.468	1.25E-03	1.30E-06	3.16E-10	0.5	2E-10	0.063	2E-11
AM-241	R	--		3.28E-10	--	--	--	--
TOTAL						2E-10		2E-11
U2A								
PU-239	3.59	6.98E-04	7.21E-07	3.16E-10	0.3	9E-11	0.035	1E-11
AM-241	R	--		3.28E-10	--	--	--	--
TOTAL						9E-11		1E-11

EXPOSURE ASSUMPTIONS (c)

	RME - Adult	CT - Adult
Beef ingestion rate (IR) (g/day) (d)	40	38
Exposure frequency (EF) (days/year)	350	150
Exposure duration (ED) (years)	30	9
Fraction ingested from contaminated source	0.95	0.95
Quantity of plant eaten by animal (Qp) (kg/d	8.8	
Quantity of soil eaten by animal (Qs) (kg/day	0.4	

BC = (Qp*VC1+Qs*Sc)*Ff

	PU-239	AM-241
Ff: Ingestion-to-beef biotransfer factor (e) (d	5.00E-07	3.50E-04

Intake = BC x IR x EF x ED x Ff

Risk = Intake x RF

NOTES:

(a) Concentrations shown are the average of the RFP and CDH collection method.
"R" represents data that were rejected by independent data validators.

(b) Cancer risk factors taken from November 1994 HEAST tables.

(c) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

(d) Source of values: "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/6-90/003)

(e) Source of Ff value: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 17
Rocky Flats RFI/RI
Effective Dose Equivalent
Ingestion of Milk
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	MILK CONCENTRATION (MC) (pCi/g)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	ADULT RESIDENT			
					RME ANNUAL INTAKE (pCi/yr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PT14192								
PU-239	2.95	5.75E-04	1.19E-07	5.18E-05	2.05E-03	1.06E-07	8.44E-04	4.37E-08
AM-241	0.52	1.23E-03	8.75E-08	3.64E-03	1.51E-03	5.51E-06	6.24E-04	2.27E-06
TOTAL						5.61E-06		2.31E-06
U1A								
PU-239	8.468	1.25E-03	2.60E-07	5.18E-05	4.49E-03	2.33E-07	1.85E-03	9.59E-08
AM-241	R	--	--	3.64E-03	--	--	--	--
TOTAL						2.33E-07		9.59E-08
U2A								
PU-239	3.59	6.98E-04	1.44E-07	5.18E-05	2.49E-03	1.29E-07	1.03E-03	5.32E-08
AM-241	R	--	--	3.64E-03	--	--	--	--
TOTAL						1.18E-05		4.87E-06

EXPOSURE ASSUMPTIONS (d)

	RME - Adult	CT- Adult
Milk ingestion rate (IR) (g/day) (e)	52	50
Exposure frequency (EF) (days/year)	350	150
Fraction ingested from contaminated source (FI)	0.95	0.95
Quantity of plant eaten by animal (Qp) (kg/day) (e)	8.8	
Quantity of soil eaten by animal (Qs) (kg/day) (e)	0.4	

MC = (Qp*VC1+Qs*Sc)*Fm

	PU-239	AM-241
Fm: Ingestion-to-beef biotransfer factor (day/kg) (f)	1.00E-07	4.00E-07

Annual Intake = MC x IR x EF x FI
EDE = DCF x Intake

NOTES:
(a) Concentrations shown are the average of the RFP and CDH collection method. "R" represents data that were rejected by independent data validators.
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (8/5/95)
(e) Source of values: "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/8-90/003)
(f) Source of Fm values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 18
Excess Lifetime Cancer Risk
Ingestion of Milk
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	MILK CONCENTRATION (MC) (pCi/g)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	ADULT RESIDENT			
					RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PT14192								
PU-239	2.95	5.75E-04	1.19E-07	3.16E-10	0.03	6E-12	0.002	6E-13
AM-241	0.52	1.23E-03	8.75E-08	3.26E-10	0.02	6E-12	0.001	5E-13
TOTAL						1E-11		1E-12
U1A								
PU-239	6.468	1.25E-03	2.60E-07	3.16E-10	0.06	2E-11	0.004	1E-12
AM-241	R	--		3.26E-10	--	--	--	--
TOTAL						2E-11		1E-12
U2A								
PU-239	3.59	6.98E-04	1.44E-07	3.16E-10	0.03	1E-11	0.002	6E-13
AM-241	R	--		3.26E-10	--	--	--	--
TOTAL						1E-11		6E-13

EXPOSURE ASSUMPTIONS (c)

	RME - Adult	CT -Adult
Milk ingestion rate (IR) (g/day) (d)	52	50
Exposure frequency (EF) (days/year)	350	150
Exposure duration (ED) (years)	30	9
Fraction ingested from contaminated source (FI)	0.4	0.25
Quantity of plant eaten by animal (Qp) (kg/day) (d)	6.8	
Quantity of soil eaten by animal (Qs) (kg/day) (d)	0.4	

MC = (Qp*VC1+Qs*Sc)*Fm

	PU-239	AM-241
Fm: Ingestion-to-beef biotransfer factor (day/kg) (e)	1.00E-07	4.00E-07

Intake = MC x IR x EF x ED x FI

Risk = Intake x RF

NOTES:
(a) Concentrations shown are the average of the RFP and CDH collection method. "R" represents data that were rejected by independent data validators.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)
(d) Source of values: "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/8-90/003)
(e) Source of Fm values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 19
Rocky Flats RFI/RI
Committed Effective Dose Equivalent
Ingestion of Sediment
Residential Exposure Scenario

			ADULT RESIDENT				CHILD RESIDENT			
RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	RME ANNUAL (mrem/yr) (c) (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PU-239	2.19	5.18E-05	76.7	0.0040	16.4	0.0008	153.3	0.008	42.0	0.0022

EXPOSURE ASSUMPTIONS (d)	RME		CT	
	Adult	Child	Adult	Child
Ingestion rate (IR) (g/day)	0.1	0.2	0.05	0.1
Exposure frequency (EF) (days/year)	350	350	234	234
Fraction ingested from contaminated source (FI)	1	1	0.64	0.82

Annual Intake = SC x IR x EF x FI
EDE = DCF x Intake

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 20
Excess Lifetime Cancer Risk
Ingestion of Sediment
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	AGE-ADJUSTED			
			RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	2.19	3.16E-10	2759.4	9E-07	198.8	6E-08

EXPOSURE ASSUMPTIONS (c)

	RME	CT
Age-adjusted ingestion rate (IRadj) (mg-yr/day)	3600	388
Exposure duration - ages 1-6 (EDc) (years)	6	2
Exposure duration - ages 7-31 (EDa) (years)	24	7
Soil ingestion rate - ages 1-6 (IRc) (mg/day)	200	100
Soil ingestion rate - ages 7-31 (IRa) (mg/day)	100	50
Exposure frequency (EF) (days/year)	350	234
Fraction ingested from contaminated source (adult)	1	0.64
Fraction ingested from contaminated source (child)	1	0.82
Conversion factor (CF) (g/mg)	0.001	0.001

IRadj = (IRc x EDc x FIc) + (IRa x EDa x FIa)
Intake = SC x IRadj x EF x CF
Risk = Intake x RF

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 22
Excess Lifetime Cancer Risk
Ingestion of Sediment
Recreational Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	AGE-ADJUSTED			
			RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	0.867	3.16E-10	39.0	1E-08	2.4	8E-10

EXPOSURE ASSUMPTIONS (c)

	RME	CT
Age-adjusted ingestion rate (IRadj) (mg-yr/day):	1800	275
Exposure duration - ages 1-6 (EDc) (years):	6	2
Exposure duration - ages 7-31 (EDa) (years):	24	7
Soil ingestion rate - ages 1-6 (IRc) (mg/day)	100	50
Soil ingestion rate - ages 7-31 (IRa) (mg/day)	50	25
Exposure frequency (EF) (days/year):	25	10
Conversion factor (CF) (g/mg)	0.001	0.001

IRadj = (IRc x EDc) + (IRa x EDa)
Intake = SC x IRadj x EF x CF
Risk = Intake x RF

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 23
Rocky Flats RFI/RI
Comitted Effective Dose Equivalent
Inhalation of Sediment
Adult Residential Exposure Scenario

RADIONUCLIDE	AIRBORNE RADIOACTIVITY CONCENTRATION (ARC) (pCi/m3)	INHALATION DOSE CONVERSION FACTOR (DCF) (a) (mrem/pCi)	RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PU-239	1.06E-06	0.31	6.26E-03	1.93E-03	1.98E-03	6.11E-04

EXPOSURE ASSUPTIONS (c)

	RME- ADULT	CT-ADULT
Exposure scenario: Resident Inhalation of contaminated soil		
Dust Concentration from surface soil (DC) (mg/m3)	0.0002	0.0002
Respirable Fraction (PM10)	1	1
Respiratory Depostion Factor (RD)	0.85	0.85
Resident Inhalation rate (IR) (m3/hr):	0.83	0.63
Exposure Time (ET) (hr/day)	24	15
Exposure frequency (EF) (days/year):	350	234
Conversion factor (CF) (1 g/1000 mg):	0.001	0.001
Pu activity in dust/Pu activity in sediment (R)	2.41	

ARC = (SC x DC x CF X R)
Annual Intake = ARC x PM10 x RD x IR x ET x EF
EDE = DCF x Intake

NOTES:
(a) Dose factors taken from Federal Guidance Report 11, "Limiting Values of Radionuclide Intake and Air Concnetration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020). Dose factors include the contribution to dose from ingrowth of decay products after intake of parent radionuclide.
(b) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(c) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 24
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Inhalation of Sediment
Adult Residential Exposure Scenario

RADIONUCLIDE	CANCER INCIDENCE RISK FACTOR FOR INHALATION (RF) (pCi)-1 (a)	AIRBORNE RADIOACTIVITY CONCENTRATION (ARC) (pCi/m3)	RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	2.78E-08	1.06E-06	0.19	5E-09	0.018	5E-10

EXPOSURE ASSUMPTIONS (b)

	RME- ADULT	CT-ADULT
Exposure scenario: Resident inhalation of contaminated soil		
Dust Concentration from surface soil (DC) (mg/m3):	0.0002	0.0002
Respirable Fraction (PM10)	1	1
Respiratory Depostion Factor (RD)	0.85	0.85
Resident Inhalation rate (IR) (m3/hr):	0.83	0.63
Exposure Time (ET) (hr/day)	24	15
Exposure frequency (EF) (days/year):	350	234
Conversion factor (CF) (1 g/1000 mg):	0.001	0.001
Exposure duration (ED) (years):	30	9
Pu activity in dust/Pu activity in sediment (R)	2.41	

ARC = (SC x DC x CF x R)
Intake = ARC x PM10 x RD x IR x ET x EF x ED

Risk = Intake x RF

NOTES:
(a) Cancer risk factors taken from November 1994 HEAST tables.
(b) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 25
Rocky Flats RFI/RI
Committed Effective Dose Equivalent
Inhalation of Sediment
Adult Recreation Exposure Scenario

RADIONUCLIDE	AIRBORNE RADIOACTIVITY CONCENTRATION (ARC) (pCi/m3)	INHALATION DOSE CONVERSION FACTOR (DCF) (a) (mrem/pCi)	RME ANNUAL INTAKE (pCi/yr)	RME COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (b)	CT ANNUAL INTAKE (pCi/yr)	CT COMMITTED EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (b)
PU-239	9.40E-07	3.08E-01	1.40E-04	4.31E-05	1.17E-05	3.61E-06

EXPOSURE ASSUMPTIONS (c)

	RME- ADULT	CT-ADULT
Dust Concentration from surface soil (DC) (mg/m3)	0.00045	0.00045
Respirable Fraction (PM10)	1	1
Respiratory Depostion Factor (RD)	0.85	0.85
Recreational inhalation rate (IR) (m3/hr)	1.4	0.83
Exposure Time (ET) (hr/day)	5	1.5
Exposure frequency (EF) (days/year)	25	10
Conversion factor (CF) (1 g/1000 mg)	0.001	0.001
Pu activity in dust/Pu activity in sediment (R)	2.41	

ARC = (SC x DC x CF)
Annual Intake = ARC x PM10 x RD x IR x ET x EF
EDE = DCF x Intake

NOTES:
(a) Dose factors taken from Federal Guidance Report 11, "Limiting Values of Radionuclide Intake and Air Concnetration and
(b) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(c) Source of values (unless otherwise noted): "Open-Space Exposure Parameters" (5/31/95)

Table 26
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Inhalation of Sediment
Adult Recreational Exposure Scenario

RADIONUCLIDE	CANCER INCIDENCE RISK FACTOR FOR INHALATION (RF) (pCi)-1 (a)	AIRBORNE RADIOACTIVITY CONCENTRATION (ARC) (pCi/m3)	RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	2.78E-08	9.40E-07	4.20E-03	1E-10	1.05E-04	3E-12

EXPOSURE ASSUMPTIONS (b)

	RME- ADULT	CT-ADULT
Dust Concentration from surface soil (DC) (mg/m3):	0.00045	0.00045
Respirable Fraction (PM10)	1	1
Respiratory Depostion Factor (RD)	0.85	0.85
Recreational inhalation rate (IR) (m3/hr):	1.4	0.83
Exposure Time (ET) (hr/day)	5	1.5
Exposure frequency (EF) (days/year):	25	10
Conversion factor (CF) (1 g/1000 mg):	0.001	0.001
Exposure duration (ED) (years):	30	9
Pu activity in dust/Pu activity in sediment (R)	2.41	

ARC = (SC x DC x CF x R)
Intake = ARC x PM10 x RD x IR x ET x EF x ED
Risk = Intake x RF

NOTES:
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 27
Rocky Flats RFI/RI
Effective Dose Equivalent
Exposure to External Radiation from Contaminated Sediment
Adult Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	SURFACE DOSE CONVERSION FACTOR (DCF) (b) (mrem-g/pCi-hr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR EXPOSURE (mrem/yr) (c)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR EXPOSURE (mrem/yr) (c)
PU-239	2.19	3.24E-08	0.00048	0.00009

EXPOSURE ASSUPTIONS (d)

	ADULT - RME	ADULT - CT
Exposure Time (ET) (hrs/day)	24	15
Exposure frequency (EF) (days/year):	350	234
Gamma Exposure Time Factor (Te)	1	0.75
Gamma Shielding Factor (1-Se)	0.8	0.5

EDE = DCF x SC x ET x EF x Te x (1-Se)

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Dose factors from Federal Guidance Report No. 12. "External Exposure to Radionuclides in Air, Water, and Soil" (EPA, 1993).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr)
(d) Source of values: "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

TABLE 28
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Exposure to External Radiation from Contaminated Sediment
Adult Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	CANCER INCIDENCE RISK FACTOR FOR EXT. EXPOSURE (b) (RF) (risk-g/pCi-y)	RME RISK OF CANCER INCIDENCE	CT RISK OF CANCER INCIDENCE
PU-239	2.19	1.26E-11	7E-10	6E-11

EXPOSURE ASSUMPTIONS (c)

	ADULT - RME	ADULT - CT
Exposure duration (ED) (years)	30	9
Gamma Shielding factor: (1-Se)	0.8	0.5
Gamma Exposure Time Factor (Te)	1	0.75
Exposure frequency ratio (EFR)	1	0.6

Risk = SC x ED x Te x (1 - Se) x EFR x RF

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values: "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)

Table 29
Rocky Flats RFI/RI
Effective Dose Equivalent
Exposure to External Radiation from Contaminated Sediment
Adult Recreation Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	SURFACE DOSE CONVERSION FACTOR (DCF) (b) (mrem-g/pCi-hr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PU-239	0.867	3.24E-08	7.02E-07	3.37E-08

EXPOSURE ASSUMPTIONS (d)

	ADULT - RME	ADULT - CT
Exposure Time (ET) (hrs/day)	5	1.5
Exposure frequency (EF) (days/year)	25	10
Gamma Exposure Time Factor (Te)	0.2	0.1
Gamma Shielding Factor (1-Se)	1	0.8

EDE = DCF x SC x ET x EF x Te x (1-Se)

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Dose factors from Federal Guidance Report No. 12. "External Exposure to Radionuclides in Air, Water, and Soil" (EPA, 1993).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 30
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Exposure to External Radiation from Contaminated Sediment
Adult Recreational Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	CANCER INCIDENCE RISK FACTOR FOR EXT. EXPOSURE (b) (RF) (risk-g/pCi-y)	RME RISK OF CANCER INCIDENCE	CT RISK OF CANCER INCIDENCE
PU-239	0.867	1.26E-11	4E-12	2E-13

EXPOSURE ASSUMPTIONS (c)

	ADULT - RME	ADULT - CT
Exposure duration (ED) (years)	30	9
Shielding factor: (1-SF)	1	0.8
Gamma Exposure Time Factor (Te)	0.2	0.1
Exposure frequency ratio (EFR)	0.07	0.03

Risk = SC x ED x Te x (1 - SF) x EFR X RF

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values: "Open-Space Exposure Parameters" (5/31/95)

Table 31
Rocky Flats RFI/RI
Effective Dose Equivalent
Ingestion of Vegetables
Residential Exposure Scenario

						ADULT RESIDENT							
RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(c)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	REPROD./STORAGE VEGETABLE/FRUIT CONCENTRATION FROM ROOT UPTAKE (VC2) (pCi/g)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	ACCTEPTABLE UPTAKE (mrem/yr)	RME ANNUAL INTAKE OF LEAFY VEGETABLES (pCi/yr)	RME ANNUAL INTAKE OF REPRO/STORAGE VEGETABLES/FRUIT (pCi/yr)	RME TOTAL PLANT INTAKE (pCi/yr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (d)	CT ANNUAL INTAKE OF LEAFY VEGETABLES (pCi/yr)	CT ANNUAL INTAKE OF REPRO/STORAGE VEGETABLES/FRUIT (pCi/yr)	CT TOTAL PLANT INTAKE (pCi/yr)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (d)
PU-239	2.19	4.24E-04	4.22E-05	5.18E-05	100	0.7	1.7	2.4	0.00013	0.095	0.2	0.333	0.00002

EXPOSURE ASSUMPTIONS (d)

	RME - Adult	CT- Adult
Vegetable ingestion rate (IRV) (g/day)	200	200
Fruit ingestion rate (IRF) (g/day)	140	140
Exposure frequency (EF) (days/year)	350	150
Fraction veg. ingested from contaminated source (Fl1)	0.4	0.25
Fraction fruit ingested from contaminated source (Fl2)	0.2	0.2
Fraction of leafy vegetables ingested (R1) **	0.06	0.06
Fraction of repro./storage vegetables ingested (R2) **	0.94	0.94
Washoff factor (WF)	1	0.5
Dry weight to wet weight conversion (CF)	0.428	0.428
Time to harvest (T) (yr)	0.12	
Surface area (SA) (m2)	0.05	
Weight of produce (WT) (kg)	0.454	

VC1= (SC x Br x CF) + (DR x T x SA/WT x .001kg/g)
VC2 = SC x Br x CF

	PU-239
Br: Soil-to-plant biotransfer factor (leafy) (e)	0.00048
Br: Soil-to-plant biotransfer factor (reprod/storage areas) (e)	0.000048
Deposition rate (pCi/m2-yr)	0.172

Annual intake of leafy veg. = VC1 X IRL X EF X Fl1 X WF X R1
Annual intake of repro./storage vegifruit. = VC2 X EF X WF X (IRF X Fl2 + IRV X R2 X Fl1)

EDE = DCF x Intake

NOTES:

** Of all fruits and vegetables consumed, it is assumed that 6% are leafy and 94% are repro./storage

(a) Concentrations shown are the 95 UCL.

(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).

(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).

(d) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (9/5/95)

(e) Source of Br and Bt values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 32
Rocky Flats RFI/RI
Excess Lifetime Cancer Risk
Ingestion of Vegetables
Residential Exposure Scenario

					ADULT RESIDENT							
RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	REPROD./STORAGE VEGETABLES/FRUIT CONCENTRATION FROM ROOT UPTAKE (VC2) (pCi/g)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	RME INTAKE OF LEAFY VEGETABLES (pCi)	RME ANNUAL INTAKE OF REPRO/STORAGE VEGETABLES/FRUIT (pCi)	RME TOTAL PLANT (mrem/yr) (d) (pCi)	RME RISK OF CANCER INCIDENCE	CT INTAKE OF LEAFY VEGETABLES (pCi)	CT ANNUAL INTAKE OF REPRO/STORAGE VEGETABLES/FRUIT (pCi)	CT TOTAL PLANT INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	2.19	4.24E-04	4.22E-05	3.16E-10	21.4	51.9	73.3	2E-06	0.86	2.1	2.99	9E-10

EXPOSURE ASSUMPTIONS (c)

	RME - Adult	CT- Adult
Vegetable ingestion rate (IRV) (g/day)	200	200
Fruit ingestion rate (IRF) (g/day)	140	140
Exposure frequency (EF) (days/year)	350	150
Exposure duration (ED) (years)	30	9
Fraction veg. ingested from contaminate	0.4	0.25
Fraction fruit ingested from contaminatec	0.3	0.2
Fraction of leafy vegetables ingested (FI	0.06	0.06
Fraction of repro./storage vegetables ing	0.94	0.94
Washoff factor (WF)	1	0.5
Dry weight to wet weight conversion (CF)	0.428	0.428

Time to harvest (T) (yr)	0.12
Surface area (SA) (m2)	0.05
Weight of produce (WT) (kg)	0.454

VC1= (SC x Bv x CF) + (DR x T x SA/WT x .001kg/g)
VC2 = SC x Br x CF

	PU-239
Bv: Soil-to-plant biotransfer factor (leafy)	00045
Br: Soil-to-plant biotransfer factor (repo	000045

Deposition rate (pCi/m2-yr) 0.172

Intake of leafy veg. = VC1 X IRL X EF X ED X FI1 X WF X R1
Annual Intake of repro./storage veg/fruit. = VC2 X EF X ED X WF X (IRF X FI2 + IRV X R2 X FI1)

RISK = INTAKE X RF

NOTES:
** Of all fruits and vegetables consumed, it is assumed that 6% are leafy and 94% are repro./storage
(a) Concentrations shown are the 95 UCL.
(b) Cancer risk factors taken from November 1994 HEAST tables
(c) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (8/5/95)
(d) Source of Bv and Br values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 33
Rocky Flats RFI/RI
Effective Dose Equivalents
Ingestion of Beef
Residential Exposure Scenarios

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	BEEF CONCENTRATION (BC) (pCi/g)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	ADULT RESIDENT			
					RME ANNUAL INTAKE (pCi/yr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PU-239	2.19	4.24E-04	4.40E-07	5.18E-05	2.46E-03	1.28E-07	6.27E-04	3.25E-08

EXPOSURE ASSUMPTIONS (d)

	RME - Adult	CT- Adult
Beef ingestion rate (IR) (g/day) (e)	40	38
Exposure frequency (EF) (days/year)	350	150
Fraction ingested from contaminated source (FI)	0.4	0.25
Quantity of plant eaten by animal (Qp) (kg/day) (e)	8.8	
Quantity of soil eaten by animal (Qs) (kg/day) (e)	0.4	

BC = (Qp*VC1+Qs*Sc)*Ff

	PU-239	AM-241
Ff: Ingestion-to-beef biotransfer factor (day/kg) (f)	5.00E-07	3.50E-04

Annual Intake = BC x IR x EF x FI
EDE = DCF x Intake

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)
(e) Source of values: "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/6-90/003)
(f) Source of Ff values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 34
Excess Lifetime Cancer Risk
Ingestion of Beef
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	BEEF CONCENTRATION (BC) (pCi/g)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	ADULT RESIDENT			
					RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	2.19	4.24E-04	4.40E-07	3.16E-10	7.39E-02	2E-11	5.64E-03	2E-12

EXPOSURE ASSUMPTIONS (c)

	RME - Adult	CT -Adult
Beeg ingestion rate (IR) (g/day) (d)	40	38
Exposure frequency (EF) (days/year)	350	150
Exposure duration (ED) (years)	30	9
Fraction ingested from contaminated source	0.4	0.25
Quantity of plant eaten by animal (Qp) (kg/da	8.8	
Quantity of soil eaten by animal (Qs) (kg/day	0.4	

BC = (Qp*VC1+Qs*Sc)*Ff

	PU-239	AM-241
Ff: Ingestion-to-beef biotransfer factor (e) (da	5.00E-07	3.50E-04

Intake = BC x IR x EF x ED x FI

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)
(d) Source of values: "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/6-90/003)
(e) Source of Ff values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 35
Rocky Flats RFI/RI
Effective Dose Equivalent
Ingestion of Milk
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	MILK CONCENTRATION (MC) (pCi/g)	INGESTION DOSE CONVERSION FACTOR (DCF) (b) (mrem/pCi)	ADULT RESIDENT			
					RME ANNUAL INTAKE (pCi/yr)	RME EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)	CT ANNUAL INTAKE (pCi/yr)	CT EFFECTIVE DOSE EQUIVALENT (EDE) 1 YR INTAKE (mrem/yr) (c)
PU-239	2.19	4.24E-04	8.80E-08	5.18E-05	6.40E-04	3.32E-08	1.65E-04	8.54E-09

EXPOSURE ASSUMPTIONS (d)

	RME - Adult	CT - Adult
Milk ingestion rate (IR) (g/day) (e)	52	50
Exposure frequency (EF) (days/year)	350	150
Fraction ingested from contaminated source (FI)	0.4	0.25
Quantity of plant eaten by animal (Qp) (kg/day) (e)	8.8	
Quantity of soil eaten by animal (Qs) (kg/day) (e)	0.4	

MC = (Qp*VC1+Qs*Sc)*Fm

	PU-239	AM-241
Fm: Ingestion-to-milk biotransfer factor (day/kg) (f)	1.00E-07	4.00E-07

Annual Intake = MC x IR x EF x FI
EDE = DCF x Intake

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Dose factors taken from Federal Guidance Report 11, "Limiting Values Of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion" (EPA-520/1-88-020).
(c) Committed effective dose equivalent expressed as committed (50 yr.) dose (mrem) due to one year of exposure (mrem/yr).
(d) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)
(e) Source of values: "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/6-90/003)
(f) Source of Fm values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

Table 36
Excess Lifetime Cancer Risk
Ingestion of Milk
Residential Exposure Scenario

RADIONUCLIDE	SAMPLE CONCENTRATION (SC) (pCi/g)(a)	LEAFY VEGETABLE CONCENTRATION (VC1) (pCi/g)	MILK CONCENTRATION (MC) (pCi/g)	CANCER INCIDENCE RISK FACTOR FOR INGESTION (RF) (pCi)-1 (b)	ADULT RESIDENT			
					RME TOTAL INTAKE (pCi)	RME RISK OF CANCER INCIDENCE	CT TOTAL INTAKE (pCi)	CT RISK OF CANCER INCIDENCE
PU-239	2.19	4.24E-04	8.80E-08	3.16E-10	1.92E-02	6E-12	1.48E-03	5E-13

EXPOSURE ASSUMPTIONS (c)

	RME - Adult	CT -Adult
Milk ingestion rate (IR) (g/day) (d)	52	50
Exposure frequency (EF) (days/year)	350	150
Exposure duration (ED) (years)	30	9
Fraction ingested from contaminated soi	0.4	0.25
Quantity of plant eaten by animal (Qp) (l	8.8	
Quantity of soil eaten by animal (Qs) (kg	0.4	

MC = (Qp*VC1+Qs*Sc)*Fm

	PU-239	AM-241
Fm: Ingestion-to-milk biotransfer factor (	1.00E-07	4.00E-07

Intake = MC x IR x EF x ED x FI
Risk = Intake x RF

NOTES:
(a) Concentrations shown are the 95 UCL.
(b) Cancer risk factors taken from November 1994 HEAST tables.
(c) Source of values (unless otherwise noted): "Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment" (6/5/95)
(d) Source of values: "Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions" (EPA/600/6-90/003)
(e) Source of Fm values: "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (ORNL-5786) (1984)

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EXECUTIVE SUMMARY

The focus of the OU 3 baseline ecological risk assessment (ERA) is on chemical stressor effects to terrestrial and aquatic ecosystems. EPA guidance was followed in the planning, sampling, and document production phases of the ERA. The format of the OU 3 ERA document closely follows the following EPA guidance:

- Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Review Draft
- Framework for Ecological Risk Assessment EPA/630/R-92/001
- Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual, Interim Final, EPA/540/1-89/001
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference Document, EPA 600/3-89/013

In addition, various components of the ERA have been documented as part of a sitewide ERA assessment in two Technical Memoranda (TMs) of the Sitewide Conceptual Model TM (SCMTM) (DOE, 1995a), and the Ecological Chemicals of Concern Screening Methodology TM (ECOCTM) (DOE, 1995b).

The EPA guidance outlines an eight-step process that involves four phases; a Preliminary Problem Formulation phase, followed by the Problem Formulation, Analysis, and Risk Characterization phases. The Preliminary Problem Formulation focuses the ERA efforts upon the chemicals of concern (COC) that drive the potential risk, and includes an evaluation of potential chemicals of concern (PCOC) exposure, effects, and risk. PCOCs are defined as inorganic compounds with concentrations or activities detected in OU 3 that are significantly elevated over background levels, and organic compounds detected in OU 3 at concentrations greater than the detection limits reported in the Rocky Flats Environmental Database System data. If no risk or effect is identified in this ERA, the remaining ERA components (Problem Formulation, Analysis, and Risk Characterization phase) are unnecessary. This document presents the Preliminary Problem Formulation for the OU 3 ERA. No further ERA components were performed because risk was not identified.

Following the procedures outlined in the EPA and DOE guidance documents, the OU 3 ERA was focused upon the evaluation of Rocky Flats-related PCOCs identified in soil (0 to 3 cm depth range from samples collected from 11 trenches and 2 soil plots collocated with plant and small mammal samples), sediment, and surface water. The PCOCs were selected by comparison of observed concentrations/activities to applicable background levels. Statistical methods were used to compare OU 3 soil data to background soil data. This approach assumes that the PCOC selection process in OU 3 is as relevant to the ERA as the human health risk assessment (HHRA). The PCOC screening process for the ERA, as documented in TM3, should be started with the list of PCOCs to determine the ECOCs. If no ECOCs are identified, then the ERA methodology is documented as a *de minimus* risk scenario. As a result of the background comparison and weight of evidence screening, the following PCOCs were identified:

- Plutonium-239, -240 in sediment of IHSS 200
- Americium-241, and plutonium-239, -240 in soil (IHSS 199)

To be conservative, americium-241 and plutonium-239, -240 were considered as PCOCs for each individual hazardous substance site (IHSS) in the aquatic risk assessment of exposure to sediment. Americium-241 was retained because it is the decay product of plutonium-239, -240.

As a final screening process, these PCOCs were evaluated by comparison of the maximum observed activity to the applicable no observed adverse effect level (NOAEL) literature benchmark values and by comparison of a determined exposure dose to a NOAEL literature-derived dose within the preliminary exposure and effects assessments (DOE, 1995b). The results of the preliminary exposure and effects assessments were combined to formulate the preliminary risk characterization and determination of ECOCs, if any.

The exposure assessment identifies the PCOC source, exposure pathways, and receptors. Because of the chemical and physical nature of americium-241 and plutonium-239, -240, the predominant pathway of exposure would be via internal absorption from ingestion (or absorption for plants). Therefore, terrestrial organisms directly exposed to soils were of principal concern. Similarly, sediment-dwelling organisms (benthic macroinvertebrates, bottom-dwelling fish, and fish eggs) were of principal concern in the aquatic evaluation. Because americium-241 and plutonium-239, -240 are alpha emitters, and because alpha particles do not successfully penetrate the epidermis (or integument or carapace of aquatic organisms), external absorption is an unlikely exposure pathway for these two radionuclides.

This ERA is not driven by ecological effects but by the presence of contaminant sources that have not been obvious ecological impacts at Rocky Flats.

The effects assessment was conducted by using an activity screen, a dose screen, and a qualitative evaluation of in-field biometric effects for aquatic measurements. The activity screen involved the comparison of observed PCOC maximum exposure-point activities to a NOAEL media activity (DOE, 1995b). The dose screen involved the comparison of measured dose (for terrestrial) or modeled dose (for aquatic) to a literature-derived NOAEL dose. The final portion of the effects evaluation involved a qualitative evaluation of field measurements of species diversity and occurrence, and bioassay analysis of surface water and sediment (aquatic evaluation only). These biometric measurements were not heavily relied upon because of the confounding nature of other natural or physical stressor effects that affect these measures (e.g., the land use of grazing will impact plant species occurrence).

The preliminary risk characterization was conducted using the hazard quotient (HQ) and hazard index (HI) method, and by compiling the information from the exposure and effects assessments for an evaluation of uncertainty and risk.

Results of the assessment revealed minimal risk to either the terrestrial or aquatic ecology from the PCOCs present within the soil and sediment of IHSS 199 and IHSS 200, respectively. The screening risk assessment results demonstrate risks two to six orders of magnitude lower than the effects threshold. Observed media activities and determined doses were well below the criteria benchmark levels. The activity HQ for americium-241 in soils (IHSS 199) was 9×10^{-5}, and for plutonium-239, -240 was 4×10^{-4}. The dose HQs for plutonium-239, -240 in terrestrial animals was 1.4×10^{-3}, and for americium-241 was 8.4×10^{-3}. Comparable values for plants were 1.0×10^{-3} for plutonium-239, -240, and 8.4×10^{-4} for americium-241. Activity HQs for plutonium-239, -240 and americium-241 in sediment were 8.1×10^{-6} and 2.0×10^{-5} for Great Western Reservoir, 1.1×10^{-6} and 2.1×10^{-6} for Standley Lake, and 9.8×10^{-7} and 1.9×10^{-6} for Mower Reservoir, respectively. Dose HQs for plutonium-239, -240 and americium-241 for benthic macroinvertebrates and fish are 0.05 and 0.006 for Great Western Reservoir,

0.003 and 0.0007 for Standley Lake, and 0.003 and 0.0006 for Mower Reservoir, respectively. An HQ of 1 suggests that contaminants occur at the level of concern (EPA, 1994).

HIs were also calculated by combining the HQs for each PCOC. The activity HI for plutonium-239, -240 and americium-241 in IHSS 200, IHSS 201, and IHSS 202 was 3.6×10^{-5}, 4.3×10^{-6} and 2.1×10^{-5}, respectively. The dose HI for plants was 1.8×10^{-3} and for terrestrial animals was 9.8×10^{-3}. The dose HI for benthic macroinvertebrates and fish (inclusive of fish eggs) was 1.1×10^{-1} for Great Western Reservoir, 7.6×10^{-3} for Standley Lake, and 6.6×10^{-3} for Mower Reservoir.

Because no ecological risks or effects were identified, there was no need for further evaluation in a formal Problem Formulation, Analysis, or Risk Characterization phase. Thus, the OU 3 ERA was concluded upon completion of the Preliminary Problem Formulation. Supplemental documentation regarding exposure and effects evaluations is provided to further verify the results.

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B1.0 INTRODUCTION

An ERA, as defined by the EPA, is "a qualitative and/or quantitative appraisal of the actual or potential effects of a hazardous waste site on plants and animals other than people and domesticated species" (EPA, 1989a). The OU 3 ERA addresses and quantifies, where possible, the ecological effects on the biotic environment of plants, animals, and aquatic organisms caused by exposure to chemicals transported from Rocky Flats. The ERA was conducted as a part of the RFI/RI process to determine if the PCOCs from Rocky Flats pose a current or potential risk to the environment within OU 3 in the absence of remedial action.

The OU 3 ERA was prepared to meet the applicable regulatory requirements and provide the information needed to evaluate whether remedial action is warranted at OU 3, based on actual or potential ecological risks. Sections within the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) include statements that both human health and the environment must be considered when assessing risks associated with releases from hazardous waste sites. Also, the National Contingency Plan (NCP) specifically states that an ERA must be performed to assess threats to the environment (40 CFR Part 300.430[e][2][i][G]) during the overall process of assessing the need to remediate a hazardous waste site. The Interagency Agreement (IAG) between DOE, EPA, and CDPHE states that one objective of the RFI/RI is to provide data to conduct the baseline risk assessment for human health and the environment for OU 3.

B1.1 PURPOSE AND OBJECTIVES

The purpose of this ERA is to evaluate the potential effects of Rocky Flats-related PCOCs on the plants, animals, and aquatic organisms residing within OU 3.

The principal objectives of the OU 3 ERA are to determine:

- OU 3 PCOC exposure to aquatic and terrestrial receptors.
- Current and potential effects to the exposed receptors.
- The risk to the ecological receptors.

To meet these objectives, field investigations were designed in order to obtain PCOC concentration/ activity information in various environmental media throughout OU 3. A discussion of the data quality objectives (DQOs), which define the data collection activities and their purpose, is provided within the work plan for the OU 3 sampling effort (DOE, 1992). A discussion of the data quality assessment (DQA) of the OU 3 data collection effort is also presented within this appendix.

B1.2 ERA PROCESS

The ERA process has evolved into a phased approach in which investigation efforts are refined depending upon the outcome of each prior phase (EPA, 1992). The first phase is to identify the "risk-drivers" of a site by conducting a Preliminary Problem Formulation (EPA, 1994). The Preliminary Problem Formulation evaluates Rocky Flats-related PCOC exposure and subsequent effects to the terrestrial and aquatic receptors. Highly conservative exposure and effects assumptions are made in order to encompass the possible risk that can occur. The results of this phase can be used to develop a plan of action to further investigate the PCOCs, exposure pathways, and effects by conducting relevant field

evaluations (EPA, 1994). If, as a result of the first phase, no risks are identified (i.e, no ECOCs pass the screen), the evaluation is essentially complete and no further action is required (EPA, 1994).
This ERA is based on four EPA ERA guidance documents, as outlined in the Executive Summary, and two TMs that summarize the general approach and methods used at Rocky Flats. The SCMTM provides information to be used in the Preliminary Problem Formulation and Problem Formulation phases of the ERA, including a description of the environmental setting, chemical pathways, exposure pathways, receptor guides, exposure parameters, and measurement endpoints
(DOE, 1995a). The ECOCTM presents the methodology for screening site data to determine which chemicals should be evaluated in the ERA (DOE, 1995b).

The current ERA framework that served as the guidance for the OU 3 ERA, is an eight-step process as outlined below (EPA 1994):

1. Preliminary Problem Formulation and Ecological Effects Evaluation

2. Preliminary Exposure Estimate and Risk Calculation

3. Problem Formulation: Assessment Endpoint Selection Testable Hypothesis

4. Conceptual Model Development: Conceptual Model Measurement Endpoint Selection and Study Design

5. Site Assessment to Confirm Ecological Sampling and Analysis Plan

6. Site Field Investigation

7. Risk Characterization

8. Risk Management

According to the EPA guidance, an ecological risk does not exist unless; 1) the stressor has the ability to cause one or more adverse effects, and 2) the stressor co-occurs with or contacts an ecological component long enough and at a sufficient intensity to elicit the identified adverse effect. A stressor is defined as "any physical, chemical [including radiological], or biological entity that can induce an adverse response" (EPA, 1992).

The first two steps in the ERA are a streamlined version of the complete framework process and are intended to allow the risk assessor and risk manager to make a rapid determination that Rocky Flats poses neither a negligible nor any ecological risk. Steps 3 through 8 are a more detailed version of the complete framework process and reflect efforts to determine a proposed site-specific, cleanup goal that is protective of the environment. This eight-step approach is not a simple linear or sequential process, but it is iterative (EPA, 1994).

For the purposes of the OU 3 ERA, an initial evaluation of Rocky Flats-related PCOC occurrence, fate and transport, exposure pathways and receptor identification was performed. This task was conducted during design and preparation of the work plan and field sampling plan process (DOE, 1992). Rocky Flats-related PCOCs were identified, along with exposure pathways and potential ecological receptors affected by exposure to these chemicals. Based upon this information, sampling activities were designed to determine effects and exposure attributable to the PCOCs.

This appendix presents the analytical results of the field investigation, which are also described in detail in the OU 3 RFI/RI report. These results were interpreted and are presented within the Preliminary Problem Formulation, Section B3.0, of this appendix. As defined within the 1994 EPA guidance, "The Preliminary Problem Formulation is intended to allow for a determination of whether the site poses no or negligible ecological risk." Conservative assumptions were used to represent the "worst-case" exposure condition, to determine if adverse effects may occur. In the OU 3 ERA, an exposure-point activity was estimated and an exposure dose screening was conducted to identify potential effects, as described in Section B3.2, attributable to site "worst-case" exposure conditions. The concentration benchmark values used were provided by the DOE in TM3 (DOE, 1995b), whereas the dose NOAEL values were derived from literature sources (i.e., Blaylock et al., 1993). PCOCs were defined as those chemicals that occur at concentrations above background. PCOCs were identified using methods presented in the CDPHE Conservative Screen Letter Report (DOE, 1994). The Letter Report presents a weight-of-evidence approach for a background comparison of surface-water and sediment data. The background comparison for soil data included a series of statistical tests recommended by Gilbert (1993).

The maximum observed PCOC concentration or activity was then used as the exposure-point concentration/activity and evaluated within the preliminary exposure assessment and preliminary effects assessment to determine effects and risk.

The results of the PCOC screening identified no ECOCs and revealed no potential risk to the OU 3 terrestrial and aquatic ecological receptors, as a result of exposure to Rocky Flats-related PCOCs. Because risk was not observed in this conservative screen, a formal Analysis, and Risk Characterization phase were not conducted.

This ERA presents the results of the Preliminary Problem Formulation which encompasses a preliminary exposure assessment, preliminary effects assessment, and a preliminary risk characterization. All of these steps are based upon "worst-case" exposure conditions as described in Section B3.0 of this appendix. This ERA is structured to evaluate both the current and potential threats to the natural environment in OU 3. The influences of other OUs were addressed to some extent by the design of the field sampling plan. Because OU 3 is the receiving system, it could exhibit effects caused by historic chemical releases from other OUs. However, there is no evidence to suggest that there has been any recent chemical releases to Great Western Reservoir, and since the Broomfield Diversion Canal was constructed in 1989, the potential for future releases through the Walnut Creek Drainage has been substantially reduced. The potential for future releases into Standley Lake has also be substantially reduced since the construction of the Woman Creek Reservoir. Woman Creek Reservoir is part of the Standley Lake Protection Project and collects effluent from Woman Creek for analysis prior to release to Standley Lake. Similarly, onsite staging ponds for the capture and treatment of industrial area/protected area (IA/PA) chemical sources are online in order to prevent transport into Woman and Walnut Creek.

B1.3 STUDY DESCRIPTION

The OU 3 ERA is based upon data collected from samples of soil (0 to 3 cm from 11 trenches and 2 soil plots collocated with terrestrial biota sampling), surface water and sediment. Sampling and analysis of biotic media were also conducted as part of the RFI/RI in order to meet the data needs of the ERA. These biotic media were sampled for the purposes of meeting DQOs specifically for the ERA. The following provides a brief description of the study location, the available environmental data used for the ERA, and the DQA process for data collection.

B1.3.1 Study Location

A comprehensive description of the Rocky Flats setting is provided in TM2 (DOE, 1995a). The following provides a brief physical description of the OU 3 setting. A detailed description of the specific ecological characteristics is provided in Section B2.0 of this appendix.

The RFI/RI activities at Rocky Flats are currently based on 16 OUs, each containing several contaminant source areas, which are designated as IHSSs. For the purposes of conducting RFI/RI Baseline ERAs, Rocky Flats has been divided into four areas: the IA/PA; the Woman Creek drainage basin; the Walnut Creek drainage basin; and the Offsite Areas. Each of the drainages contains source areas associated with several OUs, and one OU may contribute to contaminant transport in both drainages.

The OU 3 study area extends primarily eastward from the eastern boundary of Rocky Flats (Indiana Street) and consists mostly of the undeveloped land areas and the Jefferson County and City of Westminster Open Space. The OU 3 study area also includes two large water supply reservoirs (Great Western Reservoir and Standley Lake), and a smaller irrigation reservoir (Mower Reservoir) east of Rocky Flats (Figure 1-2 of the RFI/RI report). The northern and southern boundaries of OU 3 generally coincide with Colorado Highway 128 on the north, and 88th Avenue on the south (south of Standley Lake). The eastern boundary of the OU 3 ecological study area generally coincides with Simms Street in the area north of Standley Lake, and a north-south line running east of the Standley Lake Dam between 88th Avenue and 100th Avenue. The OU 3 study area encompasses four IHSSs:

- IHSS 199 Contamination of Land Surface
- IHSS 200 Great Western Reservoir and associated drainages
- IHSS 201 Standley Lake and associated drainages
- IHSS 202 Mower Reservoir and associated drainages

B1.3.2 Available Environmental Data

The database for this ERA includes information acquired from the following sources:

- OU 3-specific field investigations conducted from May to June 1993
- Abiotic and biotic data collected by the DOE as part of ongoing Rocky Flats environmental monitoring programs
- Information from scientific literature

The OU 3-specific field investigations relevant to the ERA included sampling of surface water, sediments, soil, plant and animal tissues, and fish tissue. In addition, benthic macroinvertebrate and periphyton species were collected and identified. Abiotic samples of soil, surface water and sediment samples were collocated with biotic samples (plants, small mammals, benthic macroinvertebrates, and fish) to address PCOC uptake and transfer. In addition, surface water and sediment bioassays were conducted to address toxicity of the media to laboratory organisms. Samples of benthic macroinvertebrates and periphyton were collected for the qualitative determination of species occurrence. Plant and animal communities within the OU 3 study area were also evaluated for

population and community measurements for descriptive purposes. Abiotic and biotic samples from each location were collected concurrently, or within a short interval, to allow correlations between natural abiotic parameters and the ecological measures selected for evaluating environmental stress. The sampling activities are described in detail in Section 2.0 of the OU 3 RFI/RI report.

Based on prior studies at Rocky Flats, PCOC sources and exposure pathways were identified early in the OU 3 RFI/RI process within the OU 3 Work Plan (DOE, 1992). The OU 3 Work Plan identified the Rocky Flats-related PCOCs that have been detected in the OU 3 area, and the PCOCs that are likely to have been transported to OU 3 during prior years. This initial assessment also identified the general exposure pathways that are expected at OU 3 (DOE, 1992).

The initial assessment identified radionuclides, primarily plutonium and americium, as the only Rocky Flats-related radioactive PCOCs that are consistently detected at levels above background in some areas within OU 3. These radionuclides are the result of past airborne and water-borne releases from Rocky Flats. There is no evidence that radionuclides are currently being released from Rocky Flats, other than those allowable under operating permits.

Other PCOCs (such as metals, volatile organics, and herbicides) have been detected during prior studies at other OUs closer to the main Rocky Flats facilities. These could occur within OU 3 if appropriate transfer mechanisms existed. The only logical transport mechanisms for metals, herbicides, and volatile organics are limited to water-borne mechanisms operating within the two major drainages running through Rocky Flats and then into OU 3. Thus, the metals and herbicides (atrazine and simazine only) were considered to be potential hazards only to aquatic organisms within the creeks and reservoirs, and were not considered during the investigation of the terrestrial ecosystem. Subsequent to the implementation of the OU 3 Work Plan, polychlorinated biphenlys (PCBs) were found in the sediments and some aquatic biota upstream from OU 3 ecosystems. Appendix K of this RFI/RI report details the findings of that study. Potential chemical stressors to the OU 3 ecosystems, where appropriate, were investigated as part of the field activities.

Attachment 1 presents a summary of the data used for the ERA, and Attachment 2 presents a summary of the background comparison and identification of PCOCs resulting from the background screen. The biotic media results for plant and animal tissue are presented in Attachment 3 as part of the terrestrial PCOC evaluation, and the benthic macroinvertebrate, periphyton, fish tissue, and bioassay data results are presented in Attachment 4, as part of the aquatic PCOC evaluation.

B1.3.3 PCB Sediment and Tissue Sampling

During the OU 6 RFI/RI, elevated PCB concentrations were detected in some of the A- and B-series detention ponds. These ponds are located in the North and South Walnut Creek drainages. Before 1989, Walnut Creek discharged directly into Great Western Reservoir (IHSS 200). A diversion canal was constructed in 1989 that routed the flow coming from Walnut Creek around Great Western Reservoir and back into Walnut Creek below the Great Western Reservoir dam. The detection of PCBs in the A and B ponds raised the potential that these contaminants may also be found in the reservoirs of OU 3. Because of this possibility, additional tissue sampling was initiated in OU 3 as part of the ERA portion of OU 6.

Results of sediment sampling in OUs 5 and 6 revealed no detectable levels of PCBs in terminal ponds A-4, B-5, or C-2. These results suggest that it is not likely that sediments derived from Rocky Flats are contributing PCBs to any of the offsite reservoirs or downstream ecosystems. Furthermore, a decreasing trend in PCB concentrations in fish-tissue samples from the PCB source in sediments to downstream

ecosystems supports this finding. Elevated PCB concentrations in Standley Lake are unlikely to be attributable to Rocky Flats contamination; historically, Rocky Flats has contributed less than 5 percent of the surface-water inputs to this reservoir, and upstream sites close to Rocky Flats sources have lower or nondetectable PCB concentration. Further discussions and study results are included in Appendix K.

B1.3.4 Data Quality Assessment

DQOs establish the complete set of specifications needed to design environmental data collection programs and include the level of uncertainty that the data user can accept in the decision, based on the data. The DQOs for the OU 3 ERA data collection activities were established within the OU 3 Work Plan prior to the field activities (DOE, 1992). A DQA was conducted for the OU 3 data collection by DOE. DOE audits were conducted and included an evaluation of field activities, field records (field log books, sample-collection forms, and chain-of-custody forms), data-transfer activities, and data interpretation (Neptune, 1994).

Because the OU 3 ERA represents the Preliminary Problem Formulation, the focus of the decision making was based upon the results of the chemical analysis of the abiotic media. All other data collection activities were supplemental in nature and used for the purposes of description and to confirm the exposure, effects, and risk characterization. Therefore, a greater amount of uncertainty was allowable for the biotic characteristics, such as species occurrence and diversity.

The abiotic media analysis data were gathered in support of decision making at the OU 3 study area. In general, the data were used to determine PCOCs in various media throughout OU 3. These concentrations were used to support decisions regarding the potential need for remedial action.

B1.4 ERA OVERVIEW

Section B2.0 presents an overview of the aquatic and terrestrial ecosystems within OU 3, and qualitatively describes the terrestrial and aquatic biological communities occurring in OU 3.

Section B3.0 characterizes the PCOCs, exposure pathways and receptors. The exposure dose to the receptors is quantified in Subsection B3.1, Preliminary Exposure Assessment, and compared to the literature benchmark values within Subsection B3.2, Preliminary Effects Assessment.

Subsection B3.3 combines the information developed in the exposure and ecological effects assessments, to assess if there are existing or potential ecological risks. This subsection summarizes the evidence for ecological risks at OU 3 and discusses the magnitude of those risks. There is generally a degree of uncertainty associated with estimating ecological risks; therefore, an uncertainty assessment is also presented.

Section B4.0 presents the overall assessment of risks, and provides the rationale for concluding that significant ecological risks are or are not present in OU 3.

Data summaries and the techniques for evaluating data are presented in Attachment 1, and a summary of PCOC selection methods and results are presented in Attachment 2. Comprehensive terrestrial and aquatic evaluations of the PCOCs are provided in Attachments 3 and 4.

B2.0 ECOLOGICAL SETTING

This section contains site characterization information relevant to the terrestrial and aquatic ecological settings in OU 3. Detailed descriptions of other OU 3 site characteristics such as topography, meteorology, and geology are presented in Section 2.0 of the OU 3 RFI/RI report as well as in TM2 (DOE, 1995a). The information provided here is based on qualitative surveys of OU 3 conducted for site characterization. This information was obtained during the OU 3 field activities and from previous documentation.

Habitats and ecosystems on OU 3 are influenced by land uses such as agricultural, residential, recreational, and water storage and usage. Table B2-1 provides a summary of stressors that have impacted the terrestrial and aquatic ecosystem structure. The following provides a summary of the terrestrial and aquatic ecosystem characteristics, as well as a summary of physical (abiotic) and biological (biotic) stressors present within these ecosystems.

B2.1 TERRESTRIAL ECOSYSTEM

The terrestrial ecosystems present at Rocky Flats and the surrounding area are typical of the Front Range of Colorado. The terrestrial ecosystems on OU 3 are typical High Plains short-and mid-grass prairie grasslands. The drainages are ephemeral creeks with a mixture of mesic grasslands and wetlands, with some riparian zones along lower creek bottoms. Reservoirs and ditches constructed in drainages have replaced the natural drainage system and most riparian zones. Sparse cottonwood groves and solitary trees grow in the lower drainages and around reservoirs. At the present time, the vegetation and animals in these ecosystems have been influenced by habitat fragmentation and alteration by human activities and land use. The most extensive remaining semi-natural ecosystems are upland xeric grasslands that were previously grazed.

The most important wildlife habitats within OU 3 are associated with the riparian zone surrounding the permanent water provided by reservoirs and other small impoundments. The prairie grassland provides a large expanse of habitat, but cover is limited and habitat diversity has been seriously degraded by a long history of livestock grazing. Wildlife at Rocky Flats is typical of species found in similar habitat types throughout the foothills of the Front Range of the Rocky Mountains.

The existing terrestrial habitats within OU 3 have been extensively modified by land use and management practices. Land uses and continuing management practices that have radically altered terrestrial habitats include agriculture (plowing), remediation of contaminated soil surfaces by deep chiseling, construction of the three reservoirs (Great Western Reservoir, Standley Lake, and Mower Reservoir), and the construction of roads, ditches, drainages, powerlines, railroad grades, housing, residences, and office buildings. Land-use practices that altered habitats less extensively include grazing by domestic livestock, irrigation, introduction of weeds and exotic plant species, elimination of predators, and changes in pest control. Land-use changes are continuing to occur with abandonment of plowed fields, removal of domestic grazing, creation of open spaces, and revegetation of remediated soils.

The most recent land-use change in OU 3 resulted from the Standley Lake Protection Project (SLPP) construction activities near the south side of Woman Creek and east of Indiana Street. The SLPP is one of two major components of the Option B surface-water management plan to protect existing drinking water supplies immediately downstream of Rocky Flats. Option B is summarized in Section 1.3.7 of the OU 3 RFI/RI report. The SLPP includes the construction of Woman Creek Reservoir and appurtenant

Table B2-1
Stressors Impacting the Terrestrial and Aquatic Ecosystems Within OU 3

	Physical	Chemical	Biological
Terrestrial	Land Use - grazing - residential - agriculture	Fertilizers/Pesticides	Predation, completion
Aquatic	Water Use (reservoir status)	Overland flow and runoff of surface materials into the drainages	Mower Reservoir and Standley Lake are stocked with game fish species for recreational purposes. These fish have"altered" the population, community, and ecosystem structure.

facilities (i.e., a pump station and the underground pipeline from Woman Creek Reservoir to Great Western Reservoir), the Kinnear Ditch Pipeline along the Indiana Street corridor, and the Wetlands Mitigation Site and Wildlife Habitat west of Standley Lake.

The Woman Creek Reservoir and its associated berm will replace about 50 acres of open grasslands that were formerly agricultural fields and range land dedicated by Jefferson County for open space. After construction of the reservoir and pipeline, the land topography and native grasses will be restored. The Kinnear Ditch Pipeline from Coal Creek to near Standley Lake will be an underground pipeline constructed adjacent to or in an existing road right-of-way and across open grassland pastures. The original land contours and vegetation will be reestablished after the pipeline is installed. The pipeline will terminate into a natural drainage approximately 1/3-mile upstream from Standley Lake. About 14 acres of an approximately 45-acre site at the east end of Kinnear Ditch Pipeline will be used for wetland mitigation, and the remaining land will be used for upland wildlife habitat enhancement.

The major habitat type, on the uplands outside the agriculture fields and reservoirs, is altered grasslands (short, xeric-mixed, and mesic-mixed grassland habitat). The upland grasslands are concentrated on the ridges and slopes east of Rocky Flats along Indiana Street. They are either presently grazed or have been heavily grazed in the recent past. Low-growing grasses, introduced grasses, and weedy species are common. Recent intensive activity by large prairie-dog populations have reduced many grassland habitats to a weedy/forb stage. Wetlands and riparian habitats along drainages are small and controlled by water diversions and releases. Small wetlands along drainages and the edges of reservoirs are short or tall marsh habitat, but may be seasonally dry due to water control and flow fluctuations. The riparian habitats consist of narrow zones of shrubland in the upper drainages, such as Woman Creek and the ditch leading to Mower Reservoir, or single rows of cottonwood trees along the lower broader drainages.

A variety of herbivores (plant eaters) provide a diverse selection of prey for the carnivores (meat eaters). Bull snakes, rattlesnakes, racers, and eastern short-horned lizards live in many habitats at OU 3, while western painted turtles and western plains garter snakes reside near moist habitats. Common birds

include western meadowlarks, horned larks, red-winged blackbirds, mourning doves, vesper sparrows, house finches, marsh hawks, red-tailed hawks, ferruginous hawks, rough-legged hawks, and great horned owls. Mallards and Canada geese use the small ponds as feeding and breeding areas. The most common medium-sized mammals are black-tailed prairie dogs, desert cottontails, and muskrats, along with a few black-tailed jack rabbits, white-tailed jack rabbits, and porcupines. The most common large mammal at OU 3 is the mule deer. Coyotes, striped skunks, raccoons, and long-tailed weasels are the most common carnivores, with badgers and red foxes observed occasionally. Gray foxes, bobcats, and mountain lions have been historically reported at OU 3.

Wildlife access is restricted by roads, fences, residential and commercial development, and the intrusion of human activities. Animal species that may be primary receptors of contamination include the ground-dwelling rodents. Larger animals, such as deer and raptors, use the study area but are wide ranging and not confined to OU 3.

All areas on OU 3 have had potential stresses not related to Rocky Flats. Stresses possibly impacting OU 3 and not related to contaminant releases from Rocky Flats include abiotic and biotic potential stressors.

Abiotic stressors that influence the condition of the terrestrial ecosystem on OU 3 are mainly due to the climate, soil conditions, and physical forces of wind, water, and gravity. The climate potential stressors are a combination of moisture, temperature, and seasonality. Severe potential climate stressors to the system are a result of natural disasters such as flood, drought, and fire. Soil conditions of moisture, nutrient status, texture, and physical disturbance can place stress on the plant, insect, and burrowing/digging animal populations. The surveys of OU 3 did not determine any influence of natural disasters in recent history. Some evidence of water and wind erosion was observed. Physical disturbance to the natural terrestrial ecosystems include roads, buildings, fences, golf courses, dams, irrigation, grazing, plowing, and the introduction of new species (domestic and nonnative plants and animals in competition with native species). These effects are pervasive throughout OU 3, which has been farmed since the 1800s, and more recently affected by recent urban and suburban development. There are no completely natural terrestrial communities on OU 3, and some land surfaces have been covered or converted to uses other than natural ecosystems. Potential chemical stressors related to human activities include herbicide applications, air pollution, oil/gas dispersion from roads and urban areas, and other pollutants from urban water discharge. These vary in concentrations and intensity of effects depending on how recently the chemicals have been used or released to the environment.

Potential biotic stressors on OU 3 include a combination of natural predation, competition for resources, parasite infestation, and plague or disease. Consumption of plants by herbivorous animals (including insects) and of animals by their predators is a normal function of a natural ecosystem. These biological factors become a stress with the removal of limits on the natural ecosystem function (for example, overconsumption of vegetation in a pasture can greatly reduce productivity). Prairie dogs have few predators in OU 3, and their populations are rapidly expanding; the resulting overgrazing of desirable plant species by these herbivores has created a shift in the composition of the vegetation community on OU 3.

B2.2 AQUATIC ECOSYSTEM

The aquatic ecosystems within OU 3 encompass three reservoirs including associated drainages of Great Western Reservoir, Standley Lake, and Mower Reservoir, in addition to two small, intermittent creek drainages (Woman and Walnut Creeks). The two drainages flowing into OU 3 have their

headwaters within the site boundary and both watersheds are relatively small. The Woman Creek watershed covers about 7.5 square miles south of the main site facility and flows west to east into Standley Lake. Walnut Creek flows west to east and lies north of the main site facility.

The principal biological components of the aquatic ecosystems in OU 3 are periphyton, phytoplankton, zooplankton, benthic macroinvertebrates, amphibians, aquatic plants, and fish. Aquatic habitats and communities found in OU 3 are typical of those found in the foothills region. The type of aquatic communities and diversity of species in each of these components is dependent on the type of substrate, water depth and flow regime, water quality, water flow control, and season. A limited number of fish and amphibian species are found in the OU 3 streams due to water flow control practices that leave streams dry most of the year. However, a diverse assemblage of benthic macroinvertebrates, including crayfish, mayfly larvae, caddisfly larvae, and midges have widespread distribution in these aquatic habitats. Attachment 4 provides comprehensive lists of the sampled benthic macroinvertebrates. Species of fish observed within the streams and reservoirs include:

- Standley Lake: Black crappie, Carp, Channel catfish, Gizzard shad, Green sunfish, Longnose sucker, Rainbow trout, Smallmouth bass, Walleye, White sucker, Wiper, Yellow perch
- Great Western Reservoir: Carp, Longnose sucker, White sucker
- Mower Reservoir: Largemouth bass, Longnose sucker
- Lindsey Pond (reference location): Largemouth bass
- Walnut Creek: Longnose sucker, Minnow sp.
- Woman Creek: Smallmouth bass
- Big Dry Creek: Longnose dace, Longnose sucker

Historically, DOE has placed several control structures within the Woman and Walnut Creek watersheds. These structures and associated facilities currently control most surface water that originates from the main site facility.

The major ditch within OU 3, Church Ditch, conveys water from the Clear Creek Basin near Golden, Colorado, to Great Western Reservoir. Most of the water in Great Western Reservoir, presently the City of Broomfield's water supply, comes from Clear Creek via the Church Ditch, rather than from Walnut Creek. In 1989, the City of Broomfield constructed a diversion ditch (Broomfield Ditch) around the south side of Great Western Reservoir that discharges flow into Walnut Creek below the reservoir. This ditch normally diverts any Walnut Creek flows not retained by Rocky Flats control systems around Great Western Reservoir.

Church Ditch, which runs around the north and west portions of Standley Lake, is also used to supply some water to Standley Lake. However, most Standley Lake water comes from Clear Creek near Golden via the Farmers High Line and Croke Canals. The lower reach of Woman Creek is used to convey Church Ditch water to Standley Lake. Therefore, the lower section of Woman Creek between the Church Ditch and Standley Lake usually has flowing water during the summer and early fall. The conveyance flows, plus irrigation water released by farmers in the lower Woman Creek area, have allowed several acres of wetlands to develop along lower Woman Creek. Some small sunfish and

minnows occasionally migrate into Lower Woman Creek from Standley Lake when creek flows are adequate, and some benthic macroinvertebrates are established in the reach that conveys water to Standley Lake. Discharges from Standley Lake for downstream irrigation users keep water in Big Dry Creek just below Standley Lake Dam for most of the year. However, nearly all of this water originates from Clear Creek via canals, and only a very small fraction can be attributed to natural Woman Creek flows.

The three reservoirs within OU 3 are all manmade facilities. Standley Lake, the municipal water supply for the Cities of Westminster, Thornton, Northglenn, and Federal Heights, is also a major sport fishing and recreational resource in the northwest Denver metropolitan area. Standley Lake has a normal capacity of approximately 43,000 acre-feet and a surface area of about 1,200 acres. The Colorado Division of Wildlife stocks fish in Standley Lake and manages the sport fishery that supports a large variety of sport and forage fish species.

Great Western Reservoir, the City of Broomfield's present water supply, has a normal capacity of approximately 3,250 acre-feet. The reservoir contains carp, sucker species, minnows and shiners, but apparently no game fish. There is no public access to Great Western Reservoir, and it is operated only for municipal water. Irrigation water, however, is conveyed into Walnut Creek immediately below Great Western Reservoir by Church Ditch, and infrequently by the Broomfield Diversion Ditch. Water-level fluctuations prevent extensive wetlands or aquatic vegetation along shorelines.

Mower Reservoir was developed for irrigation supply and is fed by water from a headgate on Woman Creek within the Rocky Flats buffer zone. Mower Reservoir has a surface area of about 9 acres and has a depth of 5 to 10 feet. This reservoir supports a naturally reproducing population of largemouth bass. The bass were probably stocked in the reservoir some years ago. Mower Reservoir has a dense growth of aquatic plants during the summer and cattail wetland vegetation grows along the western and southern shorelines.

Because of the presence of residential, agricultural, industrial, and recreational land uses, many of the OU 3 aquatic systems are managed for their resources. Fish populations are regularly augmented by stocking in Standley Lake. All of the aquatic systems are managed as water resources, and Standley Lake and Big Dry Creek are also managed for recreational purposes.

Potential biotic stressors on aquatic OU 3 ecosystems include natural predation, competition for resources, disease, and natural water chemistry changes (such as eutrophication). Populations within Standley Lake and Mower Reservoir are influenced by management practices. Species of fish are continually stocked and will affect existing populations of phytoplankton and zooplankton benthic macroinvertebrates and fish. Competition for habitat, as well as food resources, undergoes changes as a result of the changing population compositions. Stress resulting from competition and predation lessens when food supplies are adequate. However, an overabundance of food can result in population growth and eventual return of the competition.

Potential abiotic stressors to the OU 3 aquatic ecosystems include the resource management practices of water control, resource use for recreation purposes, and surrounding land-use patterns. All of the OU 3 water bodies are managed for various water uses, which affect water levels and turnover within the lakes, and flow within the streams. This, in turn, will affect water quality characteristics (such as pH and temperature). Standley Lake and Big Dry Creek are subject to various recreational uses that have resulted in altered physical structures (eroded riparian) and altered fish species diversity.

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B3.0 PRELIMINARY PROBLEM FORMULATION

The Preliminary Problem Formulation includes a preliminary exposure assessment, preliminary effects assessment, and risk characterization. The purpose of the Preliminary Problem Formulation is to determine, where possible, if the presence of identified PCOCs are causing an adverse effect to exposed ecological receptors. The Preliminary Problem Formulation was based on the data collected from OU 3, as described in Attachment 1. The data from the OU 3 field results for the abiotic media are presented in the OU 3 RFI/RI report. Attachment 2 provides the methods and results of the PCOC determination. Data were evaluated and screened with respect to background, and are provided in more detail in Volume I, Section 4.2. A weight-of-evidence evaluation was conducted for surface water and sediment, whereas soils were statistically evaluated (DOE, 1994a). The following PCOCs were identified:

- Plutonium-239, -240 in reservoir sediment (IHSS 200)
- Plutonium-239, -240, americium-241 in surface soil (IHSS 199)

These PCOCs were the focus for this assessment. Americium-241 was retained as a sediment PCOC as a conservative measure because americium-241 is the decay product of plutonium-239, -240. Also, as a conservative measure, plutonium-239, -240 and americium-241 in sediment were evaluated for each reservoir IHSS.

The initial step in the Preliminary Problem Formulation is the exposure assessment, which includes the identification of Rocky Flats-related PCOC exposure pathways, and receptors of concern. To date, no adverse effects have been documented or defined within the OU 3 area. Subsection B3.1 provides the preliminary exposure assessment, and describes the potential exposure pathways and receptors of concern, which are dependent upon the physical and chemical characteristics of the PCOCs.

The final step within the preliminary exposure assessment is the determination of the exposure-point concentration (or activity, because the PCOCs are radionuclides) and resultant dose to the identified ecological receptors. The media activities and dose were compared to conservative literature NOAEL benchmark values in order to determine ecological effects within the preliminary ecological effects assessment (DOE, 1995c). The effects attributable to the exposure were inferred based upon these literature NOAEL comparisons. The comparison between the exposure-point activity and dose to the appropriate benchmark value is quantified within the preliminary risk characterization using the hazard quotient (HQ) and hazard index (HI) method. The magnitude of the HQ and HI is used to identify the magnitude of risk present to the ecological receptors. When the HQ and HI values are less than 1, then the PCOC is not an ECOC and is not further evaluated for ecological risk. This follows the agency-approved ERA methodology documented in the ECOCTM (DOE, 1995b). Further analysis of effects are documented to reduce the uncertainty in the approved ECOC screening methodology. The effects assessment and risk characterization are also supplemented by the biometric measurements in aquatic ecosystems that were obtained from the field (i.e., species occurrence and surface water/sediment bioassay results). However, due to the presence of other stressors within the OU 3 environment, these biometric measure results do not definitely identify PCOC effects. Therefore, these measurements were used only as qualitative information within the preliminary effects assessment and risk characterization.

A discussion of the uncertainty involved with all of the steps within the Preliminary Problem Formulation is also presented within the preliminary risk characterization.

B3.1 PRELIMINARY EXPOSURE ASSESSMENT

The nature and extent of the Rocky Flats-related contamination in OU 3 is presented in detail in Section 4.0 of the OU 3 RFI/RI report. The focus of the Preliminary Problem Formulation is to present the Rocky Flats-related PCOCs, exposure pathways, and the receptors of concern. Ultimately, the exposure-point activity and dose is determined and an evaluation of effects is conducted by comparison to literature-derived NOAELs, or benchmark values within Subsection B3.2.

These PCOCs become stressors to the function of the ecosystem, when they are present, at an activity or dose that can potentially cause deleterious effects to the exposed biotic components. The nature and characterization of these PCOCs in OU 3, the exposure pathways, and the receptors of concern are the focus of Subsection B3.1.1; determination of the exposure-point activity and dose is presented in Subsection B3 1.2. Subsection B3.2, the preliminary effects assessment, summarizes the comparison of the derived exposure dose to benchmark NOAEL values for the determination of effects. The results of the benchmark comparison is quantified using the HQ and HI method within the risk characterization in Subsection B3.3.

Attachments 3 and 4 of this appendix provide a more in-depth evaluation of exposure and effects for the terrestrial and aquatic assessments. Methods and results of the dose determination, biometric measurements, tissues measurement, and bioassays are described in more detail. The following sections provide summaries of the terrestrial and aquatic Preliminary Problem Formulation.

B3.1.1 PCOCs, Exposure Pathways, and Receptors of Concern

As mentioned previously, the PCOCs were identified as plutonium-239, -240 and americium-241 in surface soil and plutonium -239,-240 in Great Western Reservoir sediment. The chemical and physical characteristics of these PCOCs will affect their bioavailability and, consequently, the exposure pathways to ecological receptors. The following sections discuss the PCOC characteristics in the terrestrial and aquatic environments in which they were detected, the potential exposure pathways, and receptors of concern. This follows the agency-approved ERA Site Conceptual Model documented in the SCM TM (DOE, 1995a)

Terrestrial

Previous studies have identified the Rocky Flats PCOCs in the terrestrial ecosystem as plutonium-239, -240 and americium-241 (DOE, 1991 and 1992). The source of radiological contamination of soils on OU 3 was principally from the 903 Pad where 55-gallon barrels were stored that leaked plutonium-contaminated cutting oils onto the soil. Subsequent cleanup between 1967 and 1969 released contaminants into the air. The wind dispersed the plutonium-contaminated soil downwind, to the east, and across the buffer zone boundary into what is now OU 3. The deposition onto soils was assumed to be dry settling with perhaps some wet deposition during precipitation events.

The total inventory of Rocky Flats-related plutonium in soils was estimated at about 3 curies according to Krey and Hardy (1970), with about 0.6 curies on the OU 3 study area. According to a plutonium inventory study at Rocky Flats by Little (in Hansen [ed.], 1980), more than 99 percent of the plutonium was contained in the onsite soil, mostly in the top few centimeters. The vegetation contained a smaller fraction of the plutonium, about 0.2 percent, mostly as aerial deposition on leaves and litter. Animals, principally mammals and arthropods, retained a much smaller fraction, at about 0.000001 percent.

Results of the OU 3 PCOC screen indicate that plutonium-239, -240 and americium-241 are present within OU 3 surface soil at levels above those of background. The potential exposure pathways to terrestrial receptors include ingestion of soil, dermal absorption of PCOCs in soil, and inhalation of dust-borne contaminated particulates, as shown in Figure B3-1. These soil exposure pathways are of principal concern to receptors that are in close and prolonged contact to this medium. However, because the transuranic radionuclides are not mobile within foodchains, indirect exposure via bioaccumulation is unlikely. However, in the interest of completeness, the OU 3 effort evaluated PCOC uptake into plants and small mammals to determine whether or not the PCOCs are present within the food chain. These tissue activities were used to determine dose for the terrestrial risk assessment, because the plants and small mammals were identified as the receptors of concern.

Aquatic

As presented in Attachment 2 of this appendix, the PCOCs in OU 3 aquatic environments were restricted to americium and plutonium in reservoir sediments of IHSS 200 (Great Western Reservoir). Although not above background, americium-241, the decay product of plutonium-239, -240, was retained as a PCOC in sediment as a conservative measure. Both americium and plutonium were evaluated for each IHSS, and there were no surface water PCOCs identified.

Plutonium and americium are the only Rocky Flats-derived radioactive contaminants known to exist in the OU 3 reservoirs and drainages. It has been demonstrated that plutonium has been transported from Rocky Flats via the surface water and air pathways to the reservoir and drainage sediments. Americium has also been detected in these sediments, indicating either direct waterborne or airborne transport from Rocky Flats or from the natural decay of plutonium. Concentrations of radionuclides, other than plutonium and americium (principally uranium and tritium), have also been detected at low levels. Tritium and uranium are potential Rocky Flats-derived contaminants; however, they were not identified as PCOCs within OU 3.

IHSS 200 encompasses Great Western Reservoir, offsite reaches of Walnut Creek (which formerly flowed into the reservoir from Rocky Flats), and outflows from the reservoir. The EPA (1975) concluded that historic releases of radioactive contaminants from Rocky Flats to Great Western Reservoir resulted primarily from early operational practices at Rocky Flats (1950s and 1960s), reconstruction of the holding ponds between 1970 to 1973 (which resuspended pond sediments and released some of this material to Great Western Reservoir), a 1973 tritium release from Rocky Flats, and airborne transfer of radionuclides (primarily plutonium) that sorbed to soils of the 903 Pad.

Other low-level discharges into Walnut Creek occurred between 1952 and 1979 conforming to internal guidelines, and state and federal pollution discharge regulations. These effluents contained metals, radionuclides, and other inorganic ions. Although Walnut Creek previously flowed into Great Western Reservoir, the flow has been diverted around the reservoir since construction of the Broomfield Diversion Ditch in 1989. Therefore, surface water from Rocky Flats through OU 6 to Walnut Creek no longer flows into the reservoir.

IHSS 201 encompasses Standley Lake, offsite reaches of Woman Creek (which flows into the reservoir from Rocky Flats), and outflows from the reservoir. Radioactive materials released from Rocky Flats were transported to Standley Lake through surface water (primarily in suspended sediments) or airborne particulates (fugitive dust).

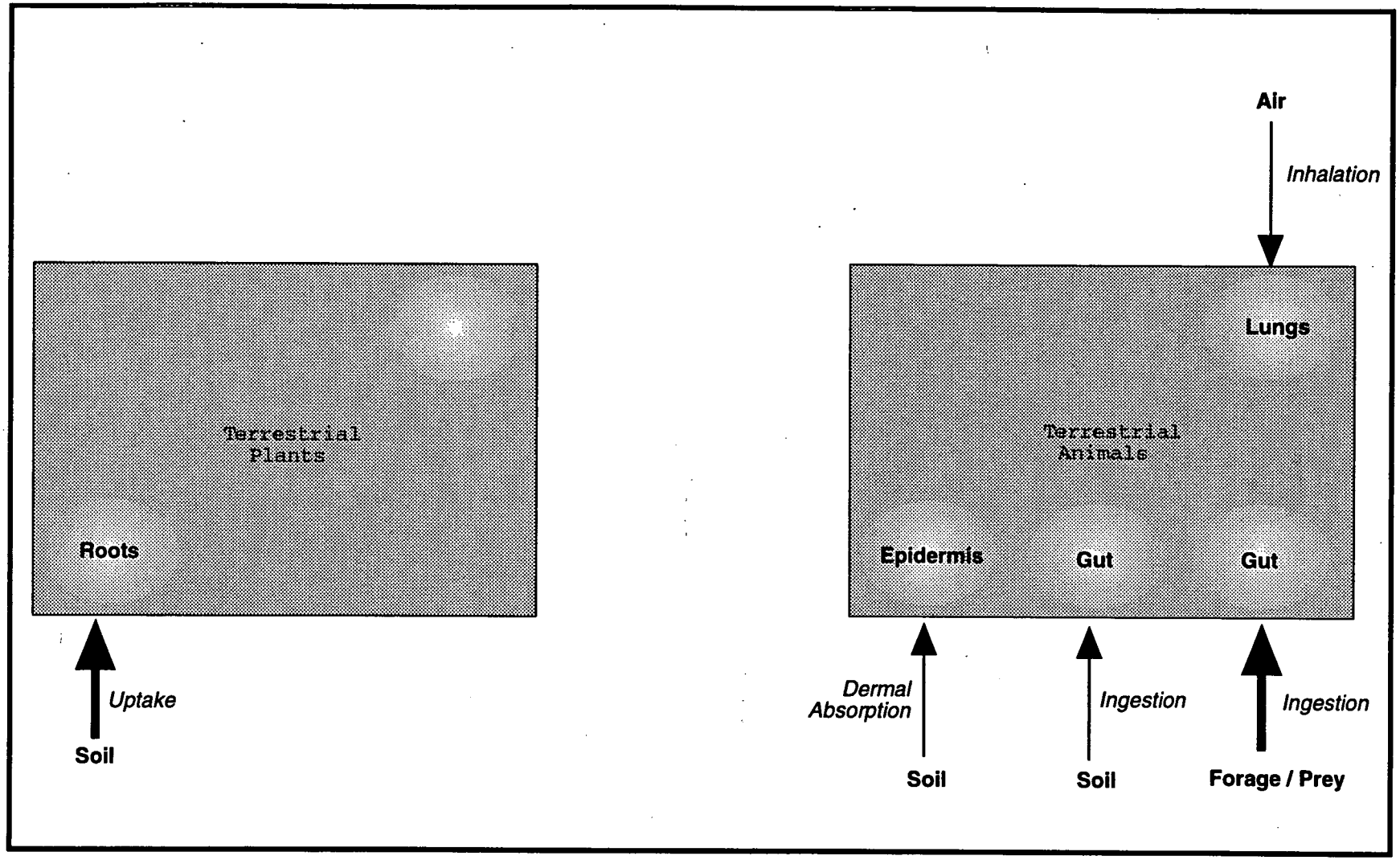

Figure B3-1
Terrestrial Exposure Pathways

IHSS 202 encompasses Mower Reservoir, offsite reaches of the irrigation ditch that feed the reservoir from Woman Creek, and outflow from the reservoir. Very limited historic data have been collected to characterize possible contamination of Mower Reservoir. Rocky Flats-derived contaminants in Mower Reservoir are believed to have been transported primarily as airborne particulates, and secondarily, by surface water through Woman Creek drainage.

Indirect sources include surface runoff, which may erode contaminated surface soil and transport it as sediments to drainages and reservoirs in OU 3. Plutonium transported in this manner tends to remain bound to the sediments during transport and after redeposition due to its high distribution coefficient (Kd), which is the ratio of activity in soil or sediment/activity in water. Values associated with plutonium equal approximately 4,500 [DOE, 1984]). As a result, bottom sediments will immobilize plutonium considerably. This strong adsorption has been demonstrated in laboratory studies of plutonium uptake by clay-rich sediments typical of surface-water impoundments found within OU 3 (CSU, 1974). The reported Kd distribution coefficients for plutonium in aquatic systems support this conclusion (Kd values of 30,000 for both plutonium-239, -240 and americium-241 have been reported by IAEA, 1982). Bioaccumulation (the activity of a chemical through a food chain) of plutonium and americium is negligible (Trabalka, et al., 1980).

In general, alpha radiation sources such as plutonium-239, -240 and americium-241 provide low external exposure because alpha particles cannot penetrate external tissues (Blaylock et al., 1993). Therefore, the resulting potential exposure pathway to aquatic receptors would be through internal exposure such as inhalation or ingestion.

Because there were no PCOCs identified for OU 3 surface waters, and because the sediment PCOCs were associated with bottom-lying sediment, the absorption of plutonium-239, -240 and americium-241 via inhalation to aquatic receptors was considered incomplete. Therefore, the remaining pathway of exposure is ingestion by bottom-dwelling organisms such as fish and benthic macroinvertebrates, or absorption across the chorion of fish eggs. Bioaccumulation of americium and plutonium through a freshwater food chain has not been demonstrated in the literature (Paine, 1974).

Figures B3-2 and B3-3 illustrate the exposure pathways that may exist for each reservoir IHSS. Many pathways are incomplete due to the chemical and physical characteristics of the PCOCs, and due to the receptor activity characteristics (pelagic versus bottom dwelling). The potential exposure pathways for the streams include direct and indirect pathways to sediment PCOCs similar to those presented for the reservoirs. The risk to aquatic receptors was evaluated independently for each reservoir IHSS because these areas are geographically isolated.

It appears that the most sensitive receptors to exposure would be bottom-dwelling organisms such as benthic macroinvertebrates and fish, that could be exposed directly to the sediment. Fish eggs may also be a receptor of concern if they settle in sediment. This life stage may also be the most sensitive to exposure effects. Therefore, the receptors of concern for the aquatic ERA were bottom-dwelling fish species, benthic macroinvertebrates, and fish eggs.

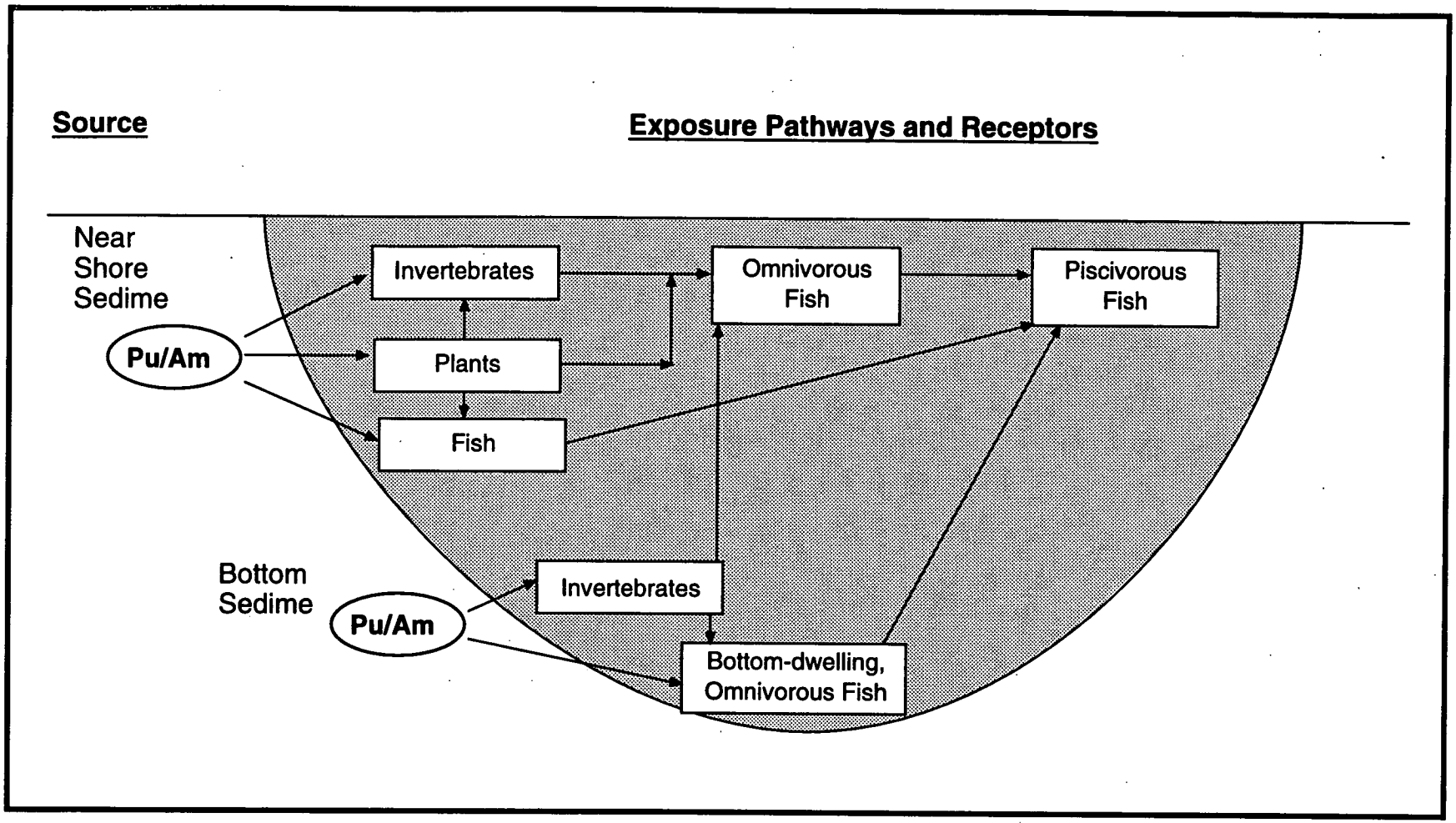

Figure B3-2
Aquatic Exposure Pathways for Great Western Reservoir

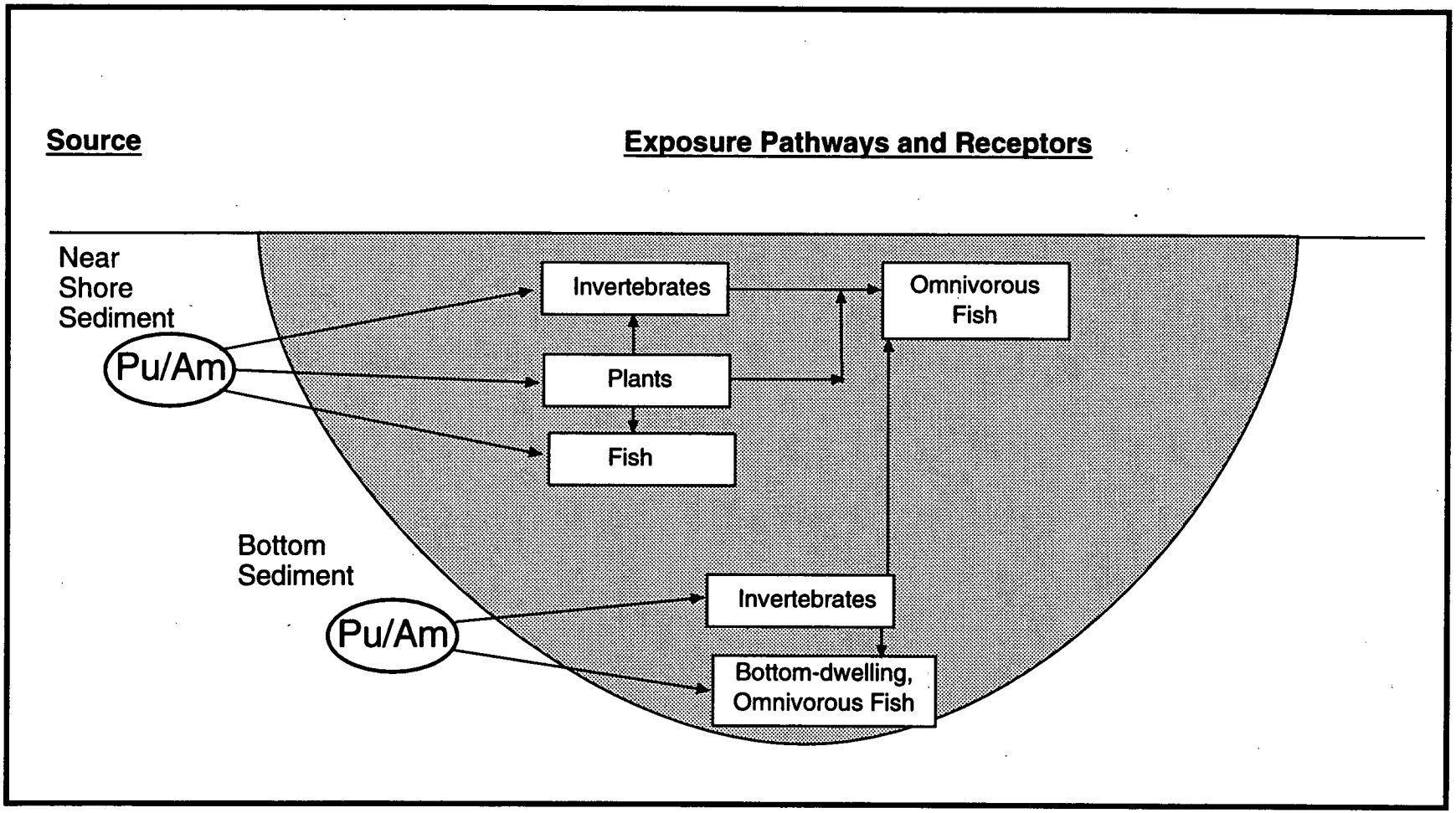

Figure B3-3
Aquatic Exposure Pathways for Standley Lake and Mower Reservoir

B3.1.2 Exposure-Point Activities and Dose

The highest measured PCOC activity was considered the exposure-point activity and was used to calculate dose. The following conservative assumptions were used for the exposure assessment:

- An area use factor of 100 percent
- Bioavailability was 100 percent
- The most sensitive life stage was exposed
- The minimum body weight, and maximum ingestion rate (where applicable) was used for dose determination

The terrestrial receptor exposure-point activity was derived from the surface-soil (0 to 3 centimeters [cm]) results. The 0 to 3 cm fraction was considered the most conservative fraction because most of the plutonium-239, -240 and americium-241 contamination is restricted to the upper layer of soil, and compiling data from additional depths would have 'diluted' summary statistics. Soils, vegetation, and small-mammal samples were collocated at 11 trench and 2 soil plot locations.

The aquatic organism exposure-point activity was the maximum plutonium-239, -240 and americium-241 activity observed from sediment collected within each IHSS. Because the aquatic receptors are not mobile between IHSSs, individual exposure assessments were conducted (this same concept applies for the exposure dose calculation).

Dose to terrestrial organisms was determined based on analytical results of the tissue measurements of PCOC content. Collocated samples of soil, vegetation, and small mammals were collected to determine uptake and transfer of the PCOCs. The resulting tissue burdens were then considered as representative site "dose" conditions.

Dose to aquatic organisms could not be determined using the method described for the terrestrial organisms (use of tissue measurements). Fish tissue was also collected in a collocated manner with surface water and sediment, however, due to the high uncertainty of the results, (detection limits varied, and the fish were stocked, which would affect their exposure duration), a modeling approach was used. The dose was quantified using a model described by Blaylock et al., (1993). This model was based upon the exposure-point activity of each PCOC and is described within Attachment 4 of this appendix. A dose for plutonium-239, -240, and americium-241 was calculated and summed to determine a total receptor dose for fish, benthic macroinvertebrates, and fish eggs.

Terrestrial

The maximum activities of plutonium and americium detected in surface soil (0 to 3 cm depth interval) were used for the terrestrial exposure and dose assessments. The maximum activities of plutonium and americium detected in surface soil (0 to 3 cm) were 1.593 and 0.272 pCi/g, respectively.

Most animal tissues sampled did not contain detectable activity levels of plutonium and americium. The maximum plutonium activity measured in animal tissue was 0.026 pCi/g (arithmetic mean = 0.002 pCi/g). The maximum ratio of plutonium activity in animal tissue to surface soil (0 to 3 cm depth interval) was 0.012 pCi/g.

The maximum americium activity detected in animal tissue was 0.160 pCi/g. This measured activity of americium is approximately 40 times greater than the mean americium activity (0.004 pCi/g) for animal

tissue, and is considered an anomalous result. Out of the 42 animal tissue samples collected, the next highest measured activity of americium was 0.007 pCi/g. The americium activity measured in the collocated soil sample (at location PT 16392) was 0.054 pCi/g. It is understood that americium does not bioconcentrate, further indicating that the 0.160 pCi/g result is an outlier. The reason for this anomalous americium activity is not known, but it is possible that the corresponding animal tissue sample could have been inadvertently contaminated after sample collection and/or sample preparation. The 0.160 pCi/g result is considered to be an anomaly and was therefore not used to calculate the maximum americium activity ratio between animal tissue and soil.

Based on the next highest measured americium activity in animal tissue (0.002 pCi/g) and corresponding collocated soil sample result (0.144 pCi/g), the maximum ratio of plutonium activity in animal tissue to surface soil was 0.014 pCi/g. At the time of this publication, no literature values for ratios of plutonium and americium activity in animal tissue to surface soil were available for comparison (Coughtrey, et al., 1985; Hansen, ed, 1980; DOE, 1995c).

The maximum plutonium activity measured in plant tissue was 0.190 pCi/g (arithmetic mean =.0.011 pCi/g). The maximum ratio of plutonium activity in plant tissue to surface soil (0 to 3 cm depth interval) was 0.466 pCi/g. The maximum detected americium activity in plant tissue was 0.016 pCi/g (arithmetic mean = 0.002 pCi/g). The maximum ratio of americium activity in plant tissue to surface soil was 0.131 pCi/g. The general literature values for ratios of plutonium and americium activity in plant tissue to soil are 0.02 and 0.07, respectively (Coughtrey, et al., 1985).

Dose to tissue of plants and animals was calculated using the maximum activity levels detected in tissue samples (see Attachment 3 for details on dose calculation). The maximum dose of americium to animal tissue was calculated to be 0.84 millirad per day (mrad/d). The maximum dose of plutonium to animal tissue was calculated to be 0.14 mrad/d. These most conservative dose levels are well below the 100 mrad/d dose considered to be protective of biotic receptors.

Using the maximum plutonium activity measured in plant tissue (0.190 pCi/g), the highest dose of plutonium to plant tissue was calculated to be 1.0 mrad/d. This is well below the dose considered protective of plant tissue (see Section B3.2.1). Previous studies have shown that 90 percent of plutonium measured on field plants is on external surfaces and contributes very little dose to internal plant tissues. Based on this information, the internal tissue dose is reduced to 0.10 mrad/d.

Aquatic

As identified in Figures B3-2 and B3-3, the potential aquatic receptors include bottom-dwelling organisms of benthic macroinvertebrates and fish. There is also the potential for eggs of cold-water fish species to become receptors because many species present within the reservoirs construct redds within sediment material. Therefore, the aquatic receptors of concern were identified as benthic macroinvertebrates, bottom-dwelling fish, and fish eggs.

Because alpha particles do not transport across external tissues (e.g., the carapace of the invertebrates or the integument of the fish), internal absorption was the primary exposure route for invertebrates and fish (Blaylock et al., 1993). External exposure, however unlikely, was evaluated for fish eggs as a conservative measure.

Direct exposure of fish to sediment is highly uncertain. Similarly, indirect exposure via ingestion of contaminated food items is also uncertain. However, in the instance that the PCOCs transfer through the

food chain, it was assumed that 100 percent of the detected PCOC activity was transferred through the food chain in the exposure dose calculations. Therefore, the maximum observed PCOC activity in sediment was used as the exposure-point activity for fish (exposed through the food chain), invertebrates, and fish eggs.

The exposure-point activities are presented within Table B3-1 for each IHSS. Because the IHSSs are not linked, independent exposure assessments were conducted. The exposure-point activities were compared directly to the literature-derived benchmark values, as presented in Subsection B3.2. In addition, a dose based upon uptake and transfer across tissues was determined based upon exposure-point activity. This dose was also compared to a literature-derived benchmark value for the determination of effects within the preliminary effects assessment, as presented in Subsection B3.2.

Dose was quantified using techniques described by Blaylock et al. (1993), and was based upon the presented exposure-point activities in Table B3-1. Dose was calculated for each receptor based upon receptors and PCOC characteristics. Attachment 4 presents an in-depth discussion of the dose calculations and results. Table B3-2 presents a summary of the quantified dose for aquatic receptors based upon the exposure-point activity presented in Table B3-1.

Table B3-1
Aquatic Receptor Reasonable Maximum Exposure-Point Activities (pCi/g)

IHSS		^{241}Am					$^{239/240}Pu$			
RME	Depth(in.)	Min.	Max.	Ave.	RME	Depth in.		Min.	Max.	Ave.
200-Great Western Reservoir	Reservoir									
	0-12	0.00	0.206	0.043	0.206	0-12	0.00	3.30	0.267	3.3
	> 12	-0.004	1.016	0.237	1.016*	> 12	-0.002	4.03	0.729	4.03*
	Stream	0.001	0.061	0.017	0.061	Stream	0.00	0.55	0.156	0.55
201-Standley Lake	Reservoir									
	0-12	0.00	0.107	0.017	0.107*	0-12	-0.015	0.553	0.033	0.553*
	Stream	0.001	0.082	0.022	0.082	Stream	-0.007	0.47	0.082	0.47
202-Mower Reservoir	Reservoir									
	0-12	0.008	0.093	0.049	0.093*	0-12	0.031	0.488	0.291	0.488*
	Stream	0.021	0.046	0.03	0.046	Stream	0.046	0.171	0.091	0.171

*Selected RME for exposure dose calculation

Table B3-2
Aquatic Exposure Point Activity and Receptor Dose (mGy/h)

	Exposure – Point Activity (pCi/g)		Receptor Dose: Benthic Macroinvertebrate[a]		Receptor Dose: Fish[a]		Receptor Dose: Fish Egg[b]	
IHSS	241Am	239/240Pu	241Am	239/240Pu[c]	241Am	239/240Pu[c]	241Am	239/240Pu[c]
200-Great Western Reservoir	1.016	4.03	0.0027	0.0101	0.0027	0.0101	0.0027	0.0101
201-Standley Lake	0.107	0.553	0.00028	0.00138	0.00028	0.00138	0.00028	0.00138
202-Mower Reservoir	0.093	0.488	0.00024	0.00123	0.00024	0.00123	0.00024	0.0012

[a]An internal exposure dose was calculated for the benthic macroinvertebrate and fish receptors.

[b]An external exposure dose was calculated for the fish eggs.

[c]Since data (sediment analytical results) are presented as total concentrations for both 239Pu and 240Pu (combined), a conservative assumption of 100 percent of the detected concentration was available as 239Pu, and 240Pu (refer to Appendix D for methods).

B3.2 PRELIMINARY EFFECTS ASSESSMENT

PCOCs, exposure pathways, and receptors of concern were discussed in Subsection B3.1.1 for the terrestrial and aquatic ecosystem. Subsection B3.1.2 summarized the exposure-point activity and dose for these exposure scenarios. This subsection describes the potential effects to receptors, as a result of exposure and response to the PCOCs, by comparison of exposure-point activity and dose to NOAEL benchmark.

If the exposure exceeded the dose level, the potential for an adverse effect may occur and require further evaluation. The risk characterization quantifies this comparison using the hazard quotient technique.

This method for preliminary effects determination is highly conservative. Attachments 3 and 4 of this appendix provide in-depth evaluations of exposure and effects using the exposure screening, as presented in Subsection B3.1, as well as other Rocky Flats-derived effects evaluation techniques, such as bioassay investigations and organism diversity. Because the benchmark screening is highly conservative, and the results of these biometric measurements are somewhat subjective, it was determined that the Rocky Flats-derived effects evaluation from the biometric measurements would be strictly supplemental to the study findings.

The following provides a discussion of the NOAEL benchmark activities and literature-derived dose. A summary of the results from the comparison of the exposure-point activity to the applicable NOAEL and dose is also provided in Subsection B3.2.2 .

B 3.2.1 Summary of NOAEL Values Used for the Effects Assessment

DOE guidance for the ERA PCOC selection techniques used at Rocky Flats was the basis for the OU 3 effort. This guidance supplies a tiered process for which PCOCs can be screened. A comparison of Rocky Flats exposure-point activities to literature-derived benchmark activities is a key component to this process. A draft document is available for radionuclide PCOC benchmark values that were used for the OU 3 ERA (DOE, 1995c). The benchmark values used are summarized in Table B3-3.

Benchmark values presented in Table B3-3 were back-calculated, based upon a dose limit of 100 mrad/d for any terrestrial or aquatic species. This dose limit is well supported in literature findings, which are discussed within the DOE (1995c) document. The benchmark values represent acceptable activities that correspond to the acceptable dose limit of 100 mrad/d. Benchmark values are presented for surface soil, surface water, and sediment.

In the 1995 DOE report, the dose limit was selected at 100 mrad/d, and the activities that would result in this dose were back-calculated using commonly accepted radiological techniques. The recommended benchmark value for soils at Rocky Flats for plutonium-239, -240 was 4000 pCi/g, and for americium-241 was 2000 pCi/g. These are activity values protective of wildlife species, and it is expected that plants and soil microorganisms will be less sensitive than wildlife. These benchmark values were used to determine a hazard attributable to the PCOC concentrations measured in soil, whereas the 100 mrad/d was the NOAEL benchmark for dose evaluation.

The 100 mrad/d dose limit is taken from the 1992 International Atomic Energy Agency document titled, "Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards" (IAEA, 1992). This report states "There is no convincing evidence from the scientific

Table B3-3
Benchmarks that would result in a 100 mrad/d (1-mGy/d) Dose

Nuclide	Benchmark		
	Soil (pCi/g)	Sediment (pCi/g)	Water (pCi/L)
Hydrogen-3	3×10^5	3×10^5	2×10^8
Strontium-89	2×10^2	7×10^3	7×10^5
Strontium-90	1×10^2	3×10^3	3×10^5
Cesium-137	8×10^1	5×10^3	8×10^3
Radium-226	5×10^0	4×10^5	4×10^2
Radium-228	3×10^0	3×10^5	3×10^2
Uranium-233/234	2×10^3	1×10^4	4×10^3
Uranium-235	2×10^3	1×10^4	4×10^3
Uranium-238	1×10^3	4×10^3	4×10^3
Plutonium-238	3×10^3	5×10^5	9×10^1
Plutonium-239	4×10^3	5×10^5	1×10^2
Americium-241	2×10^3	5×10^4	1×10^3

Source: DOE, 1995c.

literature that chronic radiation dose rates of 100 mrad/d^{-1} will harm animal or plant populations." Basically, IAEA (1992) is a compilation of numerous studies on the effects if ionizing radiation and concludes that 100 mrad/d^{-1} is an appropriate radiological NOAEL.

The NOAEL dose for aquatic life for the effects assessment was 0.4 mgy/h (1 rad/d), and was developed by the DOE-recommended dose rate limit. The dose rate limit was determined using modeling techniques described in Blaylock, et. al. 1993. This NOAEL value was most appropriate for equatic life. It has been determined that a dose rate no less than 0.4 mgy/h to the most sensitive organisms should ensure the protection of aquatic life. This dose rate is based upon a number of published reviews on the effects of radiation on aquatic organisms and is summarized in the National Council on Radiation Protection and Measurements Report No. 109 (NCRP, 1991). The NOAEL for sediment was 5×10^5 pCi/g for plutonium-239, and 5×10^4 for americium-241. These activities were compared directly to the observed exposure-activities for each IHSS.

B 3.2.2 Comparison of Exposure-Point Activities and Dose to the NOAEL Values

The maximum observed exposure-point activities for plutonium-239, -240 and americium-241 were compared to the benchmark values presented in Table B3-3, while the calculated dose was compared to a NOAEL of 100 mrad/d for the terrestrial assessment and 0.4 mgy/h for the aquatic assessment. Hazard Quotient (HQ): HQs are used to characterize risk from a single PCOC. The HQ was based upon exposures estimated from data aggregated from the abiotic media.

HQs were developed for plutonium-239, -240 and americium-241 in soil for the terrestrial assessment. HQ values were developed for plutonium-239, -240 and americium-241 in sediment for each of the reservoirs.

Hazard quotients less than 1.0 indicate exposures below the toxicological benchmark and indicates a *deminimus risk* (Suter, 1993) from a particular PCOC. Hazard quotients greater than 1.0 indicate exposure greater than benchmarks and warrant further investigation.

Hazard Index (HI): HIs are used to characterize cumulative risk from multiple PCOCs. The HI for a given source is calculated by summing the individual PCOC HQ values. HIs can be interpreted similarly to HQs with the understanding that the index relates to all PCOCs.

Hazard Indices:

A. HI total ≤ 1.0 - *de minimus* or negligible risk
B. 1.0 < HI total < 10 - minimal, possibly negligible risk
C. 10 < HI total < 100 - potentially significant risk; refinement of risk estimates needed
D. HI total > 100 - significant risk is probable; refinement of risk estimates needed, especially to identify cleanup goals

Terrestrial

The activities of contaminants in soils were evaluated for risk by calculating a ratio of the observed activities at OU 3 to the benchmark activities as a screening process. An HQ was determined using the following equation:

$$HQ = \frac{[PCOC]}{Benchmark},$$

where *HQ* is the hazard quotient, PCOC is the concentration of the PCOC, and *Benchmark* is the benchmark activity in pCi/g for soils, as shown in Table B3-3.

The highest measured plutonium activity in the soil trenches was 1.593 pCi/g, versus the plutonium benchmark value of 4000 pCi/g. This gives an HQ for plutonium of 0.0004 (1.593÷4000). Similarly, the HQ calculated for americium (using the highest measured americium activity of 0.272 pCi/g in soil) is 0.00014 (0.272÷2000). The addition of these two values gives a total HI of 0.00053 for the PCOCs at OU 3.

An HQ or HI of 1.0 would be cause for concern for contaminants in the environment. The HQs derived above are four and five orders of magnitude less than the amounts considered protective of animals in the terrestrial ecosystems.

Aquatic

Effects to aquatic organisms were determined by two techniques:

1. Comparison of maximum observed exposure-point activities to the literature-derived benchmark values as presented in Table B3-3 (activity comparisons by medium)

2. Comparison of the derived dose to the 0.4 mgy/h dose benchmark (dose comparisons)

Both comparison methods accomplish essentially the same goal. The reason for using both methods was to be conservative. The aquatic exposure-point activities were evaluated in a HQ with literature-derived benchmark values, and in a "forward-calculation" or modeling approach by calculating an internal dose for benthic macroinvertebrates, fish, and fish eggs. The techniques for the dose calculation are presented within Attachment 4. Table B3-2 summarizes the dose calculated for each aquatic receptor. This dose was compared to the 0.4 mgy/h benchmark. Results of the media comparisons are presented in Table B3-4 and indicate that all of the exposure-point activities fall below the benchmark values for sediment by at least two orders of magnitude.

HQs and HIs were calculated for each IHSS. The respective activity HQs for plutonium-239, -240 and americium-241 in sediment at Great Western Reservoir were 8.06×10^{-6} and 2.03×10^{-5}, 1.1×10^{-6} and 2.1×10^{-6} for Standley Lake, and 9.7×10^{-7} and 1.8×10^{-6} for Mower Reservoir. Results of the dose comparisons (Table B3-4) indicate that all of the derived dose levels are below the 0.4 mgy/h dose limit by at least one order of magnitude. The dose hazard quotient for plutonium-239, -240 and americium-241 in the sediment for Great Western Reservoir was 0.05 and 0.006, for Standley Lake was 0.003 and 0.0007, and for Mower Reservoir was 0.003 and 0.006.

Table B3-4
Hazard Quotients for Aquatic PCOCs

		Activity Comparison Hazard Quotient	Dose Comparison Hazard Quotient
IHSS 200-Great Western Reservoir			
Pu239	$4.03/5 \times 10^5$ pCi/g	$= 8.06 \times 10^{-6}$	0.0101/0.4 mGy/h $= 0.0252$
Pu240	$4.03/5 \times 10^5$ pCi/g	$= 8.06 \times 10^{-6}$	0.0101/0.4 mGy/h $= 0.0252$
Am241	$1.016/5 \times 10^4$ pCi/g	$= 2.03 \times 10^{-5}$	0.0027/0.4 mGy/h $= 0.00675$
		Hazard Index = 3.6×10^{-5}	Hazard Index = 5.72×10^{-2}
IHSS 201-Standley Lake			
Pu239	$0.553/5 \times 10^5$ pCi/g	$= 1.106 \times 10^{-6}$	0.00138/0.4 mGy/h $= 0.00345$
Pu240	$0.553/5 \times 10^5$ pCi/g	$= 1.106 \times 10^{-6}$	0.00138/0.4 mGy/h $= 0.00345$
Am241	$0.107/5 \times 10^4$ pCi/g	$= 2.140 \times 10^{-6}$	0.00028/0.4 mGy/h $= 0.0007$
		Hazard Index = 4.35×10^{-6}	Hazard Index = 7.6×10^{-3}
IHSS 202-Mower Reservoir			
Pu239	$0.488/5 \times 10^5$ pCi/g	$= 9.76 \times 10^{-7}$	0.0012/0.4 mGy/h $= 0.003$
Pu240	$0.488/5 \times 10^5$ pCi/g	$= 9.76 \times 10^{-7}$	0.0012/0.4 mGy/h $= 0.003$
Am241	$0.093/5 \times 10^4$ pCi/g	$= 1.86 \times 10^{-6}$	0.0024/0.4 mGy/h $= 0.0006$
		Hazard Index = 2.13×10^{-5}	Hazard Index = 6.6×10^{-3}

Hazard Index = The sum of the hazard quotients for each receptor.

B4.0 SUMMARY AND CONCLUSIONS

B4.1 TERRESTRIAL ECOSYSTEM

The ERA for terrestrial ecosystems in OU 3 was conducted by employing a preliminary exposure and effects assessment screening approach using information and data from previous sitewide studies and site-specific sampling at OU 3. The methods used to determine risks were a comparison to benchmark values in environmental media and a calculation of estimated dose to animal and plants based upon measured tissue concentrations. Field sampling was conducted at collocated locations to verify concentrations in abiotic and biotic samples, and for comparison to previous research studies at Rocky Flats and literature information. Detailed qualitative and quantitative observations and field sampling did not identify any adverse effects on biological populations or communities. A detailed analysis was not considered necessary after the screening process (DOE, 1995b).

Based on all comparisons and weight-of-evidence used during the preliminary exposure and effects assessment, it was determined that there is no excessive risk above background from the plutonium and americium PCOCs for soils in OU 3. The HI for plutonium and americium in the soil was 0.00053 (an HI equal to 1 is considered hazardous for plutonium-239, -240 and americium-241 in soil). The highest dose to tissue in one small mammal was 0.84 mrad/d, that was an outlier 40 times the average concentration measured. A dose of 100 mrad/d is considered protective of wildlife at Rocky Flats according to a radiological benchmark publication (DOE, 1995c). Based on low concentrations/activities in soil, and the lack of significant uptake and estimated effects on plants and animals, no COCs were identified for the terrestrial ecosystems in OU 3. All activities in soils and tissue doses were well below the level considered hazardous to terrestrial ecosystems.

B4.2 AQUATIC ECOSYSTEM

The PCOC background screen presented in Attachment 2 indicated the presence of plutonium-239, -240 and americium-241 at activities above background for sediment. These activities were evaluated independently for each IHSS because receptor migration is not feasible. Both exposure-point activities and exposure-dose comparisons to conservative NOAELs were conducted, as presented in Attachment 4. The activity HIs for plutonium-239, -240 and americium-241 in IHSS 200, IHSS 201, and IHSS 202 were 3.6×10^{-5}, 4.3×10^{-6} and 2.1×10^{-5}, respectively. Activity HQs for plutonium-239, -240 and americium-241 in sediment were 8.1×10^{-6} and 2.0×10^{-5} for Great Western Reservoir, 1.1×10^{-6} and 2.1×10^{-6} for Standley Lake, and 9.8×10^{-7} and 1.9×10^{-6} for Mower Reservoir, respectively. The derived dose HQs for plutonium-239, -240 and americium-241 for benthic macroinvertebrates and fish were 0.05 and 0.006 for Great Western Reservoir, 0.003 and 0.0007 for Standley Lake, and 0.003 and 0.0006 for Mower Reservoir. The dose HI for benthic macroinvertebrates and fish (inclusive of fish eggs) was 1.1×10^{-1} for Great Western Reservoir, 7.6×10^{-3} for Standley Lake, and 6.6×10^{-3} for Mower Reservoir.

Supplemental information on species occurrence and bioassay analysis support these findings. Therefore, the OU 3 aquatic communities are not being adversely impacted by the presence of the PCOCs.

Because no adverse ecological effects were identified, there was no need for further evaluation within a formal Problem Formulation, Analysis, or Risk Characterization phase. The OU 3 ERA was, thus, concluded upon completion of the Preliminary Problem Formulation.

Results of the HQ and HI evaluation for the aquatic assessment are provided in Table B3-4. All HQ and HI values are below a value of 1 indicating no risk.

The evaluations conducted were highly conservative for the following reasons and assumptions:

- It was assumed that the receptors were exposed consistently to the maximum observed activity
- The observed exposure-point activity was assumed to be 100 percent bioavailable
- Conservative assumptions were incorporated into the activity benchmark development (DOE, 1995b)
- Conservative assumptions (e.g., a [bioconcentration factor] BCF of 30) were used for the dose calculation
- The exposure-point activities were the maximum observed activities, and these levels were observed "at depth" within the sediment; Therefore these exposure-point activities are generally unavailable to potential receptors
- The exposure-point activities in the sediment were detected at locations well within the lake at water depths greater than 10 feet, reducing exposure to potential receptors

Biometric measurements were also collected for the OU 3 characterization effort. Samples of periphyton and benthic macroinvertebrates were collected for biodiversity measurements. Bioassay analysis of surface water and sediment was also conducted. The bioassays were conducted at the mouth of Woman Creek, Walnut Creek below Great Western reservoir, Church Ditch, and Big Dry Creek. The results of the biometric measurements are provided in Attachment 4. However, due to the presence of other confounding stressors that can influence the results of these measurements, they were not quantitatively relied upon for the evaluation of effects and risk from the PCOCs at Rocky Flats.

The periphyton samples indicate the presence of typical lentic community organisms. Similarly, the benthic macroinvertebrate samples show the presence of "normal" lentic and lotic populations for the Rocky Mountain Region. An in-depth evaluation of these sample results is provided in Attachment 4.

The bioassay results indicate no adverse effect to fish communities exposed to surface water. Due to control mortalities, Ceriodaphnia exposures to surface water were inconclusive. The results of sediment bioassay analyses were also of questionable quality due to test conditions.

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ATTACHMENT 1

DATA QUALITY ASSESSMENT

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1.0 INTRODUCTION

This section presents a description of the data quality assessment (DQA) conducted for the OU 3 ERA. A complete description of the OU 3 field investigation (media sampled, sampling objectives, and analytical parameters) is provided in Section 2.0 of the RFI/RI report. In addition, figures in Section 2.0 of the RFI/RI report show sampling locations for all abiotic and biotic media. Descriptions of the data sets used for data evaluations in the RFI/RI, human health risk assessment (HHRA), and the ERA are included in Appendix F of the RFI/RI report. Appendix F also describes the format of the OU 3 database, steps followed to prepare the data for quantitative analyses, and protocols followed in all data analysis tasks for the RFI/RI, including the HHRA and ERA. An electronic version of the OU 3 database is provided in Appendix E and summary statistics for all abiotic media are provided in Appendix D of the RFI/RI report. Results of the biotic media sampling are also discussed in detail in this appendix.

2.0 DATA QUALITY ASSESSMENT

The DQA seeks to determine if data are sufficient to support a specific intended use. Various data types were collected to meet the needs of the OU 3 ERA. The data collected for the ERA fall into two broad categories:

1. Abiotic media: includes chemical content analysis of soils, sediment, and surface water and toxicity bioassay analysis of surface water and sediment.

2. Biotic media: includes chemical content analysis of vegetation, small mammal, and fish tissue; as well as special enumeration and classification (biometrics) of vegetation, small mammals, benthic macroinvertebrates, and periphyton.

In general, the analytical data for abiotic media were used to select PCOCs and estimate levels of PCOCs in OU 3. These estimated activity/concentration values support decisions (many of which are based on risk) to determine the need for remedial action. A comprehensive analysis of the data precision, accuracy, representativeness, comparability, and completeness (PARCC parameters) is provided in Appendix G of the RFI/RI report. These parameters specify the level of applicable quality assurance/quality control (QA/QC) for each data type.

The analytical data for the chemical analysis results of biotic media were used to estimate contaminant uptake and transfer between media. This information was used to support conclusions on exposure. Similarly, the biometric evaluation data for the biotic media were used to support the exposure characterization.

The OU 3 Work Plan describes the data collection activities for the ERA (DOE, 1992). Due to field conditions, certain data collection could not be conducted as described in TM1 of the final OU 3 Work Plan which identifies these refinements. Data quality objectives (DQOs) were established in the OU 3 Work Plan to set forth the set of specifications needed to design the environmental data collection. The DQOs established for the abiotic media collection apply to the ERA. Because conditions at Rocky Flats could influence data for the ERA, specific DQOs were not established for the biotic media collection at the time of the Work Plan publication (details in Section 10 of the final RFI/RI Work Plan). For instance, it was determined that explicit measures of fish weight and length (growth) could not be used as an indicator of contaminant exposure effects because fish communities are enhanced by stocking practices,

diminished by fishing pressure, and influenced by many other site variables. Therefore, the biotic collection could not be strictly identified until field conditions were evaluated.

In retrospect, upon completion of the field effort, it was determined that all biometric measures gathered (vegetation percent cover, vegetation and small mammal species composition, as well as periphyton, benthic macroinvertebrate and fish species composition) could only be used to characterize the ecosystem by identifying the species present. This information could not be used to quantify cause and effect relationships between contaminant occurrence and species occurrence. The information, where appropriate, may qualitatively support ERA conclusions. In other words, the data would be used after critical decision points.

The purpose of the OU 3 ERA was to determine the risk to ecological receptors that is attributable to site-related stressors. Therefore, data collection was designed to determine conditions of PCOC occurrence in abiotic and biotic media, receptor occurrence, and potential effects to the receptors at Rocky Flats. The field activities include the collection of soil, surface water, sediment, small mammals, vegetation, and fish for chemical analysis; and the collection of benthic macroinvertebrate and periphyton population samples, in addition to measurements of vegetation cover and plant species occurrence. Laboratory bioassay tests were implemented to determine site water and sediment, and the results of these activities were used to determine the nature and extent of contamination and the transfer of PCOCs between abiotic and biotic media. These data were also used to estimate exposure to receptors. The exposure evaluation is a part of the ERA PCOC determination, and is presented in detail in Attachment 2.

Quantitative evaluation of the biometrics measurements was not used as a tool for the OU 3 ERA. In ideal situations, biometrics, such as species density and diversity, can be used to assess cause and effect relationships between contaminant occurrence and ecological receptor occurrence. However, due to the presence of other confounding factors in OU 3 that affect the outcome of these measures, an in-depth quantitative evaluation was not conducted. Table 1 presents a summary of the data collection and the uses of the resulting data.

2.1 DATA USABILITY CLASSIFICATION

Using the validation codes assigned to each data record by the independent data validators, the data usability was assessed. Any data records that contain an "R" (i.e., rejected by the independent validators) in the validation code field were considered unusable in the PCOC selection process according to data usability guidance for Environmental Restoration at Rocky Flats (EG&G, 1994 and EPA, 1990). All other data were considered acceptable for use in the PCOC selection process. Ninety-five percent of the validated data for surface soil, sediment, surface water, and groundwater (a total of 14,690 data records) were classified as usable. Table 2 summarizes the results of the data validation process by environmental medium and analytical test group.

Any nonvalidated data in the OU 3 database were assumed to be usable and, therefore, were included in the data set for the PCOC selection process, as shown in Table 2.

2.2 ASSESSMENT OF WATER-QUALITY AND PHYSICAL PARAMETERS

The analyses for sediment and surface water samples included analytes classified as water-quality parameters. The water-quality parameters include major anions found in natural waters, and general physical properties such as total suspended solids for surface water and groundwater, and TOC for

Table 1
Summary of OU 3 Field Investigations

Data Quality Objective	Intended Use of the Data for the EE (as defined in the Work Plan)-DOE, 1992	Refinements to the Work Plan	Completed Work	Redefined Use of Data Due to Refinements
Characterize Nature and Extent of Soil Contamination				
1. Characterize vertical and lateral extent of soil contamination	• To determine PCOC occurrence and exposure to terrestrial organisms.	The Rocky Flats method and the CDH method were used to collect surface soil samples as described in TM No. 1. The RFP method was added to be able to compare OU 3 data to historical data. Both the CDH and RFP methods have been used in the past. TOC, specific gravity, and grain size analyses were not performed on the surface soils. These analyses were performed on the soil trenches. One additional soil plot was sampled over the number specified in the OU 3 Work Plan because of access agreement problems. The additional location was needed to get sufficient areal distribution.	Sixty-one surface soil plots were sampled between June 1992 and June 1993.	• To determine PCOC occurrence and exposure to terrestrial organisms.
Characterize Nature and Extent of Surface Water and Sediment Contamination				
2. Characterize potential plutonium, americium, uranium, TCL volatiles (Mower Reservoir only), and TAL metals in surface water in reservoirs and drainages/ditches.	• To determine PCOC occurrence and exposure to aquatic organisms. • To determine seasonal variations of PCOC occurrence within surface water. • To assess statistical difference of PCOC occurrences between IHSSs and between seasons.	As described in TM No. 1, fewer surface water samples from the drainages/ditches were collected due to intermittent flow conditions. Reservoir surface water sampling occurred in July, September, and October, rather than during high and low reservoir capacity, therefore, seasonal variation was not observed.	A total of 53 surface water samples were collected from 33 locations. Surface water samples were collected from Standley Lake, Great Western Reservoir, and Mower Reservoir in July, September, and October 1992. Samples collected in July and October were co-located with sediment and biota sampling. Surface water samples collected in September were co-located with sediment core samples. Additional reservoir surface water samples were collected and co-located with biota samples. Six drainage/creeks locations were sampled during the surface water investigation: Walnut Creek, Dry Creek Valley ditch, Woman Creek, Broomfield Ditch, Big Dry Creek, and Coal Creek.	• To determine PCOC occurrence and exposure to aquatic organisms.

Table 1
Summary of OU 3 Field Investigations (Continued)

Data Quality Objective	Intended Use of the Data for the EE (as defined in the Work Plan)-DOE, 1992	Refinements to the Work Plan	Completed Work	Redefined Use of Data Due to Refinements
3. Characterize the potential horizontal extent or surficial plutonium, americium, uranium, TCL volatiles, and TAL metals contamination in drainages/ditches and reservoir sediments.	• To determine PCOC occurrence and exposure to aquatic organisms. • To determine seasonal variations of PCOC occurrence within sediment. • To assess statistical difference of PCOC occurrence between IHSSs and between seasons.	Eight sediment samples were collected along drainages associated with the Walnut Creek drainage area. Ten were proposed in the Work Plan. Along Woman Creek, 11 locations were sampled. At Mower, five locations were sampled along Mower Ditch, and four nearshore locations were sampled. Sediment sample locations were different than specified in the Work Plan because field conditions varied. Drainage samples were collected at Coal Creek, Smart Ditch, Walnut Creek, Church Ditch, Big Dry Creek, Woman Creek, and Broomfield Diversion Ditch.	A total of 24 drainage/ditch sediment locations were sampled during the OU 3 field investigation. In addition, 46 reservoir locations were sampled. Several sediment locations were sampled twice, once in July and once in October. Samples collected in July and October were co-located with surface water and biota samples.	• To determine PCOC occurrence and exposure to aquatic organisms.
Characterize Ecological Setting: Terrestrial Biota				
4. Characterize vegetation types.	• To identify occurring species.	None	Nine sites (four to eight transects each) of belt transects and point intercept; 13 sites (five plots each) of relieve and production plots plus three additional production plots.	• To identify occurring species.
5. Characterize animal species and populations.	• To identify occurring species.	None	13 small mammal grid trappings; 10 quantitative and 8 qualitative bird surveys; 12 qualitative herpetologic surveys.	• To identify occurring species.
6. Characterize wetlands/riparian zones.	• To identify occurring species.	None	Five qualitative surveys were conducted.	• To identify occurring species.

Table 1
Summary of OU 3 Field Investigations (Continued)

Data Quality Objective	Intended Use of the Data for the EE (as defined in the Work Plan)-DOE, 1992	Refinements to the Work Plan	Completed Work	Redefined Use of Data Due to Refinements
7. Assess bioaccumulation in vegetation.	• To determine PCOC occurrence in biotic media.	Added three vegetation sampling locations to increase sample numbers for analysis based on review of early data from OU 1 and OU 2 as stated in TM No. 1.	65 samples were collected at 13 sites.	• To determine PCOC occurrence in biotic media.
8. Assess bioaccumulation and concentration in wetland vegetation.	• To determine PCOC occurrence in biotic media.	As stated in TM No. 1, wetland vegetation was not sampled due to disturbance, heterogeneity, water management, and irrigation currently impacting wetlands.	None.	NA
9. Assess bioaccumulation in small mammals.	• To determine PCOC occurrence in biotic media.	Added three additional small mammal trapping grids to increase sample numbers for analysis based on review of early data from OU 1 and OU 2 as stated in TM No. 1.	41 samples were collected at 13 sites.	• To determine PCOC occurrence in biotic media.
Characterize Ecological Setting: Aquatic Biota				
10. Characterize benthic macroinvertebrate communities in creeks and reservoirs.	• To identify occurring species.	Two additional OU 3 creek locations were intended to be sampled. Flow regimes prohibited sampling at these locations.	Benthic macroinvertebrate sampling was conducted in Woman Creek, Walnut Creek, Big Dry Creek, Great Western Reservoir, Mower Reservoir, and Standley Lake. Samples were collected at one station per creek and three to four locations per reservoir.	• To identify occurring species.
11. Measure ecological endpoints in benthic macroinvertebrate communities and assess bioaccumulation.	• To identify species occurrence.	Bioaccumulation in tissue was not performed. Adequate tissue mass could not be obtained to meet analytical requirements.	Benthic macroinvertebrate sampling was conducted in Woman Creek, Walnut Creek, Big Dry Creek, Great Western Reservoir, Mower Reservoir, and Standley Lake, using Ponar grab sampling techniques.	NA
12. Characterize periphyton in creeks.	• To identify species occurrence.	Work not performed because flow regimes prohibited periphyton sampling in creeks.		• To identify species occurrence.

Table 1
Summary of OU 3 Field Investigations (Continued)

Data Quality Objective	Intended Use of the Data for the EE (as defined in the Work Plan)-DOE, 1992	Refinements to the Work Plan	Completed Work	Redefined Use of Data Due to Refinements
13. Characterize periphyton communities and determine colonization rates in reservoirs.	• To determine PCOC effects to the periphyton community.	Reference reservoirs were not established. Therefore, potential effects attributable to PCOC occurrence could not be identified.	Quantitative periphyton sampling was conducted in Fall 1992 at Great Western Reservoir, Mower Reservoir, and Standley Lake using floating artificial substrate samplers.	NA
14. Characterize fish communities in creeks and reservoirs.	• To identify species occurrence.	Fish were not collected from streams during sampling efforts in Fall 1992 because of low flows.	Fish sampling was conducted in Woman Creek, Walnut Creek, and Big Dry Creek in the Spring of 1992 using electroshocking techniques, and fish were collected from Great Western Reservoir, Mower Reservoir, and Standley Lake using gill nets and boat electroshocking techniques.	• To identify species occurrence.
15. Measure ecological endpoints in fish communities and assess bioaccumulation and toxicity of contaminants.	• To determine PCOC effects to the fish community. • To determine PCOC occurrence in biotic tissue.	Fish were not collected from streams during sampling efforts in Fall 1992 because of low flows. Interim evaluation of community structures indicated that fish community structure was determined by other influences such as stocking practices, fishing pressure, etc.	Fish sampling was conducted in Woman Creek, Walnut Creek, and Big Dry Creek in the Spring of 1992 using electroshocking techniques and fish were collected from Great Western Reservoir, Mower Reservoir, and Standley Lake using gill nets and boat electroshocking techniques. Samples of tissue collected from fish from reservoir and lakes were analyzed for radionuclides and metals.	• To determine PCOC occurrence in biotic tissue.

Table 2
Data Validation Summary

Medium Analytical Test Group	Total Number of Records in Database	Number of Validated Records in Database	Number of R-Validated Records in Databasea
Surface Soil			
Radionuclides	658	568 (86%)	31 (5%)
Total	658	568 (86%)	31 (5%)
Sedimentb			
Metals	6,405	6,208	302
Radionuclides	1,937	1,855	121
Volatile Organic Compounds	616	578	227
Physical Parameters	241	162	18
Total	9,199	8,803 (96%)	668 (8%)
Surface Water			
Dissolved Metals	1,362	1,177	11
Dissolved Radionuclides	323	323	45
Total Metals	1,522	1,488	12
Total Radionuclides	395	394	55
Pesticides	126	104	0
Volatile Organic Compounds	340	340	10
Water Quality	708	652	3
Total	4,776	4,478 (94%)	136 (3%)
Groundwater			
Dissolved Metals	464	348	6
Dissolved Radionuclides	41	35	0
Total Metals	464	348	3
Total Radionuclides	42	30	0
Water Quality	128	80	0
Total	1,139	841 (74%)	9 (1%)
Total-All parameters and all media	15,772	14,690 (93%)	844 (5%)

aR-Validated = Rejected by data validation process.
bSediment numbers include grab (surface) and core (subsurface) data.
Source: OU 3 Database (DB081094.8b)

Table 3
Water-Quality Parameters Not Included in the PCOC Selection Process

Sample Type[a]	Chemical Name
Sediments	Percent Solids
Sediments	Alkalinity as $CaCO_3$
Sediments	Bicarbonate as $CaCO_3$
Sediments	Carbonate as $CaCO_3$
Sediments	Nitrate/Nitrite
Sediments	Nitrite
Sediments	pH
Sediments	Total Alkalinity
Sediments	Total Organic Carbon
Surface Water	Ammonia
Surface Water	Bicarbonate as $CaCO_3$
Surface Water	Carbonate as $CaCO_3$
Surface Water	Chloride
Surface Water	Fluoride
Surface Water	Nitrate/Nitrite
Surface Water	Nitrite
Surface Water	Oil and Grease
Surface Water	Orthophosphate
Surface Water	Phosphorus
Surface Water	Sulfate
Surface Water	Sulfide
Surface Water	Total Dissolved Solids
Surface Water	Total Suspended Solids

[a]Includes IHSSs 200, 201, and 202
PCOC = Potential chemical of concern

sediment, as provided in Table 3. In general, these parameters were not considered PCOCs. Results of these analyses are used to provide information for the evaluation of the nature and extent of contamination and for the PCOC screening process, where appropriate.

ATTACHMENT 2

PCOC EVALUATION

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1.0 INTRODUCTION

The objective of the PCOC selection process is to identify those chemicals in a particular medium that are elevated above background and benchmark levels. The data will be used in the OU 3 ERA to quantify risks associated with exposure of receptors to PCOC in surface soils, stream and reservoir sediments, and surface water.

The ERA PCOC selection process includes the following steps:

1. Statistical comparison of Rocky Flats data to OU 3 data

2. Weight-of-evidence evaluations for media that statistical comparison tests are not appropriate

3. Comparison to literature benchmark values (presented in more detail in Attachments 3 and 4 of this report)

The same methodology for PCOC selection used in the CDPHE Conservative Screen Letter Report (DOE, 1994a) was used to select PCOCs for the ERA. However, for the ERA, subsurface sediments and groundwater were not considered exposure pathways for ecological receptors, and were not evaluated further.

This Attachment presents the methods and results of the first two steps of the PCOC selection process. The final step involves an in-depth evaluation of exposure fate and transport and toxicity to ecological receptors. Separate evaluations are presented in Attachment 3 (terrestrial) and Attachment 4 (aquatic) for the final step in the PCOC selection process.

2.0 DATA SETS USED IN THE PCOC SELECTION PROCESS

PCOCs are defined as inorganic analytes with concentrations or activities detected in OU 3 that are significantly elevated over background levels, and organic analytes detected in OU 3 at concentrations greater than the detection limits reported in the RFEDS data.

Data from the OU 3 RFI/RI field investigation program were prepared for quantitative data analysis tasks, (including the CDPHE Conservative Screen and ERA PCOC selection process), following standard data-treatment protocols. A detailed description of the preparation process is included in Appendix F of the RFI/RI report. In addition, surface-soil data from the Remedy Lands (DOE, 1991c) and sediment data from the 1983/1984 Sediment Investigations in Great Western Reservoir (IHSS 200) and Standley Lake (IHSS 201) (DOE, 1991a) were used in the CDPHE Conservative Screen and ERA PCOC selection process.

The OU 3 data sets used in the CDPHE Conservative Screen and PCOC selection process are summarized in Table 1 by IHSS and medium. Soil is the only OU 3 medium that has a background data set suitable for rigorous statistical comparisons. A weight-of-evidence evaluation was used to evaluate data sets for which no background data were available. This weight-of-evidence evaluation involves the application of a variety of data analysis techniques, in lieu of rigorous statistical tests. The results of the evaluations are considered together to assess if levels of chemicals in OU 3 represent background conditions or contamination. A detailed description of the weight-of-evidence approach is provided in Appendix A, Subsection 4.1.6, of the RFI/RI report.

Table 1
OU 3 Data Sets Used in the CDPHE Conservative Screen
Rocky Flats Environmental Technology Site

IHSS	Medium	Description
199	Surface Soil	61 RFI/RI plots, average of CDPHE (O - 0.25") and RFP (0 – 2") sample collection methods; 47 Jefferson County Remedy Acres locations
	Subsurface Soil	11 trenches were sampled at 10 depth intervals down to 96 cm
200	Surface Water	13 sample locations in reservoir and streams/ditches
	Surface Sediment	41 RFI/RI sample locations in reservoir and streams/ditches sampled from 0 to 6"; 51 1983/84 sample locations
	Subsurface Sediments	8 sample locations in reservoir samples at 1" and 2" depth intervals down to approximately 36"
	Groundwater	1 sample location
201	Surface Water	12 sample locations in reservoir and streams/ditches
	Surface Sediment	48 sample locations in reservoir and streams/ditches sampled from 0 to 6"; 1983/84 sample locations
	Subsurface Sediments	8 sample locations in reservoir sampled at 1" and 2" depth intervals down to approximately 36"
	Groundwater	1 sample location
202	Surface Water	8 sample locations in reservoir and streams/ditches
	Surface Sediment	14 sample locations in reservoir and streams/ditches sampled from 0 to 6"
	Subsurface Sediments	4 sample locations in reservoir sampled at 1" and 2" depth intervals down to approximately 36"

Table 2 summarizes the PCOCs identified as a result of Steps 1 and 2 of the ERA PCOC selection process. The following describes the results in more detail.

2.1 SURFACE-SOIL RESULTS

The results of the background statistical comparison indicate americium-241 and plutonium-239, -240 are PCOCs for surface soil in OU 3. These two radionuclides were identified as PCOCs by more than one statistical test (i.e., Hot-Measurement test, Slippage test, Quantile test, and Gehan test for americium-241 and plutonium-239,- 240, and t-test for plutonium-239,- 240), and the distribution pattern of americium-241 and plutonium-239,-240 activities in surface soil suggest that the reported levels are

Table 2

OU 3 PCOCs
Rocky Flats Environmental Technology Site

Media	IHSS	PCOCs
Surface Soil and Subsurface Soil	199	241Am 239/240Pu
Surface Sediment (Grab Samples)	200 (Great Western Reservoir) 201 (Standley Lake) 202 (Mower Reservoir)	239/240Pu None None
Subsurface Sediments (Core Samples)	200 (Great Western Reservoir)	239/240Pu
Copper		
	201 (Standley Lake) 202 (Mower Reservoir)	None None
Surface Water	200 (Great Western Reservoir) 201 (Standley Lake) 202 (Mower Reservoir)	None None None
Groundwater	200 (Great Western Reservoir) 201 (Standley Lake)	Strontium None

Note:

Potential chemicals of concern (PCOCs) are inorganic chemicals with detected concentrations above background levels or organic chemicals detected above reported detection limits.

not attributable to background conditions, but represent wind-blown deposition from contaminated soils onsite.

2.2 SUBSURFACE-SOIL RESULTS (TRENCH DATA)

The statistical results indicate that activities of americium-241 and plutonium-239, -240 in OU 3 subsurface soil are significantly different than background by more than one statistical test.

2.3 RESERVOIR-SEDIMENT RESULTS

Because background data were not available for rigorous statistical evaluation of reservoir sediment data, weight-of-evidence evaluations were performed for radionuclides, metals, and organic (IHSS 200 only) compounds in reservoir sediments. The weight-of-evidence approach, as applied to reservoir sediments, is described in detail in the CDPHE Conservative Screen Letter Report (DOE, 1994a). The results indicated that only plutonium-239, -240 in Great Western Reservoir (IHSS 200) was retained as a PCOC for surface sediments. The mean and maximum values for plutonium-239, -240 in IHSS 200 reservoir-sediment samples exceeded corresponding mean and maximum benchmark values.

No surface-sediment constituents detected in IHSSs 201 or 202 were retained as a result of the weight-of-evidence evaluation. plutonium-239, -240 was not retained in IHSSs 201 and 202 for the following reasons:

- For IHSS 201, the mean value of plutonium-239, -240 in OU 3 reservoir-sediment samples was less than the benchmark values, and the mean and maximum values for OU 3 stream-sediment samples were less than corresponding mean and maximum BGCR (background) stream-sediment values.

- For IHSS 202, the mean and maximum values for plutonium-239, -240 in OU 3 stream-sediment samples were less than the corresponding mean and maximum BGCR stream-sediment values.

2.4 SUBSURFACE-SEDIMENT RESULTS

The results of the weight-of-evidence evaluations indicate plutonium-239, -240 and copper are PCOCs for subsurface sediments cored in Great Western Reservoir (IHSS 200), based on the following:

- The mean and maximum copper concentrations exceed the BGCR mean and maximum values; the maximum copper concentration exceeds the maximum benchmark value.

- The mean and maximum values for plutonium-239, -240 in subsurface-sediment core samples exceed corresponding mean and maximum benchmark values and BGCR stream-sediment values.

The results of the weight-of-evidence evaluations for americium-241 and plutonium-239, -240 for IHSS 201 and IHSS 202, based on the background comparisons, indicate that they are not PCOCs.

The results of the background and benchmark comparisons for the metals for IHSS 201 and IHSS 202 indicate that all metals were eliminated except arsenic, cadmium, copper, lead, nickel, potassium, and zinc for Standley Lake (IHSS 201), and potassium for Mower Reservoir (IHSS 202). The analytes in IHSS 201 were further evaluated by spatial analyses and were eliminated as PCOCs. Potassium was not retained as a PCOC for Mower Reservoir because it is an essential nutrient.

2.5 SURFACE-WATER RESULTS

No volatile organic compounds (VOCs) were detected in surface-water samples from IHSS 202 and, therefore, there were no organic PCOCs identified. Based on the weight-of-evidence evaluations, no inorganic PCOCs were identified for surface water in IHSSs 200, 201, or 202. In general, OU 3 chemical mean and maximum values are less than corresponding background and benchmark values.

2.6 GROUNDWATER RESULTS

The results of the weight-of-evidence evaluations indicate strontium is a PCOC for groundwater (IHSS 200 only) for the following reasons:

- The mean and maximum values for strontium in OU 3 groundwater exceed corresponding mean and maximum values for BGCR groundwater samples

- The maximum value for strontium in OU 3 groundwater exceeds the maximum benchmark value

3.0 SUMMARY STATISTICS FOR OU 3 DATA AND BENCHMARK DATA

Appendix D presents statistical summaries of OU 3 data and benchmark data for sediment, surface water, and groundwater. The summary statistics for each analyte by IHSS and type include the number of detects, number of samples, frequency of detection, minimum and maximum nondetected values, minimum and maximum detected values, arithmetic mean, standard deviation, and coefficient of variation.

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
ALUMINUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			4530.00	20800.00	10910.833	4212.31	0.39
ALUMINUM	mg/kg	IHSS 201	LAKE	S	43	43	1.00			852.00	23500.00	9834.814	6623.01	0.67
ALUMINUM	mg/kg	IHSS 202	LAKE	S	15	15	1.00			7480.00	18300.00	14370.000	3096.10	0.22
ANTIMONY	mg/kg	BGCR	CREEK	B						0.80	12.40	3.290	2.73	
ANTIMONY	mg/kg	IHSS 200	CREEK	S	5	8	0.63	1.80	2.40	6.50	11.30	6.469	3.84	0.59
ANTIMONY	mg/kg	IHSS 201	CREEK	S	1	13	0.08	2.30	6.70	6.40	6.40	3.708	1.60	0.43
ANTIMONY	mg/kg	IHSS 202	CREEK	S	1	4	0.25	5.25	6.15	16.50	16.50	8.300	5.48	0.66
ANTIMONY	mg/kg	IHSS 200	LAKE	S	6	15	0.40	2.40	3.10	5.90	13.20	5.017	3.49	0.70
ANTIMONY	mg/kg	IHSS 201	LAKE	S	3	21	0.14	1.75	7.55	4.90	6.90	3.181	1.72	0.54
ANTIMONY	mg/kg	IHSS 202	LAKE	S	1	6	0.17	4.60	44.40	17.30	17.30	14.858	15.23	1.03
ARSENIC	mg/kg	BGCR	CREEK	B	53	59	0.90			0.20	17.30	2.410	2.45	
ARSENIC	mg/kg	IHSS 200	CREEK	S	8	8	1.00			3.70	9.40	5.313	1.85	0.35
ARSENIC	mg/kg	IHSS 201	CREEK	S	14	14	1.00			2.20	7.80	4.764	1.53	0.32
ARSENIC	mg/kg	IHSS 202	CREEK	S	4	4	1.00			3.00	6.80	4.875	1.56	0.32
ARSENIC	mg/kg	LOWRY	CREEK	B							16.50	4.810	3.95	
ARSENIC	mg/kg	CC-BM	LAKE	B						5.57	5.57			
ARSENIC	mg/kg	IHSS 200	LAKE	S	36	36	1.00			2.60	9.40	4.906	1.46	0.30
ARSENIC	mg/kg	IHSS 201	LAKE	S	43	43	1.00			1.20	17.70	6.963	4.34	0.62
ARSENIC	mg/kg	IHSS 202	LAKE	S	15	15	1.00			2.20	10.40	5.147	1.96	0.38
ARSENIC	mg/kg	RMNP-BM (L. Husted)	LAKE	B								2.500	0.20	
ARSENIC	mg/kg	RMNP-BM (L. Louise)	LAKE	B								2.500	0.30	
ARSENIC	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								8.400	0.20	
ARSENIC	mg/kg	RMNP-BM (The Loch)	LAKE	B								1.400	0.20	
BARIUM	mg/kg	BGCR	CREEK	B	57	57	1.00			10.60	244.00	77.910	56.38	
BARIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			78.60	243.00	136.713	50.49	0.37
BARIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			85.00	329.00	150.714	59.75	0.40
BARIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			81.50	296.00	150.950	100.64	0.67
BARIUM	mg/kg	LOWRY	CREEK	B							440.00	220.640	76.59	
BARIUM	mg/kg	CC-BM	LAKE	B						591.00	591.00			
BARIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			38.20	190.00	128.989	38.71	0.30

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
BARIUM	mg/kg	IHSS 201	LAKE	S	43	43	1.00			10.80	196.00	101.372	56.65	0.56
BARIUM	mg/kg	IHSS 202	LAKE	S	15	15	1.00			103.00	250.00	173.000	47.92	0.28
BERYLLIUM	mg/kg	BGCR	CREEK	B	27	57	0.47			1.50	1.30	0.660	1.69	
BERYLLIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			0.24	1.60	0.851	0.38	0.45
BERYLLIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			0.22	1.50	0.577	0.31	0.54
BERYLLIUM	mg/kg	IHSS 202	CREEK	S	3	3	1.00			0.41	1.40	0.783	0.54	0.69
BERYLLIUM	mg/kg	LOWRY	CREEK	B							2.10	1.040	0.48	
BERYLLIUM	mg/kg	CC-BM	LAKE	B						4.03	4.03			
BERYLLIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			0.37	1.40	0.850	0.27	0.31
BERYLLIUM	mg/kg	IHSS 201	LAKE	S	39	43	0.91	0.06	0.07	0.15	1.60	0.700	0.47	0.67
BERYLLIUM	mg/kg	IHSS 202	LAKE	S	13	14	0.93	1.00	1.00	0.54	1.50	1.061	0.27	0.25
BERYLLIUM	mg/kg	RMNP-BM (L. Husted)	LAKE	B								3.900	1.00	
BERYLLIUM	mg/kg	RMNP-BM (L. Louise)	LAKE	B								5.000	3.00	
BERYLLIUM	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								9.300	1.10	
BERYLLIUM	mg/kg	RMNP-BM (The Loch)	LAKE	B								7.400	1.30	
CADMIUM	mg/kg	BGCR	CREEK	B	6	51	0.12			0.13	1.30	0.540	0.36	
CADMIUM	mg/kg	IHSS 200	CREEK	S	3	8	0.38	0.22	0.31	0.41	1.60	0.590	0.57	0.96
CADMIUM	mg/kg	IHSS 201	CREEK	S	7	14	0.50	0.21	0.75	0.77	6.30	1.802	1.79	0.99
CADMIUM	mg/kg	IHSS 202	CREEK	S		4		0.47	0.95			0.593	0.24	0.40
CADMIUM	mg/kg	LOWRY	CREEK	B							3.80	1.040	0.99	
CADMIUM	mg/kg	CC-BM	LAKE	B						0.05	0.05			
CADMIUM	mg/kg	IHSS 200	LAKE	S	14	36	0.39	0.20	0.45	0.58	1.70	0.568	0.43	0.76
CADMIUM	mg/kg	IHSS 201	LAKE	S	22	37	0.59	0.18	0.30	0.54	5.00	1.719	1.60	0.93
CADMIUM	mg/kg	IHSS 202	LAKE	S		8		0.35	3.95			0.988	1.22	1.23
CADMIUM	mg/kg	RMNP-BM (L. Husted)	LAKE	B								0.700	0.04	
CADMIUM	mg/kg	RMNP-BM (L. Louise)	LAKE	B								0.500	0.30	
CADMIUM	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								0.340	0.03	
CADMIUM	mg/kg	RMNP-BM (The Loch)	LAKE	B								0.320	0.05	
CALCIUM	mg/kg	BGCR	CREEK	B	58	59	0.98			93.50	17100.00	3658.240	4683.60	
CALCIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			1570.00	18300.00	7782.500	5522.52	0.71
CALCIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			911.00	75000.00	13887.214	20883.28	1.51
CALCIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			6480.00	59400.00	22077.500	25024.06	1.13

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
CALCIUM	mg/kg	CC-BM	LAKE	B						12.00	12.00			
CALCIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			3260.00	33900.00	7465.000	5909.62	0.79
CALCIUM	mg/kg	IHSS 201	LAKE	S	43	43	1.00			427.00	90100.00	8091.930	14021.39	1.73
CALCIUM	mg/kg	IHSS 202	LAKE	S	15	15	1.00			7050.00	42000.00	15209.333	8374.69	0.55
CALCIUM	mg/kg	RMNP-BM (L. Husted)	LAKE	B								26.000	1.00	
CALCIUM	mg/kg	RMNP-BM (L. Louise)	LAKE	B								34.100	0.10	
CALCIUM	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								54.000	5.00	
CALCIUM	mg/kg	RMNP-BM (The Loch)	LAKE	B								47.000	6.00	
CESIUM	mg/kg	BGCR	CREEK	B	10	56	0.18				157.00	69.290	63.88	
CESIUM	mg/kg	IHSS 200	CREEK	S		8		44.95	68.50			53.381	8.03	0.15
CESIUM	mg/kg	IHSS 201	CREEK	S	3	14	0.21	6.95	104.50	3.10	19.90	40.850	32.84	0.80
CESIUM	mg/kg	IHSS 202	CREEK	S	3	4	0.75	126.50	126.50	1.80	2.00	33.050	62.30	1.89
CESIUM	mg/kg	IHSS 200	LAKE	S	9	36	0.25	6.90	78.50	14.10	29.70	36.006	26.06	0.72
CESIUM	mg/kg	IHSS 201	LAKE	S		37		5.80	71.00			26.968	25.39	0.94
CESIUM	mg/kg	IHSS 202	LAKE	S	1	9	0.11	1.25	15.75	69.80	69.80	14.744	21.57	1.46
CHROMIUM	mg/kg	BGCR	CREEK	B	47	59	0.80			0.48	29.70	8.130	7.42	
CHROMIUM	mg/kg	IHSS 200	CREEK	S	6	8	0.75	0.19	0.27	2.40	12.70	4.894	4.61	0.94
CHROMIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			2.70	31.90	8.807	7.14	0.81
CHROMIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			6.80	17.00	12.650	5.12	0.41
CHROMIUM	mg/kg	LOWRY	CREEK	B							22.90	12.350	5.54	
CHROMIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			3.70	19.80	10.947	3.79	0.35
CHROMIUM	mg/kg	IHSS 201	LAKE	S	40	43	0.93	0.22	0.24	0.89	21.40	9.897	6.91	0.70
CHROMIUM	mg/kg	IHSS 202	LAKE	S	14	15	0.93	4.40	4.40	5.10	22.10	14.800	5.14	0.35
COBALT	mg/kg	BGCR	CREEK	B	43	59	0.23			0.30	15.00	5.040	3.29	
COBALT	mg/kg	IHSS 200	CREEK	S	8	8	1.00			4.50	23.30	11.250	6.00	0.53
COBALT	mg/kg	IHSS 201	CREEK	S	14	14	1.00			2.90	10.90	7.900	2.20	0.28
COBALT	mg/kg	IHSS 202	CREEK	S	4	4	1.00			6.30	9.60	7.825	1.36	0.17
COBALT	mg/kg	LOWRY	CREEK	B							14.00	9.200	2.86	
COBALT	mg/kg	CC-BM	LAKE	B						21.30	21.30			
COBALT	mg/kg	IHSS 200	LAKE	S	36	36	1.00			3.50	13.50	8.664	2.03	0.23
COBALT	mg/kg	IHSS 201	LAKE	S	43	43	1.00			1.30	13.20	7.049	3.53	0.50
COBALT	mg/kg	IHSS 202	LAKE	S	14	15	0.93	5.85	5.85	4.40	15.30	8.357	2.55	0.31

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						98700.00	98700.00			
COPPER	mg/kg	BGCR	CREEK	B	43	59	0.73			10.15	36.70	10.150	7.88	
COPPER	mg/kg	IHSS 200	CREEK	S	8	8	1.00			8.90	37.50	20.525	8.20	0.40
COPPER	mg/kg	IHSS 201	CREEK	S	14	14	1.00			12.90	52.30	30.293	13.27	0.44
COPPER	mg/kg	IHSS 202	CREEK	S	4	4	1.00			7.30	18.20	11.125	4.83	0.43
COPPER	mg/kg	LOWRY	CREEK	B							48.30	17.580	8.98	
COPPER	mg/kg	CC-BM	LAKE	B						43.40	43.40			
COPPER	mg/kg	IHSS 200	LAKE	S	36	36	1.00			8.10	129.00	48.567	37.57	0.77
COPPER	mg/kg	IHSS 201	LAKE	S	43	43	1.00			1.20	183.00	67.919	64.90	0.96
COPPER	mg/kg	IHSS 202	LAKE	S	14	15	0.93	11.65	11.65	11.10	50.10	26.797	12.47	0.47
CYANIDE	mg/kg	IHSS 201	CREEK	S		3		0.330	0.445			0.382	0.058	
CYANIDE	mg/kg	IHSS 201	LAKE	S		21		0.305	1.250			0.440	0.199	
CYANIDE	mg/kg	IHSS 200	LAKE	S		21		0.70	0.800			0.526	0.150	
CYANIDE	mg/kg	IHSS 202	LAKE	S		6		0.600	0.90			0.767	0.121	
IRON	mg/kg	BGCR	CREEK	B	59	59	1.00			1040.00	31400.00	8852.630	6263.19	
IRON	mg/kg	IHSS 200	CREEK	S	8	8	1.00			9430.00	51700.00	25816.250	14443.51	0.56
IRON	mg/kg	IHSS 201	CREEK	S	14	14	1.00			5670.00	26800.00	15397.857	5232.17	0.34
IRON	mg/kg	IHSS 202	CREEK	S	4	4	1.00			14300.00	27000.00	19200.000	5832.67	0.30
IRON	mg/kg	CC-BM	LAKE	B						49700.00	49700.00			
IRON	mg/kg	IHSS 200	LAKE	S	36	36	1.00			4670.00	53800.00	16888.333	8712.93	0.52
IRON	mg/kg	IHSS 201	LAKE	S	43	43	1.00			3100.00	28300.00	14868.512	6835.61	0.46
IRON	mg/kg	IHSS 202	LAKE	S	15	15	1.00			10800.00	48000.00	19886.667	8631.99	0.43
IRON	mg/kg	RMNP-BM (L. Husted)	LAKE	B								1600.000	40.00	
IRON	mg/kg	RMNP-BM (L. Louise)	LAKE	B								2400.000	100.00	
IRON	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								6200.000	900.00	
IRON	mg/kg	RMNP-BM (The Loch)	LAKE	B								2300.000	300.00	
LEAD	mg/kg	BGCR	CREEK	B	59	59	1.00			2.10	244.00	22.020	36.79	
LEAD	mg/kg	IHSS 200	CREEK	S	8	8	1.00			5.30	36.20	18.513	9.36	0.51
LEAD	mg/kg	IHSS 201	CREEK	S	14	14	1.00			17.20	91.40	38.450	21.06	0.55
LEAD	mg/kg	IHSS 202	CREEK	S	4	4	1.00			12.30	21.60	16.775	3.81	0.23
LEAD	mg/kg	LOWRY	CREEK	B							380.00	28.290	66.79	
LEAD	mg/kg	CC-BM	LAKE	B						55.00	55.00			
LEAD	mg/kg	IHSS 200	LAKE	S	36	36	1.00			13.00	68.20	31.372	18.61	0.59
LEAD	mg/kg	IHSS 201	LAKE	S	43	43	1.00			2.90	317.00	63.747	67.11	1.05

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
LEAD	mg/kg	IHSS 202	LAKE	S	15	15	1.00			14.50	40.80	29.987	7.75	0.26
LEAD	mg/kg	RMNP-BM (L. Husted)	LAKE	B								43.000	0.00	
LEAD	mg/kg	RMNP-BM (L. Louise)	LAKE	B								26.000	2.00	
LEAD	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								14.000	2.00	
LITHIUM	mg/kg	BGCR	CREEK	B	41	57	0.72			1.15	20.20	7.480	5.26	
LITHIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			1.80	11.50	6.850	3.19	0.48
LITHIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			2.10	34.60	8.207	8.31	1.01
LITHIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			7.10	16.20	9.475	4.49	0.47
LITHIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			3.10	17.60	8.958	3.09	0.34
LITHIUM	mg/kg	IHSS 201	LAKE	S	42	43	0.98	0.24	0.24	0.53	17.10	7.529	4.84	0.64
LITHIUM	mg/kg	IHSS 202	LAKE	S	14	15	0.93	7.95	7.95	7.00	13.90	11.017	2.37	0.22
MAGNESIUM	mg/kg	BGCR	CREEK	B	54	59	0.92			125.50	5850.00	1473.770	1252.57	
MAGNESIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			684.00	4180.00	2305.500	1039.53	0.45
MAGNESIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			595.00	9480.00	2531.071	2234.40	0.88
MAGNESIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			2270.00	4460.00	2887.500	1053.58	0.36
MAGNESIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			1280.00	5140.00	2871.667	791.80	0.28
MAGNESIUM	mg/kg	IHSS 201	LAKE	S	43	43	1.00			197.00	6430.00	2683.442	1632.54	0.61
MAGNESIUM	mg/kg	IHSS 202	LAKE	S	15	15	1.00			2480.00	5040.00	4064.000	662.17	0.16
MANGANESE	mg/kg	BGCR	CREEK	B	58	59	0.98			9.00	1280.00	227.820	215.48	
MANGANESE	mg/kg	IHSS 200	CREEK	S	8	8	1.00			155.00	1550.00	684.000	526.56	0.77
MANGANESE	mg/kg	IHSS 201	CREEK	S	14	14	1.00			83.50	4450.00	1706.179	1447.03	0.85
MANGANESE	mg/kg	IHSS 202	CREEK	S	4	4	1.00			238.00	1170.00	548.000	423.63	0.77
MANGANESE	mg/kg	LOWRY	CREEK	B							1560.00	605.100	281.36	
MANGANESE	mg/kg	CC-BM	LAKE	B						739.00	739.00			
MANGANESE	mg/kg	IHSS 200	LAKE	S	36	36	1.00			40.50	813.00	425.914	211.90	0.50
MANGANESE	mg/kg	IHSS 201	LAKE	S	43	43	1.00			89.60	2080.00	595.379	592.16	0.99
MANGANESE	mg/kg	IHSS 202	LAKE	S	15	15	1.00			148.00	925.00	297.800	194.93	0.65
MERCURY	mg/kg	BGCR	CREEK	B	2	49	0.04			0.01	0.05	0.080	0.06	
MERCURY	mg/kg	IHSS 200	CREEK	S		8		0.03	0.07			0.046	0.01	0.25
MERCURY	mg/kg	IHSS 201	CREEK	S	3	14	0.21	0.03	0.08	0.08	0.14	0.061	0.03	0.51

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
MERCURY	mg/kg	IHSS 202	CREEK	S		4		0.03	0.11			0.045	0.04	0.89
MERCURY	mg/kg	LOWRY	CREEK	B							0.29	0.080	0.06	
MERCURY	mg/kg	CC-BM	LAKE	B						0.06	0.06			
MERCURY	mg/kg	IHSS 200	LAKE	S	4	36	0.11	0.03	0.08	0.10	0.20	0.063	0.03	0.51
MERCURY	mg/kg	IHSS 201	LAKE	S	18	42	0.43	0.00	0.10	0.08	0.60	0.116	0.12	1.06
MERCURY	mg/kg	IHSS 202	LAKE	S	1	8	0.13	0.04	0.23	0.10	0.10	0.081	0.06	0.77
MERCURY	mg/kg	RMNP-BM (L. Husted)	LAKE	B								0.030	0.01	
MERCURY	mg/kg	RMNP-BM (L. Louise)	LAKE	B								0.065	0.01	
MERCURY	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								0.050	0.00	
MERCURY	mg/kg	RMNP-BM (The Loch)	LAKE	B								0.040	0.01	
MOLYBDENUM	mg/kg	BGCR	CREEK	B	16	58	0.28			0.33	9.60	4.470	5.23	
MOLYBDENUM	mg/kg	IHSS 200	CREEK	S	6	8	0.75	0.80	0.80	3.60	17.90	7.838	6.30	0.80
MOLYBDENUM	mg/kg	IHSS 201	CREEK	S	6	14	0.43	0.35	2.30	1.60	6.70	2.379	1.87	0.78
MOLYBDENUM	mg/kg	IHSS 202	CREEK	S		4		1.80	2.10			1.900	0.14	0.07
MOLYBDENUM	mg/kg	CC-BM	LAKE	B						22.00	22.00			
MOLYBDENUM	mg/kg	IHSS 200	LAKE	S	23	36	0.64	0.24	0.85	0.58	13.30	3.077	3.47	1.13
MOLYBDENUM	mg/kg	IHSS 201	LAKE	S	20	37	0.54	0.20	1.25	0.69	7.70	1.910	2.17	1.14
MOLYBDENUM	mg/kg	IHSS 202	LAKE	S		8		0.42	15.40			3.389	5.02	1.48
NICKEL	mg/kg	BGCR	CREEK	B	39	57	0.68			0.65	25.60	6.750	5.38	
NICKEL	mg/kg	IHSS 200	CREEK	S	8	8	1.00			10.00	72.70	25.200	20.31	0.81
NICKEL	mg/kg	IHSS 201	CREEK	S	13	14	0.93	3.15	3.15	8.60	22.60	14.811	5.53	0.37
NICKEL	mg/kg	IHSS 202	CREEK	S	3	4	0.75	3.55	3.55	14.90	16.90	12.588	6.09	0.48
NICKEL	mg/kg	LOWRY	CREEK	B							131.00	15.450	22.29	
NICKEL	mg/kg	CC-BM	LAKE	B						26.20	26.20			
NICKEL	mg/kg	IHSS 200	LAKE	S	36	36	1.00			5.70	22.70	15.725	3.96	0.25
NICKEL	mg/kg	IHSS 201	LAKE	S	40	43	0.93	1.20	1.35	3.40	23.70	12.338	6.64	0.54
NICKEL	mg/kg	IHSS 202	LAKE	S	12	15	0.80	4.85	29.90	10.50	29.20	17.087	6.70	0.39
NICKEL	mg/kg	RMNP-BM (L. Husted)	LAKE	B								9.600	0.20	
NICKEL	mg/kg	RMNP-BM (L. Louise)	LAKE	B								10.000	0.00	
NICKEL	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								12.300	0.60	
NICKEL	mg/kg	RMNP-BM (The Loch)	LAKE	B								18.000	2.00	
POTASSIUM	mg/kg	BGCR	CREEK	B	43	58	0.24			57.00	3770.00	835.340	749.42	
POTASSIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			548.00	2090.00	1210.375	579.40	0.48
POTASSIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			549.00	8390.00	1794.857	1993.05	1.11

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7956.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2716.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
POTASSIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			1210.00	2760.00	1745.000	691.40	0.40
POTASSIUM	mg/kg	CC-BM	LAKE	B						15100.00	15100.00			
POTASSIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			402.00	2700.00	1573.750	598.93	0.38
POTASSIUM	mg/kg	IHSS 201	LAKE	S	43	43	1.00			163.00	3630.00	1734.512	1156.91	0.66
POTASSIUM	mg/kg	IHSS 202	LAKE	S	14	15	0.93	2755.00	2755.00	1370.00	3450.00	2777.000	639.00	0.23
SELENIUM	mg/kg	BGCR	CREEK	B	13	58	0.22			0.10	2.90	0.420		
SELENIUM	mg/kg	IHSS 200	CREEK	S	6	8	0.75	0.11	0.11	0.44	0.77	0.487	0.26	0.53
SELENIUM	mg/kg	IHSS 201	CREEK	S	3	14	0.21	0.10	0.60	1.50	2.20	0.598	0.74	1.24
SELENIUM	mg/kg	IHSS 202	CREEK	S		4		0.11	0.28			0.190	0.07	0.36
SELENIUM	mg/kg	CC-BM	LAKE	B						1.10	1.10			
SELENIUM	mg/kg	IHSS 200	LAKE	S	13	22	0.59	0.10	1.10	0.24	4.00	0.888	1.04	1.17
SELENIUM	mg/kg	IHSS 201	LAKE	S	9	32	0.28	0.10	3.50	0.16	4.50	0.892	1.02	1.15
SELENIUM	mg/kg	IHSS 202	LAKE	S	3	11	0.27	0.15	1.60	1.90	5.70	1.723	2.00	1.16
SELENIUM	mg/kg	RMNP-BM (L. Husted)	LAKE	B								1.800	0.10	
SELENIUM	mg/kg	RMNP-BM (L. Louise)	LAKE	B								1.200	0.10	
SELENIUM	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								1.800	0.40	
SELENIUM	mg/kg	RMNP-BM (The Loch)	LAKE	B								1.100	0.30	
SILICON	mg/kg	BGCR	CREEK	B	19	19	1.00				1450.00	331.530	382.31	
SILICON	mg/kg	IHSS 200	CREEK	S	8	8	1.00			128.00	1020.00	459.125	365.62	0.80
SILICON	mg/kg	IHSS 201	CREEK	S	8	8	1.00			281.00	3290.00	1167.500	937.25	0.80
SILICON	mg/kg	IHSS 202	CREEK	S	1	1	1.00			412.00	412.00	412.000		
SILICON	mg/kg	IHSS 200	LAKE	S	15	15	1.00			115.00	650.00	237.667	125.31	0.53
SILICON	mg/kg	IHSS 201	LAKE	S	13	13	1.00			82.00	396.00	197.308	79.13	0.40
SILVER	mg/kg	BGCR	CREEK	B	2	54	0.04			0.20	3.40	0.660	0.52	
SILVER	mg/kg	IHSS 200	CREEK	S	7	8	0.88	0.26	0.26	1.20	4.00	2.382	1.35	0.57
SILVER	mg/kg	IHSS 201	CREEK	S	8	14	0.57	0.25	0.75	0.79	2.10	0.942	0.58	0.62
SILVER	mg/kg	IHSS 202	CREEK	S	1	4	0.25	0.43	0.43	1.90	1.90	0.796	0.74	0.92
SILVER	mg/kg	CC-BM	LAKE	B						0.05	0.05			
SILVER	mg/kg	IHSS 200	LAKE	S	28	36	0.78	0.26	0.95	1.10	6.00	1.917	1.13	0.59
SILVER	mg/kg	IHSS 201	LAKE	S	31	35	0.89	0.23	0.50	0.48	7.70	1.995	1.77	0.89
SILVER	mg/kg	IHSS 202	LAKE	S	2	8	0.25	0.60	3.60	1.50	1.90	1.400	0.99	0.71
SODIUM	mg/kg	BGCR	CREEK	B	47	59	0.80			162.00	637.00	161.470	136.80	

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
SODIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			57.70	2490.00	535.588	811.75	1.52
SODIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			51.50	1810.00	286.107	412.13	1.44
SODIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			193.00	533.00	291.500	161.71	0.55
SODIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			43.20	997.00	268.389	240.31	0.90
SODIUM	mg/kg	IHSS 201	LAKE	S	43	43	1.00			26.00	509.00	138.735	96.81	0.70
SODIUM	mg/kg	IHSS 202	LAKE	S	15	15	1.00			171.00	1060.00	389.333	210.39	0.57
STRONTIUM	mg/kg	BGCR	CREEK	B	48	58	0.83			2.80	421.00	36.380	59.87	
STRONTIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			15.00	91.30	55.375	27.23	0.49
STRONTIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			18.30	227.00	67.286	61.12	0.91
STRONTIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			35.80	349.00	131.225	147.15	1.12
STRONTIUM	mg/kg	CC-BM	LAKE	B						202.00	202.00			
STRONTIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			26.70	154.00	57.828	24.19	0.42
STRONTIUM	mg/kg	IHSS 201	LAKE	S	43	43	1.00			2.80	423.00	49.812	62.01	1.24
STRONTIUM	mg/kg	IHSS 202	LAKE	S	15	15	1.00			47.10	190.00	82.813	32.39	0.39
THALLIUM	mg/kg	BGCR	CREEK	B	2	50	0.04				0.40	0.300	0.23	
THALLIUM	mg/kg	IHSS 200	CREEK	S		8		0.16	0.23			0.199	0.02	0.12
THALLIUM	mg/kg	IHSS 201	CREEK	S	2	14	0.14	0.12	0.75	0.28	0.38	0.256	0.16	0.63
THALLIUM	mg/kg	IHSS 202	CREEK	S	1	4	0.25	0.11	0.43	0.25	0.25	0.223	0.15	0.68
THALLIUM	mg/kg	IHSS 200	LAKE	S	1	36	0.03	0.18	1.30	0.95	0.95	0.398	0.26	0.66
THALLIUM	mg/kg	IHSS 201	LAKE	S		38		0.23	1.95			0.481	0.40	0.83
THALLIUM	mg/kg	IHSS 202	LAKE	S		8		0.15	1.20			0.656	0.48	0.74
TIN	mg/kg	BGCR	CREEK	B	16	54	0.30				27.10	7.640	6.09	
TIN	mg/kg	IHSS 200	CREEK	S		4		0.85	1.95			1.413	0.59	0.42
TIN	mg/kg	IHSS 201	CREEK	S		13		1.30	8.70			2.781	1.92	0.69
TIN	mg/kg	IHSS 202	CREEK	S		3		4.95	6.95			6.250	1.13	0.18
TIN	mg/kg	LOWRY	CREEK	B							15.50	13.670	2.02	
TIN	mg/kg	IHSS 200	LAKE	S	7	33	0.21	0.80	4.05	2.60	6.10	1.964	1.30	0.66
TIN	mg/kg	IHSS 201	LAKE	S	20	36	0.56	0.80	5.75	2.00	10.40	3.192	2.34	0.73
TIN	mg/kg	IHSS 202	LAKE	S	5	11	0.45	1.95	58.00	16.40	51.40	22.968	19.41	0.84
VANADIUM	mg/kg	BGCR	CREEK	B	53	57	0.93			2.00	73.00	18.330	14.30	

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
VANADIUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			16.10	87.70	33.913	22.62	0.67
VANADIUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			11.20	60.90	26.029	12.11	0.47
VANADIUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			28.70	51.10	37.400	9.70	0.26
VANADIUM	mg/kg	LOWRY	CREEK	B							72.90	33.310	11.88	
VANADIUM	mg/kg	CC-BM	LAKE	B						115.00	115.00			
VANADIUM	mg/kg	IHSS 200	LAKE	S	36	36	1.00			9.10	70.70	31.839	13.49	0.42
VANADIUM	mg/kg	IHSS 201	LAKE	S	43	43	1.00			4.90	50.00	24.300	12.17	0.50
VANADIUM	mg/kg	IHSS 202	LAKE	S	15	15	1.00			18.60	114.00	42.987	21.53	0.50
VANADIUM	mg/kg	RMNP-BM (L. Husted)	LAKE	B								27.300	0.10	
VANADIUM	mg/kg	RMNP-BM (L. Louise)	LAKE	B								35.000	6.00	
VANADIUM	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								55.000	6.00	
VANADIUM	mg/kg	RMNP-BM (The Loch)	LAKE	B								43.000	3.00	
ZINC	mg/kg	BGCR	CREEK	B	55	58.00	0.95			3.25	155.00	43.770	30.23	
ZINC	mg/kg	IHSS 200	CREEK	S	8	8	1.00			46.70	480.00	149.113	134.24	0.90
ZINC	mg/kg	IHSS 201	CREEK	S	14	14	1.00			53.00	1170.00	422.243	384.51	0.91
ZINC	mg/kg	IHSS 202	CREEK	S	4	4	1.00			44.60	56.60	49.475	5.31	0.11
ZINC	mg/kg	LOWRY	CREEK	B							726.00	76.750	124.61	
ZINC	mg/kg	CC-BM	LAKE	B						158.00	158.00			
ZINC	mg/kg	IHSS 200	LAKE	S	36	36	1.00			28.50	540.00	195.339	145.76	0.75
ZINC	mg/kg	IHSS 201	LAKE	S	43	43	1.00			9.00	1120.00	425.593	392.51	0.92
ZINC	mg/kg	IHSS 202	LAKE	S	15	15	1.00			40.50	193.00	81.247	34.87	0.43
ZINC	mg/kg	RMNP-BM (L. Husted)	LAKE	B								117.000	2.00	
ZINC	mg/kg	RMNP-BM (L. Louise)	LAKE	B								125.000	3.00	
ZINC	mg/kg	RMNP-BM (L. Haiyaha)	LAKE	B								72.000	4.00	
ZINC	mg/kg	RMNP-BM (The Loch)	LAKE	B								95.000	9.00	
RADIONUCLIDES														
AMERICIUM-241	pCi/g	BGCR	CREEK	B	59	59	1.00			-0.01	0.82	0.070	0.19	
AMERICIUM-241	pCi/g	IHSS 200	CREEK	S	5	5	1.00			0.00	0.06	0.017	0.02	1.43
AMERICIUM-241	pCi/g	IHSS 201	CREEK	S	13	13	1.00			0.00	0.08	0.022	0.03	1.19
AMERICIUM-241	pCi/g	IHSS 202	CREEK	S	4	4	1.00			0.02	0.05	0.030	0.01	0.39
AMERICIUM-241	pCi/g	IHSS 200	LAKE	S	34	34	1.00			0.01	0.21	0.043	0.05	1.20
AMERICIUM-241	pCi/g	IHSS 201	LAKE	S	39	39	1.00			0.00	0.11	0.017	0.02	1.36

Table B-1
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Surface Sediments
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Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
AMERICIUM-241	pCi/g	IHSS 202	LAKE	S	15	15	1.00			0.01	0.09	0.049	0.03	0.52
CESIUM-136	pCi/g	BGCR	CREEK	B							1.50	0.260		
CESIUM-137	pCi/g	IHSS 200	CREEK	S	6	6	1.00			0.05	0.57	0.179	0.21	1.15
CESIUM-137	pCi/g	IHSS 200	LAKE	S	14	14	1.00			0.03	0.19	0.080	0.05	0.66
CESIUM-137	pCi/g	IHSS 201	LAKE	S		8						0.048	0.00	0.10
GROSS ALPHA	pCi/g	BGCR	CREEK	B	45	45	1.00			2.92	72.00	22.980	0.38	
GROSS ALPHA	pCi/g	IHSS 200	CREEK	S	8	8	1.00			15.00	28.00	19.849	4.49	0.23
GROSS ALPHA	pCi/g	IHSS 201	CREEK	S	14	14	1.00			6.30	33.00	18.513	6.66	0.36
GROSS ALPHA	pCi/g	IHSS 202	CREEK	S	4	4	1.00			17.00	43.00	25.900	12.12	0.47
GROSS ALPHA	pCi/g	IHSS 200	LAKE	S	34	34	1.00			3.80	37.00	24.269	7.74	0.32
GROSS ALPHA	pCi/g	IHSS 201	LAKE	S	42	42	1.00			4.40	39.00	19.034	7.81	0.41
GROSS ALPHA	pCi/g	IHSS 202	LAKE	S	15	15	1.00			15.13	84.00	32.578	17.61	0.54
GROSS BETA	pCi/g	BGCR	CREEK	B	43	43	1.00				59.00	35.350	20.46	
GROSS BETA	pCi/g	IHSS 200	CREEK	S	8	8	1.00			20.00	37.56	28.839	5.93	0.22
GROSS BETA	pCi/g	IHSS 201	CREEK	S	14	14	1.00			17.00	36.00	27.541	4.48	0.16
GROSS BETA	pCi/g	IHSS 202	CREEK	S	4	4	1.00			20.00	31.00	23.250	5.25	0.23
GROSS BETA	pCi/g	IHSS 200	LAKE	S	34	34	1.00			9.20	37.50	25.050	4.93	0.20
GROSS BETA	pCi/g	IHSS 201	LAKE	S	42	42	1.00			8.80	56.61	25.981	8.69	0.33
GROSS BETA	pCi/g	IHSS 202	LAKE	S	15	15	1.00			27.00	53.00	32.987	6.70	0.20
PLUTONIUM-239/240	pCi/g	BGCR	CREEK	B	42	42	1.00			0.00	2.36	0.170	0.59	
PLUTONIUM-239/240	pCi/g	IHSS 200	CREEK	S	8	8	1.00			0.00	0.55	0.156	0.20	1.29
PLUTONIUM-239/240	pCi/g	IHSS 201	CREEK	S	14	14	1.00			-0.01	0.47	0.082	0.16	1.97
PLUTONIUM-239/240	pCi/g	IHSS 202	CREEK	S	4	4	1.00			0.05	0.17	0.091	0.06	0.60
PLUTONIUM-239/240	pCi/g	BGCR	LAKE	B						0.02	0.13	0.130		
PLUTONIUM-239/240	pCi/g	IHSS 200	LAKE	S	87	87	1.00			0.00	3.30	0.267	0.59	2.23
PLUTONIUM-239/240	pCi/g	IHSS 201	LAKE	S	105	105	1.00			-0.02	0.55	0.033	0.06	1.81
PLUTONIUM-239/240	pCi/g	IHSS 202	LAKE	S	15	15	1.00			0.03	0.49	0.291	0.16	0.57
RADIUM-226	pCi/g	BGCR	CREEK	B	21	21	1.00			0.43	1.80	0.850	0.36	
RADIUM-226	pCi/g	IHSS 200	CREEK	S	6	6	1.00			0.85	1.20	1.067	0.15	0.14

Table B-1
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Surface Sediments
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Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						98700.00	98700.00			
RADIUM-226	pCi/g	IHSS 200	LAKE	S	14	14	1.00			0.84	2.20	1.124	0.34	0.30
RADIUM-226	pCi/g	IHSS 201	LAKE	S	8	8	1.00			0.28	1.40	0.790	0.35	0.44
RADIUM-226	pCi/g	IHSS 200	CREEK	S	6	6	1.00			0.97	1.70	1.328	0.23	0.18
RADIUM-228	pCi/g	IHSS 200	LAKE	S	14	14	1.00			0.92	2.20	1.444	0.37	0.26
RADIUM-228	pCi/g	IHSS 201	LAKE	S	8	8	1.00			0.31	1.60	1.000	0.49	0.49
STRONTIUM-89/90	pCi/g	BGCR	CREEK	B	43	43	1.00			-0.60	1.17	0.210	0.27	
STRONTIUM-89/90	pCi/g	IHSS 200	CREEK	S	6	6	1.00			0.13	0.30	0.220	0.08	0.37
STRONTIUM-89/90	pCi/g	IHSS 200	LAKE	S	13	13	1.00			0.11	0.57	0.309	0.14	0.46
STRONTIUM-89/90	pCi/g	IHSS 201	LAKE	S	8	8	1.00			0.14	0.72	0.326	0.19	0.57
TRITIUM	pCi/L	BGCR	CREEK	B	41	41	1.00			-23.20	380.00	155.870	91.83	
TRITIUM	pCi/L	IHSS 200	CREEK	S	3	3	1.00			-81.00	170.00	51.930	126.16	2.43
TRITIUM	pCi/L	IHSS 201	CREEK	S	4	4	1.00			77.00	159.60	112.015	39.34	0.35
TRITIUM	pCi/L	IHSS 200	LAKE	S	9	9	1.00			-36.00	160.90	76.244	78.21	1.03
URANIUM-233/234	pCi/g	BGCR	CREEK	B	47	47	1.00			0.14	4.50	1.680	1.15	
URANIUM-233/234	pCi/g	IHSS 200	CREEK	S	7	7	1.00			0.94	2.66	1.369	0.58	0.43
URANIUM-233/234	pCi/g	IHSS 201	CREEK	S	14	14	1.00			0.62	4.70	1.452	1.03	0.71
URANIUM-233/234	pCi/g	IHSS 202	CREEK	S	4	4	1.00			0.96	2.09	1.288	0.54	0.42
URANIUM-233/234	pCi/g	BM	LAKE	B						5.51	228.40	11.400		
URANIUM-233/234	pCi/g	IHSS 200	LAKE	S	35	35	1.00			5.40	5.40		0.83	0.62
URANIUM-233/234	pCi/g	IHSS 201	LAKE	S	37	37	1.00			0.22	2.67	1.238	0.72	0.58
URANIUM-233/234	pCi/g	IHSS 202	LAKE	S	15	15	1.00			0.66	3.50	1.407	0.63	0.45
URANIUM-235	pCi/g	BGCR	CREEK	B	49	49	1.00			0.40	0.19	0.080	0.05	
URANIUM-235	pCi/g	IHSS 200	CREEK	S	7	7	1.00			0.03	0.20	0.072	0.06	0.86
URANIUM-235	pCi/g	IHSS 201	CREEK	S	14	14	1.00			0.03	0.20	0.078	0.04	0.58
URANIUM-235	pCi/g	IHSS 202	CREEK	S	4	4	1.00			0.06	0.14	0.085	0.04	0.44
URANIUM-235	pCi/g	BM	LAKE	B						5.51		11.400		
URANIUM-235	pCi/g	IHSS 200	LAKE	S	35	35	1.00			0.01	0.56	0.071	0.09	1.29
URANIUM-235	pCi/g	IHSS 201	LAKE	S	37	37	1.00			0.00	0.12	0.045	0.03	0.75
URANIUM-235	pCi/g	IHSS 202	LAKE	S	15	15	1.00			0.01	0.17	0.064	0.04	0.68

Table B-1
Summary Statistics for OU 3
Surface Sediments
Comparison to Benchmark Data

Chemical Name	Unit	Data Source	Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean	Standard Deviation	Coefficient of Variation
METALS														
ALUMINUM	mg/kg	BGCR	CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	IHSS 200	CREEK	S	8	8	1.00			2220.00	13800.00	8233.750	3848.05	0.47
ALUMINUM	mg/kg	IHSS 201	CREEK	S	14	14	1.00			1900.00	33200.00	8030.714	7958.47	0.99
ALUMINUM	mg/kg	IHSS 202	CREEK	S	4	4	1.00			9110.00	15200.00	11227.500	2718.15	0.24
ALUMINUM	mg/kg	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ALUMINUM	mg/kg	CC-BM	LAKE	B						96700.00	96700.00			
URANIUM-238	pCi/g	BGCR	CREEK	B	30	30	1.00			0.27	3.82	1.400		
URANIUM-238	pCi/g	IHSS 200	CREEK	S	7	7	1.00			0.87	2.23	1.400	0.51	0.36
URANIUM-238	pCi/g	IHSS 201	CREEK	S	14	14	1.00			0.62	3.90	1.339	0.84	0.63
URANIUM-238	pCi/g	IHSS 202	CREEK	S	4	4	1.00			0.79	2.15	1.205	0.63	0.53
URANIUM-238	pCi/g	BM	LAKE	B						5.51		11.400		
URANIUM-238	pCi/g	IHSS 200	LAKE	S	35	35	1.00			0.31	4.40	1.339	0.70	0.52
URANIUM-238	pCi/g	IHSS 201	LAKE	S	37	37	1.00			0.20	2.42	1.223	0.70	0.57
URANIUM-238	pCi/g	IHSS 202	LAKE	S	15	15	1.00			0.86	3.30	1.502	0.57	0.38

BGCR = Background Geochemical Characterization Report (DOE, 1993c).
CC-BM = Cherry Creek Reservoir Surface Sediment (n=1) CCBA, 1994.
RMNP-BM = Rocky Mountain National Park Lakes Surface Sediment Data (Heit, et al., 1984).
RMNP-BMS = Rocky Mountain National Park Lakes Subsurface Sediment Data (Heit, et al., 1984).
Lowry = Lowry Landfill Site Background Data (Stream Sediment) (EPA, 1992a).
BM = Marston Lake, Ralston Reservoir, Sterling Quad, Greeley Quad, Surface Sediment Data.

IHSS = Individual Hazardous Substance Site.
B = Background.
S = OU 3 (onsite).

Table B-2
Summary Statistics for
Great Western Reservoir Subsurface Sediments
Comparison to Benchmark Data

Chemical Name	Units	DATA SOURCE		Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coefficient of Variation
METALS															
ALUMINUM	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			6340.00	26100.00	13893.70	5457.02	0.39
ALUMINUM	mg/kg	CC-BM	CC-BM	LAKE	B						96700.00	96700.00			
ALUMINUM	mg/kg	BGCR		CREEK	B	59	59	1.00			549.00	25200.00	5687.610	4912.73	
ALUMINUM	mg/kg	LOWRY	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ARSENIC	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			3.60	10.40	6.49	1.67	0.26
ARSENIC	mg/kg	CC-BM		LAKE	B						5.57	5.57			
ARSENIC	mg/kg	BGCR		CREEK	B	53	59	0.90			0.20	17.30	2.410	2.45	
ARSENIC	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								0.790	0.05	
ARSENIC	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								1.000		
ARSENIC	mg/kg	LOWRY		CREEK	B							16.50	4.810	3.95	
ARSENIC	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								2.50	0.200	
ARSENIC	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								2.50	0.300	
ARSENIC	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								8.40	0.200	
ARSENIC	mg/kg	RMNP-BM	THE LOCH	LAKE	B								1.40	0.200	
BARIUM	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			81.90	205.00	161.61	28.96	0.18
BARIUM	mg/kg	CC-BM		LAKE	B						591.00	591.00			
BARIUM	mg/kg	BGCR		CREEK	B	57	57	1.00			10.60	244.00	77.910	56.38	
BARIUM	mg/kg	LOWRY		CREEK	B							440.00	220.640	76.59	
BERYLLIUM	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			0.53	2.30	1.13	0.33	0.29
BERYLLIUM	mg/kg	CC-BM		LAKE	B						4.03	4.03			
BERYLLIUM	mg/kg	BGCR		CREEK	B	27	57	0.47			1.50	1.30	0.660	1.69	
BERYLLIUM	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								3.900	0.30	
BERYLLIUM	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								7.400		
BERYLLIUM	mg/kg	LOWRY		CREEK	B								2.10	1.04	
BERYLLIUM	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								3.90	1.00	
BERYLLIUM	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								5.00	3.00	
BERYLLIUM	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								9.30	1.10	
BERYLLIUM	mg/kg	RMNP-BM	THE LOCH	LAKE	B								7.40	1.30	
CADMIUM	mg/kg	OU 3	IHSS 200	LAKE	S	22	46	0.48	0.38	0.81	0.59	2.60	0.74	0.62	0.84
CADMIUM	mg/kg	CC-BM		LAKE	B										
CADMIUM	mg/kg	BGCR		CREEK	B	6	51	0.12			0.13	1.30	0.540	0.38	
CADMIUM	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								0.320	0.07	
CADMIUM	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								0.090		
CADMIUM	mg/kg	LOWRY		CREEK	B							3.80	1.040	0.99	
CADMIUM	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								0.700	0.04	
CADMIUM	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								0.500	0.20	
CADMIUM	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								0.340	0.03	
CADMIUM	mg/kg	RMNP-BM	THE LOCH	LAKE	B								0.320	0.05	
CALCIUM	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			3900.00	15400.00	7568.70	2482.67	0.33
CALCIUM	mg/kg	CC-BM		LAKE	B										
CALCIUM	mg/kg	BGCR		CREEK	B	58	59	0.98			93.50	17100.00	3658.240	4663.60	
CALCIUM	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								12.000	2.00	
CALCIUM	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								26.500		
CALCIUM	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								26.000	1.00	
CALCIUM	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								34.100	0.10	
CALCIUM	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								54.000	5.00	
CALCIUM	mg/kg	RMNP-BM	THE LOCH	LAKE	B								47.000	6.00	

Table B-2
Summary Statistics for
Great Western Reservoir Subsurface Sediments
Comparison to Benchmark Data

Chemical Name	Units	DATA SOURCE		Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coefficient of Variation
METALS															
ALUMINUM	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			6340.00	26100.00	13693.70	5457.02	0.39
ALUMINUM	mg/kg	CC-BM	CC-BM	LAKE	B						96700.00	96700.00			
ALUMINUM	mg/kg	BGCR		CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	LOWRY	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ARSENIC	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			3.60	10.40	6.49	1.67	0.26
ARSENIC	mg/kg	CC-BM		LAKE	B						5.57	5.57			
ARSENIC	mg/kg	BGCR		CREEK	B	53	59	0.90			0.20	17.30	2.410	2.45	
ARSENIC	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								0.790	0.05	
CESIUM	mg/kg	IHSS 200		LAKE	S	28	46	0.57	12.70	27.40	12.70	39.20	16.74	7.64	0.46
CESIUM	mg/kg	BGCR		CREEK	B	10	56	0.18				157.00	69.290	63.88	
CHROMIUM	mg/kg	IHSS 200		LAKE	S	46	46	1.00			6.80	28.10	15.03	5.50	0.37
CHROMIUM	mg/kg	BGCR		CREEK	B	47	59	0.80			0.48	29.70	8.130	7.42	
CHROMIUM	mg/kg	LOWRY		CREEK	B							22.90	12.350	5.54	
COBALT	mg/kg	IHSS 200		LAKE	S	46	46	1.00			5.90	12.20	9.35	1.38	0.15
COBALT	mg/kg	CC-BM		LAKE	B						21.30	21.30			
COBALT	mg/kg	BGCR		CREEK	B	43	59	0.73			0.30	15.00	5.040	3.29	
COBALT	mg/kg	LOWRY		CREEK	B							14.00	9.200	2.66	
COPPER	mg/kg	IHSS 200		LAKE	S	46	46	1.00			15.80	311.00	94.69	78.64	0.83
COPPER	mg/kg	CC-BM		LAKE	B						43.40	43.40			
COPPER	mg/kg	BGCR		CREEK	B	43	59	0.73			10.15	36.70	10.150	7.86	
COPPER	mg/kg	LOWRY		CREEK	B							48.30	17.560	8.98	
CYANIDE	mg/kg	IHSS 200		LAKE	S		46	0.00	0.34	0.75			0.491	0.20	
IRON	mg/kg	IHSS 200		LAKE	S	46	46	1.00			9330.00	25600.00	17028.91	4005.91	0.24
IRON	mg/kg	CC-BM		LAKE	B						49700.00	49700.00			
IRON	mg/kg	BGCR		CREEK	B	59	59	1.00			1040.00	31400.00	8852.830	6263.19	
IRON	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								1100.000	100.00	
IRON	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								1900.000		
IRON	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								1600.000	40.00	
IRON	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								2400.000	100.00	
IRON	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								6200.000	900.00	
IRON	mg/kg	RMNP-BM	THE LOCH	LAKE	B								2300.000	300.00	
LEAD	mg/kg	IHSS 200		LAKE	S	46	46	1.00			14.50	126.00	47.21	27.02	0.57
LEAD	mg/kg	CC-BM		LAKE	B						55.00	55.00			
LEAD	mg/kg	BGCR		CREEK	B	59	59	1.00			2.10	244.00	22.020	36.79	
LEAD	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								10.000	7.00	
LEAD	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								14.000		
LEAD	mg/kg	LOWRY		CREEK	B							380.00	28.290	68.79	
LEAD	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								43.000	0.00	
LEAD	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								26.000	2.00	
LEAD	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								14.000	2.00	
LITHIUM	mg/kg	IHSS 200		LAKE	S	46	46	1.00			5.40	19.60	11.68	3.90	0.33
LITHIUM	mg/kg	BGCR		CREEK	B	41	57	0.72			1.15	20.20	7.480	5.26	
MAGNESIUM	mg/kg	IHSS 200		LAKE	S	46	46	1.00			1850.00	5080.00	3340.22	842.84	0.25
MAGNESIUM	mg/kg	BGCR		CREEK	B	54	59	0.92			125.50	5850.00	1473.770	1252.57	

Table B-2
Summary Statistics for
Great Western Reservoir Subsurface Sediments
Comparison to Benchmark Data

Chemical Name	Units	DATA SOURCE		Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coefficient of Variation
METALS															
ALUMINUM	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			6340.00	26100.00	13893.70	5457.02	0.39
ALUMINUM	mg/kg	CC-BM	CC-BM	LAKE	B						96700.00	96700.00			
ALUMINUM	mg/kg	BGCR		CREEK	B	59	59	1.00			549.00	25200.00	5887.610	4912.73	
ALUMINUM	mg/kg	LOWRY	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ARSENIC	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			3.60	10.40	6.49	1.67	0.26
ARSENIC	mg/kg	CC-BM		LAKE	B						5.57	5.57			
ARSENIC	mg/kg	BGCR		CREEK	B	53	59	0.90			0.20	17.30	2.410	2.45	
ARSENIC	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								0.790	0.05	
MANGANESE	mg/kg	IHSS 200		LAKE	S	46	46	1.00			153.00	772.00	383.80	158.99	0.44
MANGANESE	mg/kg	CC-BM		LAKE	B						739.00	739.00			
MANGANESE	mg/kg	BGCR		CREEK	B	58	59	0.98			9.00	1280.00	227.820	215.48	
MANGANESE	mg/kg			CREEK	B							1560.00	605.100	281.38	
MERCURY	mg/kg	IHSS 200		LAKE	S	34	46	0.74	0.06	0.10	0.07	0.30	0.15	0.09	0.58
MERCURY	mg/kg	CC-BM		LAKE	B						0.06	0.06			
MERCURY	mg/kg	BGCR		CREEK	B	2	49	0.04			0.01	0.05	0.080	0.06	
MERCURY	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								0.030		
MERCURY	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								0.050		
MERCURY	mg/kg	LOWRY		CREEK	B							0.29	0.080	0.06	
MERCURY	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								0.030	0.01	
MERCURY	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								0.065	0.01	
MERCURY	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								0.050	0.00	
MERCURY	mg/kg	RMNP-BM	THE LOCH	LAKE	B								0.040	0.01	
MOLYBDENUM	mg/kg	IHSS 200		LAKE	S	13	46	0.28	0.43	0.93	0.84	5.00	0.87	1.11	1.28
MOLYBDENUM	mg/kg	CC-BM		LAKE	B						22.00	22.00			
MOLYBDENUM	mg/kg	BGCR		CREEK	B	16	58	0.28			0.33	9.60	4.470	5.23	
NICKEL	mg/kg	IHSS 200		LAKE	S	46	46	1.00			11.20	23.80	17.24	2.81	0.16
NICKEL	mg/kg	CC-BM		LAKE	B						26.20	26.20			
NICKEL	mg/kg	BGCR		CREEK	B	39	57	0.68			0.65	25.60	6.750	5.38	
NICKEL	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								4.200	0.08	
NICKEL	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								9.000		
NICKEL	mg/kg	LOWRY		CREEK	B							131.00	15.450	22.29	
NICKEL	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								9.600	0.20	
NICKEL	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								10.000	0.00	
NICKEL	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								12.300	0.60	
NICKEL	mg/kg	RMNP-BM	THE LOCH	LAKE	B								18.000	2.00	
POTASSIUM	mg/kg	IHSS 200		LAKE	S	46	46	1.00			973.00	4000.00	2155.07	804.89	0.37
POTASSIUM	mg/kg	CC-BM		LAKE	B						15100.00	15100.00			
POTASSIUM	mg/kg	BGCR		CREEK	B	43	58	0.74			57.00	3770.00	835.340	749.42	
SELENIUM	mg/kg	IHSS 200		LAKE	S	5	46	0.11	0.83	1.90	0.86	2.45	0.75	0.32	0.43
SELENIUM	mg/kg	CC-BM		LAKE	B						1.10	1.10			
SELENIUM	mg/kg	BGCR		CREEK	B	13	58	0.22			0.10	2.90	0.420	0.56	
SELENIUM	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								0.900	0.20	
SELENIUM	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								0.760		
SELENIUM	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								1.800	0.10	
SELENIUM	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								1.200	0.10	
SELENIUM	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								1.800	0.40	
SELENIUM	mg/kg	RMNP-BM	THE LOCH	LAKE	B								1.100	0.30	

Table B-2
Summary Statistics for
Great Western Reservoir Subsurface Sediments
Comparison to Benchmark Data

Chemical Name	Units	DATA SOURCE		Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coefficient of Variation
METALS															
ALUMINUM	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			6340.00	26100.00	13893.70	5457.02	0.39
ALUMINUM	mg/kg	CC-BM	CC-BM	LAKE	B						96700.00	96700.00			
ALUMINUM	mg/kg	BGCR		CREEK	B	59	59	1.00			549.00	25200.00	5687.810	4912.73	
ALUMINUM	mg/kg	LOWRY	LOWRY	CREEK	B							32100.00	13959.330	7080.88	
ARSENIC	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			3.60	10.40	6.49	1.67	0.26
ARSENIC	mg/kg	CC-BM		LAKE	B						5.57	5.57			
ARSENIC	mg/kg	BGCR		CREEK	B	53	59	0.90			0.20	17.30	2.410	2.45	
ARSENIC	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								0.790	0.05	
SILVER	mg/kg	IHSS 200		LAKE	S	35	46	0.76	0.92	1.90	1.00	16.50	3.48	3.85	1.11
SILVER	mg/kg	CC-BM		LAKE	B						0.05	0.05			
SILVER	mg/kg	BGCR		CREEK	B	2	54	0.04			0.20	3.40	0.660	0.52	
SODIUM	mg/kg	IHSS 200		LAKE	S	46	46	1.00			74.60	224.00	136.05	29.69	0.22
SODIUM	mg/kg	BGCR		CREEK	B	47	54	0.80			162.00	637.00	161.470	136.80	
STRONTIUM	mg/kg	IHSS 200		LAKE	S	46	46	1.00			35.00	88.40	61.05	12.54	0.21
STRONTIUM	mg/kg	CC-BM		LAKE	B						202.00	202.00			
STRONTIUM	mg/kg	BGCR		CREEK	B	48	58	0.83			2.80	421.00	36.380	59.87	
THALLIUM	mg/kg	IHSS 200		LAKE	S		46		0.36	1.20			0.35	0.12	0.35
THALLIUM	mg/kg	BGCR		CREEK	B	2	50	0.04				0.40	0.300	0.23	
TIN	mg/kg	IHSS 200		LAKE	S	17	46	0.37	1.60	3.30	1.70	6.00	2.16	1.47	0.68
TIN	mg/kg	BGCR		CREEK	B	16	54	0.30				27.10	7.640	6.09	
TIN	mg/kg	LOWRY		CREEK	B							15.50	13.670	2.02	
VANADIUM	mg/kg	IHSS 200		LAKE	S	46	46	1.00			17.20	60.40	36.11	11.28	0.31
VANADIUM	mg/kg	CC-BM		LAKE	B						115.00	115.00			
VANADIUM	mg/kg	BGCR		CREEK	B	53	57	0.93			2.00	73.00	18.330	14.30	
VANADIUM	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								15.000	3.00	
VANADIUM	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								32.800		
VANADIUM	mg/kg	LOWRY		CREEK	B							72.90	33.310	11.66	
VANADIUM	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								27.300	0.10	
VANADIUM	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								35.000	6.00	
VANADIUM	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								55.000	6.00	
VANADIUM	mg/kg	RMNP-BM	THE LOCH	LAKE	B								43.000	3.00	
ZINC	mg/kg	IHSS 200		LAKE	S	48	46	1.00			46.20	480.00	186.65	108.62	0.58
ZINC	mg/kg	CC-BM		LAKE	B						158.00	158.00			
ZINC	mg/kg	BGCR		CREEK	B	55	58.00	0.95			3.25	155.00	43.770	30.23	
ZINC	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								80.000	13.00	
ZINC	mg/kg	RMNP-BMS	L.LOUISE	LAKE	B								155.000		
ZINC	mg/kg	LOWRY		CREEK	B							728.00	76.750	124.61	
ZINC	mg/kg	RMNP-BM	L.HUSTED	LAKE	B								117.000	2.00	
ZINC	mg/kg	RMNP-BM	L.LOUISE	LAKE	B								125.000	3.00	
ZINC	mg/kg	RMNP-BM	L.HAIYAHA	LAKE	B								72.000	4.00	
ZINC	mg/kg	RMNP-BM	THE LOCH	LAKE	B								95.000	9.00	
RADIONUCLIDES															
AMERICIUM-241	pCi/g	OU 3	IHSS 200	LAKE	S	40	40	1.00			0.00	1.02	0.24	0.31	1.31
AMERICIUM-241	pCi/g		BGCR	CREEK	B	35	35	1.00			-0.01	0.82	0.070	0.19	

Table B-2
Summary Statistics for
Great Western Reservoir Subsurface Sediments
Comparison to Benchmark Data

Chemical Name	Units	DATA SOURCE		Lake or Creek	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coefficient of Variation
METALS															
ALUMINUM	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			6340.00	26100.00	13893.70	5457.02	0.39
ALUMINUM	mg/kg	CC-BM	CC-BM	LAKE	B						98700.00	98700.00			
ALUMINUM	mg/kg	BGCR		CREEK	B	59	59	1.00			549.00	25200.00	5687.610	4912.73	
ALUMINUM	mg/kg	LOWRY	LOWRY	CREEK	B							32100.00	13959.330	7060.88	
ARSENIC	mg/kg	OU 3	IHSS 200	LAKE	S	46	46	1.00			3.60	10.40	6.49	1.67	0.26
ARSENIC	mg/kg	CC-BM		LAKE	B						5.57	5.57			
ARSENIC	mg/kg	BGCR		CREEK	B	53	59	0.90			0.20	17.30	2.410	2.45	
ARSENIC	mg/kg	RMNP-BMS	L.HUSTED	LAKE	B								0.790	0.05	
PLUTONIUM-239/240	pCi/g	OU 3	IHSS 200	LAKE	S	60	60	1.00			0.00	4.03	0.73	1.07	1.46
PLUTONIUM-239/240	pCi/g		BGCR	CREEK	B	42	42	1.00			0.00	2.36	0.170	0.59	
PLUTONIUM-239/240	pCi/g		BM	LAKE	B						0.02	0.13	0.130		
PLUTONIUM-239/241	pCi/g	HR-BM	HALLIGAN	LAKE	B						0.02	0.05			
PLUTONIUM-239/242	pCi/g	WL-BM	WELLINGTON	LAKE	B						0.07	0.19			
POLONIUM-210	pCi/g	OU 3	IHSS 200	LAKE	S	41	41	1.00			1.05	3.14	2.00	0.53	0.26
URANIUM-233/234	pCi/g	OU 3	IHSS 200	LAKE	S	64	64	1.00			0.75	3.90	1.32	0.41	0.31
URANIUM-233/234	pCi/g		BGCR	CREEK	B	47	47	1.00			0.14	4.50	1.680	1.15	
URANIUM-233/234	pCi/g		BM	LAKE	B						5.51	11.400			
URANIUM-235	pCi/g	OU 3	IHSS 200	LAKE	S	64	64	1.00			-0.01	0.21	0.06	0.04	0.64
URANIUM-235	pCi/g		BGCR	CREEK	B	49	49	1.00			0.40	0.19	0.080	0.05	
URANIUM-235	pCi/g		BM	LAKE	B						5.51	11.400			
URANIUM-238	pCi/g	OU 3	IHSS 200	LAKE	S	64	64	1.00			0.72	3.30	1.37	0.37	0.27
URANIUM-238	pCi/g		BGCR	CREEK	B	36	36	1.00			0.27	3.82	1.400	1.03	
URANIUM-238	pCi/g		BM	LAKE	B						5.51	11.400			

B = Background.
BGCR = Background Geochemical Characterization Report (DOE, 1993c).
BM = Marston Lake, Ralston Reservoir, Sterling Quad, Greeley Quad, Surface Sediment Data.
CC-BM = Cherry Creek Reservoir Surface Sediment (n = 1) (CCSA, 1994).
HR-BM = Halligan Reservoir Subsurface Sediment Data (Cohen et al., 1990).
IHSS = Individual Hazardous Substance Site.
Lowry = Lowry Landfill Site Background Data (Stream Sediment) (EPA, 1992a).
RMNP-BM = Rocky Mountain National Park Lakes Surface Sediment Data (Helt, et al., 1984)
RMNP-BMS = Rocky Mountain National Park Lakes Subsurface Sediment Data (Helt, et al., 1984)
S = OU 3 (onsite).
WL-BM = Wellington Lake Subsurface Sediment Data (Cohen et al., 1990).

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Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean[1]	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
		µg/L	BM-LK	B		126					2627.00	187-865		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
DISSOLVED-METALS	CESIUM	µg/L	BGCR	B	9	97	0.09	2.00	2500.00	60.00	200.00	355.86	281.41	0.79
DISSOLVED-METALS	CESIUM	µg/L	CREEK	S	0	3	0.00	50.00	50.00			25.00		
DISSOLVED-METALS	CESIUM	µg/L	200	S	4	16	0.25	50.00	50.00	50.00	60.00	31.88	12.50	0.39
DISSOLVED-METALS	CESIUM	µg/L	201	S	5	18	0.28	50.00	50.00	50.00	80.00	34.72	17.19	0.50
DISSOLVED-METALS	CESIUM	µg/L	202	S	4	13	0.31	50.00	50.00	50.00	80.00	36.54	19.51	0.53
TOTAL-METALS	CESIUM	µg/L	BGCR	B	10	120	0.08	2.00	2500.00	50.00	400.00	241.78	184.80	0.76
TOTAL-METALS	CESIUM	µg/L	CREEK	S	0	8	0.00	50.00	500.00			109.38	116.45	1.06
TOTAL-METALS	CESIUM	µg/L	200	S	5	19	0.26	50.00	500.00	50.00	90.00	69.21	82.15	1.19
TOTAL-METALS	CESIUM	µg/L	201	S		20		50.00	50.00			25.00		
TOTAL-METALS	CESIUM	µg/L	202	S	3	13	0.23	50.00	50.00	50.00	80.00	33.85	17.93	0.53
DISSOLVED-METALS	CHROMIUM	µg/L	BGCR	B	9	89	0.10	2.00	20.00	2.10	14.80	3.24	2.69	0.83
DISSOLVED-METALS	CHROMIUM	µg/L	CREEK	S	0	3	0.00	3.70	3.70			1.85		
DISSOLVED-METALS	CHROMIUM	µg/L	200	S		16		2.60	3.70			1.54	0.26	0.18
DISSOLVED-METALS	CHROMIUM	µg/L	201	S	1	18	0.06	2.60	3.70	3.80	3.80	1.71	0.59	0.34
DISSOLVED-METALS	CHROMIUM	µg/L	202	S	1	13	0.08	2.60	3.70	3.40	3.40	1.67	0.59	0.35
DISSOLVED-METALS	CHROMIUM	µg/L	BM-CR	B		14		5.00	5.00					
DISSOLVED-METALS	CHROMIUM	µg/L	BM-LK	B		5					8.00			
TOTAL-METALS	CHROMIUM	µg/L	BM-CR	B		18		5.00	5.00		5.00			
TOTAL-METALS	CHROMIUM	µg/L	BM-LK	B		145				1.00	36.00	1.52-3.67		
TOTAL-METALS	CHROMIUM	µg/L	BGCR	B	19	120	0.16	2.00	13.50	2.10	18.80	3.64	2.98	0.82
TOTAL-METALS	CHROMIUM	µg/L	CREEK	S	1	8	0.13	2.00	3.70	2.90	2.90	1.59	0.66	0.41
TOTAL-METALS	CHROMIUM	µg/L	200	S	2	19	0.11	2.00	3.70	4.30	4.40	1.72	0.97	0.57
TOTAL-METALS	CHROMIUM	µg/L	201	S	2	20	0.10	2.60	3.70	2.60	2.90	1.70	0.48	0.28
TOTAL-METALS	CHROMIUM	µg/L	202	S	1	13	0.08	2.60	3.70	65.80	65.80	6.47	17.83	2.75
DISSOLVED-METALS	COBALT	µg/L	BGCR	B	3	86	0.03	2.00	50.00	2.40	4.60	4.88	6.26	1.28
DISSOLVED-METALS	COBALT	µg/L	CREEK	S	0	3	0.00	2.30	2.30			1.15		
DISSOLVED-METALS	COBALT	µg/L	200	S	1	16	0.06	1.30	2.30	1.90	1.90	0.95	0.36	0.38
DISSOLVED-METALS	COBALT	µg/L	201	S		18		1.30	2.30			0.90	0.26	0.29
DISSOLVED-METALS	COBALT	µg/L	202	S	1	13	0.08	1.30	2.30	1.80	1.80	0.93	0.36	0.39
TOTAL-METALS	COBALT	µg/L	BGCR	B	8	116	0.07	2.00	50.00	2.70	7.90	5.35	8.07	1.51
TOTAL-METALS	COBALT	µg/L	CREEK	S	0	8	0.00	1.30	2.70			1.10	0.29	0.27
TOTAL-METALS	COBALT	µg/L	200	S	3	19	0.16	1.30	2.70	1.50	2.60	1.14	0.47	0.42
TOTAL-METALS	COBALT	µg/L	201	S	2	20	0.10	1.30	2.30	1.30	1.90	0.97	0.34	0.35

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	16.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
TOTAL-METALS	COBALT	µg/L	202	S		13		1.30	2.30			0.84	0.25	0.30
TOTAL-METALS	COBALT	µg/L	BM-LK	B		5					4.00	1.00		
DISSOLVED-METALS	COPPER	µg/L	BGCR	B	48	124	0.39	2.00	25.70	2.40	28.00	6.07	5.12	0.84
DISSOLVED-METALS	COPPER	µg/L	CREEK	S	2	3	0.67	2.40	2.40	5.50	8.10	4.93	3.48	0.71
DISSOLVED-METALS	COPPER	µg/L	200	S	9	16	0.56	1.90	2.40	2.00	9.40	3.15	2.67	0.85
DISSOLVED-METALS	COPPER	µg/L	201	S	6	18	0.33	1.90	2.40	1.90	8.10	1.77	1.66	0.94
DISSOLVED-METALS	COPPER	µg/L	202	S	5	12	0.42	1.90	2.40	2.10	4.50	1.94	1.19	0.62
DISSOLVED-METALS	COPPER	µg/L	BM-CR	B		34		1.00			49.00			
TOTAL-METALS	COPPER	µg/L	BM-LK	B		166		1.00			31.00	2.5-5.97		
TOTAL-METALS	COPPER	µg/L	BGCR	B	47	121	0.39	2.00	25.60	2.60	15.50	5.35	4.21	0.79
TOTAL-METALS	COPPER	µg/L	CREEK	S	7	8	0.88	2.30	2.30	5.80	20.90	13.24	7.40	0.56
TOTAL-METALS	COPPER	µg/L	200	S	13	15	0.87	1.90	2.30	4.30	20.90	9.25	6.35	0.69
TOTAL-METALS	COPPER	µg/L	201	S	16	17	0.94	1.90	1.90	2.80	16.50	5.84	4.25	0.73
TOTAL-METALS	COPPER	µg/L	202	S	3	13	0.23	1.90	2.40	2.20	4.50	1.58	1.11	0.70
TOTAL-METALS	CYANIDE	µg/L	BGCR	B	2	25	0.08	1.50	20.00	2.00	2.50	2.50	2.72	1.09
TOTAL-METALS	CYANIDE	µg/L	200	S		15		10.00	10.00			5.00		
TOTAL-METALS	CYANIDE	µg/L	201	S	1	16	0.063	10.00	10.00	21.50	21.50	6.03	4.13	
TOTAL-METALS	CYANIDE	µg/L	202	S		13		10.00	10.00			5.00		
DISSOLVED-METALS	IRON	µg/L	BGCR	B	107	152	0.70	3.00	316.00	9.30	1060.00	145.45	177.80	1.22
DISSOLVED-METALS	IRON	µg/L	CREEK	S	3	3	1.00			19.80	228.00	122.27	104.14	0.85
DISSOLVED-METALS	IRON	µg/L	200	S	12	15	0.80	4.00	16.30	6.60	572.00	93.62	144.89	1.55
DISSOLVED-METALS	IRON	µg/L	201	S	12	15	0.80	16.30	16.30	11.00	228.00	36.10	54.28	1.50
DISSOLVED-METALS	IRON	µg/L	202	S	13	13	1.00			7.00	71.10	35.46	22.08	0.62
DISSOLVED-METALS	IRON	µg/L	BM-CR	B		33		10.00			1900.00			
DISSOLVED-METALS	IRON	µg/L	BM-LK	B		20					80.00			
TOTAL-METALS	IRON	µg/L	BM-CR	B		35		10.00			3300.00			
TOTAL-METALS	IRON	µg/L	BM-LK	B		191		10.00			1643.00	233-631		
TOTAL-METALS	IRON	µg/L	BGCR	B	147	157	0.94	82.75	478.00	9.70	26300.00	1261.17	2865.13	2.27
TOTAL-METALS	IRON	µg/L	CREEK	S	8	8	1.00			453.00	2340.00	1218.88	719.98	0.59
TOTAL-METALS	IRON	µg/L	200	S	19	19	1.00			40.70	2340.00	1115.04	685.21	0.61
TOTAL-METALS	IRON	µg/L	201	S	20	20	1.00			37.70	1150.00	401.56	332.31	0.83
TOTAL-METALS	IRON	µg/L	202	S	13	13	1.00			56.50	328.00	156.69	75.05	0.48

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		18		14.80	16.50			7.77	0.44	0.06
DISSOLVED-METALS	LEAD	µg/L	BGCR	B	25	112	0.22	0.40	13.10	0.70	7.20	1.29	1.22	0.94
DISSOLVED-METALS	LEAD	µg/L	CREEK	S	3	3	1.00			3.60	10.20	5.93	3.70	0.62
DISSOLVED-METALS	LEAD	µg/L	200	S	16	16	1.00			1.20	5.80	3.15	1.26	0.40
DISSOLVED-METALS	LEAD	µg/L	201	S	9	18	0.50	1.00	2.20	2.10	10.20	2.65	2.61	0.99
DISSOLVED-METALS	LEAD	µg/L	202	S	12	13	0.92	1.90	1.90	2.10	11.40	4.20	2.72	0.65
DISSOLVED-METALS	LEAD	µg/L	BM-CR	B		33		1.00			14.00			
TOTAL-METALS	LEAD	µg/L	BM-LK	B		125				1.00	888.00	2.75-86		
TOTAL-METALS	LEAD	µg/L	BGCR	B	52	131	0.40	0.70	11.60	0.80	21.00	1.94	2.32	1.20
TOTAL-METALS	LEAD	µg/L	CREEK	S	8	8	1.00			0.90	11.00	7.89	3.81	0.48
TOTAL-METALS	LEAD	µg/L	200	S	19	19	1.00			0.90	18.50	7.04	4.49	0.64
TOTAL-METALS	LEAD	µg/L	201	S	17	20	0.85	2.00	2.70	2.50	10.70	4.34	2.89	0.67
TOTAL-METALS	LEAD	µg/L	202	S	13	13	1.00			2.40	37.20	7.22	9.78	1.35
DISSOLVED-METALS	LITHIUM	µg/L	BGCR	B	51	118	0.43	1.00	101.00	1.30	12.80	15.97	20.53	1.29
DISSOLVED-METALS	LITHIUM	µg/L	CREEK	S	3	3	1.00			5.80	12.00	7.90	3.55	0.45
DISSOLVED-METALS	LITHIUM	µg/L	200	S	15	16	0.94	3.70	3.70	3.80	8.20	5.58	1.52	0.27
DISSOLVED-METALS	LITHIUM	µg/L	201	S	18	18	1.00			5.90	12.00	7.65	1.41	0.18
DISSOLVED-METALS	LITHIUM	µg/L	202	S	13	13	1.00			6.50	10.80	8.22	1.34	0.16
TOTAL-METALS	LITHIUM	µg/L	BGCR	B	59	126	0.47	2.00	100.00	2.00	15.50	11.76	17.38	1.48
TOTAL-METALS	LITHIUM	µg/L	CREEK	S	7	7	1.00			3.50	11.10	7.40	2.54	0.34
TOTAL-METALS	LITHIUM	µg/L	200	S	18	18	1.00			3.50	8.70	6.34	1.45	0.23
TOTAL-METALS	LITHIUM	µg/L	201	S	20	20	1.00			4.90	11.10	7.72	1.63	0.21
TOTAL-METALS	LITHIUM	µg/L	202	S	13	13	1.00			5.20	9.40	7.29	1.35	0.19
TOTAL-METALS	LITHIUM	µg/L	BM-LK	B		16					8.00	4.38		
DISSOLVED-METALS	MAGNESIUM	µg/L	BGCR	B	133	149	0.89	3300.00	5000.00	1890.00	17800.00	5004.04	1987.74	0.40
DISSOLVED-METALS	MAGNESIUM	µg/L	CREEK	S	3	3	1.00			3080.00	6310.00	4303.33	1751.69	0.41
DISSOLVED-METALS	MAGNESIUM	µg/L	200	S	16	16	1.00			3080.00	4320.00	3941.88	273.31	0.07
DISSOLVED-METALS	MAGNESIUM	µg/L	201	S	18	18	1.00			3520.00	6310.00	5331.11	546.30	0.10
DISSOLVED-METALS	MAGNESIUM	µg/L	202	S	13	13	1.00			5930.00	7160.00	6627.69	452.59	0.07
DISSOLVED-METALS	MAGNESIUM	µg/L	BM-LK	B		33					66000.00	8760.00		
TOTAL-METALS	MAGNESIUM	µg/L	BGCR	B	134	146	0.92	4100.00	5000.00	1870.00	16600.00	5125.31	1924.26	0.38
TOTAL-METALS	MAGNESIUM	µg/L	CREEK	S	8	8	1.00			2940.00	11100.00	5297.50	2771.48	0.52
TOTAL-METALS	MAGNESIUM	µg/L	200	S	19	19	1.00			2940.00	11100.00	4328.42	1689.44	0.39
TOTAL-METALS	MAGNESIUM	µg/L	201	S	20	20	1.00			3450.00	6480.00	5338.00	596.74	0.11
TOTAL-METALS	MAGNESIUM	µg/L	202	S	13	13	1.00			5820.00	7340.00	6568.46	586.74	0.09

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	198.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
TOTAL-METALS	MAGNESIUM	µg/L	BM-LK	B		98					27000.00	9400-17600		
DISSOLVED-METALS	MANGANESE	µg/L	BGCR	B	115	148	0.78	0.94	15.00	1.00	353.00	28.47	47.75	1.68
DISSOLVED-METALS	MANGANESE	µg/L	CREEK	S	3	3	1.00			4.80	63.10	42.00	32.31	0.77
DISSOLVED-METALS	MANGANESE	µg/L	200	S	16	16	1.00			0.90	94.20	19.01	31.20	1.64
DISSOLVED-METALS	MANGANESE	µg/L	201	S	14	18	0.78	0.90	0.90	1.60	1570.00	118.88	372.43	3.13
DISSOLVED-METALS	MANGANESE	µg/L	202	S	13	13	1.00			2.70	7.90	4.85	1.73	0.36
DISSOLVED-METALS	MANGANESE	µg/L	BM-CR	B		33		5.00			1800.00			
DISSOLVED-METALS	MANGANESE	µg/L	BM-LK	B		20					31.00			
TOTAL-METALS	MANGANESE	µg/L	BM-LK	B		197					400.00	43.22-216.5		
TOTAL-METALS	MANGANESE	µg/L	BGCR	B	138	151	0.91	1.30	15.00	1.00	4060.00	87.07	343.53	3.95
TOTAL-METALS	MANGANESE	µg/L	CREEK	S	8	8	1.00			97.00	307.00	169.00	70.21	
TOTAL-METALS	MANGANESE	µg/L	200	S	19	19	1.00			6.80	210.00	71.51	66.18	0.93
TOTAL-METALS	MANGANESE	µg/L	201	S	20	20	1.00			5.50	1580.00	155.99	357.73	2.29
TOTAL-METALS	MANGANESE	µg/L	202	S	13	13	1.00			11.80	37.00	21.96	8.28	0.38
TOTAL-METALS	MANGANESE	µg/L	BM-CR	B		35		5.00			1800.00			
DISSOLVED-METALS	MERCURY	µg/L	BGCR	B	8	82	0.10	0.10	0.20	0.22	0.44	0.12	0.07	0.59
DISSOLVED-METALS	MERCURY	µg/L	CREEK	S		3		0.20	0.20			0.10		
DISSOLVED-METALS	MERCURY	µg/L	200	S	5	16	0.31	0.20	0.20	0.13	0.13	0.11	0.01	0.13
DISSOLVED-METALS	MERCURY	µg/L	201	S		18		0.10	0.20			0.09	0.02	0.27
DISSOLVED-METALS	MERCURY	µg/L	202	S	2	13	0.15	0.10	0.20	0.20	0.20	0.10	0.05	0.54
DISSOLVED-METALS	MERCURY	µg/L	BM-CR	B		34		0.10			0.20			
TOTAL-METALS	MERCURY	µg/L	BM-LK	B		112		0.10			9.00	0.05-0.36		
TOTAL-METALS	MERCURY	µg/L	BGCR	B	9	122	0.07	0.10	0.42	0.20	1.40	0.13	0.16	1.21
TOTAL-METALS	MERCURY	µg/L	CREEK	S	2	8	0.25	0.20	0.20	0.12	0.12	0.11	0.01	0.09
TOTAL-METALS	MERCURY	µg/L	200	S		19		0.10	0.20			0.09	0.02	0.26
TOTAL-METALS	MERCURY	µg/L	201	S	3	20	0.15	0.10	0.20	0.12	0.82	0.13	0.16	1.28
TOTAL-METALS	MERCURY	µg/L	202	S	2	13	0.15	0.10	0.20	0.20	0.30	0.10	0.07	0.69
DISSOLVED-METALS	MOLYBDENUM	µg/L	BGCR	B	14	92	0.15	2.00	500.00	2.50	23.40	33.19	49.35	1.49
DISSOLVED-METALS	MOLYBDENUM	µg/L	CREEK	S	3	3	1.00			3.40	6.60	4.77	1.65	0.35
DISSOLVED-METALS	MOLYBDENUM	µg/L	200	S	16	16	1.00			2.00	7.00	4.64	1.49	0.32
DISSOLVED-METALS	MOLYBDENUM	µg/L	201	S	18	18	1.00			2.70	8.80	5.17	1.44	0.28
DISSOLVED-METALS	MOLYBDENUM	µg/L	202	S	2	13	0.15	1.70	2.70	2.70	3.10	1.36	0.73	0.54
TOTAL-METALS	MOLYBDENUM	µg/L	BGCR	B	12	125	0.10	2.00	100.00	2.10	20.30	12.13	17.41	1.44

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	36.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
TOTAL-METALS	MOLYBDENUM	µg/L	CREEK	S	6	8	0.75	3.50	3.50	3.50	7.40	4.53	2.07	0.46
TOTAL-METALS	MOLYBDENUM	µg/L	200	S	17	19	0.89	3.50	3.50	3.60	8.20	5.08	1.61	0.32
TOTAL-METALS	MOLYBDENUM	µg/L	201	S	20	20	1.00			3.30	7.70	5.29	1.35	0.25
TOTAL-METALS	MOLYBDENUM	µg/L	202	S	5	13	0.38	1.70	2.70	1.90	4.40	1.78	1.00	0.56
TOTAL-METALS	MOLYBDENUM	µg/L	BM-LK	B		20					60.00	8.35		
DISSOLVED-METALS	NICKEL	µg/L	BGCR	B	4	85	0.05	3.00	40.00	6.20	21.80	7.47	5.58	0.75
DISSOLVED-METALS	NICKEL	µg/L	CREEK	S	0	3	0.00	6.00	6.00			3.00		
DISSOLVED-METALS	NICKEL	µg/L	200	S	1	16	0.06	2.60	6.00	3.50	3.50	2.18	0.92	0.42
DISSOLVED-METALS	NICKEL	µg/L	201	S	3	18	0.17	2.60	6.00	2.80	3.40	2.44	0.84	0.34
DISSOLVED-METALS	NICKEL	µg/L	202	S	2	13	0.15	2.60	6.00	2.90	6.60	2.48	1.50	0.60
DISSOLVED-METALS	NICKEL	µg/L	BM-CR	B		34		10.00			20.00			
DISSOLVED-METALS	NICKEL	µg/L	BM-LK	B		20					10.00			
TOTAL-METALS	NICKEL	µg/L	BM-LK	B		123		10.00			25.00	3.0-6.3		
TOTAL-METALS	NICKEL	µg/L	BGCR	B	15	120	0.13	3.00	40.00	3.80	12.80	7.11	5.88	0.83
TOTAL-METALS	NICKEL	µg/L	CREEK	S	1	8	0.13	2.60	11.20	2.80	2.80	3.74	1.64	0.44
TOTAL-METALS	NICKEL	µg/L	200	S	6	19	0.32	2.60	11.20	2.70	6.50	3.32	1.59	0.48
TOTAL-METALS	NICKEL	µg/L	201	S	5	20	0.25	2.60	6.00	2.80	33.10	4.18	6.89	1.65
TOTAL-METALS	NICKEL	µg/L	202	S	4	13	0.31	2.60	6.00	2.80	23.00	4.56	6.02	1.32
DISSOLVED-METALS	PHOSPHORUS	µg/L	BGCR	B	4	6	0.67	80.00	296.00	102.00	398.00	163.50	122.37	0.75
TOTAL-METALS	PHOSPHORUS	µg/L	BGCR	B	1	6	0.17	101.00	456.00	157.00	157.00	110.42	68.30	0.62
DISSOLVED-METALS	POTASSIUM	µg/L	BGCR	B	86	125	0.69	390.00	5000.00	402.00	6800.00	1612.34	1011.90	0.63
DISSOLVED-METALS	POTASSIUM	µg/L	CREEK	S	3	3	1.00			1130.00	2170.00	1626.67	521.57	0.32
DISSOLVED-METALS	POTASSIUM	µg/L	200	S	16	16	1.00			1130.00	2030.00	1559.38	181.38	0.12
DISSOLVED-METALS	POTASSIUM	µg/L	201	S	18	18	1.00			1580.00	2170.00	1858.33	122.87	0.07
DISSOLVED-METALS	POTASSIUM	µg/L	202	S	13	13	1.00			141.00	640.00	412.77	202.77	0.49
TOTAL-METALS	POTASSIUM	µg/L	BGCR	B	93	128	0.73	380.00	5000.00	493.00	6700.00	1817.03	1058.86	0.58
TOTAL-METALS	POTASSIUM	µg/L	CREEK	S	8	8	1.00			1260.00	6390.00	2811.25	1821.01	0.62
TOTAL-METALS	POTASSIUM	µg/L	200	S	19	19	1.00			1340.00	6390.00	2051.05	1105.88	0.54
TOTAL-METALS	POTASSIUM	µg/L	201	S	20	20	1.00			1260.00	2370.00	1913.50	235.85	0.12
TOTAL-METALS	POTASSIUM	µg/L	202	S	13	13	1.00			147.00	740.00	420.31	211.72	0.50
TOTAL-METALS	POTASSIUM	µg/L	BM-LK	B		35					11000.00	2150-6900		
DISSOLVED-METALS	SELENIUM	µg/L	BGCR	B	7	84	0.08	0.80	20.00	0.85	8.60	1.58	1.72	1.09

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.36	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.68	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2827.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
DISSOLVED-METALS	SELENIUM	µg/L	CREEK	S	1	3	0.33	3.70	3.70	3.90	3.90	2.53	1.18	0.47
DISSOLVED-METALS	SELENIUM	µg/L	200	S		16		2.90	3.80			1.71	0.20	0.12
DISSOLVED-METALS	SELENIUM	µg/L	201	S	3	18	0.17	2.80	3.90	3.00	3.90	2.05	0.75	0.37
DISSOLVED-METALS	SELENIUM	µg/L	202	S	1	13	0.08	2.90	3.80	3.00	3.00	1.64	0.43	0.26
DISSOLVED-METALS	SELENIUM	µg/L	BM-CR	B		16		5.00						
TOTAL-METALS	SELENIUM	µg/L	BM-CR	B		18		5.00						
TOTAL-METALS	SELENIUM	µg/L	BM-LK	B		103		1.00			5.00			
TOTAL-METALS	SELENIUM	µg/L	BGCR	B	7	120	0.06	0.80	20.00	0.80	6.20	1.27	1.19	0.93
TOTAL-METALS	SELENIUM	µg/L	CREEK	S	0	8	0.00	0.80	3.90			1.33	0.77	0.58
TOTAL-METALS	SELENIUM	µg/L	200	S		19		0.80	3.80			1.47	0.50	0.34
TOTAL-METALS	SELENIUM	µg/L	201	S	1	20	0.05	2.80	3.90	5.30	5.30	2.06	0.77	0.38
TOTAL-METALS	SELENIUM	µg/L	202	S		13		2.90	3.80			1.66	0.20	0.12
DISSOLVED-METALS	SILICON	µg/L	200	S	16	16	1.00			469.00	3100.00	1413.06	782.73	0.55
DISSOLVED-METALS	SILICON	µg/L	CREEK	S	3	3	1.00			1240.00	3390.00	2576.67	1166.63	0.45
DISSOLVED-METALS	SILICON	µg/L	201	S	18	18	1.00			865.00	3390.00	1459.33	619.80	0.42
DISSOLVED-METALS	SILICON	µg/L	202	S	13	13	1.00			410.00	3330.00	1476.69	1154.47	0.78
TOTAL-METALS	SILICON	µg/L	BGCR	B	67	67	1.00			690.00	15200.00	6076.23	3377.17	0.56
TOTAL-METALS	SILICON	µg/L	CREEK	S	8	8	1.00			928.00	7770.00	4097.25	2484.62	0.61
TOTAL-METALS	SILICON	µg/L	200	S	19	19	1.00			544.00	7770.00	2469.89	2107.20	0.85
TOTAL-METALS	SILICON	µg/L	201	S	20	20	1.00			928.00	4040.00	1636.95	880.01	0.54
TOTAL-METALS	SILICON	µg/L	202	S	13	13	1.00			348.00	3250.00	1345.23	1107.18	0.82
DISSOLVED-METALS	SILVER	µg/L	BGCR	B	9	96	0.09	2.00	30.00	2.60	9.20	2.75	2.72	0.99
DISSOLVED-METALS	SILVER	µg/L	CREEK	S	1	3	0.33	2.30	2.30	3.80	3.80	2.03	1.53	0.75
DISSOLVED-METALS	SILVER	µg/L	200	S	5	16	0.31	2.30	3.60	2.50	3.80	2.04	0.65	0.32
DISSOLVED-METALS	SILVER	µg/L	201	S		14		2.30	3.60			1.38	0.32	0.23
DISSOLVED-METALS	SILVER	µg/L	202	S		13		2.30	3.60			1.55	0.33	0.21
DISSOLVED-METALS	SILVER	µg/L	BM-CR	B		34		0.10			6.00			
TOTAL-METALS	SILVER	µg/L	BM-LK	B		114		0.10			3.00			
TOTAL-METALS	SILVER	µg/L	BGCR	B	14	116	0.12	2.00	10.00	2.10	7.20	2.49	1.56	0.63
TOTAL-METALS	SILVER	µg/L	CREEK	S	0	8	0.00	2.10	3.60			1.28	0.33	0.26
TOTAL-METALS	SILVER	µg/L	200	S		19		2.10	3.60			1.44	0.35	0.24
TOTAL-METALS	SILVER	µg/L	201	S		16		2.30	3.60			1.43	0.33	0.23
TOTAL-METALS	SILVER	µg/L	202	S		13		2.30	3.60			1.55	0.33	0.21

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean[a]	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
DISSOLVED-METALS	SODIUM	µg/L	BGCR	B	151	152	0.99	17100.00	17100.00	4190.00	44700.00	17045.66	7281.65	0.43
DISSOLVED-METALS	SODIUM	µg/L	CREEK	S	3	3	1.00			5370.00	14200.00	8946.67	4647.65	0.52
DISSOLVED-METALS	SODIUM	µg/L	200	S	16	16	1.00			5370.00	8610.00	7980.00	745.48	0.09
DISSOLVED-METALS	SODIUM	µg/L	201	S	18	18	1.00			7270.00	14200.00	11770.56	1326.77	0.11
DISSOLVED-METALS	SODIUM	µg/L	202	S	13	13	1.00			27100.00	32500.00	29761.54	1875.07	0.06
TOTAL-METALS	SODIUM	µg/L	BGCR	B	154	155	0.99	5000.00	5000.00	3700.00	45400.00	16568.90	7500.07	0.45
TOTAL-METALS	SODIUM	µg/L	CREEK	S	8	8	1.00			4610.00	40000.00	12688.00	11709.00	0.92
TOTAL-METALS	SODIUM	µg/L	200	S	19	19	1.00			4610.00	40000.00	9351.05	7531.34	0.81
TOTAL-METALS	SODIUM	µg/L	201	S	20	20	1.00			6940.00	415000.00	31817.00	90201.58	2.84
TOTAL-METALS	SODIUM	µg/L	202	S	13	13	1.00			27000.00	31200.00	29076.92	1494.52	0.05
TOTAL-METALS	SODIUM	µg/L	BM-LK	B		36					54000.00	12600-54000		
DISSOLVED-METALS	STRONTIUM	µg/L	BGCR	B	112	138	0.81	100.00	1000.00	39.90	438.00	190.88	145.58	0.76
DISSOLVED-METALS	STRONTIUM	µg/L	CREEK	S	3	3	1.00			96.20	189.00	129.07	51.98	0.40
DISSOLVED-METALS	STRONTIUM	µg/L	200	S	16	16	1.00			96.20	147.00	130.45	13.03	0.10
DISSOLVED-METALS	STRONTIUM	µg/L	201	S	18	18	1.00			102.00	189.00	159.00	16.95	0.11
DISSOLVED-METALS	STRONTIUM	µg/L	202	S	13	13	1.00			114.00	137.00	124.62	7.54	0.06
TOTAL-METALS	STRONTIUM	µg/L	BGCR	B	117	135	0.87	100.00	1000.00	37.40	408.00	177.31	130.50	0.74
TOTAL-METALS	STRONTIUM	µg/L	CREEK	S	8	8	1.00			77.90	306.00	150.61	77.86	0.52
TOTAL-METALS	STRONTIUM	µg/L	200	S	19	19	1.00			77.90	306.00	135.66	45.80	0.34
TOTAL-METALS	STRONTIUM	µg/L	201	S	20	20	1.00			98.40	186.00	157.42	17.74	0.11
TOTAL-METALS	STRONTIUM	µg/L	202	S	13	13	1.00			114.00	132.00	122.69	6.01	0.05
TOTAL-METALS	STRONTIUM	µg/L	BM-LK	B		16					456.00	248.94		
DISSOLVED-METALS	THALLIUM	µg/L	BGCR	B	2	97	0.02	0.90	15.00	1.20	1.20	1.63	1.48	0.90
DISSOLVED-METALS	THALLIUM	µg/L	CREEK	S	0	3	0.00	0.90	0.90			0.45		
DISSOLVED-METALS	THALLIUM	µg/L	200	S		16		0.90	4.30			1.82	0.48	0.26
DISSOLVED-METALS	THALLIUM	µg/L	201	S		18		0.90	1.60			0.64	0.12	0.19
DISSOLVED-METALS	THALLIUM	µg/L	202	S		13		0.90	4.50			1.16	0.69	0.60
TOTAL-METALS	THALLIUM	µg/L	BGCR	B	3	124	0.02	0.60	40.00	1.60	3.40	1.68	2.15	1.28
TOTAL-METALS	THALLIUM	µg/L	CREEK	S	0	8	0.00	0.90	1.80			0.67	0.21	0.31
TOTAL-METALS	THALLIUM	µg/L	200	S		19		0.90	4.30			1.68	0.56	0.33
TOTAL-METALS	THALLIUM	µg/L	201	S		20		0.90	1.60			0.64	0.11	0.18
TOTAL-METALS	THALLIUM	µg/L	202	S		13		0.90	4.50			1.23	0.77	0.62
TOTAL-METALS	THALLIUM	µg/L	BM-LK	B		18					12.00			

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
DISSOLVED-METALS	TIN	µg/L	BGCR	B	17	98	0.17	9.30	136.00	10.80	72.40	27.74	21.15	0.76
DISSOLVED-METALS	TIN	µg/L	CREEK	S	0	3	0.00	12.50	12.50			6.25		
DISSOLVED-METALS	TIN	µg/L	200	S		16		6.20	12.50			4.48	1.61	0.36
DISSOLVED-METALS	TIN	µg/L	201	S	5	17	0.29	6.20	12.50	6.30	13.70	7.01	3.09	0.44
DISSOLVED-METALS	TIN	µg/L	202	S	1	13	0.08	6.20	12.50	8.10	8.10	4.70	1.86	0.40
TOTAL-METALS	TIN	µg/L	BGCR	B	18	118	0.15	7.00	136.00	11.00	180.00	19.61	22.01	1.12
TOTAL-METALS	TIN	µg/L	CREEK	S	0	8	0.00	6.20	12.50			4.88	1.31	0.27
TOTAL-METALS	TIN	µg/L	200	S	3	19	0.16	6.20	12.50	7.00	9.70	5.41	2.08	0.38
TOTAL-METALS	TIN	µg/L	201	S		20		6.20	12.50			4.52	1.61	0.36
TOTAL-METALS	TIN	µg/L	202	S	1	13	0.08	6.20	12.50	6.50	6.50	4.57	1.66	0.36
DISSOLVED-METALS	VANADIUM	µg/L	BGCR	B	13	106	0.12	2.00	50.00	2.00	12.10	4.20	5.55	1.32
DISSOLVED-METALS	VANADIUM	µg/L	CREEK	S	0	3	0.00	3.30	3.30			1.65	0.00	0.00
DISSOLVED-METALS	VANADIUM	µg/L	200	S	2	16	0.13	2.50	3.30	2.70	3.40	1.65	0.59	0.36
DISSOLVED-METALS	VANADIUM	µg/L	201	S		18		2.50	3.30			1.45	0.21	0.14
DISSOLVED-METALS	VANADIUM	µg/L	202	S	6	13	0.46	2.50	3.30	2.90	6.10	2.76	1.59	0.58
TOTAL-METALS	VANADIUM	µg/L	BGCR	B	33	120	0.28	2.00	60.00	2.00	18.20	6.64	8.22	1.24
TOTAL-METALS	VANADIUM	µg/L	CREEK	S	2	8	0.25	2.50	3.50	3.80	4.80	2.29	1.28	0.56
TOTAL-METALS	VANADIUM	µg/L	200	S	10	19	0.53	2.50	3.50	2.80	8.00	3.15	2.08	0.66
TOTAL-METALS	VANADIUM	µg/L	201	S	1	20	0.05	2.50	3.30	3.80	3.80	1.56	0.56	0.36
TOTAL-METALS	VANADIUM	µg/L	202	S	6	13	0.46	2.50	3.30	2.50	6.40	2.60	1.56	0.60
DISSOLVED-METALS	ZINC	µg/L	BGCR	B	86	138	0.62	1.70	44.00	2.40	111.50	14.08	18.21	1.29
DISSOLVED-METALS	ZINC	µg/L	CREEK	S	3	3	1.00			13.30	44.90	28.00	15.91	0.57
DISSOLVED-METALS	ZINC	µg/L	200	S	8	16	0.50	5.70	10.10	5.80	30.40	10.63	9.35	0.88
DISSOLVED-METALS	ZINC	µg/L	201	S	12	18	0.67	5.70	10.10	7.00	44.90	11.74	9.49	0.81
DISSOLVED-METALS	ZINC	µg/L	202	S	8	13	0.62	5.70	10.10	5.70	143.00	18.46	37.80	2.05
DISSOLVED-METALS	ZINC	µg/L	BM-CR	B		34		5.00			670.00			
DISSOLVED-METALS	ZINC	µg/L	BM-LK	B		20					20.00			
TOTAL-METALS	ZINC	µg/L	BM-LK	B		144				1.00	89.00	16.46-27		
TOTAL-METALS	ZINC	µg/L	BGCR	B	104	151	0.69	1.70	60.40	1.90	480.00	32.74	62.29	1.90
TOTAL-METALS	ZINC	µg/L	CREEK	S	8	8	1.00			15.00	158.00	91.58	59.59	0.65
TOTAL-METALS	ZINC	µg/L	200	S	19	19	1.00			13.80	158.00	46.46	44.32	0.91
TOTAL-METALS	ZINC	µg/L	201	S	17	20	0.85	10.10	10.10	12.80	184.00	38.60	47.49	1.23
TOTAL-METALS	ZINC	µg/L	202	S	7	13	0.54	5.70	10.10	6.60	18.00	8.18	5.49	0.67

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.68	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
RADIONUCLIDES														
DISSOLVED-RADS	AMERICIUM-241	pCi/L	BGCR	B	34	34	1.00			-0.010	0.500	0.070	0.129	1.83
DISSOLVED-RADS	AMERICIUM-241	pCi/L	CREEK	S	3	3	1.00			-0.002	0.003	0.001	0.003	3.77
DISSOLVED-RADS	AMERICIUM-241	pCi/L	200	S	14	14	1.00			-0.003	0.018	0.004	0.005	1.56
DISSOLVED-RADS	AMERICIUM-241	pCi/L	201	S	14	14	1.00			-0.004	0.013	0.003	0.005	1.39
DISSOLVED-RADS	AMERICIUM-241	pCi/L	202	S	12	12	1.00			-0.019	0.116	0.013	0.034	2.63
TOTAL-RADS	AMERICIUM-241	pCi/L	BGCR	B	106	106	1.00			-0.021	0.038	0.004	0.008	1.93
TOTAL-RADS	AMERICIUM-241	pCi/L	BM-LK	B		48					0.117	(-)0.013-0.019		
TOTAL-RADS	AMERICIUM-241	pCi/L	CREEK	S	5	5	1.00			-0.001	0.007	0.004	0.003	0.78
TOTAL-RADS	AMERICIUM-241	pCi/L	200	S	16	16	1.00			-0.005	0.017	0.005	0.005	1.00
TOTAL-RADS	AMERICIUM-241	pCi/L	201	S	17	17	1.00			-0.001	0.026	0.006	0.007	1.04
TOTAL-RADS	AMERICIUM-241	pCi/L	202	S	12	12	1.00			0.000	0.017	0.006	0.005	0.86
DISSOLVED-RADS	GROSS ALPHA	pCi/L	BGCR	B	60	60	1.00			-1.380	5.000	0.687	1.123	1.63
DISSOLVED-RADS	GROSS ALPHA	pCi/L	200	S	16	16	1.00			-0.420	2.700	0.485	0.716	1.48
DISSOLVED-RADS	GROSS ALPHA	pCi/L	201	S	15	15	1.00			-0.580	1.400	0.782	0.473	0.60
DISSOLVED-RADS	GROSS ALPHA	pCi/L	202	S	12	12	1.00			-0.130	1.900	0.496	0.545	1.10
TOTAL-RADS	GROSS ALPHA	pCi/L	BGCR	B	85	85	1.00			-2.000	13.000	1.513	2.238	1.48
TOTAL-RADS	GROSS ALPHA	pCi/L	200	S	15	15	1.00			0.072	2.200	1.124	0.727	0.65
TOTAL-RADS	GROSS ALPHA	pCi/L	201	S	15	15	1.00			0.440	1.900	1.178	0.489	0.41
TOTAL-RADS	GROSS ALPHA	pCi/L	202	S	11	11	1.00			-0.250	1.200	0.520	0.445	0.86
DISSOLVED-RADS	GROSS BETA	pCi/L	BGCR	B	61	61	1.00			-0.676	41.820	4.687	6.777	1.45
DISSOLVED-RADS	GROSS BETA	pCi/L	200	S	16	16	1.00			0.080	2.900	1.621	0.831	0.51
DISSOLVED-RADS	GROSS BETA	pCi/L	201	S	15	15	1.00			-0.140	4.300	1.956	1.025	0.52
DISSOLVED-RADS	GROSS BETA	pCi/L	202	S	12	12	1.00			-0.250	2.100	0.762	0.735	0.96
TOTAL-RADS	GROSS BETA	pCi/L	BGCR	B	82	82	1.00			-0.400	36.000	4.552	5.520	1.21
TOTAL-RADS	GROSS BETA	pCi/L	200	S	18	18	1.00			0.270	4.700	2.776	1.304	0.47
TOTAL-RADS	GROSS BETA	pCi/L	201	S	20	20	1.00			-0.010	4.300	2.177	1.108	0.51
TOTAL-RADS	GROSS BETA	pCi/L	202	S	13	13	1.00			-2.100	3.000	0.821	1.421	1.73
DISSOLVED-RADS	PLUTONIUM-239/240	pCi/L	BGCR	B	36	36	1.00			-0.123	0.900	0.116	0.204	1.76
DISSOLVED-RADS	PLUTONIUM-239/240	pCi/L	BM-LK	B		55					0.206	0.004-0.016		
DISSOLVED-RADS	PLUTONIUM-239/240	pCi/L	CREEK	S	2	2	1.00			0.004	0.008	0.006	0.001	0.28
DISSOLVED-RADS	PLUTONIUM-239/240	pCi/L	200	S	9	9	1.00			-0.003	0.002	0.000	0.002	-7.82
DISSOLVED-RADS	PLUTONIUM-239/240	pCi/L	201	S	13	13	1.00			-0.002	0.009	0.002	0.003	1.30

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
DISSOLVED-RADS	PLUTONIUM-239/240	pCi/L	202	S	10	10	1.00			-0.001	0.003	0.001	0.001	1.91
TOTAL-RADS	PLUTONIUM-239/240	pCi/L	BGCR	B	105	105	1.00			-0.016	0.048	0.004	0.008	1.96
TOTAL-RADS	PLUTONIUM-239/240	pCi/L	CREEK	S	7	7	1.00			-0.001	0.001	0.000	0.001	2.65
TOTAL-RADS	PLUTONIUM-239/240	pCi/L	200	S	13	13	1.00			-0.001	0.005	0.002	0.002	0.80
TOTAL-RADS	PLUTONIUM-239/240	pCi/L	201	S	19	19	1.00			0.000	0.009	0.002	0.002	1.08
TOTAL-RADS	PLUTONIUM-239/240	pCi/L	202	S	12	12	1.00			-0.005	0.030	0.005	0.010	1.84
TOTAL-RADS	TRITIUM	pCi/L	BGCR	B	73	73	1.00			-800.000	751.000	75.705	209.217	2.76
TOTAL-RADS	TRITIUM	pCi/L	BM-LK	B		60					147.000	(-)19-147		
TOTAL-RADS	TRITIUM	pCi/L	200	S	5	5	1.00			-29.100	144.300	47.776	83.228	1.74
DISSOLVED-RADS	URANIUM-233/234	pCi/L	BGCR	B	55	55	1.00			-0.016	1.800	0.359	0.365	1.01
DISSOLVED-RADS	URANIUM-233/234	pCi/L	CREEK	S	2	2	1.00			0.480	0.480	0.480		
DISSOLVED-RADS	URANIUM-233/234	pCi/L	200	S	12	12	1.00			0.140	0.560	0.418	0.124	0.30
DISSOLVED-RADS	URANIUM-233/234	pCi/L	201	S	12	12	1.00			0.430	1.200	0.741	0.227	0.31
DISSOLVED-RADS	URANIUM-233/234	pCi/L	202	S	10	10	1.00			0.170	0.699	0.350	0.182	0.52
TOTAL-RADS	URANIUM-233/234	pCi/L	BGCR	B	79	79	1.00			-0.007	3.213	0.486	0.550	1.13
TOTAL-RADS	URANIUM-233/234	pCi/L	BM-LK	B		56					2.100	0.32-1.3		
TOTAL-RADS	URANIUM-233/234	pCi/L	CREEK	S	6	6	1.00			0.078	1.273	0.693	0.532	0.77
TOTAL-RADS	URANIUM-233/234	pCi/L	200	S	12	12	1.00			0.190	1.200	0.609	0.313	0.51
TOTAL-RADS	URANIUM-233/234	pCi/L	201	S	20	20	1.00			0.078	1.300	0.749	0.354	0.47
TOTAL-RADS	URANIUM-233/234	pCi/L	202	S	13	13	1.00			0.080	0.820	0.388	0.238	0.61
DISSOLVED-RADS	URANIUM-235	pCi/L	BGCR	B	56	56	1.00			-0.018	0.895	0.140	0.203	1.45
DISSOLVED-RADS	URANIUM-235	pCi/L	CREEK	S	2	2	1.00			0.000	0.310	0.155	0.219	1.41
DISSOLVED-RADS	URANIUM-235	pCi/L	200	S	12	12	1.00			-0.081	0.510	0.072	0.168	2.33
DISSOLVED-RADS	URANIUM-235	pCi/L	201	S	12	12	1.00			-0.004	0.710	0.146	0.257	1.76
DISSOLVED-RADS	URANIUM-235	pCi/L	202	S	10	10	1.00			-0.198	0.140	0.020	0.094	4.73
TOTAL-RADS	URANIUM-235	pCi/L	BGCR	B	75	75	1.00			-0.030	0.376	0.049	0.075	1.52
TOTAL-RADS	URANIUM-235	pCi/L	BM-LK	B		8					0.100			
TOTAL-RADS	URANIUM-235	pCi/L	CREEK	S	6	6	1.00			0.000	0.170	0.081	0.075	0.92
TOTAL-RADS	URANIUM-235	pCi/L	200	S	12	12	1.00			-0.039	0.410	0.082	0.125	1.53
TOTAL-RADS	URANIUM-235	pCi/L	201	S	20	20	1.00			-0.021	0.270	0.070	0.074	1.06
TOTAL-RADS	URANIUM-235	pCi/L	202	S	13	13	1.00			-0.028	0.145	0.032	0.059	1.83
DISSOLVED-RADS	URANIUM-238	pCi/L	BGCR	B	55	55	1.00			0.000	1.700	0.277	0.270	0.98

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean*	Standard Deviation	Coefficient of Variation
NOTE:														
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METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	36.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
DISSOLVED-RADS	URANIUM-238	pCi/L	BM-LK	B	10						2.000	0.910		
DISSOLVED-RADS	URANIUM-238	pCi/L	CREEK	S	2	2	1.00			0.380	0.410	0.395	0.021	0.05
DISSOLVED-RADS	URANIUM-238	pCi/L	200	S	12	12	1.00			-0.046	0.580	0.296	0.186	0.63
DISSOLVED-RADS	URANIUM-238	pCi/L	201	S	12	12	1.00			-0.043	0.730	0.408	0.236	0.58
DISSOLVED-RADS	URANIUM-238	pCi/L	202	S	10	10	1.00			-0.255	0.420	0.135	0.193	1.43
TOTAL-RADS	URANIUM-238	pCi/L	BGCR	B	55	55	1.00			0.000	1.820	0.364	0.432	1.18
TOTAL-RADS	URANIUM-238	pCi/L	BM-LK	B		56					5.500	0.28-1.49		
TOTAL-RADS	URANIUM-238	pCi/L	CREEK	S	6	6	1.00			-0.022	0.870	0.524	0.333	0.64
TOTAL-RADS	URANIUM-238	pCi/L	200	S	12	12	1.00			-0.024	0.870	0.433	0.225	0.52
TOTAL-RADS	URANIUM-238	pCi/L	201	S	20	20	1.00			-0.022	1.100	0.618	0.292	0.47
TOTAL-RADS	URANIUM-238	pCi/L	202	S	12	12	1.00			0.091	0.650	0.285	0.168	0.59

*For benchmark data, range of means is presented.
B = Background.
BGCR = Background Geochemical Characterization Report (1993c).
S = OU 3 (onsite).

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean[a]	Standard Deviation	Coefficient of Variation
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DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	988.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
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TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.66	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		16		14.80	16.50			7.77	0.44	0.06
DISSOLVED-METALS	ANTIMONY	µg/L	201	S		17		14.80	16.50			7.80	0.44	0.06
DISSOLVED-METALS	ANTIMONY	µg/L	202	S		13		14.80	16.50			7.73	0.43	0.06
TOTAL-METALS	ANTIMONY	µg/L	BGCR	B	13	119	0.11	7.00	60.00	7.30	54.80	14.28	9.72	0.68
TOTAL-METALS	ANTIMONY	µg/L	CREEK	S	0	8	0.00	14.80	19.80			8.66	1.09	0.13
TOTAL-METALS	ANTIMONY	µg/L	200	S		19		14.80	19.80			8.11	0.89	0.11
TOTAL-METALS	ANTIMONY	µg/L	201	S		20		14.80	16.50			7.78	0.43	0.06
TOTAL-METALS	ANTIMONY	µg/L	202	S		13		14.80	16.50			7.73	0.43	0.06
TOTAL-METALS	ANTIMONY	µg/L	BM-LK	B		46					86.00			
DISSOLVED-METALS	ARSENIC	µg/L	BGCR	B	4	93	0.04	0.70	10.00	0.90	1.60	1.27	1.26	1.00
DISSOLVED-METALS	ARSENIC	µg/L	CREEK	S	0	3	0.00	2.60	2.60			1.30		
DISSOLVED-METALS	ARSENIC	µg/L	200	S	3	16	0.19	1.90	2.90	2.40	2.40	1.46	0.51	0.35
DISSOLVED-METALS	ARSENIC	µg/L	201	S	1	18	0.06	1.90	3.20	2.90	2.90	1.36	0.46	0.34
DISSOLVED-METALS	ARSENIC	µg/L	202	S	13	13	1.00			2.90	6.30	4.14	0.99	0.24
DISSOLVED-METALS	ARSENIC	µg/L	BM-CR	B		16		5.00	5.00					
DISSOLVED-METALS	ARSENIC	µg/L	BM-LK	B		5					1.00			
TOTAL-METALS	ARSENIC	µg/L	BGCR	B	15	110	0.14	0.50	11.50	1.00	2.90	1.59	1.55	0.98
TOTAL-METALS	ARSENIC	µg/L	CREEK	S	3	8	0.38	2.60	3.20	0.70	1.30	1.25	0.31	0.25
TOTAL-METALS	ARSENIC	µg/L	200	S	6	19	0.32	1.90	2.90	0.70	2.90	1.32	0.59	0.44
TOTAL-METALS	ARSENIC	µg/L	201	S		20		2.20	3.20			1.45	0.18	0.13
TOTAL-METALS	ARSENIC	µg/L	202	S	13	13	1.00			3.10	6.60	4.92	0.94	0.19
TOTAL-METALS	ARSENIC	µg/L	BM-CR	B		18		5.00	5.00					
TOTAL-METALS	ARSENIC	µg/L	BM-LK	B		106					10.00			
DISSOLVED-METALS	BARIUM	µg/L	BGCR	B	102	144	0.71	24.50	200.00	18.80	391.00	48.63	34.98	0.72
DISSOLVED-METALS	BARIUM	µg/L	CREEK	S	3	3	1.00			20.70	43.10	28.40	12.74	0.45
DISSOLVED-METALS	BARIUM	µg/L	200	S	16	16	1.00			20.70	48.90	37.01	6.39	0.17
DISSOLVED-METALS	BARIUM	µg/L	201	S	18	18	1.00			21.40	43.10	35.11	4.18	0.12
DISSOLVED-METALS	BARIUM	µg/L	202	S	13	13	1.00			20.30	31.40	24.69	3.31	0.13
TOTAL-METALS	BARIUM	µg/L	BGCR	B	112	131	0.85	46.50	200.00	28.40	306.00	63.69	31.66	0.50
TOTAL-METALS	BARIUM	µg/L	CREEK	S	8	8	1.00			25.40	80.10	37.84	18.36	0.49
TOTAL-METALS	BARIUM	µg/L	200	S	19	19	1.00			27.00	80.10	43.09	11.49	0.27
TOTAL-METALS	BARIUM	µg/L	201	S	20	20	1.00			25.40	44.50	35.89	4.52	0.13
TOTAL-METALS	BARIUM	µg/L	202	S	13	13	1.00			20.40	34.70	25.98	3.60	0.14
TOTAL-METALS	BARIUM	µg/L	BM-LK	B		75					250.00	47-103		

Table B-3
Comparison to Benchmark Data
Surface Water

Main Test Group Code	Chemical Name	New Unit	Data Source	Area	Number of Detects	Number of Samples	Frequency of Detection	Minimum Nondetected Value	Maximum Nondetected Value	Minimum Detected value	Maximum Detected Value	Mean[a]	Standard Deviation	Coefficient of Variation
NOTE:														
BM-CR = Benchmark Stream Values (Ralston Creek, Croke Canal, Farmer's Highline canal (Arvada, 1994))														
BM-LK = Benchmark Lakes/Reservoir Values (Chatfield Reservoir, Cherry Creek, Bear Creek Lake, and Harriman Lake (Arvada, 1994; EPA, 1993 and 1994))														
METALS														
DISSOLVED-METALS	ALUMINUM	µg/L	BGCR	B	56	133	0.42	9.00	454.00	13.30	1050.00	87.33	160.32	1.84
DISSOLVED-METALS	ALUMINUM	µg/L	CREEK	S	2	3	0.67	17.30	17.30	455.00	739.00	400.88	368.17	0.92
DISSOLVED-METALS	ALUMINUM	µg/L	200	S	12	16	0.75	14.70	17.30	15.20	3230.00	448.56	938.07	2.09
DISSOLVED-METALS	ALUMINUM	µg/L	201	S	12	17	0.71	14.70	17.30	16.40	455.00	70.16	140.78	2.01
DISSOLVED-METALS	ALUMINUM	µg/L	202	S	5	13	0.38	14.70	17.30	17.50	47.80	16.35	14.61	0.89
TOTAL-METALS	ALUMINUM	µg/L	BGCR	B	106	139	0.76	18.70	968.00	25.00	6560.00	758.89	1360.09	1.79
TOTAL-METALS	ALUMINUM	µg/L	CREEK	S	8	8	1.00			344.00	1990.00	1042.88	668.61	0.64
TOTAL-METALS	ALUMINUM	µg/L	200	S	19	19	1.00			32.20	4260.00	1402.48	1035.07	0.74
TOTAL-METALS	ALUMINUM	µg/L	201	S	20	20	1.00			65.20	1540.00	404.47	356.02	0.88
TOTAL-METALS	ALUMINUM	µg/L	202	S	13	13	1.00			25.90	196.00	92.55	55.68	0.60
TOTAL-METALS	ALUMINUM	µg/L	BM-LK	B		126					2627.00	187-665		
DISSOLVED-METALS	ANTIMONY	µg/L	BGCR	B	20	91	0.22	7.50	104.00	7.50	35.10	15.91	10.14	0.64
DISSOLVED-METALS	ANTIMONY	µg/L	CREEK	S	0	2	0.00	16.50	16.50			8.25		
DISSOLVED-METALS	ANTIMONY	µg/L	200	S		18		14.80	16.50			7.77	0.44	0.06
DISSOLVED-METALS	BERYLLIUM	µg/L	BGCR	B	8	89	0.09	0.20	8.00	0.65	17.00	1.08	1.88	1.74
DISSOLVED-METALS	BERYLLIUM	µg/L	CREEK	S	0	3	0.00	0.40	0.40			0.20		
DISSOLVED-METALS	BERYLLIUM	µg/L	200	S		18		0.30	0.40			0.17	0.03	0.15
DISSOLVED-METALS	BERYLLIUM	µg/L	201	S		18		0.30	0.40			0.18	0.03	0.15
DISSOLVED-METALS	BERYLLIUM	µg/L	202	S		13		0.30	0.40			0.17	0.03	0.15
TOTAL-METALS	BERYLLIUM	µg/L	BGCR	B	9	115	0.08	0.20	5.00	0.60	4.80	0.78	0.87	1.12
TOTAL-METALS	BERYLLIUM	µg/L	CREEK	S	1	8	0.13	0.30	0.60	0.36	0.36	0.25	0.07	0.29
TOTAL-METALS	BERYLLIUM	µg/L	200	S	1	19	0.05	0.30	0.60	0.40	0.40	0.20	0.07	0.35
TOTAL-METALS	BERYLLIUM	µg/L	201	S	1	20	0.05	0.30	0.40	0.36	0.36	0.18	0.05	0.27
TOTAL-METALS	BERYLLIUM	µg/L	202	S		13		0.30	0.40			0.17	0.03	0.15
TOTAL-METALS	BERYLLIUM	µg/L	BM-LK	B		42			2.00					
DISSOLVED-METALS	CADMIUM	µg/L	BGCR	B	5	77	0.06	1.40	5.00	2.30	3.50	1.77	0.62	0.35
DISSOLVED-METALS	CADMIUM	µg/L	CREEK	S	1	3	0.33	1.40	1.40	2.50	2.50	1.30	1.04	0.80
DISSOLVED-METALS	CADMIUM	µg/L	200	S	1	16	0.06	1.40	1.50	1.50	1.50	0.78	0.19	0.25
DISSOLVED-METALS	CADMIUM	µg/L	201	S	2	18	0.11	1.40	1.50	2.50	2.50	0.93	0.57	0.62
DISSOLVED-METALS	CADMIUM	µg/L	202	S	1	13	0.08	1.40	1.50	1.80	1.80	0.82	0.30	0.36
DISSOLVED-METALS	CADMIUM	µg/L	BM-CR	B		33		1.00	5.00		2.50			
TOTAL-METALS	CADMIUM	µg/L	BM-LK	B		142		0.10			7.00	0.23-1.33		
TOTAL-METALS	CADMIUM	µg/L	BGCR	B	3	108	0.03	1.40	5.00	2.60	4.20	1.69	0.68	0.40
TOTAL-METALS	CADMIUM	µg/L	CREEK	S	3	8	0.38	1.40	2.30	2.40	2.80	1.47	0.93	0.63
TOTAL-METALS	CADMIUM	µg/L	200	S	3	19	0.16	1.40	2.30	1.90	2.80	1.02	0.64	0.63
TOTAL-METALS	CADMIUM	µg/L	201	S	1	20	0.05	1.40	1.50	2.40	2.40	0.81	0.37	0.46
TOTAL-METALS	CADMIUM	µg/L	202	S	2	13	0.15	1.40	1.50	4.00	9.00	1.62	2.39	1.48
DISSOLVED-METALS	CALCIUM	µg/L	BGCR	B	153	153	1.00			6760.00	79300.00	24056.86	10904.89	0.45
DISSOLVED-METALS	CALCIUM	µg/L	CREEK	S	3	3	1.00			13900.00	27200.00	18566.67	7484.87	0.40
DISSOLVED-METALS	CALCIUM	µg/L	200	S	16	16	1.00			13900.00	22000.00	19156.25	1822.44	0.10
DISSOLVED-METALS	CALCIUM	µg/L	201	S	18	18	1.00			14600.00	27200.00	23127.78	2520.46	0.11
DISSOLVED-METALS	CALCIUM	µg/L	202	S	13	13	1.00			11200.00	14200.00	12792.31	1028.32	0.08
TOTAL-METALS	CALCIUM	µg/L	BGCR	B	153	153	1.00			5505.75	74600.00	24071.96	10675.23	0.44
TOTAL-METALS	CALCIUM	µg/L	CREEK	S	8	8	1.00			11000.00	47200.00	21212.50	12141.48	0.57
TOTAL-METALS	CALCIUM	µg/L	200	S	19	19	1.00			11000.00	47200.00	19621.05	7339.13	0.37
TOTAL-METALS	CALCIUM	µg/L	201	S	20	20	1.00			12600.00	26100.00	22085.00	3340.39	0.15
TOTAL-METALS	CALCIUM	µg/L	202	S	13	13	1.00			11100.00	13900.00	12676.92	840.79	0.07
TOTAL-METALS	CALCIUM	µg/L	BM-LK	B	41						72000.00	33290-37380		

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Table B-4
Comparison to
Benchmark Data
Groundwater

Well No.	Test Group	Parameter	Unit	No. Of Detects	No. of Samples	Freq. of Detect	Min. Nondetect	Max. Nondetect	Max. Nondetect	Min. Detect	Max. Detect	Arith. Mean	Stand. Dev.	m + 2s	Upper Geo Chem. Min	Upper Geo Chem Max	Upper Geo. Chem, Mean	Std. Dev.	Mean Plus 2 SD	Min Lower Geo	Max Lower Geo	Mean Lower Geo	Std. Dev.	Mean Plus 2 SD	Min (Dragun)	Max (Dragun)	Standard (1)
49192	DMETAL	ALUMINUM	ug/L	1	8	0.13	13.0	40.0	20	47.1	47.1	16.231	13.249	42.730	2.5	1838	58.52	87.29	234.1	3	256	48.81	44.02	136.85	<	1000	5000 (eg)
49292	DMETAL	ALUMINUM	ug/L		8		13.0	40.0	20					0.000	2.5	1038	58.52	87.29	234.1	3	256	48.81	44.02	136.85	<	1000	5000 (eg)
49192	TMETAL	ALUMINUM	ug/L	8	8	1.00				985	23400	8499.375	9254.575	27008.525	22.6	19950	2742.8	4248.73	11248	11	11700	1782	2773.43	7338.86	<	1000	
49292	TMETAL	ALUMINUM	ug/L	5	8	0.63	24.1	48.8	23	28.2	338	72.019	108.713	288.445	22.6	19950	2742.8	4248.73	11240	11	11700	1782	2773.43	7338.86	<	1000	
49192	TRADS	AMERICIUM-241	pCi/L	7	7	1.00				0	0.021	0.007	0.008	0.023	-0.01	0.1	0.01	0.01	0.03	0	0.1	0.01	0.02	0.05			
[illegible]	DMETAL	[illegible]	ug/L	[illegible]																							
49292	DMETAL	ANTIMONY	ug/L		8		13.0	36.0	18					0.000	3	54.1	17.34	11.1	39.54	4	35.85	15.5	9.17	33.84			
49192	TMETAL	ANTIMONY	ug/L	1	8	0.13	13.0	36.0	18	27.5	27.5	12.750	7.231	27.212	3.6	88.6	18.19	12.85	44.89	3.5	41.3	15.62	10.4	36.42			
[illegible]	[illegible]	[illegible]	ug/L																								
49192	DMETAL	ARSENIC	ug/L	1	8	0.13	1.0	3.0	1.5	1	1	0.913	0.372	1.557	0.4	15	1.83	1.84	5.31	0.4	8.2	2.41	1.7	5.81	<1	30	50 (dw)
49292	DMETAL	ARSENIC	ug/L	8	8	0.75	2.0	3.0	1.5	2	25	5.138	8.679	21.278	0.4	15	1.83	1.84	5.31	0.4	8.2	2.41	1.7	5.81	<1	30	50 (dw)
49192	TMETAL	ARSENIC	ug/L	5	8	0.63	1.7	3.0	1.5	2.3	8.9	2.884	2.138	7.253	0.35	5	1.86	1.71	5.37	0.35	7	2.76	2.02	8.8	<1	30	
49292	TMETAL	ARSENIC	ug/L	5	8	0.63	2.0	3.0	1.5	2.7	3.8	2.525	1.071	4.668	0.35	5	1.86	1.71	5.37	0.35	7	2.76	2.02	8.8	<1	30	
49192	DMETAL	BARIUM	ug/L	8	8	0.75	16.0	23.0	12	24.2	55	28.838	15.310	58.458	14.75	203	83.42	34.56	152.5	34.8	132.5	84.18	21.79	127.76	10	500	1000 (dw)
49292	DMETAL	BARIUM	ug/L	7	8	0.88	16.0	16.0	8	29.3	35	28.625	8.504	45.633	14.75	203	83.42	34.56	152.5	34.8	132.5	84.18	21.79	127.76	10	500	1000 (dw)
49192	TMETAL	BARIUM	ug/L	8	8	1.00				34.8	188	80.300	58.329	196.957	25.9	317	102.44	45.37	193.2	61.5	303	113.95	51.97	217.89	10	500	
49292	TMETAL	BARIUM	ug/L	8	8	1.00				29.3	38.5	32.913	3.323	39.558	25.9	317	102.44	45.37	193.2	61.5	303	113.95	51.97	217.89	10	500	
49192	DMETAL	BERYLLIUM	ug/L		8		1.0	1.0	0.5					0.000	0.15	4	1.01	0.83	2.67	0.3	2.5	0.9	0.73	2.36	<10	10	
49292	DMETAL	BERYLLIUM	ug/L		8		1.0	1.0	0.5					0.000	0.15	4	1.01	0.83	2.67	0.3	2.5	0.9	0.73	2.36	<10	10	
49192	TMETAL	BERYLLIUM	ug/L	4	8	0.50	1.0	1.0	0.5	1.1	1.8	0.913	0.473	1.859	0.4	4.8	1.07	0.87	2.81	0.3	2.5	0.86	0.74	2.34	<10	10	
49292	TMETAL	BERYLLIUM	ug/L		8		1.0	1.0	0.5					0.000	0.4	4.8	1.07	0.87	2.81	0.3	2.5	0.86	0.74	2.34	<10	10	
49192	WQ	BICARB AS CACO3	ug/L	8	8	1.00	8.0	8.0		230	445.8	372.284	68.875	509.643	46.9	756	224	151.72	527.4	63	719	234	102.96	439.96			
49292	WQ	BICARB AS CACO3	ug/L	8	8	1.00	8.0	8.0		420	480	444.881	18.889	481.428	46.9	756	224	151.72	527.4	63	719	234	102.96	438.96			
49192	DMETAL	CADMIUM	ug/L		8		2.0	4.0	2					0.000	0.5	8.8	1.73	1.26	4.25	0.5	7.5	1.78	1.33	4.42	<1	1	
49292	DMETAL	CADMIUM	ug/L		8		2.0	4.0	2					0.000	0.5	8.8	1.73	1.26	4.25	0.5	7.5	1.78	1.33	4.42	<1	1	
49192	TMETAL	CADMIUM	ug/L	1	8	0.13	2.0	4.0	2	2.8	2.8	1.063	0.585	2.853	0.5	11.1	1.84	1.29	4.22	0.5	3.5	1.45	0.75	2.95	<1	1	
49292	TMETAL	CADMIUM	ug/L		8		2.0	4.0	2					0.000	0.5	11.1	1.84	1.29	4.22	0.5	3.5	1.45	0.75	2.95	<1	1	
49192	DMETAL	CALCIUM	ug/L	8	8	1.00				267000	4E+05	313375.000	28597.194	368569.387	15150	184000	55414.6	32564.1	1E+05	8190	78400	34535.8	23552.8	81641.4	<500000	500000	
49292	DMETAL	CALCIUM	ug/L	8	8	1.00				84900	99100	88312.500	4348.542	97009.585	15150	184000	55414.6	32564.1	1E+05	8190	78400	34535.8	23552.8	81641.4	<500000	500000	
49192	TMETAL	CALCIUM	ug/L	8	8	1.00				273000	4E+05	314250.000	26782.180	367774.360	15950	186000	55030.2	31687.8	1E+05	10800	91900	36382	23881.5	84144.94	<500000	500000	
49292	TMETAL	CALCIUM	ug/L	8	8	1.00				82200	99100	88975.000	5312.989	99600.978	15950	186000	55030.2	31687.8	1E+05	10800	91900	36382	23881.5	84144.94	<500000	500000	
49192	WQ	CARB AS CACO3	ug/L	2	8	0.25	0.7	1.0	0.5	1.14	2.9	0.882	0.857	2.578	0	32	1.825	3.48	8.785	0	19.1	3.3	4.2	11.7			
49292	DMETAL	CESIUM	ug/L	2	8	0.33	12.0	36.0	18	18	41	18.500	11.958	42.417	2	2500	202.2	285.69	773.6	2	500	160.88	178.94	520.76			
49192	TMETAL	CESIUM	ug/L	2	8	0.25	12.0	50.0	25	25	50	18.938	14.218	48.378	2	500	154.42	198.79	552	2	500	131.59	175.16	481.91			
49292	TMETAL	CESIUM	ug/L		5		12.0	36.0	18					0.000	2	500	154.42	198.79	552	2	500	131.59	175.16	481.91			
49192	WQ	CHLORIDE	ug/L	8	8	1.00	8.0	8.0		96	110	97.540	7.737	113.014	1.2	110	12.2	12.93	38.06	1.6	430	100	126.1	356.2			
49292	WQ	CHLORIDE	ug/L	8	8	1.00	8.0	8.0		24.69	33	29.259	3.685	36.589	1.2	110	12.2	12.93	38.06	1.6	430	100	126.1	356.2			
49192	DMETAL	CHROMIUM	ug/L		8		2.0	4.0	2					0.000	1	23.2	4.84	3.8	12.44	1	15.5	3.97	3.15	10.27	<1	5	
49292	DMETAL	CHROMIUM	ug/L		8		2.0	4.0	2					0.000	1	23.2	4.84	3.8	12.44	1	15.5	3.97	3.15	10.27	<1	5	
49192	TMETAL	CHROMIUM	ug/L	5	8	0.63	4.0	5.2	2.8	3.7	29	11.838	11.049	33.134	1	31.85	7.01	8.88	20.37	1	21.4	5.25	4.61	14.47	<1	5	
49292	DMETAL	COBALT	ug/L		8		3.0	8.0	3					0.000	1	29	8.8	9.04	24.88	1	25	5.18	7.88	20.82	<10	10	
49192	TMETAL	COBALT	ug/L	4	8	0.50	3.0	8.0	3	5.3	16.8	8.400	5.885	17.730	1	38.4	7.84	8.87	26.98	1	25	5.55	8.18	21.91	<10	10	
49292	TMETAL	COBALT	ug/L		8		3.0	8.0	3					0.000	1	39.4	7.84	8.87	26.98	1	25	5.55	8.18	21.91	<10	10	
49192	DMETAL	COPPER	ug/L	2	8	0.25	2.0	4.0	2	3	3.8	1.850	1.073	3.996	0.5	20.9	5.01	4.42	13.85	0.5	12.5	4.17	3.83	11.83	<1	30	1000(sec)

Table B-4
Comparison to
Benchmark Data
Groundwater

Well No.	Test Group	Parameter	Unit	No. of Detects	No. of Samples	Freq. of Detect	Min. Nondetect	Max. Nondetect	Max. Nondetect	Min. Detect	Max. Detect	Arith. Mean	Stand. Dev.	m + 2s	Upper Geo Chem. Min	Upper Geo Chem Max	Upper Geo. Chem, Mean	Std. Dev.	Mean Plus 2 SD	Min Lower Geo	Max Lower Geo	Mean Lower Geo	Std. Dev.	Mean Plus 2 SD	Min (Dragun)	Max (Dragun)	Standard (1)
49192	DMETAL	ALUMINUM	ug/L	1	8	0.13	13.0	40.0	20	47.1	47.1	16.231	13.249	42.730	2.5	1036	59.52	87.29	234.1	3	256	48.81	44.02	136.85	<5	1000	5000 (ag)
49292	DMETAL	ALUMINUM	ug/L		8		13.0	40.0	20					0.000	2.5	1036	59.52	87.29	234.1	3	256	48.81	44.02	136.85	<5	1000	5000 (ag)
49192	TMETAL	ALUMINUM	ug/L	8	8	1.00				985	23400	9499.375	8254.575	27008.525	22.6	19950	2742.8	4248.73	11240	11	11700	1792	2773.43	7338.86	<5	1000	
49292	TMETAL	ALUMINUM	ug/L	5	8	0.63	24.1	48.8	23	28.2	338	72.018	108.713	289.445	22.6	19950	2742.8	4248.73	11240	11	11700	1792	2773.43	7338.86	<5	1000	
49192	TRADS	AMERICIUM-241	pCi/L	7	7	1.00				0	0.021	0.007	0.008	0.023	-0.01	0.1	0.01	0.01	0.03	0	0.1	0.01	0.02	0.05			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
49292	DMETAL	ANTIMONY	ug/L		8		13.0	38.0	18					0.000	3	54.1	17.34	11.1	39.54	4	35.65	15.5	8.17	33.84			
49192	TMETAL	ANTIMONY	ug/L	1	8	0.13	13.0	38.0	18	27.5	27.5	12.750	7.231	27.212	3.6	86.6	18.19	12.85	44.89	3.5	41.3	15.62	10.4	36.42			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
49192	DMETAL	ARSENIC	ug/L	1	8	0.13	1.0	3.0	1.5	1	1	0.813	0.372	1.557	0.4	15	1.63	1.84	5.31	0.4	6.2	2.41	1.7	5.81	<1	30	50 (dw)
49292	TMETAL	COPPER	ug/L	2	8	0.25	2.0	4.0	2	4.4	4.9	2.038	1.854	5.346	1	105	10.67	12.21	35.09	1	125	11.99	21.92	55.83	<1	30	
49192	WQ	FLUORIDE	ug/L	8	8	1.00	0.0	0.0		0.26	0.4	0.305	0.042	0.389	0.1	2.9	0.611	0.472	1.555	0.12	2	0.949	0.465	1.879			
49292	WQ	FLUORIDE	ug/L	8	8	1.00	0.0	0.0		0.89	1	0.939	0.048	1.035	0.1	2.9	0.611	0.472	1.555	0.12	2	0.949	0.465	1.879			
49192	DMETAL	IRON	ug/L	6	7	0.86	3.2	3.2	1.6	50.9	464	262.071	179.968	622.008	1	1106.5	56.26	113.44	283.1	1.5	181	33.67	35.32	104.31	10	10000	300 (sec)
49292	DMETAL	IRON	ug/L	8	8	1.00				498	715	617.625	78.249	774.122	1	1106.5	56.26	113.44	283.1	1.5	181	33.67	35.32	104.31	10	10000	300 (sec)
49192	TMETAL	IRON	ug/L	8	8	1.00				2210	27100	11575.000	11442.736	34460.471	6.5	27100	3017.34	4994.5	13006	9.8	16900	2239.92	3697.44	9634.8	10	10000	
49292	TMETAL	IRON	ug/L	8	8	1.00				753	1300	898.500	174.585	1247.670	6.5	27100	3017.34	4994.5	13006	9.8	16900	2239.92	3697.44	9634.8	10	10000	
49192	DMETAL	LEAD	ug/L	1	8	0.13	1.0	2.0	1	2.6	2.6	0.888	0.728	2.343	0.2	64	1.59	4.71	11.01	0.4	41.6	1.8	5.27	12.34	<15	15	50 (dw)
49292	DMETAL	LEAD	ug/L	1	8	0.13	1.0	2.0	1	5.9	5.9	1.288	1.837	4.962	0.2	64	1.59	4.71	11.01	0.4	41.6	1.8	5.27	12.34	<15	15	50 (dw)
49192	TMETAL	LEAD	ug/L	7	8	0.88	2.0	2.0	1	1.8	20.1	7.888	7.722	23.332	0.5	25	3.26	3.64	10.54	0.5	17.7	3.82	4.29	12.4	<15	15	
49292	TMETAL	LEAD	ug/L	1	8	0.13	1.0	2.0	1	1.7	1.7	0.775	0.437	1.648	0.5	25	3.26	3.64	10.54	0.5	17.7	3.82	4.29	12.4	<15	15	
49192	DMETAL	LITHIUM	ug/L	8	8	1.00				346	483	420.375	48.914	520.003	0.5	250	33.95	54.3	142.6	2	104	38.53	27.84	94.21	1	150	2500 (ag)
49292	TMETAL	LITHIUM	ug/L	8	8	1.00				72.2	78.6	74.850	2.056	78.961	1.1	268	33.75	48.76	131.3	6.2	108	40.89	29.29	99.27	1	150	
49192	DMETAL	MAGNESIUM	ug/L	8	8	1.00				51200	89400	78587.500	11892.908	102373.315	2120	46300	10038.3	8309	26856	1720	16400	6072.16	4067.56	14207.28	<400000	400000	
49292	DMETAL	MAGNESIUM	ug/L	8	8	1.00				21200	23800	22000.000	858.570	23717.140	2120	46300	10038.3	8309	26856	1720	16400	6072.16	4067.56	14207.28	<400000	400000	
49192	TMETAL	MAGNESIUM	ug/L	8	8	1.00				55300	97700	80487.500	12075.292	104638.084	2230	47900	10315.6	7956.43	26229	1950	19700	6879.46	5030.81	16741.08	<400000	400000	
49292	TMETAL	MAGNESIUM	ug/L	8	8	1.00				20700	24300	22087.500	1133.185	24353.869	2230	47900	10315.6	7956.43	26229	1950	19700	6879.46	5030.81	16741.08	<400000	400000	
49192	DMETAL	MANGANESE	ug/L	8	8	1.00				197	377	283.250	58.341	411.932	0.5	440	27.47	67.43	162.3	0.5	30.2	9.29	7.24	23.77	<1	1000	50 (sec)
49292	DMETAL	MANGANESE	ug/L	8	8	1.00				53.2	64.9	58.800	4.920	68.640	0.5	440	27.47	67.43	162.3	0.5	30.2	9.29	7.24	23.77	<1	1000	50 (sec)
49192	TMETAL	MANGANESE	ug/L	8	8	1.00				327	959	485.250	227.284	939.779	0.5	584	79.59	108.18	296	1	710	61.87	125.21	312.29	<1	1000	
49292	TMETAL	MANGANESE	ug/L	8	8	1.00				52.8	70.2	60.113	5.717	71.546	0.5	584	79.59	108.18	296	1	710	61.87	125.21	312.29	<1	1000	
49192	DMETAL	MERCURY	ug/L		8		0.2	0.2	0.1					0.000	0.05	0.69	0.11	0.07	0.25	0.05	1.2	0.13	0.15	0.43			
49292	DMETAL	MERCURY	ug/L		8		0.2	0.2	0.1					0.000	0.05	0.69	0.11	0.07	0.25	0.05	1.2	0.13	0.15	0.43			
49192	TMETAL	MERCURY	ug/L		8		0.2	0.2	0.1					0.000	0.1	0.27	0.12	0.04	0.2	0.1	0.24	0.13	0.05	0.23			
49292	TMETAL	MERCURY	ug/L		8		0.2	0.2	0.1					0.000	0.1	0.27	0.12	0.04	0.2	0.1	0.24	0.13	0.05	0.23			
49192	DMETAL	MOLYBDENUM	ug/L	1	8	0.13	4.0	15.0	7.5	8.8	8.8	4.663	2.013	10.488	1	114	19.84	33.94	87.52	1	100	16.86	27.01	70.88	<1	30	100 (ag)
49292	DMETAL	MOLYBDENUM	ug/L	1	8	0.13	4.0	15.0	7.5	5.1	5.1	4.163	1.898	8.158	1	114	19.64	33.94	87.52	1	100	16.86	27.01	70.88	<1	30	100 (ag)
49192	TMETAL	MOLYBDENUM	ug/L		8		5.0	15.0	8					0.000	1	100	24.09	39.47	103	1	100	18.59	33.45	85.49	<1	30	
49292	TMETAL	MOLYBDENUM	ug/L	1	8	0.13	4.0	15.0	7.5	10.2	10.2	5.200	2.673	10.548	1	100	24.09	39.47	103	1	100	18.59	33.45	85.49	<1	30	
49192	DMETAL	NICKEL	ug/L	1	8	0.13	5.0	14.0	7	9.6	9.6	4.888	2.444	9.775	1	35.8	7.01	7.18	21.37	1	20	5.81	6.26	18.33	<10	50	200 (ag)
49292	DMETAL	NICKEL	ug/L		8		5.0	14.0	7					0.000	1	35.8	7.01	7.18	21.37	1	20	5.81	6.26	18.33	<10	50	200 (ag)
49192	TMETAL	NICKEL	ug/L	2	8	0.25	8.0	33.1	17	24	30.3	11.888	10.633	32.935	1	71.6	10.58	9.49	29.56	1	24.5	8.7	7.25	23.2	<10	50	
s150	TMETAL	NICKEL	ug/L		8		5.0	14.0	7					0.000	1	71.6	10.58	9.49	29.56	1	24.5	8.7	7.25	23.2	<10	50	

Table B-4
Comparison to
Benchmark Data
Groundwater

Well No.	Test Group	Parameter	Unit	No. Of Detects	No. of Samples	Freq. of Detect	Min. Nondetect	Max. Nondetect	Max. Nondetect	Min. Detect	Max. Detect	Arith. Mean	Stand. Dev.	m + 2s	Upper Geo Chem. Min	Upper Geo Chem Max	Upper Geo. Chem. Mean	Std. Dev.	Mean Plus 2 SD	Min Lower Geo	Max Lower Geo	Mean Lower Geo	Std. Dev.	Mean Plus 2 SD	Min (Dragun)	Max (Dragun)	Standard (1)
49192	DMETAL	ALUMINUM	ug/L	1	8	0.13	13.0	40.0	20	47.1	47.1	16.231	13.249	42.730	2.5	1036	59.52	87.29	234.1	3	256	48.81	44.02	136.85	<3	1000	5000 (sg)
49292	DMETAL	ALUMINUM	ug/L		8		13.0	40.0	20					0.000	2.5	1036	59.52	87.29	234.1	3	256	48.81	44.02	136.85	<3	1000	5000 (sg)
49192	TMETAL	ALUMINUM	ug/L	8	8	1.00				985	23400	8499.375	8254.575	27008.525	22.6	19950	2742.8	4248.73	11240	11	11700	1792	2773.43	7338.86	<3	1000	
49292	TMETAL	ALUMINUM	ug/L	5	8	0.63	24.1	46.8	23	28.2	338	72.019	108.713	289.445	22.6	19950	2742.8	4248.73	11240	11	11700	1792	2773.43	7338.86	<3	1000	
49192	TRADS	AMERICIUM-241	pCi/L	7	7	1.00				0	0.021	0.007	0.008	0.023	-0.01	0.1	0.01	0.01	0.03	0	0.1	0.01	0.02	0.05			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
49292	DMETAL	ANTIMONY	ug/L		8		13.0	36.0	18					0.000	3	54.1	17.34	11.1	39.54	4	35.85	15.5	8.17	33.84			
49192	TMETAL	ANTIMONY	ug/L	1	8	0.13	13.0	36.0	18	27.5	27.5	12.750	7.231	27.212	3.6	86.8	18.19	12.85	44.89	3.5	41.3	15.62	10.4	36.42			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
49192	DMETAL	ARSENIC	ug/L	1	8	0.13	1.0	3.0	1.5	1	1	0.813	0.372	1.557	0.4	15	1.83	1.84	5.31	0.4	6.2	2.41	1.7	5.81	<1	30	50 (dw)
49192	WQ	NITRATE/NITRITE	MG/L	5	8	0.63	0.0	0.0	0	0.3	0.522	0.285	0.238	0.756	0.01	12	1.048	1.81	4.668	0.01	3.6	0.861	0.945	2.751			
49292	WQ	NITRATE/NITRITE	MG/L	4	8	0.50	0.0	0.1	0	0.027	0.07	0.031	0.023	0.077	0.01	12	1.048	1.81	4.668	0.01	3.6	0.861	0.945	2.751			
49192	TRADS	PLUTONIUM-239/240	pCi/L	7	7	1.00				-0.013	0.085	0.011	0.033	0.078	-0.01	0.22	0	0.02	0.04	0	0.05	0	0.01	0.02			
49292	TRADS	PLUTONIUM-239/240	pCi/L	7	7	1.00				-0.00101	0.001	0.000	0.001	0.002	-0.01	0.22	0	0.02	0.04	0	0.05	0	0.01	0.02			
49192	DMETAL	POTASSIUM	ug/L	8	8	1.00				8890	11300	10090.000	671.452	11832.904	160	8110	1371.5	1069.01	3510	366	5800	2731.18	1612.39	5955.96	1000	10000	
49292	DMETAL	POTASSIUM	ug/L	8	8	1.00				2890	4020	3575.000	386.153	4347.306	160	8110	1371.5	1069.01	3510	366	5800	2731.18	1612.39	5955.96	1000	10000	
49192	TMETAL	POTASSIUM	ug/L	8	8	1.00				10200	14800	11925.000	1737.609	15400.218	243	8370	1731.21	1176.59	4084	516	6870	2846.38	1725.69	6297.76	1000	10000	
49292	TMETAL	POTASSIUM	ug/L	7	8	0.88	4090.0	4090.0	2050	3210	3830	3430.625	597.151	4624.926	243	8370	1731.21	1176.59	4084	516	6870	2846.38	1725.69	6297.76	1000	10000	
49292	DRAD	RADIUM-226	pCi/L	1	1	1.00	0.0	0.0		0.7	0.7	0.700		0.700	0.06	0.53	0.26	0.11	0.48	0.47	2.99	1.72	1.78	5.28			
49192	DMETAL	SELENIUM	ug/L		8		1.0	3.0	1.5					0.000	0.5	173	5.58	19.07	43.72	0.5	6	1.34	1.09	3.52	<1	10	10 (dw)
49292	DMETAL	SELENIUM	ug/L	1	8	0.13	1.0	3.0	1.5	1.5	1.5	0.969	0.388	1.745	0.5	173	5.58	19.07	43.72	0.5	6	1.34	1.09	3.52	<1	10	10 (dw)
49192	DMETAL	SILICON	ug/L	8	8	1.00				5840	6700	6355.000	276.922	6908.844	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5000	100000	
49292	DMETAL	SILICON	ug/L	8	8	1.00				4780	5510	5267.500	233.162	5733.823	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5000	100000	
49192	TMETAL	SILICON	ug/L	8	8	1.00				8140	53600	23485.000	18505.896	60496.793	4399	51650	15565	10797.3	37160	3720	29500	9427.5	6831.12	22689.74	5000	100000	
49292	TMETAL	SILICON	ug/L	8	8	1.00				5110	6260	5535.000	432.633	6400.266	4399	51650	15565	10797.3	37160	3720	29500	9427.5	6831.12	22689.74	5000	100000	
49192	DMETAL	SILVER	ug/L	1	8	0.13	3.0	13.0	6.5	8.4	8.4	2.800	2.260	7.319	1	11.8	2.84	2.12	7.08	1	9.4	2.69	2.01	6.71	<3	5	50 (dw)
49292	DMETAL	SILVER	ug/L		8		3.0	13.0	6.5					0.000	1	11.8	2.84	2.12	7.08	1	9.4	2.69	2.01	6.71	<3	5	50 (dw)
49192	TMETAL	SILVER	ug/L		8		3.0	5.0	2.5					0.000	1	10	2.35	1.8	5.95	1	10	2.19	2.03	6.25	<3	5	
49292	TMETAL	SILVER	ug/L		8		3.0	5.0	2.5					0.000	1	10	2.35	1.8	5.95	1	10	2.19	2.03	6.25	<3	5	
49192	DMETAL	SODIUM	ug/L	8	8	1.00				425000	6E+05	497000.000	39122.518	575245.036	2500	252000	32013	43687.7	1E+05	11000	452000	142013	135522	413055.8	<1000000	1000000	
49292	DMETAL	SODIUM	ug/L	8	8	1.00				243000	3E+05	262500.000	10915.258	284330.516	2500	252000	32013	43687.7	1E+05	11000	452000	142013	135522	413055.8	<1000000	1000000	
49192	TMETAL	SODIUM	ug/L	8	8	1.00				403000	5E+05	488000.000	40492.801	568985.601	2500	194000	30081.9	40019.7	1E+05	11500	434000	139228	134404	408036.7	<1000000	1000000	
49292	TMETAL	SODIUM	ug/L	8	8	1.00				258000	3E+05	282875.000	3842.507	270160.014	2500	194000	30081.9	40019.7	1E+05	11500	434000	139228	134404	408036.7	<1000000	1000000	
49192	DMETAL	STRONTIUM	ug/L	8	8	1.00				3860	5390	4892.500	483.876	5860.251	50	1910	323.6	303.58	930.8	89.5	1140	383.02	294.27	971.56	100	4000	
49292	DMETAL	STRONTIUM	ug/L	8	8	1.00				1090	1290	1163.750	60.695	1285.141	50	1910	323.6	303.58	930.8	89.5	1140	383.02	294.27	971.56	100	4000	
49192	TMETAL	STRONTIUM	ug/L	8	8	1.00				3860	5590	4873.750	495.723	5865.196	58.1	1770	312.61	271.09	854.8	100	1170	399.78	312.58	1024.94	100	4000	
49292	TMETAL	STRONTIUM	ug/L	8	8	1.00				1090	1280	1160.000	71.114	1302.227	58.1	1770	312.61	271.09	854.8	100	1170	399.78	312.58	1024.94	100	4000	
49192	WQ	SULFATE	ug/L	8	8	1.00	0.0	0.0		1600	3800	2023.875	744.887	3513.650	2.9	1200	88	174.61	435.2	0.6	1200	124	250.87	625.74			
49292	WQ	SULFATE	ug/L	8	8	1.00	0.0	0.0		340	690	438.013	115.158	668.328	2.9	1200	88	174.61	435.2	0.6	1200	124	250.87	625.74			
49192	WQ	TDS	ug/L	8	8	1.00	0.0	0.0		2500	3183	2995.500	222.354	3440.207	68	1580	355	312.01	979	120	1700	545	445.29	1435.58			
49292	WQ	TDS	ug/L	8	8	1.00	0.0	0.0		1000	1100	1071.500	44.603	1160.706	68	1580	355	312.01	979	120	1700	545	445.29	1435.58			
49192	DMETAL	THALLIUM	ug/L		8		1.0	4.0	2					0.000	0.3	5	1.64	1.63	4.9	0.3	10	1.72	1.87	5.46			
49292	DMETAL	THALLIUM	ug/L	1	8	0.13	1.0	4.0	2	1.2	1.2	1.025	0.602	2.229	0.3	5	1.64	1.63	4.9	0.3	10	1.72	1.87	5.46			
49192	TMETAL	THALLIUM	ug/L		8		1.0	4.0	2					0.000	0.45	5	1.87	1.78	5.19	0.45	5	1.4	1.5	4.4			

Table [redacted]
Comparison to
Benchmark Data
Groundwater

Well No.	Test Group	Parameter	Unit	No. Of Detects	No. of Samples	Freq. of Detect	Min. Nondetect	Max. Nondetect	Mean. Nondetect	Min. Detect	Max. Detect	Arith. Mean	Stand. Dev.	Arithmetic Mean + 2SD	Upper Geo Chem. Min	Upper Geo Chem Max	Upper Geo. Chem., Mean	Std. Dev.	Mean Plus 2 SD	Min Lower Geo	Max Lower Geo	Mean Lower Geo	Std. Dev.	Mean Plus 2 SD	Min (Dragun)	Max (Dragun)	Standard (1)
49192	DMETAL	ALUMINUM	ug/L	1	8	0.13	13.0	40.0	20	47.1	47.1	18.231	13.249	42.730	2.5	1030	50.52	87.29	234.1	3	256	48.61	44.02	136.85	Δ	1000	5000 (ag)
49292	DMETAL	ALUMINUM	ug/L		8		13.0	40.0	20					0.000	2.5	1030	50.52	87.29	234.1	3	256	48.61	44.02	136.85	Δ	1000	5000 (ag)
49192	TMETAL	ALUMINUM	ug/L	8	8	1.00				995	23400	9499.375	9254.575	27908.525	22.6	19950	2742.8	4248.73	11240	11	11700	1792	2773.43	7338.86	Δ	1000	
49292	TMETAL	ALUMINUM	ug/L	9	9	0.83	24.1	40.0	23	28.2	338	72.019	108.713	289.445	22.6	19950	2742.8	4248.73	11240	11	11700	1792	2773.43	7338.86	Δ	1000	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49192	DMETAL	ANTIMONY	ug/L	7	7	1.00				0	0.021	0.007	0.008	0.023	-0.01	0.1	0.01	0.01	0.03	0	0.1	0.01	0.02	0.05			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49292	DMETAL	ANTIMONY	ug/L		8		13.0	30.0	19					0.000	3	54.1	17.34	11.1	39.54	4	35.05	15.5	9.17	33.84			
49192	TMETAL	ANTIMONY	ug/L	1	8	0.13	13.0	30.0	19	27.5	27.5	12.750	7.231	27.212	3.0	66.0	19.19	12.05	44.09	3.5	41.3	15.62	10.4	36.42			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49192	DMETAL	ARSENIC	ug/L	1	8	0.13	1.0	3.0	1.5	1	1	0.913	0.372	1.557	0.4	15	1.63	1.94	5.31	0.4	6.2	2.41	1.7	5.81	<1	30	50 (dw)
49292	TMETAL	THALLIUM	ug/L		8		1.0	4.0	2					0.000	0.45	5	1.67	1.76	5.19	0.45	5	1.4	1.5	4.4			
49192	DMETAL	TIN	ug/L	3	8	0.38	10.0	13.0	6.5	36.9	46.1	19.150	16.483	56.077	2	340	30.96	37.34	105.6	4.7	100	23.07	25.3	73.67	<200	200	
49292	DMETAL	TIN	ug/L	3	8	0.38	10.0	13.0	6.5	31.2	46.3	17.550	16.071	49.692	2	340	30.96	37.34	105.6	4.7	100	23.07	25.3	73.67	<200	200	
49192	TMETAL	TIN	ug/L	2	8	0.25	10.0	20.0	15	30.4	47.0	19.275	17.010	53.312	4.7	100	33.99	35.33	104.5	4.7	100	27.46	31.16	89.82	<200	200	
49292	DRADS	URANIUM-233/234	pCi/L	8	8	1.00				0.3117	1.2	0.694	0.322	1.338	-0.02	100.5	6.23	23.94	54.11	-0.01	15.33	1.84	2.65	7.34			
49192	TRADS	URANIUM-233/234	pCi/L	2	2	1.00				3.4	4.8	4.000	0.849	5.697	0	184	15.62	38.75	93.12	0.15	1.52	0.77	0.57	1.91			
49292	TRADS	URANIUM-233/234	pCi/L	2	2	1.00				0.84	0.87	0.755	0.163	1.080	0	184	15.62	38.75	93.12	0.15	1.52	0.77	0.57	1.91			
49192	DRADS	URANIUM-235	pCi/L	8	8	1.00				0.029	0.29	0.135	0.117	0.369	-0.04	4.8	0.2	0.64	1.48	-0.04	0.23	0.03	0.06	0.15			
49292	DRADS	URANIUM-235	pCi/L	8	8	1.00				-0.025	0.18	0.083	0.075	0.213	-0.04	4.8	0.2	0.64	1.48	-0.04	0.23	0.03	0.06	0.15			
49192	TRADS	URANIUM-235	pCi/L	2	2	1.00				0.12	0.2	0.160	0.057	0.273	-0.02	0.29	0.02	1.38	3.38	0	0.04	0.03	0.02	0.07			
49292	TRADS	URANIUM-235	pCi/L	2	2	1.00				0	0.003	0.042	0.059	0.159	-0.02	0.29	0.02	1.38	3.38	0	0.04	0.03	0.02	0.07			
49192	DRADS	URANIUM-238	pCi/L	8	8	1.00				0.26	2.5	1.653	0.916	3.485	-0.04	135.0	4.77	17.71	40.19	-0.16	0.01	0.77	1.53	3.83			
49292	TRADS	URANIUM-238	pCi/L	2	2	1.00				0.7	0.91	0.805	0.148	1.102	0	108	10.84	27.73	66.3	0.17	0.53	0.35	0.26	0.87			
49192	DMETAL	VANADIUM	ug/L		8		2.0	14.0	7					0.000	0.6	50	7.92	8.73	25.38	0.5	25	6.71	7.6	21.91	<1	10	
49292	DMETAL	VANADIUM	ug/L		8		2.0	14.0	7					0.000	0.6	50	7.92	8.73	25.38	0.5	25	6.71	7.6	21.91	<1	10	
49192	TMETAL	VANADIUM	ug/L	4	8	0.50	2.0	14.0	7	6.2	70.2	25.750	29.488	84.732	1	123	13.91	14.09	41.99	0.5	48.7	10.43	11.26	32.95	<1	10	
49292	TMETAL	VANADIUM	ug/L		8		2.0	14.0	7					0.000	1	123	13.91	14.09	41.99	0.5	48.7	10.43	11.26	32.95	<1	10	
49192	DMETAL	ZINC	ug/L	3	8	0.38	2.0	3.0	1.5	5.0	47.0	8.319	16.029	40.378	1	137	14.03	17.87	49.77	1	80.9	10.96	10.2	31.36	<10	2000	5000 (sec)
49292	DMETAL	ZINC	ug/L	3	8	0.38	3.0	10.7	5.4	3.1	16.5	4.000	4.974	14.748	1	137	14.03	17.87	49.77	1	80.9	10.96	10.2	31.36	<10	2000	5000 (sec)
49192	TMETAL	ZINC	ug/L	8	8	1.00				18.2	156	63.200	58.033	179.266	4.2	496	37.16	49.8	136.8	5	189	52.45	51.31	155.07	<10	2000	
49292	TMETAL	ZINC	ug/L	3	8	0.38	2.0	12.8	6.3	9.5	20.5	6.950	6.686	20.323	4.2	496	37.16	49.8	136.8	5	189	52.45	51.31	155.07	<10	2000	

(1) Colorado Basic Standards--(dw) drinking water, (sec) secondary, (ag) agricultural.

(a) Boyles et al.

(b) Lowry Landfill background data.

Notes:

CDPHE Screen Report/Draft 2/Table B4.

DMETAL = Dissolved metal (filtered).

TMETAL = Total metal (unfiltered).

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ATTACHMENT 3

TERRESTRIAL PCOC EVALUATION

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1.0 INTRODUCTION

The purpose of this evaluation is to present the PCOC characteristics relating to exposure, dose, and effects on biota associated with the terrestrial ecosystems in OU 3. The principal concern with respect to terrestrial biotic receptors are the radionuclides—plutonium-239, -240 and americium-241—that are contained in the soils within OU 3. The field studies at OU 3 were designed to concurrently measure contaminant activities in the soil medium and activities in biota living in or on the soils, using the activity data to calculate the radionuclides to plant and animal tissues. In addition, soil media activities at OU 3 were compared to benchmark values that are generally considered to be protective of animal species, and by extrapolation to plants. The radiological benchmark values are environmental media activities of contaminants that produce a dose limit less than 100 mrad/d; the level at which the contaminants have no population effects. These benchmark values for radionuclides were summarized by (DOE, 1995c), who provide the approach and rationale for these values.

2.0 ANALYSIS OF EXPOSURE

A complete exposure pathway and analysis requires a contaminant source, release, and transport mechanism that moves the contaminant into areas where living organisms can come in contact with the contaminant, and an uptake mechanism that allows the contaminant to become incorporated into the biological receptor. Historically, contaminants from Rocky Flats could have been released and transported to terrestrial receptors within OU 3 by the mechanisms shown in Figure B3-1 in Section B3.0 of this ERA. The principal concern regarding terrestrial receptors is the radionuclides that occur in the surface soils of OU 3. The radionuclides, PCOCs (plutonium and americium), are the result of past airborne dispersion of contaminated particulates from soils at Rocky Flats. The source of contamination of soils on OU 3 was principally from a storage area, the 903 Pad. Other inputs from Rocky Flats-related release events were not significant, and global fallout added only minor amounts to the contamination in OU 3. The deposition onto OU 3 soils was assumed to be dry settling, with perhaps some wet deposition during precipitation events.

For terrestrial biota, soils on OU 3 are the principal source media where the radionuclides have been deposited. Surface waters and sediments within OU 3 are potentially contaminated as a result of the transport mechanisms from site releases discussed in Attachment 4, Aquatic PCOC Evaluation. However, the terrestrial receptors are not exposed to sediments and surface waters on a continual basis. In addition, there were no PCOCs identified in surface waters.

2.1 PHYSICAL AND CHEMICAL PROPERTIES, AND BIOAVAILABILITY OF PCOCs

The primary PCOCs for terrestrial ecosystems are the radionuclides, plutonium-239, -240 and americium-241 (see Attachment 2 for methodology used to select PCOCs). Documentation on PCOCs is presented in TM 4 (DOE, 1994b), and summarized in Attachment 2 of this ERA.

2.1.2 Source

Previous studies have identified the PCOCs in the terrestrial ecosystem as the transuranic elements, plutonium-239, -240 and americium-241 (DOE, 1991, 1991c, and 1992). The source was principally from the area of the 903 Pad where 55-gallon barrels were stacked that leaked plutonium-contaminated cutting oil onto the soil. Subsequent cleanup between 1967 and 1969 released contaminants into the air.

The plutonium dispersion and deposition was downwind to the east and across the buffer zone boundary into OU 3. The deposition onto soils was assumed to be dry settling, with perhaps some wet deposition during precipitation events.

Of the radionuclides of concern in OU 3, plutonium has been the most intensively studied in environmental research related to weapons production at Rocky Flats. The information presented within this document uses numerous previous studies, both at Rocky Flats and other plutonium-contaminated sites in arid and semi-arid regions. Americium is similar in behavior to plutonium, and is generally measured in similar studies as the decay product of plutonium. Uranium is from natural sources, and if there are contributions from Rocky Flats, they are small and unquantifiable, and are difficult to distinguish from background. Isotopic ratios of uranium have been used in an attempt to differentiate naturally occurring uranium from enriched, depleted, and weapons-grade uranium used at Rocky Flats (DOE, 1993b).

The nature and extent of contamination in soils are discussed in Section 4.0 of the RFI/RI report. Studies of plutonium activities for the 11 soil trenches (and 2 soil plots-all collocated with the plant and small mammal tissue collection) in OU 3 indicate that the highest activities are within the top 3 centimeters of soil, and rapidly decrease with soil depth.

The total OU 3 inventory of plutonium in the soils related to the Rocky Flats releases was estimated at about 3 curies according to Krey and Hardy (1970), with about 0.6 curies on the OU 3 study area. According to a plutonium inventory study at Rocky Flats by Little (1980), more than 99 percent of the plutonium was contained in the onsite soil, mostly in the top few centimeters. The vegetation contained a smaller fraction of the plutonium, about 0.2 percent, mostly as aerial deposition on leaves and litter. Animals, principally mammals and arthropods, had a much smaller fraction at about 0.000001 percent.

2.1.2 Transport

The processes that control movement of transuranic elements within ecosystems are chemical, physical, and biotic (Hansen, 1980; Friesen, 1992). Soluble forms have different bioavailability than insoluble forms, and this alters the transport across physiological membranes in plants and animals. The erosive forces of wind, water, and gravity redistribute radionuclides, and can move contaminants onto the surfaces of plants and animals. Biotic transport processes include animal ingestion, burrowing, and surface transport.

The main physical processes that affected movement of radiological contaminants in the terrestrial ecosystems after dispersal from Rocky Flats were primarily due to dry deposition by wind on soil and vegetation surfaces, and subsequent movement by resuspension (Whicker, 1979 and 1980). Washing of contaminants from vegetation into the soil by precipitation, the percolation of contaminant-bearing solutions into lower soil layers, and movement of contaminated particles during surface-water runoff are all considered to be secondary transport mechanisms. The relative rates of these transport processes are not known.

Studies of plutonium movement and fate in arid-zone soils and terrestrial ecosystems have shown distribution patterns as a function of time and depth (Whicker, 1979 and 1980; Hansen, 1980; Friesen, 1992). A weathering or "aging" process of transuranics in soils over time was observed as a result of chemical changes, principally oxidation to stable states, binding and adsorption to soil particles, microbial transformations, and slow movement into the soil profile from the soil surface. The net result of these changes has reduced bioavailability of plutonium (Ibrahim, 1992).

According to Whicker (1979), activities of plutonium in litter, plants, and arthropods in grasslands were significantly correlated to activities in soils. This study also found a great deal of difference in soil activities from different areas, and also in activities in plants and animals. Correlations indicated that most of the plutonium associated with biotic samples was actually external. Movement of plutonium in the environment was principally by physical means, rather than by physiological mechanisms related to biota. Plutonium activities in terrestrial biota were too variable to show statistically significant differences in taxonomic groups within sample locations. This variability in biota increased at sites with low and variable soil-contaminant activities.

2.1.3 Uptake and Transfer

To evaluate potential stress to ecosystem components as a function of the PCOCs existing within OU 3, plutonium and americium were characterized for the nature and extent of contamination, as well as uptake and transfer within the terrestrial ecosystem. Transport is a function of total amounts in the inventory of soils and the distribution on the surface and into the soil profile. Activities in soils and bioavailability will influence movement and behavior in the ecosystem components such as plant uptake and subsequent transfer to animals. Resuspension, percolation, and deposition affect activities in the ecosystem components of soils and biota. The potential exposure to biota posed by radionuclides in OU 3 is related to dispersion from soil to plants and animals by measurement of uptake.

In terrestrial animals, ingestion and transfer across the gut wall is the principal uptake mechanism from contaminated forage and prey. Intake of contaminants via inhalation of particulates from air is a minor pathway in comparison to ingestion because of the low levels of PCOCs in the air and the low transfer rates involved. Terrestrial animals can also become exposed by ingesting surface water, and via incidental ingestion of soil and sediments. These pathways are not of concern because PCOCs in surface water within OU 3 have not been identified, and the incidental ingestion of soil and sediments generally accounts for only a small portion of the total quantity of material ingested per day. Also, the PCOCs (radionuclides) in the terrestrial ecosystems at OU 3 are tightly bound to soils and sediments and are not readily bioavailable for uptake.

The absorption of contaminants from particulates deposited on the leaves of vegetation is a minor uptake mechanism in plants. The principal uptake mechanisms for vegetation are cellular transport mechanisms within roots of terrestrial plants that transfer contaminants from the soil into plant tissue. Studies of the soil-to-plant transfer of plutonium in the grassland vegetation at Rocky Flats showed that more than 90 percent of the plutonium was on plant surfaces as foliar contamination (Whicker, 1979). Plant uptake through roots and translocation to aboveground portions were in trace amounts and accounted for only a small portion of the total measured plant activities. Activity ratios for plant uptake from soils ranged from 0.0000001 to 0.001 for transuranic elements (Adriano, et al., 1980). Roots were the most important component in transfer mechanisms from the soil column, and translocation to stem and fruit was limited at less than 10 percent of aboveground portions, and less than 1.0 percent of this was in fruit or grain. The chemical form and quantity of plutonium was a key factor in soil to plant transfers in this investigation (Wildung and Garland, 1980).

In the terrestrial ecosystems, it was determined that the target receptor species would be in contact with soil through various exposure routes and would be sensitive to contaminant effects. Vegetation and small mammals were the logical choice for target species selection. Plants also had the greatest biomass of any terrestrial ecosystem component and were the primary producers in the ecosystem that was eaten by first-level consumers. Small mammals were sampled as a first-level consumer that was potentially exposed by eating vegetation, ingestion of soil, inhalation of soil particles, and body surface contamination of fur.

Insects and soil invertebrates were not sampled because these biotic components had more diffuse and heterogenous populations, and were not necessarily a primary consumer. The biotic components that were also not considered for sampling were large herbivores and secondary consumers such as carnivores and raptors, which are wide-ranging and not confined to OU 3 or the locations being sampled. Bald eagles around Standley Lake are unlikely receptors, due to their wide-ranging habits, and to the lack of bioaccumulation of PCOCs in the food chain.

Studies on animal radionuclide activities at Rocky Flats showed low activities, as well as highly uneven, and occasionally nondetectable levels of plutonium in small mammals and arthropods in areas close to the 903 Pad (Whicker, 1979; Little, 1980). Animal activities that transport or redistribute plutonium include burrowing activities of gophers and prairie dogs, and wide-ranging large herbivore activities, such as foraging by deer (Hiatt, 1977). Burrowing activities transport soil from deeper soil layers to the surface.

Biological transfer rates between trophic levels in food chains from soil microorganisms to top carnivores in grassland ecosystems have not been experimentally studied. Most uptake observed in mammals, arthropods, and herbivorous rodents was presumably from primary food sources such as vegetation (Whicker, 1975). Literature sources have indicated that the low and variable activities, and uneven distributions in prey species preclude contaminant measurement in carnivores—particularly, top carnivores such as mountain lions, and large raptors including bald eagles. Concentrations in carnivores were not measured or estimated in any of the studies reviewed due to the localized contamination of plutonium at Rocky Flats, and due to the wide-ranging activities of the few existing carnivores. The low abundance of predators and lack of bioconcentration preclude conducting adequate field sampling that would yield meaningful data.

2.2 METHODS AND RESULTS OF FIELD INVESTIGATIONS

2.2.1 Field Methodology

In general, the OU 3 ecological field-sampling program provided data necessary to characterize terrestrial communities, and measure the accumulation of PCOCs in terrestrial plant and animal tissue. The purpose and objectives of the terrestrial field sampling program were to develop a thorough familiarization with site characteristics, sample for biotic components, and measure for bioaccumulation. Qualitative surveys were followed by quantitative sampling of terrestrial ecosystems and biota. The quantitative surveys were conducted to describe the ecosystems, and measure the ecological consequences of contaminants released from the source areas. The field investigations were not able to measure indicators of impacts or stresses (ecological endpoints) resulting solely from radionuclide contamination. The DQOs for the ERA field study are provided in the OU 3 Work Plan (DOE, 1992).

The field-sampling program for terrestrial communities was directed at sampling grassland vegetation and small mammal populations at specific locations on OU 3. The station locations and the vegetation types sampled were chosen to be consistent with the early season qualitative surveys, and corresponded to soil pit and surficial-soil sampling locations for site characterization (inclusive of 11 trenches and 2 soil plots).

The field-sampling procedures were developed following protocols recommended by the EPA (1987, 1988, 1989b, 1989d, 1992), the U.S. Fish and Wildlife Service (1981a, 1981b), and the Standard Operation Procedures (SOPs) developed for Rocky Flats (DOE, 1991b). SOP 5.13, Development of Field Sampling Plans, for biological sampling during the field activities was used to develop sampling

procedures. This SOP included procedures for sampling organisms, and protocol to be followed. All ecological data and sample collecting followed the procedures provided in the Ecology SOP (Volume V) (DOE, 1991b), with appropriate Rocky Flats-specific objectives.

The field-sampling activities were correlated in time and space parameters so that abiotic data were collected concurrently with biotic data. The ecological field sampling was carefully integrated with the RFI/RI sampling for OU 3 to coordinate the water, sediment, and soil- sampling efforts with the ecological sampling. At all of the terrestrial sample locations, vegetation sampling sites were located in the same areas and preceded soil sampling. In addition to planning sampling events during the same time frame, other RFI/RI sampling procedures and analytical protocols for water, sediment, soil, and air samples were reviewed to ensure that the data necessary to develop and model exposure pathways during the ERA would be acquired.

The field-sampling program consisted of a short initial qualitative field survey conducted in May and June 1992. The terrestrial sampling followed with a single quantitative field-sampling event in mid-summer. The quantitative sampling was conducted by two taxonomic groups for terrestrial ecosystems, vegetation, and small mammals. During the quantitative sampling, the sampling teams recorded qualitative observations to assist in interpretation of the field data collected during the program.

The reconnaissance and qualitative field survey developed a thorough familiarization with OU 3 characteristics to guide the location and types of quantitative field surveys. All prominent features and general observations of OU 3 were recorded in the reconnaissance field surveys including topography, drainages, soils, vegetation, animals, wetlands, and the relationship of these features to land use. The site was visited on a initial familiarization field trip in which the major habitat types and ecosystems were observed and noted. Qualitative vegetation, bird, and mammal surveys followed protocol in Sections EE.7.0, EE.9.0 and EE.10.0 in the Ecology SOP (DOE, 1991b).

The physical limits of the proposed quantitative-sampling locations were determined and staked. General observations were conducted of the vegetation, small and large mammals, predators, birds, and signs of animals (tracks, scat, skeletons, burrows, etc.). At sampling locations close to the site boundaries, plants and animals were examined for signs of impacts or effects of contaminants. Observations on recent biological activities that impeded or increased the movement of soil contaminants were noted. In particular, visual surveys were made for prairie dogs, ants, and burrowing animals such as gophers, which bring large amounts of subsurface soil to the surface where it is redistributed by wind. Observations were made for badger and fox which excavate dens or dig in search of prey. Threatened and endangered species of plants and animals potentially present on OU 3 were identified and appropriate habitats surveyed.

Qualitative surveys for mammals, birds, and reptiles were conducted by systematically driving and walking the area on preselected routes at appropriate times, and by opportunistic sightings during all OU 3 visits. Bird surveys were conducted at dawn and dusk. Records were kept of species and other features observed such as numbers, condition, habitat, and activities. Other evidence of animals or birds including burrows, scat, and nests were recorded.

Based on information from the other sites and DOE reports, snow-accumulation depressions and protected slopes on the lee side of windbreaks downgradient of the source areas are sensitive indicators of contaminant deposition via the air pathway. These types of areas were located and delineated for later quantitative sampling. Mesic and wetland plant communities in drainages and depressions were too

small and scattered to systematically sample, and were subject to present management disturbances for water control.

Sampling sites for terrestrial tissue collection were selected to represent gradients of contaminant activity from east to west of the site boundary, and north to south along Indiana Street in OU 3. The approach to the collection and analysis of field data was based on discussions at a series of meetings at the EG&G offices in July 1992 after analysis of OU 1 data. The conclusion of those meetings was that more attention for OU 3 would be given to the concurrent sampling of abiotic and biotic data for the purposes of statistical analysis and the interpretation of results. The emphasis on the sampling plan was to determine if there was exposure and dose to biotic components by uptake of radionuclides in plant or animal tissue.

2.2.2 Field Investigation Techniques for Biotic Sampling

Quantitative sampling of terrestrial ecosystems at OU 3 were conducted to complete an inventory of the ecosystems for a site characterization and to measure ecological stress, if possible. The quantitative sampling program included measuring biotic parameters at selected sampling stations and measuring contaminant activities in tissue samples. The quantitative sampling supplemented qualitative survey information used for characterizing the ecosystems, identifying major plant and animal receptors, and developing exposure pathways. Qualitative observations continued to be recorded when field biologists were conducting quantitative sampling.

The parameters chosen for quantitative sampling were determined by the needs of the ERA. Based on previous studies and information, the principal contaminants are plutonium and americium which are generally immobile in the environment and are not bioaccumulated. For this reason the primary producers (above-ground plant biomass) and a primary, herbaceous consumer (mice, deer mice, and microtines) were chosen as the most likely to show contaminant uptake. If these two principal components of the food chain do not show measurable accumulations, hence ecological effects, then higher components in the food chain would not be affected. In order to be conservative, total above-ground vegetation was clipped, and whole small mice were collected. Vegetation was not washed to remove surface contamination, nor were mice dissected to measure distribution of radionuclides.

Field-sampling operations measuring bioaccumulation and conducting sampling studies of terrestrial species are described in the following subsections. The field procedures were integrated with similar ecological assessment field studies at OU 6 (Walnut Creek) and OU 5 (Woman Creek), with the National Pollutant Discharge Elimination System (NPDES) program at Rocky Flats which assesses water quality of plant discharges, and with routine monitoring and special sampling events conducted by the State. Selection of sampling locations was coordinated with other RFI/RI sampling, specifically for soil pits and surficial-soil sampling locations. The planning and preparation for field sampling at OU 3 included development of sample and waste management protocols that are integrated, and in conformance, with sample and waste management procedures and (QA/QC) requirements for Environment Restoration (ER).

Vegetation

The grassland communities at the sampling locations were measured for plant-species composition, cover, and productivity using standardized procedures for site characterization and modified procedures, as discussed here, for quantitative sampling. These parameters give the best indication of the structure

and function of dryland vegetation. The sampling protocol followed Section EE.10 in the Ecology SOP (DOE, 1991b), except as noted.

Mid-summer data were collected, and tissue samples were collected for analysis at the same time. Data collected were analyzed to assess the following variables:

- Total plant cover
- Cover by perennial grasses, annual grasses, perennial forbs, and annual or biennial forbs
- Cover by individual species
- Richness (number of species)
- Production (standing biomass in grams per square meter (g/m^2) and pounds per acre (lbs/acre)
- Height (in centimeters)

Sampling locations coincided with soil pits or surface soil-sampling in areas of suspected contamination along gradients of contaminant activities. The 13 locations chosen were modified, based on results of the qualitative field surveys conducted in the late spring, and chosen to represent the habitat types determined during the qualitative surveys. The locations for sampling grassland vegetation corresponded with the soil-sampling locations with additional locations, based on grassland vegetation types. Within the sampling area, transects for vegetative cover and clipping plots for productivity were located close on the soil-sampling points or in areas of well-developed vegetation.

Two types of quantitative surveys were used for cover and productivity estimates; point intercept transects for grasslands and 5 contiguous round 0.5 m^2 plots for productivity and tissue-sample collections. In the intercept transects, plant species were recorded based on the number of occurrences, and notes were made on height, condition, and phenology. For productivity in grasslands, vegetation in 0.5 m2 plots were clipped to within 1/2 inch of the ground surface according to the current season's growth by species or type of species, and bagged for dry weight and tissue analysis. The number of transects or quadrats for both cover and productivity were determined by a sample adequacy formula. The sample adequacy was determined to be 5 to 8 sample plots. Sample procedures followed the RFI/RI Work Plan and Section EE.10 in the Ecology SOP (DOE, 1991b) with the following pattern. Five contiguous round plots were sampled at the soil-pit locations for a combination of species composition, cover, productivity and plant-tissue sampling. All clipped vegetation was composited for each 0.5 square meter plot for weight and tissue analysis. The samples clipped for productivity and wet/dry weight analysis were collected in bags, oven-dried (104°C for 24 hours) to a constant weight, and weighed.

Vegetation samples collected for tissue analysis were not dried, but bagged and frozen immediately. Sample procedures followed the sample preparation and packaging specified by the laboratory protocols for the selected analytes and were generally consistent with DOE (1991b). Tissue-sample analysis provided data on activities of contaminants in vegetation as an indication of bioconcentration.

QA/QC followed procedures defined in DOE (1991b). Tissue-sample collections were controlled according to the Quality Assurance Project Plan (QAPP), and there were no deviations from this plan.

Small Mammals

Small mammal populations were surveyed to determine habitat use and relative abundance. The data were used in development of pathway models, and the exposure assessment. For community evaluation, endpoints included:

- Richness (number of species)
- Abundance (number per trapping period) by species
- Mean weight

Small mammals, particularly deer mice and microtines, are primary consumers of vegetation and form the basis for the link to the higher levels in the food chain leading to top carnivores. Alternate species, prairie dogs or pocket gophers, were not collected for tissue analysis since the small mammal collection was adequate, and the larger mammals would duplicate efforts. The contaminants sampled and analyzed in small mammals were the same as for vegetation; plutonium and americium. Sampling locations coincided with vegetation-sampling plots for tissue analysis in areas of suspected contamination.

There was one trapping period in mid-summer run for four consecutive nights. Small mammals were collected using the live-trapping techniques described in DOE (1991b). Thirteen locations were collocated with vegetation study plots. A 5m x 5m grid of 25 Sherman live traps was positioned at each location. Traps were spaced 5 meters apart, with each trap covered by a sheet metal hood to provide protection against sun and rain. Traps were baited during evenings with a rolled oats mixture (Omalene horse feed), and checked for 4 mornings. This trapping effort resulted in 100 trap-nights (25 traps for 4 nights) at each of the 13 locations.

Captured animals were marked by hair clipping and released after the following information was recorded: species, weight, sex, reproductive status, age class, if previously marked (a recapture), and trap number. Trapping was performed between July 14 and August 8, 1992, and only during typical (not inclement) weather. All information was recorded on standard data sheets.

Specimens collected for tissue analysis were restricted to small mammals. Collections were made at the 13 small mammal, live-trapping locations described above. Animals collected for tissue analysis were sacrificed, and the dead animals placed in plastic sample containers in a cooler with Blue ice for up to 4 hours. After 4 hours or less, the samples were placed in a freezer until shipped. Labeling, handling, and shipping of small mammals for laboratory analysis were consistent with DOE (1991). Samples collected for tissue analysis followed the sample preparation and packaging specified by the laboratory protocols for the selected analytes. Special attention to procedures minimized the chance of harm to the animals not intended for tissue analysis, and avoided injury to the workers from animal bites or scratches.

QA/QC followed procedures defined in SOP 5.0, and there was no variance from the SOP or QAPP. This information is stored as original field data and electronic computer files at Rocky Flats.

Other Wildlife Studies

Other wildlife species observed were other larger mammals, small birds, reptiles and amphibians, raptorial birds, and threatened and endangered species.

The small birds observed included all passerines (perching birds), as well as woodpeckers, swifts, and hummingbirds. Ten locations, previously selected by the Vegetation Study Team, were sampled on the OU 3 study area. Three 100 x 100 meter contiguous plots were centered on each of these ten locations. The corners and central positions along the perimeters of each plot were marked with a flagged stake. All birds seen or heard within each plot were recorded while walking along plot center lines. A standard data sheet was used to record bird sightings, as well as information on temperature, wind speed, cloud cover, and time of observations. All small-bird sampling was performed between June 2 and 18, 1992.

Raptors (eagles, hawks, falcons, owls) were recorded from a vehicle while driving on the roads in the project area, and during the course of other field activities. The objectives of the raptor studies were to obtain a list of the species present at OU 3, and to obtain an estimate of abundance. Special attention was given to examining large trees for nests, and prairie-dog colonies for the presence of burrowing owls.

Reptiles and amphibians were searched for throughout the area, with special attention given to searches in moist habitats. Also, snakes were searched for beneath logs and debris, and were identified, when found, as road kills. As with raptor studies, the objectives were to obtain a species list and an estimate of abundance. Surveys of state - or federally-listed threatened or endangered wildlife were an integral part of the studies described above. No specific studies designed solely for identifying threatened or endangered wildlife were performed. There are other intensive programs at Rocky Flats that deal specifically with surveys for threatened and endangered species, including areas on OU 3.

The entire quantitative database of the terrestrial-field investigation has been entered into an electronic data format (Dbase IV) in the Technical Information System in RFEDS. This data is also in the Sitewide Ecological Database (SED). Original field data forms are also deposited with RFEDS. This field data and information for site characterization is available, but is not summarized or presented here because the preliminary two-phase assessment did not determine significant risks.

3.0 ANALYSIS OF EFFECTS

The potential effects of the Rocky Flats related radionuclides on the terrestrial ecosystems were considered at the individual and population levels. The potential effects stem from the radionuclides disrupting the individuals ability to perform the normal functions of growth, reproduction, and basic survival. The stress on the individual is then reflected in potential reductions or changes in biomass production, species composition, and population size. The potential effects of the contaminants reflect the results of exposure to increasing activities of the PCOCs. Examples of these can be:

- Decrease in vigor and resistance to natural stressors
- Reduction in vegetative productivity and animal biomass
- Shift in species composition

Decreases in an individual's vigor and resistance to natural stressors such as disease, parasites, and predation are the first potential effects to be demonstrated at the lowest activity of radionuclides that begin to show effects. Significant decreases in individual vigor and resistance is reflected in a reduction in overall vegetative productivity and animal biomass. Reduced vegetative productivity is a consequence of slowed growth and seed production. Low animal biomass is a result of stunted growth and low reproduction rates.

Population and community level potential effects are a shift in species composition and a decrease in overall production or population size due to reduced reproduction and individual mortality. Some species of plants and animals are more resistant to radionuclides due to rapid growth or population turnover rates, influx from surrounding populations, or a larger gene pool to allow adaption to the stressor. High levels of exposure to radionuclides would result in shifts in species composition to these more resistant species. Decreases in overall population due to reduced reproduction and individual mortality, would be the potential effect at extremely high levels of radionuclide activities.

3.1 TOXICITY OF PCOCS

The activity and toxicity of transuranic and radionuclide elements have been moderately researched for effects to terrestrial ecosystem components, however, experimental studies on exposure and high dose rates have been widely investigated (DOE, 1995c). The bioavailability and toxicity of transuranic radionuclides to exposed receptors is site specific. Review of literature information provided a view point of conditions and effects that can occur within terrestrial ecosystems at OU 3. This literature information, in combination with site-specific investigations, was used to determine OU 3-specific effects of the PCOCs to terrestrial life.

A recent report (DOE, 1995c) determined radiological benchmark values for wildlife at Rocky Flats. The benchmark activities are the safe-exposure level in the media that will not result in an adverse effect or dose to the exposed animal. In this study, a dose limit was selected at 100 mrad/day, and the media activity that would result in this dose was back-calculated, using commonly accepted radiological techniques. The recommended benchmark value for soils at Rocky Flats for plutonium-239, -240 was 4000 pCi/g, and for americium-241 was 2000 pCi/g. These values are protective of wildlife species, and it is expected that plants and soil microorganisms will be less sensitive. These benchmarks were used to determine a hazard for the PCOCs at OU 3. The toxicity and effects of the PCOCs, plutonium and americium, in open ecosystems is presented in following discussions.

Effects of irradiation on terrestrial organisms in natural ecosystems from contamination of radionuclides have not been measured or quantified in the field, especially transuranics. Ecosystems and terrestrial populations tolerate higher levels of transuranic elements due to low solubility, immobility in natural systems, low uptake rates, and a lack of penetrating radiations as compared to isotopes of iodine, strontium, and cesium (Whicker, 1980). Direct experiments in the field applying transuranics have not been conducted because large quantities of radionuclides would need to be applied to elicit an effect.

Examination of plutonium-contaminated environments at the Site (Whicker, 1979 and 1980), and the Nevada Test Site (Wallace and Romney, 1972; Friesen, 1992) failed to detect effects in biological attributes related to plutonium contamination. These studies lacked suitable control of the abiotic factors in the analysis of biotic effects analyzed in natural environments, so that cause and effects relationships could be determined. There were no detection of effects based on observations and testing of animals and plants studied. Existing data used to predict ecological hazards from transuranic contamination have not been extensively modeled. Models have concentrated on human dose and effects, and generally have been considered as protective of natural populations. However, this assumption has not been adequately tested.

Direct effects of alpha emitters, such as plutonium, have been measured in a few laboratory animal species, but not plants (DOE, 1995c). These studies are not applicable to the study of ecological effects in the field due to the differences in the activities used, and as being several orders of magnitude higher. There are no models adequate for equating effects at the low levels generally present in environments to

natural populations or ecosystems. The presently known levels of plutonium in the environment have not produced any discernable ecological effects (Hansen, ed.,1980).

3.2 ECOLOGICAL EFFECTS EVALUATION

The results of collocated environmental sampling of contaminants in soils, animal tissue, and plant tissue are presented in this section. The plant and animal tissue are analyzed for detections, activity ratios, and other comparisons. Dose calculations based on the tissue activities are presented and compared to the benchmark values.

3.2.1 PCOC Activities in Soils and Biotic Tissues

Information on the characteristics of the small mammal and plant-tissue samples are presented in Tables 3-1 and 3-2. Table 3-3 presents the summary statistics of contaminant activities measured in the terrestrial sampling at OU 3 and Table 3-4 presents the total results of the sampling. The following discusses the results of this sampling for percent of detects; maximum, mean, and average activities; and the activity ratios between soils and biological samples. The concentration ratios for co-located soil and biological samples are presented on Table 3-5.

Most animal tissues sampled did not contain detectable activity levels of plutonium and americium. The maximum plutonium activity measured in animal tissue was 0.026 pCi/g (arithmetic mean = 0.002 pCi/g). The maximum ratio of plutonium activity in animal tissue to surface soil (0 to 3 cm depth interval) was 0.012.

The maximum americium activity detected in animal tissue was 0.160 pCi/g. This measured activity of americium is approximately 40 times greater than the mean americium activity (0.004 pCi/g) for animal tissue, and is considered an anomalous result. Out of the 42 animal tissue samples collected, the next highest measured activity of americium was 0.007 pCi/g. The americium activity measured in the collocated soil sample (at location PT16392) was 0.054 pCi/g. It is understood that americium does not bioconcentrate, further indicating that the 0.160 pCi/g result is an outlier. The reason for this anomalous americium activity is not known, but it is possible that the corresponding animal tissue sample could have been inadvertently contaminated after sample collection and/or sample preparation. The 0.160 pCi/g result is considered to be an anomaly and was therefore not used to calculate the maximum americium activity ratio between animal tissue and soil.

Based on the next highest measured americium activity in animal tissue (0.002 pCi/g) and corresponding collocated soil sample result (0.144 pCi/g), the maximum ratio of plutonium activity in animal tissue to surface soil was 0.014. At the time of this publication, no literature values for ratios of plutonium and americium activity in animal tissue to surface soil were available for comparison (Coughtrey, et al., 1985; Hansen, ed, 1980; DOE, 1995c).

The maximum plutonium activity measured in plant tissue was 0.190 pCi/g (arithmetic mean = 0.011 pCi/g). The maximum ratio of plutonium activity in plant tissue to surface soil (0 to 3 cm depth interval) was 0.466. The maximum detected americium activity in plant tissue was 0.016 pCi/g (arithmetic mean = 0.002 pCi/g). The maximum ratio of americium activity in plant tissue to surface soil was 0.131. General literature values for ratios of plutonium and americium activity in plant tissue to soil are 0.02 and 0.07, respectively (Coughtrey, et al., 1985).

The above referenced activity values were used in the following section to calculate dose to plant and animal tissue for comparison to a dose limit considered safe, and for comparison to media activities as benchmark values. The effects evaluation is based on these comparisons.

3.2.2 Calculation of Dose Based on Tissue Activities

The dose to the tissue of plants and animals can be calculated if the tissue activity is known. The equation for estimated dose for radionuclides deposited in tissue is as follows (DOE, 1995c):

$$R = \frac{(3.2 \times 10^3 \text{ dis/d/pCi}) \sum Ci \times Éi}{(6.25 \times 10^4 \text{ MeV/g/mrad})}$$

where

R = dose rate (mrad/d)
Éi = effective absorbed energy (MeV per disintegration [dis] for nuclide i in the organism)
Ci = activity of radionuclide i in the tissue of concern

As a conservative measure, the maximum activity detected in any biotic sample was used to calculate dose. The radiation dose from maximum radionuclide tissue concentrations are presented on Table 3-6. The maximum americium activity detected in animal tissue was 0.160 pCi/g. This gives a maximum calculated dose of americium to animal tissue of 0.84 mrad/d, and a most conservative dose HQ of 8.4×10^{-3}. Using the maximum plutonium activity (0.026 pCi/g) gives a calculated dose of plutonium to animal tissue of 0.14 mrad/d.

The calculated dose of plutonium (using the maximum plutonium tissue activity of 0.190 pCi/g) and americium (using the maximum americium activity of 0.016 pCi/g) to plant tissue was 1.0 mrad/d and 0.084 mrad/d, respectively. The corresponding plant tissue dose HQ values for plutonium and americium were calculated to be 1×10^{-2} and 8.4×10^{-4}.

The calculated plutonium and americium dose values for plant and animal tissue are well below the 100 mrad/d dose considered protective of animal and vegetative tissue. The resultant dose HQs for plant and amimal tissue are well below the level of concern HQ value of 1.0.

3.2.3 Comparisons of Activity Levels to Benchmark Values

The activities of contaminants in soils can be evaluated for risk by calculating a ratio of the observed activity at OU 3 to the benchmark as a screening process. An HQ can be determined using (DOE, 1995c):

$$HQ = \frac{[PCOC]}{\text{Benchmark}}$$

where HQ is the hazard quotient, PCOC is the measured activity of the PCOC, and Benchmark is the benchmark activity in pCi/g for soils.

For a conservative estimate of risk at OU 3, the highest measured soil activity for plutonium in the soil trenches was 1.6 pCi/g versus a benchmark value of 4000 pCi/g. The HQ for plutonium is 4×10^{-4} (1.593÷4000). Similarly, the HQ calculated for americium at a activity of 0.3 pCi/g in soil is 9×10^{-5}

(0.272÷3000). The addition of these two values gives a total hazard index (HI) of 5×10^{-4} for the PCOCs at OU 3.

An HQ or HI of 1.0 would be cause for concern for contaminants in the environment. The HI calculated for environmental contaminants is about four orders of magnitude (four thousand times) less than the amount considered protective of animals in the terrestrial ecosystems at Rocky Flats.

Based on the results of the Preliminary Exposure and Effects Evaluation, the PCOCs as identified in Attachment 2 for the terrestrial ecosystems, plutonium and americium in soils were not identified as contaminants of concern. The activities of these radiological contaminants in soils were well below those considered toxic to small mammals. Conservative estimates of OU 3 exposure activities in soils did not exceed benchmark values. The total HI for the radiological PCOCs was 5×10^{-4}, well below 1, which is considered protective of biota. The highest dose to an animal was calculated to be 0.84 mrad/d for americium. The highest dose to plant tissue was calculated to be 0.10 mrad/d for plutonium. This dose is well below the 100 mrad/d considered protective of animal and plant life.

4.0 UNCERTAINTIES ASSOCIATED WITH ANALYSIS

The preliminary screening process for the terrestrial portion of this ERA has sources of uncertainty. The risk estimates are dependent on numerous assumptions and other sources of uncertainty such as measurement variability and the stochastic (inherent randomness) nature of natural ecosystem processes. To address uncertainties, the preliminary assessment was, of necessity, conservative. In the assessment process, the following sources of uncertainty and limitations are present:

- Inherent variability of measurements and of the complex nature of ecological parameters and populations being assessed
- Parameter values from literature and extrapolation to a field situation in unmanaged ecosystems
- Variance estimates for all statistics, especially for the low number of detects and the values measured
- Assumptions and the range of conditions underlying use of statistics and models

The intentional use of conservative assumptions and the maximum values for contaminant activities to calculate dose and HQs reduced inputs of the uncertainty in the values derived. These unrealistic scenarios are unlikely to occur under conditions in natural environments, and therefore, ensure that the risk evaluations handle the inherent uncertainty in natural terrestrial ecosystems. The uncertainty is further reduced by the low exposure and doses calculated for biotic tissues, and the extremely low HQs based on benchmark values which have additional safety factors.

5.0 SUMMARY AND CONCLUSIONS

The ERA for terrestrial ecosystems on OU 3 was conducted by employing a preliminary exposure and effects assessment screening approach, and using information and data from previous sitewide studies and site-specific sampling at OU 3. The methods used to determine risks were comparison to benchmark values in environmental media, and calculation of estimated dose to animal and plants based on measured tissue activities. Field sampling was collocated to verify activities in abiotic and biotic samples, and for

comparison to previous research studies at OU 3 and literature information. Detailed qualitative and quantitative observations and field sampling did not identify effects on biological populations or communities.

In the risk characterization, risks were determined to be unlikely, based on all comparisons and other weight-of-evidence during the preliminary exposure and effects assessment. The HQ was 0.00049 (1 is considered hazardous), and highest dose to tissue in one small mammal was 0.84 mrad/d, an outlier that was 40 times the average activity measured. A dose of 100 mrad/d is considered protective of wildlife according to a radiological benchmark publication (DOE, 1995c). The PCOCs did not qualify as ecological chemicals of concern (ECOCs) mainly based on low activities in soils and the low bioavailability, hence uptake and dose to plant and animal tissue.

There is no required mitigation for ECOCs on OU 3 based on the ecological risks to terrestrial plants and animals assessed during this ERA. All of the abiotic media activities in soils and tissue doses were well below the level considered hazardous in terrestrial ecosystems.

Table 3-1
Small Mammal
Tissue Samples Collected

Sample Number	Location Number	Species	Number Collected	Weight
BIO3300CH	BIO01292	vole	1	46
BIO3301CH	BIO01292	vole	1	50
BIO3302CH	BIO01292	vole	1	57
BIO3303CH	BIO01292	vole	1	50
BIO3304CH	BIO01292	vole	1	47
BIO3305CH	BIO01292	deer mouse	2	36
BIO3306CH	BIO00392	vole	1	52
BIO3307CH	BIO00392	vole	1	51
BIO3308CH	BIO00392	deer mouse	3	66
BIO3309CH	BIO01092	deer mouse	2	39
BIO3310CH	BIO01092	deer mouse	2	37
BIO3311CH	BIO01092	deer mouse	3	53
BIO3312CH	BIO01492	vole	1	30
BIO3313CH	BIO01492	vole	1	29
BIO3314CH	BIO01492	vole	1	57
BIO3315CH	BIO00792	vole	1	48
BIO3316CH	BIO00792	vole	1	52
BIO3317CH	BIO00792	vole	1	
BIO3318CH	BIO01992	deer mouse	2	41
BIO3319CH	BIO01992	deer mouse	1	43
		pocket mouse	1	
BIO3320CH	BIO01992	deer mouse	2	62
BIO3321CH	BIO01892	deer mouse	2	31
BIO3322CH	BIO01892	deer mouse	2	39
BIO3323CH	BIO01892	deer mouse	2	30
BIO3324CH	BIO02092	vole	1	44
BIO3325CH	BIO02092	vole	1	54
BIO3326CH	BIO02092	vole	1	39
BIO3327CH	BIO011092	deer mouse	2	45
BIO3328CH	BIO011092	deer mouse	3	58
BIO3329CH	BIO011092	deer mouse	3	56
BIO3330CH	BIO005092	vole	1	52
BIO3331CH	BIO005092	vole	1	54
BIO3332CH	BIO005092	vole	1	44
BIO3333CH	BIO006092	pocket mouse	1	45
BIO3334CH	BIO006092	deer mouse	2	33
BIO3335CH	BIO006092	deer mouse	2	33
BIO3336CH	BIO008092	pocket mouse	1	30
BIO3337CH	BIO008092	deer mouse	2	31
BIO3338CH	BIO008092	pocket mouse	2	61
BIO3339CH	BIO004092	deer mouse	2	34
BIO3340CH	BIO004092	deer mouse	2	36
BIO3341CH	BIO004092	deer mouse	2	33

Table 3-2
Terrestrial Vegetation Tissue Samples Collected

Sample Number	Location Number	Date	Community Type	Habitat	Wt.
BIO3011CH	BIO00392	7/21/92	mesic meadow	moist meadow	214
BIO3012CH	BIO00392	7/21/92	mesic meadow	moist meadow	195
BIO3013CH	BIO00392	7/21/92	mesic meadow	moist meadow	199
BIO3014CH	BIO00392	7/21/92	mesic meadow	moist meadow	190
BIO3015CH	BIO00492	8/14/92	xeric to mesic meadow	short grassland	140
BIO3016CH	BIO00492	8/14/92	xeric to mesic meadow	short grassland	111
BIO3017CH	BIO00492	8/14/92	xeric to mesic meadow	short grassland	99
BIO3018CH	BIO00492	8/14/92	xeric to mesic meadow	short grassland	87
BIO3019CH	BIO00492	8/14/92	xeric to mesic meadow	short grassland	56
BIO3020CH	BIO00492	8/14/92	xeric to mesic meadow	short grassland	71
BIO3021CH	BIO00592	7/16/92	mesic meadow	moist meadow	294
BIO3022CH	BIO00592	7/16/92	mesic meadow	moist meadow	314
BIO3023CH	BIO00592	7/16/92	mesic meadow	moist meadow	333
BIO3024CH	BIO00592	7/16/92	mesic meadow	moist meadow	294
BIO3025CH	BIO00592	7/16/92	mesic meadow	moist meadow	321
BIO3026CH	BIO00692	7/10/92	xeric upland	xeric mixed grassland	81
BIO3027CH	BIO00692	7/10/92	xeric upland	xeric mixed grassland	68
BIO3028CH	BIO00692	7/10/92	xeric upland	xeric mixed grassland	64
BIO3029CH	BIO00692	7/10/92	xeric upland	xeric mixed grassland	158
BIO3030CH	BIO00692	7/10/92	xeric upland	xeric mixed grassland	68
BIO3031CH	BIO00792	7/15/92	mesic meadow	moist meadow	252
BIO3032CH	BIO00792	7/15/92	mesic meadow	moist meadow	220
BIO3033CH	BIO00792	7/15/92	mesic meadow	moist meadow	272
BIO3034CH	BIO00792	7/15/92	mesic meadow	moist meadow	215
BIO3035CH	BIO00792	7/15/92	mesic meadow	moist meadow	331
BIO3036CH	BIO00892	7/15/92	xeric upland	xeric mixed grassland	99
BIO3037CH	BIO00892	7/15/92	xeric upland	xeric mixed grassland	41
BIO3038CH	BIO00892	7/15/92	xeric upland	xeric mixed grassland	49
BIO3039CH	BIO00892	7/15/92	xeric upland	xeric mixed grassland	68
BIO3040CH	BIO00892	7/15/92	xeric upland	xeric mixed grassland	64
BIO3046CH	BIO01092	7/15/92	mesic meadow	mesic mixed grassland	114
BIO3047CH	BIO01092	7/15/92	mesic meadow	mesic mixed grassland	106
BIO3048CH	BIO01092	7/15/92	mesic meadow	mesic mixed grassland	91
BIO3049CH	BIO01092	7/15/92	mesic meadow	mesic mixed grassland	90
BIO3050CH	BIO01092	7/15/92	mesic meadow	mesic mixed grassland	65
BIO3051CH	BIO01192	7/17/92	mesic meadow	mixed grassland complex	190
BIO3052CH	BIO01192	7/17/92	mesic meadow	mixed grassland complex	157
BIO3053CH	BIO01192	7/17/92	mesic meadow	mixed grassland complex	166
BIO3054CH	BIO01192	7/17/92	mesic meadow	mixed grassland complex	236
BIO3055CH	BIO01192	7/17/92	mesic meadow	mixed grassland complex	187
BIO3056CH	BIO01292	7/20/92	mesic meadow	moist meadow	179
BIO3057CH	BIO01292	7/20/92	mesic meadow	moist meadow	157
BIO3058CH	BIO01292	7/20/92	mesic meadow	moist meadow	175
BIO3059CH	BIO01292	7/20/92	mesic meadow	moist meadow	240
BIO3060CH	BIO01292	7/20/92	mesic meadow	moist meadow	145
BIO3066CH	BIO01492	7/27/92	mesic meadow	moist meadow	222
BIO3067CH	BIO01492	7/27/92	mesic meadow	moist meadow	216
BIO3068CH	BIO01492	7/27/92	mesic meadow	moist meadow	246
BIO3069CH	BIO01492	7/27/92	mesic meadow	moist meadow	239
BIO3070CH	BIO01492	7/27/92	mesic meadow	moist meadow	227
BIO3086CH	BIO01892	7/21/92	xeric upland	xeric mixed grassland	71

Table 3-2
Terrestrial Vegetation Tissue Samples Collected

Sample Number	Location Number	Date	Community Type	Habitat	Wt.
BIO3087CH	BIO01892	7/21/92	xeric upland	xeric mixed grassland	63
BIO3088CH	BIO01892	7/21/92	xeric upland	xeric mixed grassland	57
BIO3089CH	BIO01892	7/21/92	xeric upland	xeric mixed grassland	68
BIO3090CH	BIO01892	7/21/92	xeric upland	xeric mixed grassland	54
BIO3091CH	BIO01992	8/6/92	xeric upland	short grassland	52
BIO3092CH	BIO01992	8/6/92	xeric upland	short grassland	58
BIO3093CH	BIO01992	8/6/92	xeric upland	short grassland	117
BIO3094CH	BIO01992	8/6/92	xeric upland	short grassland	52
BIO3095CH	BIO01992	8/6/92	xeric upland	short grassland	53
BIO3096CH	BIO02092	8/7/92	xeric to mesic slope	xeric mixed grassland	63
BIO3097CH	BIO02092	8/7/92	xeric to mesic slope	xeric mixed grassland	51
BIO3098CH	BIO02092	8/7/92	xeric to mesic slope	xeric mixed grassland	39
BIO3099CH	BIO02092	8/7/92	xeric to mesic slope	xeric mixed grassland	103
BIO3100CH	BIO02092	8/7/92	xeric to mesic slope	xeric mixed grassland	101

Table 3-3
Summary Statistics of Plant and Animal Tissue Analysis for Concentrations of Plutonium and Americium

Matrix	Chemical	Num of Detects	Num of Samples	Detect Freq	Minimum Detect	Maximum Detect	Arith. Mean	Standard Deviation
Small Mammal	AM-241	3	42	0.071	0.004	0.160	0.004	0.025
Small Mammal	PU-239/240	9	41	0.220	0.001	0.026	0.002	0.005
Vegetation	AM-241	36	65	0.554	0.001	0.016	0.002	0.003
Vegetation	PU-239/240	44	65	0.677	0.000	0.190	0.011	0.027
Trench (all)	AM-241	41	41	1.000	-0.002	0.272	0.031	0.054
Trench (all)	PU-239/240	81	81	1.000	-0.006	1.593	0.118	0.267
Trench (0-3cm)	AM-241	4	4	1.000	0.079	0.272	0.156	0.082
Trench (0-3cm)	PU-239/240	9	9	1.000	0.006	1.593	0.588	0.550
Surface Soil	AM-241	2	2	1.000	0.054	0.099	0.076	0.032
Surface Soil	PU-239/240	2	2	1.000	0.115	0.665	0.390	0.389

Table 3-4
Results of Sample Analysis for Media Concentration of Plutonium and Americium

Matrix	Location	Sample Number	Sampling Date	Depth	Am Results	Am Error	Pu Results	Pu Error
Sm Mammal	BI000392	BI03306CH	8/13/92		0.007	0.015	0.000	0.001
Sm Mammal	BI000392	BI03307CH	7/29/92		-0.001	0.003	0.001	0.002
Sm Mammal	BI000392	BI03308CH	7/29/92		0.002	0.002	0.000	0.001
Sm Mammal	BI000492	BI03339CH	8/8/92		0.001	0.005	0.001	0.001
Sm Mammal	BI000492	BI03340CH	8/8/92		-0.001	0.008	0.000	0.001
Sm Mammal	BI000492	BI03341CH	8/8/92		0.006	0.006	0.000	0.002
Sm Mammal	BI000592	BI03330CH	7/17/92		0.001	0.002	0.001	0.001
Sm Mammal	BI000592	BI03331CH	7/17/92		0.000	0.001	0.000	0.000
Sm Mammal	BI000592	BI03332CH	7/17/92		-0.004	0.005	0.000	0.001
Sm Mammal	BI000692	BI03333CH	7/30/92		0.006	0.003	0.026	0.004
Sm Mammal	BI000692	BI03334CH	7/30/92		0.003	0.003	0.001	0.002
Sm Mammal	BI000692	BI03335CH	7/30/92		-0.004	0.004	0.001	0.003
Sm Mammal	BI000792	BI03315CH	8/13/92		-0.002	0.002	0.003	0.002
Sm Mammal	BI000792	BI03316CH	8/13/92		0.000	0.005	0.003	0.003
Sm Mammal	BI000792	BI03317CH	8/13/92		0.002	0.007	0.000	0.001
Sm Mammal	BI000892	BI03336CH	7/17/92		0.004	0.003	0.013	0.004
Sm Mammal	BI000892	BI03337CH	7/17/92		0.001	0.002	0.000	0.003
Sm Mammal	BI000892	BI03338CH	7/17/92		0.001	0.004	0.006	0.005
Sm Mammal	BI001092	BI03309CH	8/9/92		0.000	0.002		
Sm Mammal	BI001092	BI03310CH	8/9/92		-0.001	0.003	0.000	0.001
Sm Mammal	BI001092	BI03311CH	8/9/92		0.000	0.002	0.002	0.002
Sm Mammal	BI001192	BI03327CH	7/28/92		0.000	0.002	0.002	0.002
Sm Mammal	BI001192	BI03328CH	7/28/92		0.002	0.004	-0.001	0.003
Sm Mammal	BI001192	BI03329CH	7/28/92		0.001	0.003	0.001	0.001
Sm Mammal	BI001292	BI03300CH	7/28/92		0.001	0.002	0.000	0.003
Sm Mammal	BI001292	BI03301CH	7/28/92		0.000	0.005	0.000	0.003
Sm Mammal	BI001292	BI03302CH	7/28/92		-0.002	0.001	0.001	0.001
Sm Mammal	BI001292	BI03303CH	7/28/92		0.000	0.002	0.000	0.001
Sm Mammal	BI001292	BI03304CH	7/28/92		-0.001	0.002	0.000	0.003
Sm Mammal	BI001292	BI03305CH	7/28/92		0.000	0.003	0.001	0.001
Sm Mammal	BI001492	BI03312CH	7/29/92		-0.003	0.003	0.000	0.001
Sm Mammal	BI001492	BI03313CH	7/29/92		0.000	0.003	0.002	0.002
Sm Mammal	BI001492	BI03314CH	7/29/92		0.000	0.002	0.001	0.001
Sm Mammal	BI001892	BI03321CH	7/29/92		-0.001	0.003	0.002	0.003
Sm Mammal	BI001892	BI03322CH	7/29/92		0.001	0.003	0.001	0.002
Sm Mammal	BI001892	BI03323CH	7/29/92		0.000	0.005	0.001	0.002
Sm Mammal	BI001992	BI03318CH	8/14/92		-0.001	0.007	0.001	0.001
Sm Mammal	BI001992	BI03319CH	8/14/92		0.001	0.007	0.003	0.003
Sm Mammal	BI001992	BI03320CH	8/14/92		0.000	0.002	0.000	0.002
Sm Mammal	BI002092	BI03324CH	8/13/92		0.004	0.004	-0.001	0.001
Sm Mammal	BI002092	BI03325CH	8/13/92		0.160	0.021	0.000	0.001
Sm Mammal	BI002092	BI03326CH	8/13/92		0.002	0.005	0.000	0.001
Vegetation	BI000392	BI03011CH	7/21/92		0.001	0.001	0.001	0.000
Vegetation	BI000392	BI03012CH	7/21/92		0.000	0.001	0.000	0.001
Vegetation	BI000392	BI03013CH	7/21/92		0.001	0.001	0.000	0.001
Vegetation	BI000392	BI03014CH	7/21/92		0.001	0.001	0.000	0.001
Vegetation	BI000392	BI03015CH	7/21/92		0.000	0.001	0.000	0.001
Vegetation	BI000492	BI03016CH	8/14/92		0.000	0.001	0.001	0.001
Vegetation	BI000492	BI03017CH	8/14/92		0.000	0.001	0.000	0.001

For analysis, all data were considered detects

Table 3-4
Results of Sample Analysis for Media Concentration of Plutonium and Americium

Matrix	Location	Sample Number	Sampling Date	Depth	Am Results	Am Error	Pu Results	Pu Error
Vegetation	BI000492	BI03018CH	8/14/92		0.001	0.001	0.001	0.001
Vegetation	BI000492	BI03019CH	8/14/92		0.001	0.001	0.000	0.000
Vegetation	BI000492	BI03020CH	8/14/92		0.001	0.001	0.003	0.001
Vegetation	BI000592	BI03021CH	7/16/92		0.000	0.001	0.001	0.001
Vegetation	BI000592	BI03022CH	7/16/92		0.000	0.001	0.000	0.000
Vegetation	BI000592	BI03023CH	7/16/92		0.000	0.001	0.000	0.000
Vegetation	BI000592	BI03024CH	7/16/92		0.000	0.001	0.000	0.001
Vegetation	BI000592	BI03025CH	7/16/92		0.001	0.002	0.000	0.000
Vegetation	BI000692	BI03026CH	7/10/92		0.000	0.001	0.000	0.000
Vegetation	BI000692	BI03027CH	7/14/92		0.000	0.001	0.001	0.001
Vegetation	BI000692	BI03028CH	7/14/92		0.000	0.001	0.000	0.000
Vegetation	BI000692	BI03029CH	7/14/92		0.000	0.000	0.000	0.000
Vegetation	BI000692	BI03030CH	7/14/92		0.000	0.000	0.000	0.001
Vegetation	BI000792	BI03031CH	7/15/92		0.002	0.001	0.009	0.002
Vegetation	BI000792	BI03032CH	7/15/92		0.002	0.001	0.006	0.001
Vegetation	BI000792	BI03033CH	7/16/92		0.002	0.001	0.024	0.003
Vegetation	BI000792	BI03034CH	7/16/92		0.002	0.001	0.011	0.002
Vegetation	BI000792	BI03035CH	7/16/92		0.003	0.001	0.004	0.001
Vegetation	BI000892	BI03036CH	7/15/92		0.002	0.001	0.014	0.002
Vegetation	BI000892	BI03037CH	7/15/92		0.003	0.002	0.012	0.004
Vegetation	BI000892	BI03038CH	7/15/92		0.007	0.002	0.032	0.005
Vegetation	BI000892	BI03039CH	7/15/92		0.003	0.002	0.012	0.002
Vegetation	BI000892	BI03040CH	7/15/92		0.007	0.004	0.025	0.004
Vegetation	BI001092	BI03046CH	8/6/92		0.002	0.001	0.011	0.003
Vegetation	BI001092	BI03047CH	8/6/92		0.002	0.001	0.012	0.002
Vegetation	BI001092	BI03048CH	8/6/92		0.002	0.001	0.006	0.002
Vegetation	BI001092	BI03049CH	8/6/92		0.001	0.001	0.010	0.003
Vegetation	BI001092	BI03050CH	8/6/92		0.003	0.001	0.015	0.003
Vegetation	BI001192	BI03051CH	7/17/92		0.000	0.001	0.003	0.001
Vegetation	BI001192	BI03052CH	7/17/92		0.000	0.001	0.002	0.001
Vegetation	BI001192	BI03053CH	7/17/92		0.001	0.001	0.001	0.001
Vegetation	BI001192	BI03054CH	7/17/92		0.000	0.001	0.000	0.001
Vegetation	BI001192	BI03055CH	7/17/92		0.001	0.001	0.001	0.001
Vegetation	BI001292	BI03056CH	7/20/92		0.000	0.001	0.001	0.001
Vegetation	BI001292	BI03057CH	7/20/92		0.000	0.001	0.000	0.003
Vegetation	BI001292	BI03058CH	7/20/92		0.001	0.001	0.000	0.001
Vegetation	BI001292	BI03059CH	7/20/92		0.000	0.002	0.000	0.000
Vegetation	BI001292	BI03060CH	7/20/92		0.000	0.001	0.000	0.001
Vegetation	BI001492	BI03066CH	7/27/92		0.002	0.002	0.012	0.002
Vegetation	BI001492	BI03067CH	7/27/92		0.003	0.001	0.011	0.002
Vegetation	BI001492	BI03068CH	7/27/92		0.011	0.002	0.076	0.007
Vegetation	BI001492	BI03069CH	7/27/92		0.004	0.001	0.025	0.003
Vegetation	BI001492	BI03070CH	7/27/92		0.003	0.001	0.014	0.002
Vegetation	BI001892	BI03086CH	7/21/92		0.001	0.002	0.001	0.001
Vegetation	BI001892	BI03087CH	7/21/92		0.001	0.003	0.001	0.001
Vegetation	BI001892	BI03088CH	7/21/92		-0.001	0.001	0.001	0.001
Vegetation	BI001892	BI03089CH	7/21/92		0.008	0.005	0.005	0.002
Vegetation	BI001892	BI03090CH	7/21/92		0.016	0.006	0.190	0.013
Vegetation	BI001992	BI03091CH	8/6/92		0.011	0.004	0.045	0.005

For analysis, all data were considered detects

Table 3-4
Results of Sample Analysis for Media Concentration of Plutonium and Americium

Matrix	Location	Sample Number	Sampling Date	Depth	Am Results	Am Error	Pu Results	Pu Error
Vegetation	BI001992	BI03092CH	8/6/92		0.003	0.003	0.018	0.003
Vegetation	BI001992	BI03093CH	8/6/92		0.003	0.001	0.013	0.002
Vegetation	BI001992	BI03094CH	8/6/92		0.006	0.002	0.023	0.004
Vegetation	BI001992	BI03095CH	8/6/92		0.013	0.003	0.079	0.008
Vegetation	BI002092	BI03096CH	8/7/92		0.001	0.001	0.001	0.001
Vegetation	BI002092	BI03097CH	8/7/92		0.003	0.001	0.000	0.001
Vegetation	BI002092	BI03098CH	8/7/92		0.001	0.001	0.001	0.001
Vegetation	BI002092	BI03099CH	8/7/92		0.001	0.001	0.000	0.001
Vegetation	BI002092	BI03100CH	8/7/92		0.000	0.001	0.000	0.000
Trench	TR02792	TR02001CH	10/26/92	96 cm	0.016	0.009	0.017	0.012
Trench	TR02792	TR02002CH	10/26/92	72 cm	0.002	0.003	0.004	0.004
Trench	TR02792	TR02003CH	10/26/92	48 cm	0.003	0.004	0.004	0.004
Trench	TR02792	TR02004CH	10/26/92	36 cm	0.007	0.007	0.003	0.004
Trench	TR02792	TR02005CH	10/26/92	24 cm	0.004	0.005	0.015	0.013
Trench	TR02792	TR02007CH	10/26/92	18 cm	0.010	0.007	0.017	0.021
Trench	TR02792	TR02008CH	10/26/92	0-3 cm	0.272	0.046	1.412	0.233
Trench	TR02792	TR02009CH	10/26/92	3-6 cm	0.074	0.020	0.266	0.063
Trench	TR02792	TR02010CH	10/26/92	6-9 cm	0.015	0.008	0.075	0.027
Trench	TR02792	TR02011CH	10/26/92	9-12 cm	0.005	0.006	0.016	0.015
Trench	TR02892	TR02020CH	10/23/92	96 cm			0.005	0.007
Trench	TR02892	TR02021CH	10/23/92	72 cm			0.002	0.004
Trench	TR02892	TR02022CH	10/23/92	48 cm			0.001	0.004
Trench	TR02892	TR02023CH	10/23/92	36 cm			0.003	0.004
Trench	TR02892	TR02024CH	10/23/92	24 cm			0.008	0.008
Trench	TR02892	TR02026CH	10/23/92	18 cm			0.007	0.007
Trench	TR02892	TR02027CH	10/23/92	0-3 cm			0.279	0.043
Trench	TR02892	TR02028CH	10/23/92	3-6 cm			0.084	0.031
Trench	TR02892	TR02029CH	10/23/92	6-9 cm			0.017	0.009
Trench	TR02892	TR02030CH	10/23/92	9-12 cm			0.013	0.010
Trench	TR02992	TR02039CH	10/27/92	96 cm			0.015	0.009
Trench	TR02992	TR02040CH	10/27/92	72 cm			0.004	0.007
Trench	TR02992	TR02041CH	10/27/92	48 cm			0.016	0.009
Trench	TR02992	TR02042CH	10/27/92	36 cm			0.012	0.008
Trench	TR02992	TR02043CH	10/27/92	24 cm			0.010	0.007
Trench	TR02992	TR02046CH	10/27/92	0-3 cm			0.521	0.100
Trench	TR02992	TR02047CH	10/27/92	3-6 cm			0.204	0.047
Trench	TR02992	TR02048CH	10/27/92	6-9 cm			0.036	0.017
Trench	TR02992	TR02050CH	10/27/92	9-12 cm			0.017	0.012
Trench	TR03092	TR02058CH	10/23/92	96 cm	0.004	0.005	0.004	0.009
Trench	TR03092	TR02059CH	10/23/92	72 cm	0.004	0.005	0.015	0.016
Trench	TR03092	TR02060CH	10/23/92	48 cm	0.002	0.004	0.000	0.008
Trench	TR03092	TR02061CH	10/23/92	36 cm	0.004	0.008	-0.006	0.012
Trench	TR03092	TR02062CH	10/23/92	24 cm	0.004	0.004	0.011	0.016
Trench	TR03092	TR02064CH	10/23/92	18 cm	0.004	0.005	0.017	0.011
Trench	TR03092	TR02065CH	10/23/92	0-3 cm	0.079	0.022	0.439	0.068
Trench	TR03092	TR02066CH	10/23/92	3-6 cm	0.093	0.024	0.381	0.100
Trench	TR03092	TR02067CH	10/23/92	6-9 cm	0.037	0.015	0.136	0.031
Trench	TR03092	TR02068CH	10/23/92	9-12 cm	0.010	0.007	0.031	0.016
Trench	TR03192	TR02077CH	10/22/92	96 cm			0.004	0.004

For analysis, all data were considered detects

Table 3-4
Results of Sample Analysis for Media Concentration of Plutonium and Americium

Matrix	Location	Sample Number	Sampling Date	Depth	Am Results	Am Error	Pu Results	Pu Error
Trench	TR03192	TR02078CH	10/22/92	72 cm			0.009	0.007
Trench	TR03192	TR02079CH	10/22/92	48 cm			0.008	0.009
Trench	TR03192	TR02080CH	10/22/92	36 cm			0.006	0.005
Trench	TR03492	TR02134CH	10/21/92	96 cm	0.006	0.005	0.000	0.007
Trench	TR03492	TR02135CH	10/21/92	72 cm	0.002	0.003	0.002	0.004
Trench	TR03492	TR02136CH	10/21/92	48 cm	0.011	0.016	0.009	0.009
Trench	TR03492	TR02137CH	10/21/92	36 cm	-0.002	0.004	0.012	0.013
Trench	TR03492	TR02138CH	10/21/92	24 cm	0.008	0.011	0.010	0.008
Trench	TR03492	TR02140CH	10/21/92	18 cm	0.003	0.006	0.040	0.020
Trench	TR03492	TR02141CH	10/21/92	0-3 cm	0.144	0.032	1.593	0.266
Trench	TR03492	TR02142CH	10/21/92	3-6 cm	0.059	0.030	0.328	0.087
Trench	TR03492	TR02143CH	10/21/92	6-9 cm	0.042	0.015	0.174	0.038
Trench	TR03492	TR02144CH	10/21/92	9-12 cm	0.018	0.010	0.084	0.034
Trench	TR03592	TR02153CH	10/19/92	96 cm			0.000	0.006
Trench	TR03592	TR02154CH	10/19/92	72 cm			0.003	0.006
Trench	TR03592	TR02155CH	10/19/92	48 cm			0.001	0.005
Trench	TR03592	TR02156CH	10/19/92	36 cm			0.005	0.005
Trench	TR03592	TR02157CH	10/19/92	24 cm			0.007	0.007
Trench	TR03592	TR02159CH	10/19/92	18 cm			0.014	0.010
Trench	TR03592	TR02160CH	10/19/92	0-3 cm			0.280	0.051
Trench	TR03592	TR02161CH	10/19/92	3-6 cm			0.653	0.092
Trench	TR03592	TR02162CH	10/19/92	6-9 cm	0.015	0.008	0.066	0.022
Trench	TR03592	TR02163CH	10/19/92	9-12 cm			0.308	0.070
Trench	TR03692	TR02172CH	10/26/92	96 cm	0.003	0.004		
Trench	TR03692	TR02173CH	10/26/92	72 cm	0.001	0.002	0.004	0.010
Trench	TR03692	TR02174CH	10/26/92	48 cm	0.001	0.002	0.000	0.008
Trench	TR03692	TR02175CH	10/26/92	36 cm	0.007	0.006	0.016	0.016
Trench	TR03692	TR02176CH	10/26/92	24 cm	0.002	0.003	0.002	0.013
Trench	TR03692	TR02178CH	10/26/92	18 cm	0.011	0.007	0.109	0.039
Trench	TR03692	TR02179CH	10/26/92	0-3 cm	0.128	0.027	0.596	0.211
Trench	TR03692	TR02180CH	10/26/92	3-6 cm	0.112	0.026	0.484	0.152
Trench	TR03692	TR02181CH	10/26/92	6-9 cm	0.030	0.012	0.314	0.150
Trench	TR03692	TR02182CH	10/26/92	9-12 cm	0.017	0.009		
Trench	TR03792	TR02191CH	10/20/92	96 cm			0.002	0.006
Trench	TR03792	TR02192CH	10/20/92	72 cm			0.002	0.004
Trench	TR03792	TR02193CH	10/20/92	48 cm			0.069	0.024
Trench	TR03792	TR02194CH	10/20/92	36 cm			0.000	0.000
Trench	TR03792	TR02195CH	10/20/92	24 cm			0.006	0.006
Trench	TR03792	TR02197CH	10/20/92	18 cm			-0.004	0.004
Trench	TR03792	TR02198CH	10/20/92	0-3 cm			0.163	0.039
Trench	TR03792	TR02199CH	10/20/92	3-6 cm			0.049	0.017
Trench	TR03792	TR02200CH	10/20/92	6-9 cm			0.028	0.014
Trench	TR03792	TR02201CH	10/20/92	9-12 cm			0.013	0.010
Surf Soil	PT16392	SS16392AVG			0.054		0.115	
Surf Soil	PT18592	SS18592AVG			0.099		0.665	

For analysis, all data were considered detects

Table 3-5
Results of Co-located Sample of Detects for Concentration Ratios

Matrix	Location Number	Am-241	Pu-239/240	Am-241 Concentration Ratio with Soil	Pu-239/240 Concentration Ratio with Soil
Small Mammal	BIO00392	0.007	0.001	--	0.004
Vegetation	BIO00392	0.001	0.001	--	0.004
Soil (0-3cm)	TR02892	n/r	0.279		
Small Mammal	BIO00492	0.006	0.001	--	0.002
Vegetation	BIO00492	0.001	0.003	--	0.006
Soil (0-3cm)	TR02992	n/r	0.521		
Small Mammal	BIO00592	0.001	0.001	0.013	0.002
Vegetation	BIO00592	0.001	0.001	0.013	0.002
Soil (0-3cm)	TR03092	0.079	0.439		
Small Mammal	BIO00692	0.006	0.026	--	--
Vegetation	BIO00692	--	0.001	--	--
Soil (0-3cm)	TR03192	n/r	n/r		
Small Mammal	BIO00792	0.002	0.003	--	--
Vegetation	BIO00792	0.003	0.024	--	--
Soil (0-3cm)	TR03392	n/r	n/r		
Small Mammal	BIO00892	0.004	0.013	--	--
Vegetation	BIO00892	0.007	0.032	--	--
Soil (0-3cm)	TR03292	n/r	n/r		
Small Mammal	BIO01092	0.000	0.002	0.000	0.003
Vegetation	BIO01092	0.003	0.015	0.023	0.025
Soil (0-3cm)	TR03692	0.128	0.596		
Small Mammal	BIO01192	0.002	0.002	0.014	0.001
Vegetation	BIO01192	0.001	0.003	0.007	0.002
Soil (0-3cm)	TR03492	0.144	1.593		
Small Mammal	BIO01292	0.001	0.001	--	0.004
Vegetation	BIO01292	0.001	0.001	--	0.004
Soil (0-3cm)	TR03592	n/r	0.280		
Small Mammal	BIO01492	0.000	0.002	--	0.012
Vegetation	BIO01492	0.011	0.076	--	0.466
Soil (0-3cm)	TR03792	n/r	0.163		
Small Mammal	BIO01892	0.001	0.002	0.004	0.001
Vegetation	BIO01892	0.008	0.190	0.029	0.135
Soil (0-3cm)	TR02792	0.272	1.412		
Small Mammal	BIO01992	0.001	0.003	0.010	0.005
Vegetation	BIO01992	0.013	0.079	0.131	0.119
Soil (0-3cm)	PT18592	0.099	0.665		
Small Mammal	BIO02092	0.160	0.000	2.963	0.000
Vegetation	BIO02092	0.003	0.001	0.056	0.009
Soil (0-3cm)	PT16392	0.054	0.115		

n/r = not reported

Table 3-6
Calculation of Tissue Dose

Tissue	Radionuclide	OU 3 Maximum Tissue Concentration (pCi/g)	dis/d/pCi	MeV/g/mrad	Effective Absorbed Dose (MeV/dis)	Biological Damage Factor[2]	Whole Body Dose (mrad/day)	Body Burden Required for Critical Dose Rate (pCi/g)[1]
Animal	Plutonium-239/240	0.026	3.20E+03	6.25E+04	5.15	20	0.14	19
Animal	Americium-241	0.16	3.20E+03	6.25E+04	5.15	20	0.84	19
Plant	Plutonium-239/240	0.016	3.20E+03	6.25E+04	5.15	20	0.08	19
Plant	Americium-241	0.19	3.20E+03	6.25E+04	5.15	20	1.00	19

[1]Recommended dose rate by IAEA is 0.1 rad/day

[2]Biological Damage Factor included to account for the increased damage from the alpha particle.

ATTACHMENT 4

AQUATIC PCOC EVALUATION

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1.0 INTRODUCTION

The ERA process encompasses several phases including the Preliminary Problem Formulation, Problem Formulation, Analysis Phase, and the Risk Characterization. The Preliminary Problem Formulation as defined by EPA (1994), focuses the purpose of the ERA on identifying the COCs which may contribute to ecological risk. This phase includes a screen of COCs, a preliminary exposure assessment, effects assessment, and risk characterization.

The remaining PCOCs (those that occur above background) are evaluated for final PCOC determination using an activity screening process. This screen evaluates the exposure and effects attributable to the PCOCs in the source medium (sediment) by comparing exposure-point activities to NOAEL benchmark activities and by comparison of a modeled dose (based upon the exposure-point activity) to a NOAEL literature-derived dose.

This section addresses the sediment PCOC exposure and effects to aquatic life. Section 2.0 provides a summary of the aquatic OU 3 abiotic and biotic media collection efforts.

Section 3.0 presents a literature and field evaluation of the PCOC fate, transport, bioavailability and exposure. Exposure is quantified using modeling techniques described by Blaylock et al., 1993. This discussion includes the field investigation methods and results that were designed to determine exposure within the aquatic ecosystem.

Section 4.0 presents a discussion of the potential effects attributable to PCOC exposure. The effects assessment was conducted by 1) comparison of exposure-point activities to NOAEL benchmark activities (activity comparison), 2) comparison of the quantified exposure dose to a NOAEL dose, and 3) evaluation of Rocky Flats field investigation measurements of effects (i.e., bioassays and population biometrics).

Section B3.0 of this appendix presents a summary of results within the Preliminary Problem Formulation. Attachments 3 and 4 presented the supporting methods and results from which these conclusions were based. A more in-depth presentation of field methods and results are provided in this attachment.

2.0 METHODS AND RESULTS OF THE FIELD-INVESTIGATION METHODS

Collocated samples of surface water, sediment, fish, and benthic macroinvertebrates were collected for the OU 3 ERA. Surface water and sediment were collected and analyzed for metals, radionuclide, and volatile organic chemical content (where appropriate), as described within the RFI/RI report. Fish tissue was collected and analyzed for metals and radionuclide content. Benthic macroinvertebrate and periphyton samples were collected to qualitatively characterize species assemblages. Collocated surface-water samples were not collected with the periphyton. The specific sampling locations chosen for the OU 3 aquatic efforts are depicted for each IHSS in the RFI/RI report.

2.1 ABIOTIC MEDIA

Surface-water and sediment samples were collected from each IHSS and from locations within Walnut Creek, Woman Creek, and Big Dry Creek. Samples were analyzed for metals, (total and dissolved for the surface water), radionuclides (total and dissolved), and target organic compounds (Mower Reservoir only). Methods of collection, preservation, and analysis are provided within the RFI/RI report. At the

time of abiotic and biotic media collection, water-quality characteristics were also measured, and a summary of the results are provided in Table 4-1 of this attachment.

Bioassay analysis of surface water and sediment collected from Walnut Creek, Woman Creek, Church Ditch, and Big Dry Creek were also conducted. Samples were collected and analyzed in a laboratory setting to determine toxicity to laboratory organisms (Fathead minnows, Ceriodaphnia, and Hyallela azteca). The results of the bioassay analysis are presented in Section 4.0 of this attachment.

Results of the surface-water and sediment analysis are provided in the RFI/RI report. Results of the surface water and sediment analysis from OU 3 parallel literature findings in that the PCOCs were identified in sediment (at depth) and there were no PCOCs identified in surface water.

2.2 BIOTIC MEDIA

Biotic-media samples of fish, benthic macroinvertebrates, and periphyton were collected. The fish were collected to characterize the population (species occurrence) and to analyze various tissues for PCOC content. The benthic-macroinvertebrate samples were collected for species identification and enumeration. The periphyton samples were collected for species identification. The following describes the field collection and results.

2.2.1 Fish

The purpose of the OU 3 fish sampling was to characterize the fish populations within the OU 3 aquatic systems. The activities performed during the sampling periods to complete the effort included:

- Backpack-electroshocking of stream sample location areas
- Boat-electroshocking of lake and reservoir sample location areas
- Gill-net deployment and retrieval within lake and reservoir sampling areas
- Fish-processing activities which included measurement of total length and weight, species identification, and observations for external incidence of disease
- Fish-tissue collection for analysis of the fillet, the whole body, and the whole body without internal organs from the sampling locations
- Fish-tissue collection from a reference pond location (Lindsey Pond) for qualitative comparative purposes

All fish-collection locations were collocated with surface water, sediment, and benthic macroinvertebrate sample locations. These activities were conducted in accordance with SOP EE.5.4, Sampling of Fishes (DOE, 1991), other related and relevant SOPs, and the RFI/RI Final Work Plan for OU 3, unless otherwise noted (DOE, 1992).

Fish were collected at two time periods (summer and fall) from Standley Lake, Great Western Reservoir, and Mower Reservoir. The stream locations (Big Dry Creek, Walnut Creek, and Woman Creek) were only sampled during the summer due to low flows during the fall effort. Lindsey Pond was sampled once during the fall.

Electroshocking-Capture Techniques

A backpack-electroshocking unit was used to sample the three stream locations during the summer months. A 50-foot area of the stream-sampling location was traversed with a one-pass electroshocking event. Electroshock unit specifications were dependent upon water quality conditions. In general, shocking was sustained for approximately 20 minutes within the sampling reach, fish were immediately captured, and retained in live wells for processing. Fish that were not identified in the field, were preserved in 10 percent buffered formalin for later identification.

A boat-shocker apparatus was used for the reservoir sampling in conjunction with gill nets for the capture of fish. Boat-electroshocking activities occurred after nightfall, and locations to be sampled were electroshocked for 15-minute intervals along the shoreline. Fish were captured and retained in live wells for processing. All fish were identified to species (where possible), measured for total length and weight, and processed for potential fish-tissue analyses. Those species that were unidentifiable, were preserved in 10 percent buffered formalin for later identification. Those fish retained for tissue analysis were wrapped in aluminum foil and maintained at refrigerator temperature until further processing was completed (within 24 hours after catch). Fish were then processed for tissue-sample extraction. Fish within each trophic class (where possible and applicable) were retained from each station for tissue analysis (herbivores, primary predator, etc). Whole body, fillet, and whole body (without internal organs) tissue samples were collected, when adequate and appropriate catch were available.

Monofilament gill nets (250 feet in total length, 6 feet in depth) with variable mesh sizes were deployed throughout the reservoirs for additional fish sampling. Nets were generally set perpendicular to the shoreline, starting from a designated sampling location and proceeding toward the shore. Nets were bottom set with the largest mesh size in the deepest portion of the sampling area. Nets were often set for several hours to a maximum of an overnight set (12 to 16 hours). Fish were retrieved from the net and retained within live wells for processing.

Fish were processed for tissue-sample selection in a similar manner to all other fish collection. Fish were identified to species, and measured for total length and weight. Observations of external disease were also noted. A summary of the fish collected within each system is presented in Table 4-2, while a presentation of the subset of fish used for tissue analysis is presented in Table 4-3. The analysis requested for the tissue samples included select metals and radionuclide analysis.
For QA/QC purposes, duplicate tissue samples were submitted for analyses. To create a duplicate sample, the fish tissue was divided into right and left fillet portions. Each fillet was then submitted as a separate sample. Raw data results of the tissue analysis are provided at the end of this report. Results are presented by species and tissue type within each reservoir. A summary of the results of plutonium-239, -240 and americium-241 analyses are provided in Table 4-4.

2.2.2 Benthic Macroinvertebrates

Triplicate samples of benthic macroinvertebrates were collected from collocated locations with sediment and surface water. Samples were collected using a petite ponar dredge for the lake locations, and a surber bottom sampler for the stream locations. Samples from the stream and lakes were preserved and shipped to VERSAR Laboratories for species identification and enumeration. The benthic-macroinvertebrate sample collection was conducted in accordance with SOP.EE.5.2, Sampling of Benthic macroinvertebrate (DOE, 1991c).

Table 4-5 presents a summary of the Percent Benthic Macroinvertebrate Species Composition of stream samples. Tables 4-6 through 4-9 present results of all of the samples by sampling event. Samples were collected in spring and fall (round 1 versus round 2). Tables 4-6 and 4-7 present the results of the spring sampling effort, and Tables 4-8 and 4-9 present the results of the fall effort. Results of the species composition and population characteristics are presented in detail in Section 4.0.

2.2.3 Periphyton

Periphyton were collected from artificial substrates within all of the reservoirs. Due to the influence of water draw-downs, the substrates were collected and only analyzed for species composition. The periphyton sample collection was conducted in accordance with SOP.EE.5.1, Sampling of Periphyton (DOE, 1991c). Raw data results of both the macroinvertebrate and periphyton species composition results are included in this attachment.

3.0 EXPOSURE ASSESSMENT

Aquatic organism exposure is dependent upon PCOC, receptor, and environmental characteristics because these factors influence the bioavailability of chemicals within the environment. To determine the exposure pathways and potential receptors at the OU 3 area, an evaluation of PCOC physical and chemical properties was conducted. Literature information as well as the results of OU 3 investigations were used to determine the exposure pathways and receptors requiring evaluation.

The following subsection addresses the potential exposure conditions of OU 3 by presenting a discussion of literature and site information regarding PCOC properties. The methods for the quantitative evaluation of exposure conditions are presented in Subsection 3.2 by determination of the exposure-point activity and calculation of exposure dose. The results are then presented in Subsections 4.1, 4.2, and 4.3.

3.1 PHYSICAL AND CHEMICAL PROPERTIES, AND BIOAVAILABILITY OF PCOCS

Literature reports were reviewed to determine the physical and chemical properties of plutonium-239, -240 and americium-241. Only plutonium-239, -240 was identified as a PCOC from the background evaluation as provided in Attachment 2. However, americium-241 was also retained as a conservative measure, because it is the decay product of plutonium.

Transuranic radionuclides, in general, tend to accumulate in bottom sediment. From this location, they can subsequently accumulate in biota and be transferred through the aquatic food chain. Aquatic organisms can receive external radiation exposure from radionuclides in water, sediment, and from other biota such as vegetation. They can also receive internal radiation exposure from radionuclides ingested via food and water and from radionuclides absorbed through the skin and respiratory organs (NCRP, 1991).

Wahlgren (1973) has shown that 95 percent of the plutonium added to Lake Michigan as a result of atmospheric fallout from weapons testing is rapidly removed from the water column to sediments. Further studies of Lake Michigan by Alberts et. al., (1974) have demonstrated that plutonium is strongly associated with the sediments and is not easily solubilized under aerobic conditions. Stagnant, polluted systems, however, could have a greater solubilizing effect due to the high activities of complexing organic material (EPA, 1978).

The fate of plutonium in flowing water systems has been studied in the Great Miami River where discharges have occurred. These studies by Bartelt (1975) and Mullen (1977) are consistent with the Lake Michigan studies. Plutonium was found associated with the sediments and at least 90 percent of the radioactivity which moves down the river does so as a result of the resuspension/entrainment of bottom sediments. Even though the chemical behavior of plutonium in freshwater is not completely understood, the studies to date have demonstrated that plutonium will quickly associate with the solid phase, and under the redox conditions normally encountered in the environment, solubilization will be minimal (EPA, 1978). As long as the water body is maintained at a fairly constant level and large areas of the sediment bed are not exposed and allowed to dry, thereby creating a wind resuspension problem, the plutonium activity committed to the water will be bound there in a form which is relatively insoluble in biological systems (EPA, 1978).

3.2 TECHNIQUES FOR THE EXPOSURE ASSESSMENT

The Rocky Flats-related discharge of radionuclides to the OU 3 area was created by historic releases. This source can potentially contribute to a low-dose rate exposure to the existing aquatic ecology. The PCOCs were identified as plutonium-239, -240 and americium-241 in sediment. Plutonium-239, -240 was identified as a PCOC from the comparison to background screen, whereas americium-241 was retained only as a conservative assumption, because it is the decay product of plutonium. Based upon the receptor survey activities conducted as part of the OU 3 ERA field effort, it was determined that the most likely receptors to exposure were bottom-dwelling fish, benthic macroinvertebrates, and fish eggs.

Because the PCOCs are likely to be bound to the sediment, exposure is uncertain. However, it was assumed that 100 percent of the maximum observed detected activity for each IHSS would be available to these receptor organisms. However, the potential effects attributable to an increased exposure to chronic irradiation is unlikely to be detectable because of the natural fluctuations in the sizes of populations or organisms in the OU 3 aquatic environments. In addition, Standley Lake and Mower Reservoir fish populations are supplemented by stocking practices. Therefore, any observations of population effects to these specifics may be confounded by these other factors. Similarly, the benthic macroinvertebrate and periphyton population structures are likely to be highly influenced by habitat characteristics (i.e., depth, water quality, turbidity etc.). Therefore, since effects may not be directly observable, an exposure assessment was conducted to determine whether the determined PCOC exposure conditions will result in an adverse effect.

The maximum observed activity was used as a conservative exposure-point activity, which in turn was used for exposure-dose calculation. The following subsections provide a summary of the methods and results for the exposure-point activity determination (Subsection 3.2.1) and exposure-dose calculation (Subsection 3.2.2).

3.2.1 Exposure-Point Activities

As described in Attachment 1, all applicable data sources were summarized and evaluated for PCOC determination. Results from the sediment analysis (all depth fractions) were summarized and presented within the RFI/RI report. The maximum observed activity in each IHSS was evaluated as the exposure-point activity.

Because each IHSS is hydrologically isolated from each other, aquatic receptors from one IHSS are most likely not going to be exposed to other IHSS areas. Therefore, individual IHSS exposure and effects assessments were conducted.

The maximum observed activity from each IHSS was considered the reasonable maximum exposure-point activity. A summary of these exposure-point activities is provided in Table 4-10. These exposure-point activities served as the basis for the internal (and external for fish eggs) dose quantification, as described in the following subsection.

3.2.2 Calculation of Exposure Dose

For the purpose of this assessment, exposure to fish, invertebrates, and fish eggs were conducted using techniques described by Blaylock et. al., (1993). It should be noted that the determination of exposure to a "target species" is not applicable since exposure to aquatic organisms (all species) to a radiation is conducted by the same technique, as described in the following subsections.

Several factors make estimating the radiation dose to an organism difficult. Different radionuclides are differentially distributed among the organs and tissues of an organism, affecting the radiation dose that sensitive organs and tissues receive. In addition, the relative significance of internal and external sources of radiation to an organism can be markedly altered by the size and behavior of the organism. One approach that is used in assessing the risk of adverse ecological effects is to select indicator species of organisms for study.

In general, α-radiation sources such as plutonium-239, -240 and americium-241 are not considered to contribute significant external exposure because these particles cannot penetrate external tissue. Therefore, an evaluation of internal exposure via ingestion was conducted. Because radionuclides were not identified in surface water, exposure was evaluated for the ingestion of sediment only.

Exposure was quantified for plutonium-239, -240 and americium-241 in each IHSS using techniques described by Blaylock et al., (1993). The results of the exposure-dose quantification are presented in Table 4-11. After determining the dose rate to an organism from each individual radioisotope in the environment, the total dose to the organism is determined by summing the individual PCOC dose (in dose equivalents) from all radioisotopes. The total dose rate was then compared to the 0.4 mgy/h benchmark value in the effects assessment (Blaylock, et al., 1993).

For all organisms regardless of size, the internal dose rate from α-radiation closely approaches the dose rate from an infinite source because essentially all the energy from α-particles is absorbed within the organism. The internal dose rate from α-radiation (applies for both plutonium-239, -240 and americium-241) is calculated as follows:

$$D_\alpha = (5.76 \times 10^{-4}) E_\alpha n_\alpha C_o \qquad (4\text{-}1)$$

where:

D_α is the internal dose rate from α-radiation ($\mu G_y/h$)
E_α is the energy of the α-particle (MeV)
n_α is the proportion of transitions producing an α-particle of energy E_α (unitless)
C_o is the activity of the radionuclide in the organism (Bq/kg wet weight)

This equation can also be used to determine exposure to fish eggs assuming that all the radiation from internal α-emitters remains within the egg and that all external α-radiation is stopped by the chorion.

The 5.76×10^{-4} term, is a unit conversion factor used to calculate dose for organisms exposed to sediment surrounding them during certain life stages (fish eggs invertebrates). If α-particles of more than one energy level are produced during the decay of a radioisotope, the dose rate from all transitions are summed to obtain the total α-dose rate. It is assumed that external α-radiation from water and sediment is insignificant for aquatic organisms.

In all calculations, it is assumed that a constant level of radioactivity is present from the maximum observed PCOC activity and that the radioactivity in the organism is in equilibrium with that in the environment. The activity levels used in these examples are calculated based upon the maximum observed activities of plutonium-239, -240 and americium-241. The energy values (MeV) used in the following examples were obtained from Table 4-12.

Example Calculation of Aquatic Organism Exposure Dose to Plutonium-239, -240 in Sediment

Exposure Dose: $D_\alpha = 5.76 \times 10^{-4} E_\alpha n_\alpha C_o$

For plutonium-239, -240 an $E_\alpha n_\alpha$ value of 5.24 was used

C_o = the plutonium-239, -240 activity in the organism and was based upon the following three steps:

1. The exposure-point activity for plutonium-239, -240 was 4.03 pCi/g dry weight sediment (the maximum observed activity)

2. This exposure-point activity (in picocuries per gram) was converted to Becquerels per kilogram (Bq/kg) wet weight sediment by conducting the following:

   (a) Convert dry weight to wet weight using a conversion factor or 0.75 (Blaylock et al., 1993)

   4.03 pCi/g x 0.75 = 3.0225 pCi/g wet weight

   (b) Convert picocuries to Becquerels (1 Bq = 27.027 pCi)

   $\frac{3.0225 \text{ pCi/g}}{27.027 \text{ Bq}}$ = 0.1118 Bq/g wet weight

   (c) Convert Bq/g wet weight to Bq/kg wet weight

   0.1118 Bq/g x 1000 g/kg = 111.8 Bq/kg wet weight

3. Calculate C_o by assuming the sediment exposure-point activity is 100 percent bioavailable and can concentrate within the exposed organism by a factor of 30 (see Table 4-12; BCF = 30 for plutonium-240)

   111.8 Bq/kg wet weight sediment x 30 = 3354.97 Bq/kg wet weight tissue

Therefore, with a C_0 value of 3354.97 Bq/kg wet weight tissue, the exposure dose is:

$$D_\alpha = 5.76 \times 10^{-4} (5.24) (3354.97) = 10.12\ \mu G_y/h \text{ converted to } 0.0101\ mG_y/h$$

Only an internal α-dose rate from plutonium-239, -240 is considered because external sources would not penetrate the outer covering of fish or benthic macroinvertebrates, and because these PCOCs were not identified in surface water, which would provide the most significant media source for external exposure.

Table 4-12 gives the average α-energies for selected α-emitters including those in naturally occurring α-decay chains. Bioaccumulation factors for freshwater fish for selected radioisotopes are also included in Table 4-12. These factors can be used to estimate the activity of a radioisotope in freshwater fish from the activity in the surrounding water. For the purposes of this assessment, however, the bioaccumulation factors were used to determine fish-tissue activities as a result of exposure to sediment. It should also be noted that Rocky Flats-derived bioaccumulation factors could not be developed because plutonium-239, -240 and americium-241 were not detected in surface water, and tissue activities were primarily below detection limits.

External exposure to fish eggs was conducted using Equation 4-1 as well. In the interest of conservativeness, a dose for plutonium-239, -240 and americium-241 was calculated. The sediment analysis results were reported as pCi/g of both plutonium and americium, therefore, it was assumed that the maximum observed activity represented the activity of plutonium-239 individually, as provided in Table 4-11.

4.0 EFFECTS ASSESSMENT

An analysis of effects was conducted by the following: (1) comparison of the maximum observed PCOC activity to a NOAEL media benchmark activity; (2) comparison of a modeled dose to a literature-derived NOAEL dose; (3) evaluation of field-derived site measurements of effects which include species occurrence and diversity analysis of media toxicity using bioassays, and measurement of PCOC activities in receptor tissues. The 'effect' to the OU 3 aquatic receptors was determined by a weight-of-evidence evaluation of the results of these three analyses steps. The first two analyses are completed by the comparison of a modeled exposure condition to a no observed adverse effect level. Section 3.0 of this attachment presented the techniques for the determination of the exposure-point activities and quantification of dose to receptor organisms.

The third and remaining analyses of effects method was by the evaluation of the aquatic ecosystem function characteristics of species occurrence and diversity, analysis of media toxicity using bioassays, and the measurement of PCOC activity in receptor tissues, as presented in this section.

All three analyses techniques were used for the effects assessment to provide a weight-of-evidence evaluation. Any one technique alone may have been insufficient for the assessment. By using all three techniques, the level of uncertainty is thereby reduced.

4.1 EXPOSURE-ACTIVITY EVALUATION

An evaluation of effects was conducted by comparing the reasonable maximum exposure-point activity to a NOAEL benchmark value. These benchmark values were presented in Table B3-3 of this appendix. A comparison of the maximum observed exposure-point activity for each IHSS to the literature

benchmark value using the hazard quotient (HQ) and hazard index (HI) approach. Results are presented in Table 4-16 that indicate HQ and HI values well below a level of 1 indicating that risk to aquatic life is unlikely.

4.2 EXPOSURE-DOSE EVALUATION

The DOE guideline for radiation dose rates from environmental sources recommends limiting the radiation dose to aquatic biota to 0.4 mgy/h (1 rad/day), and is based on results of previously cited reviews summarized in NCRP Report No. 109 (NCRP, 1991). The conclusion from these reviews is that at 0.4 mgy/h, there is no evidence that deleterious effects have been expressed at the population level for aquatic biota. Tables 4-13 through 4-15 contain summaries from the literature reviewed in NCRP Report No. 109 on reproductive effects in fish exposed to chronic irradiation. In these chronic irradiation studies, effects were not detected unless the dose rates were much greater than 0.4 mgy/h. The NRCP report recommends that if the results of radiological models of exposure indicate that a radiation dose rate of 0.4 mgy/h is exceeded, then a more detailed evaluation of the potential ecological consequences of radiation exposure to the endemic populations should be conducted.

The exposure dose to fish, fish eggs, and benthic macroinvertebrates was conducted using techniques described in Subsection 3.2. The resulting dose measurements are presented in Table 4-11, and the HQs and HIs for each receptor and PCOC are presented in Table 4-16. Results indicate that the exposure dose HQs and HIs are below a level of 1, indicating risk to aquatic life is unlikely.

4.3 FIELD MEASUREMENT EFFECT

Assessment of the ecological impact of contaminants on aquatic systems can involve measuring changes in either structural or functional characteristics. In general, structural measurements involve counts of organisms (abundance, number of taxa, etc.), whereas functional measurements involve rate processes (primary productivity, detritus processing, and nutrient cycling). There is some evidence suggesting that measurement of ecosystem function is ecologically relevant; however, owing to the functional redundancy of ecosystems, greater variability of functional parameters and the comparative difficulty in measuring these parameters, the usefulness of functional variables for detecting effects of contaminants may be limited. The distribution and abundance of various groups of aquatic organisms, including protozoans, algae, diatoms, phytoplankton, zooplankton, macroinvertebrates, and fish, have been employed routinely as indicators of the impact of contaminants on aquatic systems (Cairns, 1983).

The activity of contaminants in aquatic organisms is also frequently employed as an indicator of impact. Because activities of contaminants in water are often highly variable and may be below detection, a predictive relationship between contaminants in abiotic samples and organisms may be useful for monitoring impact. Furthermore, because organisms are mobile and continuously exposed to contaminants, they integrate contaminant activities over time and space, thus providing a better indicator of contaminant levels in the ecosystems. Moriarity et al., (1984), however, has noted limitations of this approach and suggested that it is often more appropriate to analyze abiotic samples. It is recommended that levels of contaminants be measured in both biotic and abiotic components of aquatic systems. The data quality objectives of the aquatic OU 3 field effort were developed to conduct collocated sampling of abiotic and biotic components of the ecosystem.

Biomonitoring approaches for evaluating the impact of contaminants typically involve comparison of reference sites to impacted and recovery sites. Ideally, these locations should be similar in all respects except for the presence of contaminants (Green, 1979). However, because of natural changes in

structural and functional parameters within a system, (as demonstrated in OU 3) as well as variation in other parameters such as substrate composition and vegetation, it is often difficult to locate comparable references and impacted sites. Consequently, effects caused by the presence of contaminants are confounded by natural changes in aquatic systems. In systems that receive multiple impacts from several sources, the determination of specific causes for observed changes is greatly complicated. The OU 3 environment exemplifies an ecosystem with natural and manmade perturbations. Because of the complexity of the ecosystems, a suitable reference location was not located. Samples of fish were collected from Lindsey Pond, a pond located within Rocky Flats that was considered an appropriate background. The fish captured were analyzed for PCOC tissue content for comparative purposes.

The following subsections provide a discussion of the results of the in-field measurements of population characteristics, tissue results and bioassay results. Data summaries from the laboratory are provided in this attachment.

4.3.1 Fish-Population Characteristics

Fish were sampled from all stream and reservoir ecosystems of OU 3. The populations encountered resembled "stocked" assemblages within Mower Reservoir and Standley Lake. Whereas Great Western Reservoir and the stream ecosystems were populated by a variety of naturally occurring, typically opportunistic species (such as longnose suckers, minnows, and carp).

Mower Reservoir contained strictly bass and longnose suckers. The captured bass were all of similar size and age-class structure. Evidence of catfish occurrence was noted, but no catfish were captured. Standley Lake contained a diversity of gamefish species of various age classes. The most commonly captured species was the rainbow trout.

4.3.2 Characteristics of the Benthic-Macroinvertebrate Population

The distribution and abundance of benthic macroinvertebrates are routinely employed as indicators of water quality. Because of their influence on various functional parameters in aquatic systems, such as primary productivity, detritus processing, and energy flow, benthic macroinvertebrates are an important component of aquatic habitats. These organisms are often quite abundant, have a relatively short generation time, and represent several functional feeding groups. Finally, because of their close association with the substrate, tendency to bioaccumulate toxic materials, and their importance in aquatic food chains, benthic invertebrates are useful for monitoring the transport of contaminants in aquatic systems.

Considerable research effort has been devoted to describing responses of benthic communities to contaminants. Winner et al., (1980) reported that responses of benthic invertebrates to pollution are predictable and proposed, using benthic community structure as an index of heavy metal pollution. In a study of the relationship among metal activities, water-quality criteria, and benthic-community structure in 15 U.S. streams, LaPoint et al., (1984) noted that benthic communities responded in a "predictable and indicative manner, which overall may be more sensitive than any single species (toxicity) tests." Clements et al., (1988) compared community responses of benthic invertebrates to contaminants in the field and in outdoor experimental streams and concluded that these responses were highly predictable.

Change in percent composition of dominant macroinvertebrate taxa is probably the most useful indicator of the impact of contaminants. Because benthic organisms show considerable variability in their

sensitivity to toxicants, differences in percent composition among field sites may be employed to assess the degree of contamination.

The distribution of benthos within lake environments is generally influenced by depth. The shallow, littoral zone usually exhibits the greatest diversity and abundance of organisms. As the depth increases, community diversity decreases shifting towards dipterans, principally chironomids, and oligochaetes. Distribution within the deep profundal zone will depend upon such physical and chemical parameters as dissolved oxygen, temperature, and availability of organic and inorganic substrate. Stream benthic invertebrate assemblages are influenced by flow, temperature, stream order, bottom substrate composition, and other factors.

The following provides an evaluation of the benthic macroinvertebrate assemblages observed within the OU 3 aquatic ecosystems by sampling period (fall versus summer). Summary tables are provided in Tables 5 through 8. Raw data reports from the laboratory are included in this attachment.

Great Western Reservoir

Benthic samples collected in this reservoir were taken from the profundal zone. Composition of the benthic community was dominated by dipterans, principally *Chironomus* sp., *Procladius* sp., *Harnischia* sp., and oligochaetes, principally immature tubificid worms with and without capilliform hairs. This community structure is representative of a eutrophic lake under the scheme of Thienemann (1925). The community structure, as sampled, represents a typical community structure to be expected in a lake of this size and depth.

Summer - Oligochaeta (aquatic worms) and *Diptera* (flies, mosquitoes, midges) dominated the summer benthic faunal assemblage of Great Western Reservoir. The dominant oligochaetes were immature.

Tubificidae (47.3 percent relative total abundance). *Diptera* were dominated by *Procladius* sp. (22.5 percent), *Chironomus* sp. (16.6 percent) and *Harnischia* sp. (5.9 percent).

A total of 12 taxa were collected in the summer sampling. The average density per sample was approximately 2,253 organisms. Dominant trophic feeding guilds were collector-gatherers (75.1 percent) and predators (22.5 percent). The collector-gatherers were principally detrital processors represented by the oligochaetes. Predators were represented principally by *Procladius* sp.

The profundal community structure of Great Western Reservoir, from the summer sampling, was typical for a mesotrophic to eutrophic lake (Wetzel, 1983). As lakes become more eutrophic, shifts occur in percent composition of the dominant groups of benthic animals in the profundal zone with a predominance of Chironomidae and oligochaetes.

Fall - Oligochaeta (aquatic worms) and *Diptera* (flies, mosquitos, midges) also dominated the fall benthic faunal assemblage of Great Western Reservoir. The dominant oligochaetes were immature *Tubificidae* (58.9 percent, relative total abundance) and *Dero* sp. (5.3 percent). *Diptera* were dominated by *Chironomus* (23.7 percent) and *Procladius* sp. (8.8 percent).

A total of 9 taxa were collected in the fall sampling. The average density per sample was approximately 5,000 organisms. Dominant trophic feeding guilds were collector-gatherers (90.1 percent) and predators (8.8 percent). The collector-gatherers were principally detrital processors represented by the oligochaetes and *Chironomus* sp. Predators were represented principally by *Procladius* sp.

The profundal community structure of Great Western Reservoir at the time of the fall sampling was again typical for a mesotrophic to eutrophic lake (Wetzel, 1983). As lakes become more eutrophic, shifts occur in percentage composition of the dominant groups of benthic animals in the profundal zone with a predominance of Chironomidae and oligochaetes. The benthic community was quite similar to that present during the summer sampling suggesting little change in the reservoir benthic habitat.

Standley Lake

Benthic macroinvertebrate collections in Standley Lake were also taken in the profundal zone. As with Great Western Reservoir, the community composition was generally dominated by chironomids, principally *Chironomus* sp., *Dicrotendipes* sp., *Procladius* sp., and oligochaetes, principally *Dero digitata*; *Dero* sp., and immature tubificids worms with and without capilliform hairs. Again, the community structure within the profundal zone of Standley Lake is typical of a eutrophic lake (Thienemann, 1925) and not unusual for a lake of this size and depth.

Summer - Oligochaeta (aquatic worms) and Diptera (flies, mosquitos, midges) dominated the summer faunal assemblage of the benthos of Standley Lake. The dominant oligochaetes were *Dero* sp. (45.5 percent relative total abundance), immature *Tubificidae* without capilliform chaete (19.4 percent) and immature *Tubificidae* with capilliform chaete (8.6 percent). Diptera were dominated by Chironomus sp. (17.4 percent).

Twenty-one invertebrate taxa were collected from the Standley Lake benthos. The average density per replicate was approximately 8,230 organisms. The dominant trophic feeding guild was collector-gatherers (97 percent). Most of the benthos were detrital processors.

Benthic macroinvertebrate community structure in lakes are generally divided into littoral communities and profundal communities. Littoral community structure usually consists of a rich fauna due to substratum heterogeneity and greater competitive interactions (Wetzel, 1983). In contrast, profundal areas are more homogenous and become more so as the lake ages or increases in productivity. As lakes become more eutrophic a shift usually occurs in the percentage composition of the dominant groups of benthic animals in the profundal zone. In general there is a reduction in the number of chironomids and other taxa and an increase in oligochaete worms. Based on the above description the benthic macroinvertebrate community structure is probably indicative of a mesotrophic to eutrophic system.

Fall - Oligochaeta (aquatic worms), Bivalvia (clams, mussels) and Diptera (flies, mosquitos, midges) dominated the fall benthos assemblage of Standley Lake. The dominant oligochaetes were *Dero* sp. (13.3 percent relative total abundance), and immature *Tubificidae* without capilliform chaete (21.9 percent). The dominant bivalve was *Sphaerium striatum* (30.9 percent). Diptera were dominated by Chironomus sp. (15.9 percent).

Twenty-six invertebrate taxa were collected in the fall sampling. The average density per sample was approximately 4,660 organisms. Dominant trophic feeding guilds were collector-gatherers (61.1 percent), collector-filterers (32.8 percent) and predators (5.5 percent). The collector-gatherers were principally detrital processors represented by the oligochaetes. Collector-filters were represented by the sphaerid clams and the predators were represented principally by *Procladius* sp., *Thienemannimyia* sp., and *Oecetis* sp.

The benthic invertebrate community structure for Standley Lake was more diverse in the fall. The more complex profundal community structure suggests some changes in physical and chemical attributes of the

habitat. Possible changes could be an increase in dissolved oxygen on the bottom, and increased diversity of food resources associated with the bottom material. The invertebrate community structure in the fall suggests a less eutrophic nature to the lake than what was indicated in the summer assemblage.

Mower Reservoir

Mower Reservoir is physically different when compared to Great Western Reservoir and Standley Lake. In fact, Mower Reservoir is more of a pond as defined by Welch (1952), "very small, shallow bodies of standing water in which the relatively quiet water and extensive plant occupancy are common characteristics". It is in such habitats that many groups of invertebrates attain maximum diversity and abundance. This was definitely the case in Mower Reservoir which had the highest standing crop and the most diverse community structure of the three reservoirs sampled. The community structure was dominated by dipterans such as *Chironomus* sp., *Procladius* sp., *Pseudochironomus* sp., *Parametrioenemus* sp., *Thienemannimyia* sp., and *Corynonura* sp., oligochaetes, principally immature tubificid worms with and without capilliform hairs, but also included other groups such as ephemeropterans, principally *Baetis* sp. and *Caenis* sp., odonats, *Ischnura* sp., gastropods, *Gyraulus* sp., and amphipods, *Hyalella azteca.*

This pond exhibits many of the characteristic common to the well-vegetated littoral zone of larger lakes. Ponds such as Mower Reservoir are often highly productive habitats with largely organic substrates, and may become anoxic at the mud-water interface during the summer. Because of the small volume and large surface to volume ratio, the thermal conditions in these ponds are more responsive to temperature fluctuations than lakes.

The benthic community structure in Mower Reservoir may be considered typical of shallow ponds with extensive vegetation.

Summer - Oligochaeta (aquatic worms), Diptera (flies, mosquitos, midges), and Amphipoda dominated the summer benthic faunal assemblage in Mower Reservoir. The dominant oligochaetes were immature *Tubificidae* (48.2 percent relative total abundance). Diptera were dominated by *Chironomus* sp. (13.7 percent) and *Procladius* sp. (9.7 percent). *Hyalella azteca* (8.7 percent) was the dominant amphipod.

A total of 36 taxa were collected in the summer sampling. The average density per sample was approximately 40,867 organisms. Dominant trophic feeding guilds were collector-gatherers (73.1 percent relative total abundance), predators (11.1 percent) and shredders (8.7 percent). The collector-gatherers were principally detrital processors represented by the oligochaetes and *Chironomus* sp. Predators were represented principally by *Procladius* sp., while *Hyalella azteca* was the principal shredder.

The profundal community structure of Mower Reservoir at the time of the summer sampling was typical for a mesotrophic to eutrophic lake (Wetzel, 1983). The shallowness of the lake coupled with the large amount of vegetation enhanced the habitat diversity and thus the high taxa richness. Although Chironomidae and oligochaetes dominated the benthic fauna numerically, the diverse food resources supported many other organisms. The faunal representatives from this reservoir suggest it was biologically quite different from Standley Lake and Great Western Reservoir.

Walnut Creek

Trichoptera (caddisflies), Diptera (flies, mosquitoes, midges), and Ephemeroptera (mayflies) represented the dominant macroinvertebrate groups collected from Walnut Creek. The dominant caddisflies were *Cheumatopsyche* sp. (23.1 percent relative total abundance), and *Hydropsyche* sp. (15.1 percent). Diptera of importance were *Simulium* sp. (15.4 percent) and *Eukiefferiella* sp. (10.4 percent). The dominant mayfly was *Baetis* sp. (9.8 percent).

A total of 26 invertebrate taxa were collected from the Walnut Creek study area. The average density of organisms per replicate was 4,493. Major functional groups consisted of collector-filterers (61.4 percent relative total abundance), collector-gatherers (25.6 percent), and scrapers (8.0 percent). Taxa representing insect orders that are generally considered sensitive to pollution (Ephemeroptera, Plecoptera, and Trichoptera; EPT) represented approximately 56 percent of the total density.

In general, the benthic assemblage was representative of lotic erosional and depositional habitats. A diverse mixture of habitat use, trophic feeding guilds, with collector-filterers predominating, suggesting a typical invertebrate assemblage for this type of western stream.

Woman Creek

Trichoptera (caddisflies), Diptera (flies, mosquitoes, midges), Ephemeroptera (mayflies), Plecoptera (stoneflies), and Oligochaeta (aquatic worms) represented the dominant invertebrate groups collected from Woman Creek. The dominant caddisflies were *Chematopsyche* sp. (20.0 percent relative total abundance), and *Hydropsyche* sp. (7.8 percent). Diptera of importance were *Eukiefferiella* sp. (18.8 percent) and *Cricotopus* sp. (5.2 percent). The dominant mayfly was *Baetis* sp. (7.1 percent). *Hespoperla pacifica* represented the only stonefly (6.5 percent). Immature Tubificidae without capilliform chaete represented the dominant aquatic worm.

A total of 28 macroinvertebrate taxa were collected from the Woman Creek study area. The average density was approximately 2,053 organisms per replicate. Major functional group structure was collector-gatherers (45.5 percent relative total abundance), collector-filterers (35.4 percent), predators (14.3 percent), scrapers (3.4 percent) and shredders (1.4 percent). Taxa representing insect orders that are generally considered sensitive to pollution (Ephemeroptera, Plecoptera, and Trichoptera; EPT) represented approximately 44 percent of the total density.

In general, the benthic assemblage of the Woman Creek study site represented a typical lotic erosional and depositional habitat community. A diverse mixture of habitat use (i.e., clinger-net spinners, burrowers, sprawlers) and trophic feeding guilds (i.e., collector-filters, scrapers, predators) were present. The invertebrate assemblage was typical for this type of habitat.

Big Dry Creek

Diptera (flies, mosquitos, midges), Ephemeroptera (mayflies) and Trichoptera (caddisflies) represented the dominant invertebrate groups collected from the Big Dry Creek study area. The dominant Diptera were *Cricotopus* sp. (32.6 percent relative total abundance), *Eukiefferiella* sp. (20.0 percent), and *Simulium* sp. (4.3 percent). *Baetis* sp. (12.1 percent) represented the most abundant mayfly. The dominant caddisfly at this site was *Hydroptila* sp. (8.2 percent).

The total number of invertebrate taxa collected at this site was 25. Average density of organisms collected per replicate was approximately 15,507. Major functional group structure was represented by collector-gatherers (83.3 percent relative abundance), piercer-herbivores (9.1 percent), collector-filterers (7.1 percent), scrapers (0.38 percent) and predators (0.14 percent). Taxa representing insect orders that are generally considered sensitive to pollution (Ephemeroptera, Plecoptera, and Trichoptera; EPT) represented approximately 22 percent of the total density.

In general, the benthic assemblage of the Big Dry Creek study area represented typical lotic erosional and depositional habitat communities. Dominant taxa changed somewhat when compared qualitatively to that of Woman Creek and Walnut Creek. The average abundance per replicate increased substantially over the other two creeks and was probably due to the location of the sampling area, which was just downstream of Standley Lake (reservoir). A diverse mixture of habitat use (i.e., clingers, burrowers, sprawlers) was present, but trophic feeding guilds were dominated by collector-gatherers, different when compared to Woman Creek and Walnut Creek. As stated above the presences of the lake outfall just upstream may have influenced the macroinvertebrate structure and dominant trophic feeding group assemblage.

4.3.3 Periphyton-Population Characteristics

Periphyton communities consist of a diverse assemblage of organisms attached to underwater surfaces. Aquatic microbes, fungi protozoans, algae, and diatoms are the most common groups comprising the periphyton; however, most biomonitoring studies have focused on algae and periphyton. Algae and periphyton are important components of both lentic and lotic systems and are the principal primary producers in many systems. Because these organisms form the base of aquatic food chains, they are important in the transfer of energy and contaminants to higher trophic levels. More importantly, these groups are highly sensitive to contaminants, making them good indicators of water quality (Patrick, 1957; Cairns et al., 1972). Much of the early research in pollution biology focused on the distribution and abundance of these organisms (Carpenter, 1924). The use of algae and periphyton as indicators of water quality may be limited because of taxonomic difficulties. For example, Patrick (1978) noted that a typical diatom community in an unpolluted habitat may consist of 300 to 400 species.

Periphyton was characterized within each of the reservoirs by leaving artificial substrate samplers in place over a 48-hour period. The samples were analyzed for periphyton abundance and biomass.

A total of 118 species were identified. These species were comprised of diatoms (78 species), green algae (14 species), and blue-green algae (Cyanophyta). The following provides a summary of the periphyton composition by system.

Standley Lake

The periphyton community structure was dominated by Cyanophyta (blue-green algae) and Bacillariophyceae (diatoms). The dominant blue-green was *Schizothrix calciola* (48.7 percent relative total abundance). The dominant diatoms were *Achnanthes minutissima* (14.0 percent) and *Fragilaria pinnata* (13.4 percent). Diatoms represented the most diverse group with 62 species. *Schizothrix calciola*, a blue-green algae, was the most abundant at 6,900 cells per square millimeter. The average total abundance for all algae per sample was 4,726.

The large abundance of the blue-green algae *Schizothrix calciola*, a known sewage pond inhabitant (Palmer, 1977), suggests some potential organic enrichment to the lake. Although the high number of

diatoms species and evenness of distribution among these species would suggest good water quality (Palmer, 1977), the dominance of *Achnanthes minutissima* and *Fragilaria pinnata* also suggests organic enrichment (Lowe, 1974). Sufficient amounts of nutrients are probably present to sustain a moderate algal population of diverse content. The predominance of one or two species in large numbers usually indicates a degraded or eutrophic situation. Therefore, the trophic status of the reservoir would probably be termed mesotrophic to eutrophic.

Great Western Reservoir

The periphyton community structure was dominated by Cyanophyta (blue-green algae), Bacillariophyceae (diatoms), and Chlorophyta (green algae). The dominant blue-green algae was *Schizothrix calciola* (72.6 percent relative total abundance). The dominant diatoms were *Achnanthes minutissima* (6.6 percent) and *Cymbella microcephala* (5.5 percent). Diatoms represented the most diverse group with 60 species. *Schizothrix calciola*, a blue-green algae, was the most abundant. The average total abundance for all algae per sample was 7,181.

Schizothrix calciola was also the dominant alga in Standley Lake suggesting some similarity in physicochemical conditions. This particular taxa is a known sewage pond inhabitant (Palmer, 1977), again suggesting some potential organic enrichment to the reservoir. Although, the high number of diatoms species and evenness of the distribution of abundance among these species would suggest good water quality (Palmer, 1977). The predominance of *Achnanthes minutissima* and *Cymbella microcephala* would also suggest some organic constituent break down (possibly ammonia) (Lowe, 1974).

As with Standley Lake, Great Western Reservoir would probably be classified as mesotrophic to eutrophic based on the algal flora as well as the benthic fauna.

Mower Reservoir

The periphyton community structure was dominated by Bacillariophyceae (diatoms), Chlorophyta (green algae) and Cyanophyta (blue-green algae). The dominant diatoms were *Cocconeis placentula v. lineata* (52.6 percent relative total abundance) and *Epithemia turgida* (4.3 percent). The dominant green algae was *Stegeoclonium lubricum* (19.5 percent). The dominant blue-green algae was *Schizothrix calciola* (15.5 percent). Diatoms represented the most diverse group with 18 species and the most abundant group with 4,443.

The predominance of the diatom *Cocconeis placentula v. lineata* suggests a somewhat higher pH (range 7-9) and an abundance of inorganic nutrients (Lowe, 1974).

4.3.4 Bioassay and Toxicity Testing

Although field sampling may provide information on the presence of contaminants in a particular habitat, this approach provides little insight into the potential toxicity of these contaminants. The presence or absence of organisms in an area is a complex function of physical, chemical, and biological characteristics of the system. As a consequence, it is often difficult to determine direct cause and effect relationships between the presence of contaminants and community structure or function. Furthermore, results of field biomonitoring often show all-or-none responses and may provide little indication of the relative degree of contamination.

Toxicity tests are routinely employed to estimate the potential adverse effects of contaminants on aquatic organisms. Typically these tests employ surrogate species and require that investigators assume responses of these simple laboratory procedures to be indicative of responses in more complex systems (i.e., ecosystems). Although these tests have been criticized because of their lack of environmental realism when used in conjunction with field monitoring, they provide necessary supporting evidence for determining the degree of impact of contaminants.

Samples of surface water and sediment were collected from Woman Creek (prior to the confluence with Standley Lake), south Walnut Creek (below Great Western Reservoir), Big Dry Creek, and from three locations within Mower Reservoir. The samples of surface water were collected for the determination of OU 3 chronic toxicity to Fathead minnows and ceriodaphnia. The sediment samples were evaluated for chronic toxicity to *Hyallela azteca*. Endpoints employed in the OU 3 laboratory toxicity testing included mortality, growth, and reproduction.

The surface water bioassays were a renewal exposure regime in which site water samples were collected at two time intervals during the test in order to provide a duplication of site conditions over a chronic time period. Due to poor control ceriodaphnia reproduction, the ceriodaphnia test had to be repeated at a later date.

The results were reviewed and certain test conditions raised concerns regarding the exposure regime within the laboratory. The test organisms were supplied by different sources, the laboratory food varied during the test exposure, and control reproduction for the ceriodaphnia remained low (within the second test as well). Therefore, the results of the tests are provided for qualitative purposes only, recognizing the data limitations due to the laboratory conditions.

The results of the tests are provided in Table 4-17, and indicate no toxicity associated with surface water to Fathead minnows. The chronic endpoints (reproduction) for the ceriodaphnia tests could not be used due to the low birth rates measured in all control and exposure samples. However, survival was not significantly different from controls.

Results of the Hyallela sediment testing indicated a difference between control and treated exposure organisms for Walnut creek. The results of the chemical analysis for this location are attached to this document. The results are not different from the other creek analyses (i.e., Big Dry Creek, Woman Creek, etc.) Due to the small sample size a statistical evaluation could not be conducted. However, it should be noted, that physical conditions of low flow were apparent within all of the creek locations which may have impacted the habitat suitability of the sediment substrate. Due to the low flow conditions, effects observed in the Walnut creek sample are difficult to relate to PCOCoccurrence.

4.3.5 PCOC Activities in Receptor Tissues

A summary of tissue activities was presented in Table 4-4. Results were typically at or below detection limits. Conclusions could not be drawn regarding PCOC uptake and accumulation for many of the species analyzed since these organisms were stocked (which would affect exposure), and plutonium-239, -240 and americium–241 were infrequently detected in all media.

5.0 SUMMARY AND CONCLUSIONS

The results of the exposure assessment and effects assessment were combined in a weight-of-evidence evaluation to determine if the PCOCs plutonium-239, -240 and americium-241 are of concern to aquatic biota.

Exposure point activities were compared to NOAEL media benchmark activities and exposure dose levels were compared to the NOAEL dose. Results of both comparisons were quantified using the HQ and HI method, and the results of the HQ and HI evaluation indicate that risk to aquatic life is unlikely.

Population measurements were gathered for fish, benthic macroinvertebrates, and periphyton. Results indicate no adverse effect to these populations.

Bioassay analysis of surface water and sediment was conducted at various areas within OU 3. Certain test results were unusable due to test conditions of control mortality. However, the remaining test results indicate no adverse effect to laboratory organisms exposed to surface water.

Tissue analysis of PCOC content was conducted for fish captured from each IHSS. Results were generally below detection limits. However, these results were not heavily relied upon because of uncertainty of the analyses, and because many of the fish are stocked which, thereby, limits their exposure.

Overall, there is sufficient evidence from all of these measurements of exposure and effects to draw the conclusion that adverse effects or risk to aquatic life within OU 3 is unlikely as a result of PCOC exposure.

Table 4-1

Water Quality

SAMPLE NUMBER	DATE COLL.	DEPTH (Ft.)	WATER TEMP (Deg. C)	D.O. (Mg/L)	PH (Units)	CONDUCTIVITY (UMHOS)	TURBIDITY (NTU)	HARDNESS (Mg/L)	ALKALINITY (Mg/L)
WALNUT CREEK									
BIO15192	07/08/92	0.00	16.0	6.20	6.27	20	16.3	70	63
BIO15192	07/10/92	0.00	18.0	7.90	7.92	105	15.6	52	30
WOMAN CREEK									
BIO15292	07/13/92	0.00	17.0	7.30	7.46	154	11.4	50	43
BIG DRY CREEK									
BIO15392	07/09/92	0.00	14.0	5.40	5.99	60	11.4	108.5	
GREAT WESTERN RESERVOIR									
BIO17192	07/11/92	0.00	22.0	8.10	7.76	201	24.4	64	54
BIO17192	07/11/92	10.00	21.0	6.40					
BIO17192	07/11/92	15.00	20.0	6.30					
BIO17192	09/28/92	7.87	16.0	7.53	8.10	186		70	53
BIO17192	09/30/92	7.87	17.6	10.75	8.20	186		72	55
BIO17292	07/11/92	0.00	22.0	7.50	7.90	208	24.6	73	46
BIO17292	07/11/92	5.00	21.0	6.50					
BIO17292	07/11/92	10.00	20.0	6.20					
BIO17292	07/11/92	15.00	20.0	6.00					
BIO17292	07/11/92	20.00	20.0	6.00					
BIO17292	07/11/92	24.00	20.0	6.00					
BIO17292	09/29/92	18.04	16.2	4.92	8.00	184		67	51
BIO17292	09/30/92	18.04	17.5	8.89	8.11	186		70	51
BIO17392	07/11/92	0.00	21.0	6.80	8.26	200	26.4	76	43
BIO17392	07/11/92	10.00	20.0	6.50					
BIO17392	07/11/92	20.00	20.0	6.20					
BIO17392	07/11/92	30.00	20.0	6.00					
BIO17392	07/11/92	40.00	20.0	5.80					
BIO17392	09/29/92	34.12	16.0	3.65	7.96	184		66	42
BIO17392	09/30/92	34.12	16.5	12.12	8.12	186		70	59
MOWER RESERVOIR									
BIO17692	10/06/92	4.98			9.96	262	1.3	87	83
BIO17692	10/07/92	3.93	11.1		10.13	272	0.8	77	63
BIO17692	07/17/92	0.00	22.0	8.40	10.10	233	1.5	88	93
BIO17692	07/17/92	2.50	19.0	8.80					
BIO17692	07/17/92	5.00	19.0	4.40					
BIO17792	10/06/92	4.49	13.6		9.98	272	1.12	74	96
BIO17792	10/07/92	4.59	11.1		10.25	274	3.2	80	68
BIO17792	07/17/92	0.00	21.0	9.20	10.40	240	1.4	77	90
BIO17792	07/17/92	2.50	19.0	6.30					
BIO17792	07/17/92	5.00	19.0	4.00					
BIO17892	10/06/92	4.49	14.0		10.25	274	1.4	90	86
BIO17892	07/17/92	0.00	19.0	8.00	9.80	245	2.3	72	87
BIO17892	07/17/92	3.00	18.0	7.00					
BIO17892	07/17/92	6.00	18.0	3.80					
STANDLEY LAKE									
BIO18192	10/13/92	13.12	14.8	3.60	8.30	226	5.11	84	48
BIO18192	10/14/92	13.00	13.8	8.60	7.80	228	8.6	85	77
BIO18292	10/13/92	20.01	14.8	7.60	8.20	228	5.3	89	39
BIO18292	10/19/92	20.01	13.9	10.00	8.30	226	5.2	89	40
BIO18392	10/13/92	8.85	14.5	8.40	8.10	230	5.9	80	40
BIO18392	10/19/92	13.12	13.6	10.20	8.20	226	5.8	99	44
BIO18492	10/14/92	80.00	14.6	5.90	8.00	226	4.5	81	49
BIO18492	10/19/92	57.08	13.6	9.00	8.00	226	6.3	90	34
BIO18492	07/31/92	0.00	23.0	7.60	8.00	177	1.4	90	52
BIO18492	07/31/92	0.00	23.0	7.00	7.45	187	1.73	73	44
BIO18492	07/31/92	16.00	21.0	6.80					
BIO18492	07/31/92	29.00	21.0	6.00					
BIO18492	07/31/92	33.00	20.0	4.80					
BIO18492	07/31/92	58.00	16.0	1.00					
GREAT WESTERN RESERVOIR									
BIO19192	08/18/92	5.00	24.0	7.00	8.13	193	12.66	64	47
BIO19192	08/26/92	5.00	20.0	7.40	8.40	172	15.42	67	40
BIO19192	09/01/92	5.00	20.0	5.80	6.48	206	14.27	76	45
BIO19192	09/11/92	0.16	18.0	6.60	6.40	220	14.24	82	41
BIO19292	08/18/92	5.00	23.0	7.40	8.08	190	13.81	69	
BIO19292	08/26/92	5.00	20.0	7.40	8.32	168	15.2	84	39
BIO19292	09/01/92	5.00	19.0	5.80	7.04	167	13.7	85	56
BIO19292	09/11/92	0.16	19.0	7.40	7.52	201	11.84	66	52
BIO19392	08/18/92	5.00	22.0	7.20	7.87	208	12.54	66	
BIO19392	08/26/92	5.00	20.0	7.80	8.30	176	16		40
BIO19392	09/01/92	5.00	19.0	5.80	7.38	181	13.35	80	48
BIO19392	09/11/92	0.16	18.0	6.80	7.52	181	12.55	69	38
MOWER RESERVOIR									
BIO19492	08/18/92	4.00	22.0	7.40	10.50	266	1.16	66	87
BIO19492	08/26/92	5.00	17.0	8.00	9.80	310	0.52	70	77
BIO19492	09/11/92	0.16	20.0	7.40	10.36	395	0.96	63	74
BIO19492	09/02/92	0.16	16.0	8.00	9.65	344	1.11	80	81
BIO19592	08/18/92	4.00	23.0	7.20	10.47	250	0.75	61	
BIO19592	08/26/92	5.00	17.0	7.80	10.05	247	0.47	65	73
BIO19592	09/11/92	0.16	21.0	7.40	10.31	263	1.27	68	76
BIO19592	09/02/92	0.16	16.8	10.00	10.05	303	0.85	68	68

Table 4-1

Water Quality

SAMPLE NUMBER	DATE COLL.	DEPTH (Ft.)	WATER TEMP (Deg. C)	D.O. (Mg/L)	PH (Units)	CONDUCTIVITY (UMHOS)	TURBIDITY (NTU)	HARDNESS (Mg/L)	ALKALINITY (Mg/L)
BIO19692	08/18/92	5.00	23.0	6.00	10.13	224	3.55	73	
BIO19692	08/26/92	5.00	17.0	7.60	9.70	283	0.72	64	82
BIO19692	09/11/92	0.16	20.0	6.80	10.36	363	0.75	70	62
BIO19692	09/02/92	0.16	16.0	9.00	10.05	334	0.79	75	82
STANDLEY LAKE									
BIO19792	08/18/92	4.00	22.0	7.00	7.11	241	3.38	76	48
BIO19792	08/26/92	5.00	21.0	7.00	8.62	217	4.72	86	47
BIO19792	09/11/92	0.16	21.0	7.60	8.06	196	8.71	76	50
BIO19892	08/18/92	5.00	22.0	7.40	7.67	216	3.18	78	
BIO19892	08/26/92	5.00	21.0	7.00	8.30	222	3.6	75	38
BIO19892	09/11/92	0.16	21.0	7.20	7.95	181	4.6	81	51
BIO19992	08/18/92	5.00	23.0	7.20	7.88	219	2.77	78	
BIO19992	08/26/92	5.00	21.0	7.00	8.10	220	4.24	75	39
BIO19992	09/11/92	0.16	21.0	7.60	7.91	175	8.2	77	51
LINDSEY POND									
LINDSEY	10/08/92		10.1		7.75	228		70	128
STANDLEY LAKE									
SD09492	07/29/92	0.00	22.0	7.40	7.05	265	2.73		
SD09492	07/29/92	9.00	22.0	7.00					
SD09492	07/29/92	17.00	21.0	5.00					
SD09692	07/29/92	0.00	22.0	7.60	6.50	295	2.24		
SD09692	07/29/92	9.00	22.0	7.20					
SD09692	07/29/92	17.00	22.0	7.00					
GREAT WESTERN RESERVOIR									
SD12592	07/14/92	0.00	18.0	7.80	7.55	217	25.3	72	55
SD12592	07/14/92	10.00	17.0	7.60					
SD12592	07/14/92	20.00	17.0	7.60					
SD12692	07/14/92	0.00	19.0	8.00	8.30	234			
SD12692	07/14/92	10.00	20.0	7.80					
SD12692	07/14/92	20.00	19.0	7.60					
SD12792	07/14/92	0.00	19.0	7.20	6.73	244	24.8	73	60
SD12792	07/14/92	10.00	20.0	7.00					
SD12792	07/14/92	20.00	19.0	6.50					
SD12792	07/14/92	30.00	19.0	6.40					
SD12792	07/14/92	40.00	19.0	6.20					
MOWER RESERVOIR									
SD15192	07/22/92	0.00	24.0	9.40	10.70	268	1.28	72	
SD15292	07/22/92	0.00	24.5	11.00	10.90	265	1.55	69	
SD15392	07/22/92	0.00	23.5	8.70	10.70	257	1.91	52	
WALNUT CREEK									
SED00392	08/10/92	0.16	21.0	7.80	8.71	358	2.1	236	216
SED00392	08/12/92	0.16	14.0	10.50	8.45	470	0.41	203	195
SED00392	08/13/92	0.16	22.0	7.90	7.46	380	4.2	197	180
SED00392	08/14/92		13.0	6.80	6.95	345	0.4	198	140
SED00392	08/31/92	0.16	17.0	8.00	8.53	448	0.85	164	129
SED00392	09/02/92	0.16	19.2	8.80	5.54	531	1.8	195	213
SED00392	09/03/92	0.16	19.8	8.30	7.56	448	2.1	190	215
SED00392	09/04/92	0.16	22.0	9.40	6.67	567	1.9	195	215
MOWER RESERVOIR									
SED01392	08/10/92	0.16	20.0	8.00	9.13	198	0.6	88	75
SED01392	08/10/92		20.0	8.00	9.13	198	0.6	88	75
SED01392	08/10/92		22.0	8.60	9.89	211	0.6	68	75
SED01392	08/12/92	0.16	19.0	7.20	10.20	279	0.64	68	73
SED01392	08/13/92	0.16	22.0	7.00	9.89	292	1.14	74	85
SED01392	08/14/92	0.16	18.0	5.80	8.68	231	0.4	72	102
SED01392	08/31/92	5.00	17.0	8.00	9.72	275	1.13	71	63
SED01392	09/02/92	0.16	16.0	8.80	9.14	280	0.76	73	92
SED01392	09/03/92	0.16	20.7	13.40	9.78	318	1.3	71	70
SED01392	09/04/92	0.16	20.8		10.30	352	1.2	59	80
WOMAN CREEK									
SED02092	08/10/92	0.16	25.0	4.90	8.90	513	3.4	245	160
SED02092	08/12/92	0.16	15.5	9.80	8.80	534	2.64	210	170
SED02092	08/13/92	0.16	24.0	7.20	7.54	528	1.18	186	153
SED02092	08/14/92		16.0	7.20	6.87	385	1.4	104	82
SED02092	08/31/92	0.16	17.0	7.80	8.24	479	1.85	189	217
SED02092	09/02/92	0.16	22.0	9.40	8.01	521	1.21	171	158
SED02092	09/03/92	0.16	24.5	5.90	7.65	505	1.48	180	133
SED02092	09/04/92	0.16	26.5	6.20	7.32	570	1.14	172	137
BIG DRY CREEK									
SED02592	08/10/92	0.16	16.0	7.80	8.20	174	5.6	95	49
SED02592	08/12/92	0.16	15.0	10.70	8.75	255	4.51	107	52
SED02592	08/13/92	0.16	20.0	7.40	7.57	218	6.35	89	49
SED02592	08/14/92		14.0	8.00	7.23	285	5.9	172	150
MOWER RESERVOIR									
SED15192	08/10/92	0.16	22.0	8.60	9.89	211	0.6	68	75
SED15192	08/12/92	0.16	19.0	8.20	10.20	285	0.92	71	75
SED15192	08/13/92	0.16	21.0	7.20	9.67	241	0.77	72	74
SED15192	08/14/92	0.16	18.0	7.60	9.73	235	0.5	57	76
SED15292	08/10/92	0.16	22.0	8.20	10.40	214	0.5	65	80
SED15292	08/12/92	0.16	20.0	8.40	10.20	285	0.8	71	61
SED15292	08/13/92	0.16	21.0	8.40	9.90	238	2.08	72	76

Table 4-1

Water Quality

SAMPLE NUMBER	DATE COLL.	DEPTH (Ft.)	WATER TEMP (Deg. C)	D.O. (Mg/L)	PH (Units)	CONDUCTIVITY (UMHOS)	TURBIDITY (NTU)	HARDNESS (Mg/L)	ALKALINITY (Mg/L)
SED15292	08/14/92	0.16	18.0	8.20	10.33	240	0.3	76	71
WALNUT CREEK									
SW00292	07/18/92	0.00	17.0	8.20	6.80	191	18.1	64	41
BIG DRY CREEK									
SW00392	07/18/92	0.00	16.5	8.10	8.20	130	20.2	63	33
SW00792	07/18/92	0.00	14.5	8.10	7.80	231	10.5	92	61
GREAT WESTERN RESERVOIR									
SW02192	07/14/92	5.00	20.0	6.50					
SW02192	07/15/92	0.00	21.0	6.80	7.45	245	24.3	61	58
SW02192	07/15/92	10.00	20.0	6.40					
SW02192	07/15/92	15.00	19.0	6.20					
SW02292	07/15/92	0.00	22.0	8.00	7.86	213	24.5	63	52
SW02292	07/15/92	10.00	20.0	7.80					
SW02292	07/15/92	20.00	19.0	7.60					
SW02392	07/16/92	0.00	20.0	7.20	7.45	195	24.5	74	34
SW02392	07/16/92	10.00	19.0	7.00					
SW02392	07/16/92	20.00	18.0	6.80					
SW02392	07/16/92	30.00	18.0	6.80					
SW02392	07/16/92	40.00	17.0	6.60					
SW02492	07/16/92	0.00	19.0	6.40	7.35	196	25.1	62	36
SW02492	07/16/92	5.00	19.0	6.80					
SW02492	07/16/92	9.00	18.0	6.60					
SW02592	07/16/92	0.00	19.0	6.60	7.20	212	27.1	71	52
SW02592	07/16/92	10.00	17.0	6.20					
SW02592	07/16/92	20.00	17.0	6.20					
SW02592	07/16/92	30.00	17.0	6.20					
SW02592	07/16/92	40.00	17.0	6.20					
MOWER RESERVOIR									
SW02692	07/20/92	0.00	23.0	9.40	11.17	297	1.6	52	
SW02692	07/20/92	2.50	21.0	8.80					
SW02692	07/20/92	5.00	19.0	1.00					
SW02792	07/20/92	0.00	23.0	8.00	10.95	290	2.03		
SW02792	07/20/92	2.50	21.0	9.20					
SW02792	07/20/92	5.00	19.0	1.00					
SW02892	07/20/92	0.00	22.0	9.00	10.70	282	1.8	51	
SW02892	07/20/92	2.00	21.0	9.40					
SW02892	07/20/92	4.00	20.0	1.80					
SW02992	07/20/92	0.00	20.0	9.20	10.70	281	2.1	58	
SW02992	07/20/92	2.50	20.0	9.00					
SW02992	07/20/92	5.00	19.0	7.80					
SW03092	07/21/92	0.00	20.5	8.20	10.70	255	1.7	64	
STANDLEY LAKE									
SW03192	07/27/92	0.00	24.0	8.20	7.90	261	1.64	71	46
SW03192	07/27/92	8.00	22.0	8.00					
SW03192	07/27/92	16.00	21.0	7.80					
SW03292	07/29/92	10.00	21.0	6.80					
SW03292	07/29/92	20.00	21.0	6.40					
SW03292	07/30/92	0.00	22.0	7.00	8.83	246	2.4	89	69
SW03392	07/27/92	0.00	21.0	7.80	6.85	260	1.87	71	46
SW03392	07/27/92	9.00	21.0	7.60					
SW03392	07/27/92	18.00	21.0	7.60					
SW03492	07/28/92	0.00	22.0	8.80	8.02	207	1.7	87	60
SW03492	07/28/92	10.00	21.0	8.40					
SW03492	07/28/92	20.00	20.0	8.00					
SW03592	07/27/92	0.00	22.0	8.00					
SW03592	07/27/92	25.00	21.0	6.60					
SW03592	07/27/92	25.00	20.0	7.00					
SW03592	07/27/92	27.00	20.0	6.20					
SW03592	07/27/92	29.00	20.0	5.60					
SW03592	07/27/92	31.00	19.0	4.40					
SW03592	07/27/92	33.00	19.0	3.80					
SW03592	07/27/92	35.00	18.0	3.00					
SW03592	07/27/92	37.00	18.0	2.40					
SW03592	07/27/92	39.00	18.0	2.40					
SW03592	07/27/92	41.00	17.0	2.20					
SW03592	07/27/92	43.00	17.0	2.00					
SW03592	07/27/92	45.00	16.0	1.80					
SW03592	07/27/92	47.00	16.0	1.80					
SW03592	07/27/92	50.00	16.0	1.80					
SW03592	07/27/92	50.00	16.0	1.80					
SW03592	07/27/92	75.00	14.0	0.60					
SW03592	07/27/92	82.00	13.0	0.20					
SW03592	07/28/92	5.00	21.0	8.00					
SW03592	07/28/92	10.00	21.0	7.90					
SW03592	07/28/92	15.00	21.0	7.90					
SW03592	07/28/92	20.00	20.5	7.00					
SW03592	07/28/92	25.00	19.0	5.80					
SW03592	07/28/92	30.00	18.0	3.60					
SW03592	07/28/92	35.00	17.0	2.00					
SW03592	07/28/92	40.00	16.5	1.90					
SW03592	07/28/92	45.00	16.0	1.90					

Table 4-1

Water Quality

SAMPLE NUMBER	DATE COLL.	DEPTH (Ft)	WATER TEMP (Deg. C)	D.O. (Mg/L)	PH (Units)	CONDUCTIVITY (UMHOS)	TURBIDITY (NTU)	HARDNESS (Mg/L)	ALKALINITY (Mg/L)
SW03592	07/28/92	50.00	15.0	1.80					
SW03592	07/28/92	55.00	15.0	1.90					
SW03592	07/28/92	60.00	15.0	1.90					
SW03592	07/28/92	65.00	14.0	1.80					
SW03592	07/28/92	70.00	14.0	1.60					
SW03592	07/28/92	75.00	14.0	1.60					
SW03592	07/29/92	0.00	22.0	8.20	8.44	257	1.5	100	50
SW03592	07/29/92	30.00	18.0	3.60	7.78	230	3.5	101	51
SW03592	08/05/92	79.00	21.8	7.60	7.26	196	0.85	148	46
SW03592		75.00	13.9	1.80	8.45	395	9.4	128	60
REFERENCE									
SEDREF92	08/13/92	0.16	15.0	6.20	5.80	297	5.06	134	97

Electroshocking-Capture Techniques

A backpack-electroshocking unit was used to sample the three stream locations during the summer months. A 50-foot area of the stream-sampling location was traversed with a one-pass electroshocking event. Electroshock unit specifications were dependent upon water quality conditions. In general, shocking was sustained for approximately 20 minutes within the sampling reach, fish were immediately captured, and retained in live wells for processing. Fish that were not identified in the field, were preserved in 10 percent buffered formalin for later identification.

A boat-shocker apparatus was used for the reservoir sampling in conjunction with gill nets for the capture of fish. Boat-electroshocking activities occurred after nightfall, and locations to be sampled were electroshocked for 15-minute intervals along the shoreline. Fish were captured and retained in live wells for processing. All fish were identified to species (where possible), measured for total length and weight, and processed for potential fish-tissue analyses. Those species that were unidentifiable, were preserved in 10 percent buffered formalin for later identification. Those fish retained for tissue analysis were wrapped in aluminum foil and maintained at refrigerator temperature until further processing was completed (within 24 hours after catch). Fish were then processed for tissue-sample extraction. Fish within each trophic class (where possible and applicable) were retained from each station for tissue analysis (herbivores, primary predator, etc). Whole body, fillet, and whole body (without internal organs) tissue samples were collected, when adequate and appropriate catch were available.

Monofilament gill nets (250 feet in total length, 6 feet in depth) with variable mesh sizes were deployed throughout the reservoirs for additional fish sampling. Nets were generally set perpendicular to the shoreline, starting from a designated sampling location and proceeding toward the shore. Nets were bottom set with the largest mesh size in the deepest portion of the sampling area. Nets were often set for several hours to a maximum of an overnight set (12 to 16 hours). Fish were retrieved from the net and retained within live wells for processing.

Fish were processed for tissue-sample selection in a similar manner to all other fish collection. Fish were identified to species, and measured for total length and weight. Observations of external disease were also noted. A summary of the fish collected within each system is presented in Table 4-2, while a presentation of the subset of fish used for tissue analysis is presented in Table 4-3. The analysis requested for the tissue samples included select metals and radionuclide analysis.
For QA/QC purposes, duplicate tissue samples were submitted for analyses. To create a duplicate sample, the fish tissue was divided into right and left fillet portions. Each fillet was then submitted as a separate sample. Raw data results of the tissue analysis are provided at the end of this report. Results are presented by species and tissue type within each reservoir. A summary of the results of plutonium-239, -240 and americium-241 analyses are provided in Table 4-4.

2.2.2 Benthic Macroinvertebrates

Triplicate samples of benthic macroinvertebrates were collected from collocated locations with sediment and surface water. Samples were collected using a petite ponar dredge for the lake locations, and a surber bottom sampler for the stream locations. Samples from the stream and lakes were preserved and shipped to VERSAR Laboratories for species identification and enumeration. The benthic-macroinvertebrate sample collection was conducted in accordance with SOP.EE.5.2, Sampling of Benthic macroinvertebrate (DOE, 1991c).

Table 4-2
Summary of The Number of Fish Collected Per Reservoir/Creek for The Era

Species	Standley Lake	Great Western Reservoir	Mower Reservoir	Walnut Creek	Woman Creek	Big Dry Creek	Lindsey Pond (Reference Location)	Total
Black Crappie	1	0	0	0	0	0	0	1
Carp	36	35	0	0	0	0	0	71
Channel Catfish	4	0	0	0	0	0	0	4
Gizzard Shad	1	0	0	0	0	0	0	1
Green Sunfish	5	0	0	0	0	0	0	5
Largemouth Bass	0	0	80	0	0	0	8	88
Longnose Dace	0	0	0	0	0	1	0	1
Longnose Sucker	2	8	1	3	0	21	0	35
Minnow sp.	0	0	0	16	0	0	0	16
Rainbow Trout	68	0	0	0	0	0	0	68
Smallmouth Bass	33	0	0	0	1	0	0	34
Walleye	5	0	0	0	0	0	0	5
White Sucker	3	25	0	0	0	0	0	28
Wiper	6	0	0	0	0	0	0	6
Yellow Perch	73	0	0	0	0	0	0	73
Total	237	68	81	19	1	22	8	436

Table 4-3
Summary of the Number of Fish Samples for Tissue Analysis

Species	Standley Lake	Great Western Reservoir	Mower Reservoir	Lindsey Pond	Total
Black Crappie	0	0	0	0	0
Carp	9	7	0	0	16
Channel Catfish	2	0	0	0	2
Gizzard Shad	0	0	0	0	0
Green Sunfish	0	0	0	0	0
Bass sp.	0	0	13	4	17
Longnose Dace	0	0	0	0	0
Sucker sp.	4	7	1	0	12
Minnow sp.	0	5	0	0	5
Rainbow Trout	8	0	0	0	8
Walleye/Perch	8	0	0	0	8
Total	31	19	14	4	68

Table 4-4

Surface Water and Fish Tissue Potential COC Content

		Fish Tissue								
	Surface Water	Perch Walleye (WB)	Carp (WB)	Carp (WBX)	Minnows (WB)	Sucker sp. (WB)	Bass (M)	Bass (WB)	Channel Catfish (WB)	Rainbow Trout (WB)
Great Western Reservoir										
$^{239/240}Pu$	0.000-0.005	NA	NA	0.001-0.001	0.001-0.006	0.001-0.006	NA	NA	NA	NA
^{241}Am	-0.005-0.017	NA	NA	0.002-0.002	-0.001-0.003	0.001-0.004	NA	NA	NA	NA
Standley Lake										
$^{239/241}Pu$	0.000-0.009	0.001-0.002	-0.001-0.001	-0.001-0.034	NA	-0.001-0.002	NA	NA	0.002-0.002	0.002-0.002
	-0.001-0.026	-0.001-0.002	-0.001-0.001	**	NA	**	NA	NA	**	**
Mower Reservoir										
$^{239/240}Pu$	-0.005-0.030	NA	NA	NA	NA	0.004-0.004	0.001-0.001	NA	NA	NA
^{241}Am[1]	0.000-0.017	NA	NA	NA	NA	**	0.004-0.004	NA	NA	NA
Lindsey Pond (Background)										
$^{239/240}Pu$	NA	NA	NA	NA	NA	NA	0.001-0.001			
^{241}Am[1]	NA	NA	NA	NA	NA	NA	0.001-0.001			

WB = Whole Body
WBX = Whole body without entrails
M = muscle

Units for tissue are pCi/g, and pCi/L for surface water
** = ^{241}Am was not analyzed.
NA = Not analyzed since these species did not occur.

Table 4-5
Percent Benthic Macroinvertebrate Species Compositon of Stream Samples

	Woman Creek			Walnut Creek			Big Dry Creek		
Species	**BI03603CH**	**BI03604CH**	**BI03605CH**	**BI03600CH**	**BI03601CH**	**BI03602CH**	**BI03606CH**	**BI03607CH**	**BI03608CH**
Agapetus sp.					4.0	2.5	0.3		
Baetis sp	9.5	6.9		9.5	7.5	13.1	9.3	17.4	13.2
Cheumatopsyche sp.	17.0	13.8	35.5	16.7	21.4	27.8		2.2	0.5
Chironomidae pupae	1.0	3.4		7.1			9.5	7.1	10.7
Cricotopus sp.	8.5						34.9	23.6	34.4
Cyphon sp. adult			3.2	4.7					
Dicrotendipes sp.							2.8		
Disonycha fumata lodingi				2.4					
Dolichopodidae		3.4							
Dugisia sp.							0.2		
Empidae sp. B							0.2		
Empididae sp. A		6.9							
Empididae			3.2			0.8			
Enchytraeidae		3.4							0.3
Eukiefferiella sp.	25.5		17.2	4.7	10.4	12.3	17.9	26.3	21.5
Helicopsyche borealis	3.2								
Hemerodromia							0.3		
Hesperoperla pacifica	3.2	10.3	12.9		0.6				
Homoptera	1.0		12.9	2.4	2.3	1.6		1.3	0.8
Hydatophylax hesperus			3.2						
Hydracarina sp.						0.8	0.2		0.5
Hydropsyche sp.	12.7			11.9	17.9	12.3			
Hydropsychidae					5.8	2.5			
Hydropsychidae pupa	1.0				0.6				
Hydroptila sp.							12.7	5.8	2.7
Hydrothassa sp.						0.8			
Imm. Tubificid w/cap. Chaete							0.3	0.4	

Table4-5
Percent Benthic Macron Vertebrate Species Composition of Stream Samples (continued)

	Woman Creek			Walnut Creek			Big Dry Creek		
Species	**BI03603CH**	**BI03604CH**	**BI03605CH**	**BI03600CH**	**BI03601CH**	**BI03602CH**	**BI03606CH**	**BI03607CH**	**BI03608CH**
Agapetus sp.					4.0	2.5	0.3		
Baetis sp	9.5	6.9		9.5	7.5	13.1	9.3	17.4	13.2
Cheumatopsyche sp.	17.0	13.8	35.5	16.7	21.4	27.8		2.2	0.5
Chironomidae pupae	1.0	3.4		7.1			9.5	7.1	10.7
Cricotopus sp.	8.5						34.9	23.6	34.4
Imm. Tubificid w/o Cap. Chaete	4.3	3.4	9.7		0.6	1.6	1.6	2.2	1.1
Limnodrilus udekemianus								0.4	0.5
Limnodrilus hoffmeisteri		3.4						1.8	
Lumbriculidae		3.4							
Lumbriculidae							0.3		
Lymnaea sp.							0.7		
Macrovelia sp.						1.6			
Mesovelia sp. (juv)	1.0	6.9			1.2	2.5			0.3
Mesovelia sp.			3.2						
Microvelia sp.			3.2						
Ophiogomphus sp.			3.2						
Petrophila sp.				2.4	3.5				
Petrophila pupa					2.9	2.5			
Phaenopsectra sp.		6.9	3.2		1.2	0.8	2.1		
Physella sp.			3.2			0.8			
Polypedilum sp.				9.5					
Pyralidae sp.					0.6				
Simulidae pupae	1.0	3.4		2.4	1.2	0.8	0.2	0.4	1.8
Simulium sp.	5.3	3.4		21.4	17.3	10.7	1.9	2.2	9.1
Stenopelmus rufinasus				2.4	0.6				
Stictochironomus sp.								3.6	
Tipula sp.	1.0				0.6	0.8			
Trepobates sp.			3.2						

Table4-5
Percent Benthic Macron Vertebrate Species Composition of Stream Samples (continued)

	Woman Creek			Walnut Creek			Big Dry Creek		
Species	BI03603CH	BI03604CH	BI03605CH	BI03600CH	BI03601CH	BI03602CH	BI03606CH	BI03607CH	BI03608CH
Agapetus sp.					4.0	2.5	0.3		
Baetis sp	9.5	6.9		9.5	7.5	13.1	9.3	17.4	13.2
Cheumatopsyche sp.	17.0	13.8	35.5	16.7	21.4	27.8		2.2	0.5
Chironomidae pupae	1.0	3.4		7.1			9.5	7.1	10.7
Cricotopus sp.	8.5						34.9	23.6	34.4
Tricorythodes							1.1	0.4	0.8
Turbellaria				2.4					
Tvetenia sp.	4.3	3.4				0.8	3.2	4.4	1.1

Blank spaces indicate species not present within the sample.

Table 4-6
Sampling Round 1
Species NOT Detected

ORDER	FAMILY	GENUS	SPECIES
Coleoptera	Dytiscidae	Agabus	sp. larva
Trichoptera	Glossosonatidae	Agapetus	sp.
Diptera	Ceratopogonidae cf.	Palpomyia	sp.
Trichoptera	Hydropsychidae	Cheumatopsyche	sp.
Hemiptera	Corixidae	Corixidae	
Coleoptera	Scirtidae	Cyphon	sp. adult
Coleoptera	Chrysomelidae	Disonycha	fumata lodingi
Diptera	Dolichopodidae	Dolichopodidae	
Tricladida	Planariidae	Dugesia	sp.
Diptera	Empidadae	Empididae	sp.
Diptera	Empidadae	Empididae	sp. A
Diptera	Empidadae	Empididae	sp. B
Haplotaxida	Enchytraeidae	Enchytraeidae	
Trichoptera	Helicopsychidae	Helicopsyche	borealis
Diptera	Empidadae	Hemerodromia	sp.
Plecoptera	Perlidae	Hesperoperla	pacifica
Trichoptera	Limnephilinae	Hydatophylax	hesperus
Trichoptera	Hydropsychidae	Hydropsyche	sp.
Trichoptera	Hydropsychidae	Hydropsychidae	
Trichoptera	Hydropsychidae	Hydropsychidae	pupa
Trichoptera	Hydroptilidae	Hydroptila	sp.
Coleoptera	Chrysomelidae	Hydrothassa	sp.
Haplotaxida	Tubificidae	Limnodrilus	udekemianus
Haplotaxida	Lumbriculidae	Lumbriculidae	
Lymnophila	Lymnoaeidae	Lymnaea	sp.
Hemiptera	Macroveliidae	Macrovelia	sp.
Hemiptera	Mesoveliidae	Mesovelia	sp.
Hemiptera	Mesoveliidae	Mesovelia	sp. (juv)
Diptera	Chironomidae	Microtendipes	sp.
Hemiptera	Veliidae	Microvelia	sp.
Trichoptera	Leptoceridae	Oecetis	sp.
Odonata	Gomphidae	Ophiogomphus	sp.
Trichoptera	Hydroptilidae	Oxyethira	sp.
Diptera	Chironomidae	Paratanytarsus	sp.
Lepidoptera	Pyralidae	Petrophila	pupa
Lepidoptera	Pyralidae	Petrophila	sp.
Bivalvia	Sphaeriidae	Pisidium	sp.
Diptera	Chironomidae	Pseudochironomus	fulviventris
Diptera	Chironomidae	Pseudochironomus	sp.
Lepidoptera	Pyralidae	Pyralidae	sp.
Diptera	Simuliidae	Simuliidae	pupae
Diptera	Simuliidae	Simulium	sp.
Coleoptera	Curculionidae	Stenopelmus	rufinasus
Diptera	Chironomidae	Stictochironomus	sp.
Diptera	Tipulidae	Tipula	sp.
Hemiptera	Gerridae	Trepobates	sp.
Ephemeroptera	Triconythidae	Tricorythodes	sp.
		Turbellaria	
Diptera	Chironomidae	Tvetenia	sp.
Diptera	Chironomidae	Xenochironomus	sp.

Table 4-7
Sampling Round 1 - Detected Species Percentages

				ORDER →	Haplotaxida		Ephemeroptera		Ephemeroptera		Diptera		Diptera		Diptera		Odonata		Diptera		Diptera		Diptera		Diptera		Diptera		Haplotaxida	
				FAMILY →	Tubificidae		Baetidae		Caenidae		Chaoboridae		Chironomidae		Chironomidae		Coenagrionidae		Chironomidae		Chironomidae		Chironomidae		Chironomidae		Chironomidae		Naididae	
				GENUS →	Autodrilus		Baetis		Caenis		Chaoborus		Chironomidae		Chironomus		Coenagrionidae		Corynoneura		Cricotopus		Cricotopus/Orthocladius		Cryptochironomus		Cryptotendipes		Dero	
				SPECIES →	pigueti		sp.		sp.		sp.		pupae		sp.		juv.		sp.		sp.		spp.		sp.		sp.		digitata	
System*	Sample Location	Sample Number	QC Code	Total Count	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03609CH	REAL	1520	80	5.26	0		0		0		0		0		0		0		40	2.63			0				0	
GWR	BI017192	BI03610CH	REAL	1080	0		0		0		0		0		120	11.11	0		0		40	3.70			0				0	
GWR	BI017192	BI03611CH	REAL	600	0		0		0		0		0		0		0		0		0				0				0	
GWR	BI017292	BI03612CH	REAL	360	0		0		0		0		0		0		0		0		0				0				0	
GWR	BI017292	BI03613CH	REAL	560	0		0		0		0		40	7.14	0		0		0		0				0				0	
GWR	BI017292	BI03614CH	REAL	480	0		0		0		0		0		40	8.33	0		0		0				0				0	
GWR	BI017392	BI03615CH	REAL	800	0		0		0		0		0		360	45.00	0		0		0				0				0	
GWR	BI017392	BI03616CH	REAL	520	0		0		0		0		0		240	46.15	0		0		0				0				0	
GWR	BI017392	BI03617CH	REAL	840	0		0		0		0		0		360	42.86	0		0		0				0				0	
MR	BI017692	BI03618CH	REAL	9640	160	1.66	0		0		40	0.41	0		1040	10.79			0		0		0		0		80	0.83	0	
MR	BI017692	BI03619CH	REAL	14040	240	1.71	40	0.28	0		0		0		880	6.27			0		0		0		0		0		0	
MR	BI017692	BI03620CH	REAL	8080	160	1.98	120	1.49	40	0.50	40	0.50	0		1120	13.86	80	0.99	0		0				0				0	
MR	BI017692	BI03621CH	DUP	9040	0		40	0.44	0		0		0		960	10.62	0		0		0				0				0	
MR	BI017692	BI03622CH	DUP	8200	240	2.93	160	1.95	0		0		0		1280	15.61	0		0		0				0				0	
MR	BI017692	BI03623CH	DUP	11200	160	1.43	400	3.57	40	0.36	160	1.43	0		880	7.86	0		0		80	0.71			0				0	
MR	BI017792	BI03624CH	REAL	7360	0		320	4.35	80	1.09	80	1.09	120	1.63	80	1.09	0		320	4.35	240	3.26			0				0	
MR	BI017792	BI03625CH	REAL	13600	0		840	6.18	2120	15.59	0		40	0.29	960	7.06			1360	10.00	0		0		0		0		0	
MR	BI017792	BI03626CH	REAL	8440	0		720	8.53	1080	12.80	0		200	2.37	240	2.84			160	1.90	0		0		0		0		0	
MR	BI017892	BI03627CH	REAL	4880	0		40	0.82	0		0		0		1400	28.69			0		0		0		0		0		0	
MR	BI017892	BI03628CH	REAL	15680	160	1.02	0		0		80	0.51	0		5120	32.65			0		0		0		0		0		0	
MR	BI017892	BI03629CH	REAL	12440	240	1.93	120	0.96	0		0		0		2920	23.47			0		0		0		0		0		0	
SL	BI018192	BI03630CH	REAL	3560	80	2.25	0		0		0		0		680	19.10			0		0		0		0		0		1280	35.96
SL	BI018192	BI03631CH	REAL	5000	0		0		0		0		0		960	19.20	0		0		0				0				160	3.20
SL	BI018192	BI03632CH	REAL	1640	80	4.88	0		0		0		0		240	14.63	0		0		0				40	2.44			880	53.66
SL	BI018192	BI03633CH	DUP	3480	240	6.90	0		0		0		0		480	13.79			0		0		80	2.30	80	2.30	80	2.30	1200	34.48
SL	BI018192	BI03634CH	DUP	3880	80	2.06	0		0		0		0		680	17.53			0		0		0		0		0		2400	61.86
SL	BI018192	BI03635CH	DUP	4320	80	1.85	0		0		0		40	0.93	840	19.44			0		0		0		0		0		640	14.81
SL	BI018292	BI03636CH	REAL	2440	0		0		0		0		0		200	8.20			0		0		0		0		0		1680	68.85
SL	BI018292	BI03637CH	REAL	3120	0		0		0		0		0		200	6.41			0		0		0		0		0		2400	76.92
SL	BI018292	BI03638CH	REAL	2080	0		0		0		0		0		160	7.69			0		0		0		0		0		1240	59.62
SL	BI018392	BI03639CH	REAL	360	0		0		0		0		0		200	55.56			0		0		0		0		0		0	
SL	BI018392	BI03640CH	REAL	400	0		0		0		0		0		200	50.00			0		0		0		0		0		0	
SL	BI018392	BI03641CH	REAL	1080	0		0		0		0		40	3.70	840	77.78			0		0		0		0		0		80	7.41
SL	BI018492	BI03642CH	REAL	320	0		0		0		0		0		0				0		0		0		0		0		0	
SL	BI018492	BI03643CH	REAL	600	0		0		0		0		0		0				0		0		0		0		0		40	6.67
SL	BI018492	BI03644CH	REAL	640	0		0		0		0		0		40	6.25			0		0		0		0		0		40	6.25

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-7
Sampling Round 1 - Detected Species Percentages

				Haplotaxida Naididae Dero sp.		Diptera Chironomidae Dicrotendipes sp.		Diptera Chironomidae Eukiefferiella sp.		Diptera Chironomidae Glyptotendipes sp.		Cymnophila Planorbidae Gyraulus sp.		Coleoptera Haliplidae Haliplus sp. A larva		Coleoptera Haliplidae Haliplus sp. B larva		Diptera Chironomidae Harnischia sp.		Hirudinidae Hirudinea		Homoptera (semiaquatic) Homoptera		Amphipoda Talitridae Hyalella azteca		Hydracarina Hydracarina sp.		Haplotaxida Tubificidae Ilyodrilus templetoni	
System*	Sample Location	Sample Number	QC Code	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03609CH	REAL	0		0		40	2.63			0		0		0		40	2.63	0		0		0		0					
GWR	BI017192	BI03610CH	REAL	0		0		0				0		0		0		80	7.41	0		0		0		0					
GWR	BI017192	BI03611CH	REAL	0		0		0				0		0		0		80	13.33	0		0		0		0					
GWR	BI017292	BI03612CH	REAL	0		0		0				0		0		0		0		0		0		0		40	11.11				
GWR	BI017292	BI03613CH	REAL	0		0		0				0		0		0		120	21.43	0		0		0		0					
GWR	BI017292	BI03614CH	REAL	0		0		0				0		0		0		0		0		0		0		0					
GWR	BI017392	BI03615CH	REAL	0		0		0				0		0		0		40	5.00	0		0		0		0					
GWR	BI017392	BI03616CH	REAL	0		0		0				0		0		0		40	7.69	0		0		0		40	7.69				
GWR	BI017392	BI03617CH	REAL	40	4.76	0		0				0		0		0		0		0		0		0		0					
MR	BI017692	BI03618CH	REAL	0		0		0		0		0		0		0		0		0		40	0.41	40	0.41	0		0			
MR	BI017692	BI03619CH	REAL	0		0		0		0		0		0		0		0		0		0		80	0.57	80	0.57	0			
MR	BI017692	BI03620CH	REAL	0		0		0				0		0		0		0		0		0		120	1.49	120	1.49				
MR	BI017692	BI03621CH	DUP	0		240	2.66	80	0.88			80	0.88	0		0		0		1200	13.27	0		80	0.88	320	3.54				
MR	BI017692	BI03622CH	DUP	0		0		0				0		0		0		0		0		0		240	2.93	200	2.44				
MR	BI017692	BI03623CH	DUP	0		0		0				0		0		0		0		0		0		160	1.43	120	1.07				
MR	BI017792	BI03624CH	REAL	0		80	1.09	0				520	7.07	80	1.09	40	0.54	0		0		0		3240	44.02	0					
MR	BI017792	BI03625CH	REAL	0		160	1.18	0		0		1040	7.65	120	0.88	200	1.47	0		40	0.29	0		3200	23.53	0		0			
MR	BI017792	BI03626CH	REAL	0		0		0		80	0.95	1920	22.75	40	0.47	120	1.42	0		0		0		2640	31.28	40	0.47	0			
MR	BI017892	BI03627CH	REAL	0		0		0		80	1.84	0		0		0		0		0		0		0		0		0			
MR	BI017892	BI03628CH	REAL	0		0		0		0		0		0		40	0.26	0		0		0		120	0.77	280	1.79	0			
MR	BI017892	BI03629CH	REAL	0		0		0		0		80	0.84	40	0.32	40	0.32	0		0		0		800	6.43	280	2.25	0			
SL	BI018192	BI03630CH	REAL	0		80	2.25	0		0		0		0		0		0		0		0		0		0		0			
SL	BI018192	BI03631CH	REAL	###	39.20	0		0				0		0		0		0		0		0		0		0					
SL	BI018192	BI03632CH	REAL	0		0		0				0		0		0		0		0		0		0		0					
SL	BI018192	BI03633CH	DUP	0		0		0		0		0		0		0		0		0		0		0		0		0			
SL	BI018192	BI03634CH	DUP	0		0		0		0		0		0		0		0		0		0		0		0		0			
SL	BI018192	BI03635CH	DUP	###	16.67	0		0		0		0		0		0		0		0		0		0		0		80	2.06		
SL	BI018292	BI03636CH	REAL	0		0		0		0		0		0		0		0		0		0		0		0		0			
SL	BI018292	BI03637CH	REAL	0		0		0		0		0		0		0		0		0		0		0		0		0			
SL	BI018292	BI03638CH	REAL	0		40	1.92	0		0		0		0		0		0		0		0		0		40	1.28	0			
SL	BI018392	BI03639CH	REAL	0		0		0		0		0		0		0		0		0		0		0		0		0			
SL	BI018392	BI03640CH	REAL	40	10.00	0		0		0		0		0		0		0		0		0		0		0		0			
SL	BI018392	BI03641CH	REAL	0		0		0		0		0		0		0		0		0		0		0		0		0			
SL	BI018492	BI03642CH	REAL	40	12.50	0		0		0		0		0		0		0		0		0		0		0		0			
SL	BI018492	BI03643CH	REAL	40	6.67	0		0		0		0		0		0		0		0		0		0		40	12.50	0			
SL	BI018492	BI03644CH	REAL	40	6.25	0		0		0		0		0		0		0		0		0		0		40	6.25	0			

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-7
Sampling Round 1 - Detected Species Percentages

System*	Sample Location	Sample Number	QC Code	Haplotaxida Tubificidae Imm. Tubificid w/ Cap. Chaet		Haplotaxida Tubificidae Imm. Tubificid w/o Cap. Chaet		Odonata Proteneuridae Ischnura sp.		Haplotaxida Tubificidae Limnodrilus hoffmeisteri		Bivalvia Sphaeriidae Musculium sp.		Haplotaxida Naididae Nais communis		Haplotaxida Naididae Nais sp.		Diptera Chironomidae Orthocladiinae		Diptera Chironomidae Orthocladius sp.		Diptera Chironomidae Parametriocnemus sp.		Coleoptera Haliplidae Peltodytes sp. larva		Diptera Chironomidae Phaenopsectra sp.	
				Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03609CH	REAL	0		1040	68.42			80	5.26			0		0		0						0		0	
GWR	BI017192	BI03610CH	REAL	0		800	74.07			0				0		0		0						0		0	
GWR	BI017192	BI03611CH	REAL	0		440	73.33			40	6.67			0		0		0						0		0	
GWR	BI017292	BI03612CH	REAL	0		80	22.22			0				0		0		0						0		0	
GWR	BI017292	BI03613CH	REAL	0		80	14.29			0				0		0		0						0		0	
GWR	BI017292	BI03614CH	REAL	0		120	25.00			0				0		0		0						0		0	
GWR	BI017392	BI03615CH	REAL	0		240	30.00			0				0		0		0						0		0	
GWR	BI017392	BI03616CH	REAL	0		120	23.08			0				0		0		0						0		0	
GWR	BI017392	BI03617CH	REAL	0		280	33.33			0				0		0		0						0		0	
MR	BI017692	BI03618CH	REAL	1040	10.79	6000	62.24	0		160	1.66	0		0		0				0		0				80	0.83
MR	BI017692	BI03619CH	REAL	640	4.56	10760	76.64	0		160	1.14	0		0		0				0		80	0.57			0	
MR	BI017692	BI03620CH	REAL	560	6.93	3360	41.58			80	0.99			0		0		80	0.99					40	0.50	80	0.99
MR	BI017692	BI03621CH	DUP	1120	12.39	4280	47.35			0				0		0		0						0		0	
MR	BI017692	BI03622CH	DUP	640	7.80	4400	53.66			80	0.98			0		0		0						0		0	
MR	BI017692	BI03623CH	DUP	1280	11.43	6880	61.43			560	5.00			0		0		0						0		0	
MR	BI017792	BI03624CH	REAL	400	5.43	1200	16.30			0				0		0		160	2.17					0		0	
MR	BI017792	BI03625CH	REAL	480	3.53	760	5.59	0		0		0		0		0				0		1680	12.35			0	
MR	BI017792	BI03626CH	REAL	80	0.95	80	0.95	40	0.47	0		0		0		0				0		240	2.84			0	
MR	BI017892	BI03627CH	REAL	640	13.11	2160	44.26	40	0.82	80	1.64	40	0.82	0		0				0		0				0	
MR	BI017892	BI03628CH	REAL	960	6.12	6120	39.03	0		80	0.51	0		0		0				0		0				0	
MR	BI017892	BI03629CH	REAL	480	3.86	4800	38.59	0		0		0		0		0				0		0				0	
SL	BI018192	BI03630CH	REAL	480	13.48	800	22.47	0		0		0		0		0				0		0				0	
SL	BI018192	BI03631CH	REAL	400	8.00	1200	24.00			80	1.60			160	3.20	80	1.60	0						0		0	
SL	BI018192	BI03632CH	REAL	0		320	19.51			0				0		0		0						0		0	
SL	BI018192	BI03633CH	DUP	160	4.60	840	24.14	0		160	4.60	0		0		0				0		0				0	
SL	BI018192	BI03634CH	DUP	80	2.06	240	6.19	0		0		0		0		0				0		0				0	
SL	BI018192	BI03635CH	DUP	200	4.63	1520	35.19	0		0		0		120	2.78	0				80	1.85	0				0	
SL	BI018292	BI03636CH	REAL	320	13.11	240	9.84	0		0		0		0		0				0		0				0	
SL	BI018292	BI03637CH	REAL	400	12.82	80	2.56	0		0		0		0		0				0		0				0	
SL	BI018292	BI03638CH	REAL	320	15.38	160	7.69	0		80	3.85	0		0		0				0		0				0	
SL	BI018392	BI03639CH	REAL	40	11.11	120	33.33	0		0		0		0		0				0		0				0	
SL	BI018392	BI03640CH	REAL	80	20.00	0		0		0		0		0		40	10.00			0		0				0	
SL	BI018392	BI03641CH	REAL	40	3.70	40	3.70	0		40	3.70	0		0		0				0		0				0	
SL	BI018492	BI03642CH	REAL	0		240	75.00	0		0		0		0		0				0		0				0	
SL	BI018492	BI03643CH	REAL	160	26.67	320	53.33	0		0		0		0		40	6.67			0		0				0	
SL	BI018492	BI03644CH	REAL	160	25.00	280	43.75	0		0		0		0		40	6.25			0		0				0	

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-7
Sampling Round 1 - Detected Species Percentages

System*	Sample Location	Sample Number	QC Code	Lymnophila Physidae Physella sp.		Lymnophila Physidae		Diptera Chironomidae Polypedilum sp.		Diptera Chironomidae Procladius sp.		Diptera Chironomidae Rheotanytarsus sp.		Bivalvia Sphaeriidae Sphaerium striatum		Diptera Chironomidae Tanypus sp.		Diptera Chironomidae Tanytarsus sp.		Diptera Chironomidae Thienemannimyia sp.	
				Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03609CH	REAL	0				40	2.63	160	10.53									0	
GWR	BI017192	BI03610CH	REAL	0				0		40	3.70									0	
GWR	BI017192	BI03611CH	REAL	0				0		40	6.67									0	
GWR	BI017292	BI03612CH	REAL	0				0		240	66.67									0	
GWR	BI017292	BI03613CH	REAL	0				0		320	57.14									0	
GWR	BI017292	BI03614CH	REAL	0				0		320	66.67									0	
GWR	BI017392	BI03615CH	REAL	0				0		160	20.00									0	
GWR	BI017392	BI03616CH	REAL	0				0		80	15.38									0	
GWR	BI017392	BI03617CH	REAL	0				0		160	19.05									0	
MR	BI017692	BI03618CH	REAL	0		0		0		960	9.96	0		0		0		0		0	
MR	BI017692	BI03619CH	REAL	0		0		0		1080	7.69	0		0		0		0		0	
MR	BI017692	BI03620CH	REAL	0				0		2080	25.74									0	
MR	BI017692	BI03621CH	DUP	0				0		640	7.08									0	
MR	BI017692	BI03622CH	DUP	0				0		960	11.71									0	
MR	BI017692	BI03623CH	DUP	160	1.43			0		320	2.86									0	
MR	BI017792	BI03624CH	REAL	0				0		160	2.17									240	3.26
MR	BI017792	BI03625CH	REAL	160	1.18	120	0.88	0		0		80	0.59	0		0		0		240	1.76
MR	BI017792	BI03626CH	REAL	0		120	1.42	80	0.95	0		0		0		0		0		560	6.64
MR	BI017892	BI03627CH	REAL	0		0		0		400	8.20	0		0		0		0		0	
MR	BI017892	BI03628CH	REAL	0		0		0		2640	16.84	0		0		80	0.51	0		0	
MR	BI017892	BI03629CH	REAL	0		0		0		2640	21.22	0		0		0		0		0	
SL	BI018192	BI03630CH	REAL	0		0		0		80	2.25	0		0		0		80	2.25	0	
SL	BI018192	BI03631CH	REAL	0				0		0										0	
SL	BI018192	BI03632CH	REAL	0				0		80	4.88									0	
SL	BI018192	BI03633CH	DUP	0		0		0		80	2.30	80	2.30	0		0		0		0	
SL	BI018192	BI03634CH	DUP	0		0		0		320	8.25	0		0		0		0		0	
SL	BI018192	BI03635CH	DUP	0		0		0		0		0		80	1.85	0		0		0	
SL	BI018292	BI03636CH	REAL	0		0		0		0		0		0		0		0		0	
SL	BI018292	BI03637CH	REAL	0		0		0		0		0		0		0		0		0	
SL	BI018292	BI03638CH	REAL	0		0		0		80	3.85	0		0		0		0		0	
SL	BI018392	BI03639CH	REAL	0		0		0		0		0		0		0		0		0	
SL	BI018392	BI03640CH	REAL	0		0		0		40	10.00	0		0		0		0		0	
SL	BI018392	BI03641CH	REAL	0		0		0		0		0		0		0		0		0	
SL	BI018492	BI03642CH	REAL	0		0		0		0		0		0		0		0		0	
SL	BI018492	BI03643CH	REAL	0		0		0		0		0		0		0		0		0	
SL	BI018492	BI03644CH	REAL	0		0		0		0		0		0		0		0		0	

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-8
Sampling Round 2
Species NOT Detected

ORDER	FAMILY	GENUS	SPECIES
Coleoptera	Dytiscidae	Agabus	sp. larva
Trichoptera	Glossosonatidae	Agapetus	sp.
Trichoptera	Hydropsychidae	Cheumatopsyche	sp.
Odonata	Coenagionidae	Coenagrionidae	juv.
Diptera	Chironomidae	Cricotopus/Orthocla	spp.
Diptera	Chironomidae	Cryptotendipes	sp.
Coleoptera	Scirtidae	Cyphon	sp. adult
Coleoptera	Chrysomelidae	Disonycha	fumata lodingi
Diptera	Dolichopodidae	Dolichopodidae	
Tricladida	Planaridae	Dugesia	sp.
Diptera	Empidadae	Empididae	sp. A
Diptera	Empidadae	Empididae	sp. B
Haplotaxida	Enchytraeidae	Enchytraeidae	
Trichoptera	Helicopsychidae	Helicopsyche	borealis
Diptera	Empidadae	Hemerodromia	sp.
Plecoptera	Perlidae	Hesperoperla	pacifica
Homoptera (semiaquatic)		Homoptera	
Trichoptera	Limnephilinae	Hydatophylax	hesperus
Trichoptera	Hydropsychidae	Hydropsyche	sp.
Trichoptera	Hydropsychidae	Hydropsychidae	
Trichoptera	Hydropsychidae	Hydropsychidae	pupa
Trichoptera	Hydroptilidae	Hydroptila	sp.
Coleoptera	Chrysomelidae	Hydrothassa	sp.
Haplotaxida	Tubificidae	Ilyodrilus	templetoni
Haplotaxida	Tubificidae	Limnodrilus	udekemianus
Haplotaxida	Lumbriculidae	Lumbriculidae	
Hemiptera	Mesoveliidae	Mesovelia	sp.
Hemiptera	Mesoveliidae	Mesovelia	sp. (juv)
Hemiptera	Veliidae	Microvelia	sp.
Haplotaxida	Naididae	Nais	communis
Haplotaxida	Naididae	Nais	sp.
Odonata	Gomphidae	Ophiogomphus	sp.
Diptera	Chironomidae	Orthocladiinae	
Diptera	Chironomidae	Orthocladius	sp.
Coleoptera	Haliplidae	Peltodytes	sp. larva
Lepidoptera	Pyralidae	Petrophila	pupa
Lepidoptera	Pyralidae	Petrophila	sp.
Lymnophila	Physidae	Physidae	
Lepidoptera	Pyralidae	Pyralidae	sp.
Diptera	Simuliidae	Simuliidae	pupae
Diptera	Simuliidae	Simulium	sp.
Coleoptera	Curculionidae	Stenopelmus	rufinasus
Diptera	Chironomidae	Stictochironomus	sp.
Diptera	Tipulidae	Tipula	sp.
Hemiptera	Gerridae	Trepobates	sp.
Ephemeroptera	Triconythidae	Tricorythodes	sp.
		Turbellaria	
Diptera	Chironomidae	Tvetenia	sp.

Table 4-9
Sampling Round 2 - Detected Species Percentages

					ORDER ->	Haplotaxida		Ephemeroptera		Ephemeroptera		Diptera		Diptera		Diptera		Diptera		Hemiptera		Diptera		Diptera		Diptera		Haplotaxida	
					FAMILY ->	Tubificidae		Baetidae		Caenidae		Ceratopogonidae cf.		Chaoboridae		Chironomidae		Chironomidae		Corixidae		Chironomidae		Chironomidae		Chironomidae		Naididae	
					GENUS ->	Autodrilus		Baetis		Caenis		Palpomyia		Chaoborus		Chironomidae		Chironomus		Corixidae		Corynoneura		Cricotopus		Cryptochironomus		Dero	
					SPECIES ->	piguet		sp.		sp.		sp.		sp.		pupae		sp.				sp.		sp.		sp.		digitata	
System*	Sample Location	Sample Number	QC Code	Total Count	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03562CH	REAL	920	160	17.39	0		0		0		0		0		40	4.35	0		0		0		0		0	
GWR	BI017192	BI03563CH	REAL	680	0		0		0		0		0		0		120	17.65	0		0		0		0		0	
GWR	BI017192	BI03564CH	REAL	880	160	18.18	0		0		0		0		0		40	4.55	0		0		0		0		0	
GWR	BI017292	BI03565CH	REAL	1520	0		0		0		0		0		0		640	42.11	0		0		0		0		80	5.26
GWR	BI017292	BI03566CH	REAL	1280	0		0		0		0		0		0		40	3.13	0		0		0		0		0	
GWR	BI017292	BI03567CH	REAL	1480	0		0		0		0		0		0		760	51.35	0		0		0		0		0	
GWR	BI017392	BI03568CH	REAL	4040	0		0		0		0		0		0		880	21.78	0		0		0		0		240	5.94
GWR	BI017392	BI03569CH	REAL	2520	0		0		0		0		0		0		680	26.98	0		0		0		0		160	6.35
GWR	BI017392	BI03570CH	REAL	1760	0		0		0		0		0		0		360	20.45	0		0		0		0		0	
GWR	BI017692	BI03571CH	REAL	6680	0		0		0		0		160	2.40	40	0.60	1360	20.36	0		0		0		0		0	
GWR	BI017692	BI03572CH	REAL	10440	0		0		0		0		280	2.68	80	0.77	3120	29.89	0		0		0		0		0	
GWR	BI017692	BI03573CH	REAL	12880	0		0		0		40	0.31	40	0.31	160	1.24	3360	26.09	0		0		0		0		0	
GWR	BI017692	BI03574CH	DUP	8720	0		0		80	0.92	0		0		0		880	10.09	0		0		0		0		0	
GWR	BI017692	BI03575CH	DUP	8160	0		160	1.96	160	1.96	0		360	4.41	120	1.47	1360	16.67	0		0		0		0		0	
GWR	BI017692	BI03576CH	DUP	7800	0		40	0.51	0		0		600	7.69	40	0.51	1600	20.51	0		0		0		0		0	
MR	BI017792	BI03577CH	REAL	15320	0		80	0.52	520	3.39	0		40	0.26	200	1.31	720	4.70	0		480	3.13	0		0		0	
MR	BI017792	BI03578CH	REAL	15720	0		120	0.76	1680	10.69	0		360	2.29	280	1.78	560	3.56	0		240	1.53	0		0		40	0.25
MR	BI017792	BI03579CH	REAL	9760	0		160	1.64	880	9.02	0		240	2.46	120	1.23	200	2.05	0		0		80	0.82	0		0	
MR	BI017892	BI03580CH	REAL	19320	0		40	0.21	80	0.41	40	0.21	240	1.24	120	0.62	5880	30.43	0		0		0		0		0	
MR	BI017892	BI03581CH	REAL	12744	0		120	0.94	240	1.88	40	0.31	200	1.57	80	0.63	3600	28.25	0		0		0		0		0	
MR	BI017892	BI03582CH	REAL	27280	0		80	0.29	600	2.20	0		360	1.32	0		5240	19.21	0		0		0		0		0	
SL	BI018192	BI03583CH	REAL	4640	0		0		40	0.86	0		0		40	0.86	160	3.45	40	0.86	0		0		80	1.72	400	8.62
SL	BI018192	BI03584CH	REAL	1480	0		0		0		0		0		0		120	8.11	0		0		0		0		560	37.84
SL	BI018192	BI03585CH	REAL	5320	480	9.02	0		0		0		0		0		40	0.75	0		0		0		80	1.50	560	10.53
SL	BI018292	BI03586CH	REAL	760	0		0		0		0		0		0		280	36.84	0		0		0		0		240	31.58
SL	BI018292	BI03587CH	REAL	520	0		0		0		0		0		0		40	7.69	0		0		0		0		240	46.15
SL	BI018292	BI03588CH	REAL	240	0		0		0		0		0		0		0		0		0		0		0		40	16.67
SL	BI018392	BI03589CH	REAL	1960	0		0		0		0		0		0		800	40.82	0		0		0		0		160	8.16
SL	BI018392	BI03590CH	REAL	2200	0		0		0		0		0		40	1.82	840	38.18	80	3.64	0		0		0		0	
SL	BI018392	BI03591CH	REAL	680	0		0		0		0		0		0		400	58.82	0		0		0		0		40	5.88
SL	BI018492	BI03592CH	REAL	560	0		0		0		0		0		0		80	14.29	0		0		0		0		0	
SL	BI018492	BI03593CH	REAL	200	0		0		0		0		0		0		160	80.00	0		0		0		0		0	
SL	BI018492	BI03594CH	REAL	80	0		0		0		0		0		0		40	50.00	0		0		0		0		0	

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-9
Sampling Round 2 - Detected Species Percentages

				ORDER ->	Haplotaxida		Diptera		Diptera		Diptera		Diptera		Cymnophila		Coleoptera		Coleoptera		Diptera		Hirudinidae		Amphipoda		Hydracarina	
				FAMILY ->	Naididae		Chironomidae		Empididae		Chironomidae		Chironomidae		Planorbidae		Haliplidae		Haliplidae		Chironomidae		Hirudinea		Talitridae			
				GENUS ->	Dero		Dicrotendipes		Empidida		Euklefferiella		Glyptotendipes		Gyraulus		Haliplus		Haliplus		Harnischia				Hyalella		Hydracarina	
				SPECIES ->	sp.		sp.		sp.		sp.		sp.		sp.		sp. A larva		sp. B larva		sp.				azteca		sp.	
System*	Sample Location	Sample Number	QC Code	Total Count	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03562CH	REAL	920	0		0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017192	BI03563CH	REAL	680	0		0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017192	BI03564CH	REAL	880	0		0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017292	BI03565CH	REAL	1520	0		0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017292	BI03566CH	REAL	1280	80	6.25	0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017292	BI03567CH	REAL	1480	80	5.41	0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017392	BI03568CH	REAL	4040	0		0		0		0		0		0		0		0		0		0		0		40	0.99
GWR	BI017392	BI03569CH	REAL	2520	0		0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017392	BI03570CH	REAL	1760	160	9.09	0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017692	BI03571CH	REAL	6880	0		0		0		0		0		40	0.60	0		0		0		0		0		480	7.19
GWR	BI017692	BI03572CH	REAL	10440	0		0		0		0		80	0.77	40	0.38	0		0		0		40	0.38	0		680	6.51
GWR	BI017692	BI03573CH	REAL	12880	0		0		0		0		0		560	4.35	0		0		0		0		0		80	0.62
GWR	BI017692	BI03574CH	DUP	8720	0		0		0		0		160	1.83	160	1.83	0		0		0		0		0		320	3.67
GWR	BI017692	BI03575CH	DUP	8160	0		0		40	0.49	0		0		80	0.98	0		0		0		0		40	0.49	200	2.45
GWR	BI017692	BI03576CH	DUP	7800	0		0		40	0.51	0		80	1.03	80	1.03	0		0		0		0		40	0.51	1560	20.00
MR	BI017792	BI03577CH	REAL	15320	0		240	1.57	0		0		0		7000	45.69	120	0.78	80	0.52	0		0		680	4.44	440	2.87
MR	BI017792	BI03578CH	REAL	15720	0		160	1.02	0		80	0.51	0		1280	8.14	0		520	3.31	0		0		1080	6.87	520	3.31
MR	BI017792	BI03579CH	REAL	9760	0		360	3.69	0		0		0		760	7.79	0		360	3.69	0		0		600	6.15	0	
MR	BI017892	BI03580CH	REAL	19320	0		160	0.83	40	0.21	0		400	2.07	480	2.48	0		0		0		0		40	0.21	1520	7.87
MR	BI017892	BI03581CH	REAL	12744	0		0		0		0		160	1.26	680	5.34	0		0		0		0		120	0.94	680	5.34
MR	BI017892	BI03582CH	REAL	27280	0		0		40	0.15	0		80	0.29	2800	10.26	0		80	0.29	0		0		520	1.91	5800	21.26
SL	BI018192	BI03583CH	REAL	4640	0		0		0		0		0		0		0		0		0		0		0		120	2.59
SL	BI018192	BI03584CH	REAL	1480	0		40	2.70	0		0		0		0		0		0		0		0		0		0	
SL	BI018192	BI03585CH	REAL	5320	0		80	1.50	0		0		0		0		0		0		40	0.75	0		0		40	0.75
SL	BI018292	BI03586CH	REAL	760	0		0		0		0		0		0		0		0		0		0		0		40	5.26
SL	BI018292	BI03587CH	REAL	520	0		0		0		0		0		0		0		0		0		0		0		0	
SL	BI018292	BI03588CH	REAL	240	0		80	33.33	0		0		0		0		0		0		0		0		0		40	16.67
SL	BI018392	BI03589CH	REAL	1960	40	2.04	0		0		0		0		0		0		0		0		0		0		40	2.04
SL	BI018392	BI03590CH	REAL	2200	0		80	3.64	0		0		0		0		0		0		80	3.64	0		0		0	
SL	BI018392	BI03591CH	REAL	680	0		80	11.76	0		0		0		0		0		0		0		0		0		0	
SL	BI018492	BI03592CH	REAL	560	200	35.71	0		0		0		0		0		0		0		0		0		0		0	
SL	BI018492	BI03593CH	REAL	200	0		0		0		0		0		0		0		0		0		0		0		0	
SL	BI018492	BI03594CH	REAL	80	0		0		0		0		0		0		0		0		0		0		0		0	

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-9
Sampling Round 2 - Detected Species Percentages

					ORDER ->	Haplotaxida		Haplotaxida		Odonata		Haplotaxida		Lymnophila		Hemiptera		Diptera		Bivalvia		Trichoptera		Trichoptera	
					FAMILY ->	Tubificidae		Tubificidae		Protoneuridae		Tubificidae		Lymnaeidae		Macrovelidae		Chironomidae		Sphaeriidae		Leptoceridae		Hydroptilidae	
					GENUS ->	Imm. Tubificid w/ Cap. Chaets		Imm. Tubificid w/o Cap. Chaet		Ischnura		Limnodrilus		Lymnaea		Macrovelia		Microtendipes		Musculium		Oecetis		Oxyethira	
					SPECIES ->					sp.		hoffmeisteri		sp.		sp.		sp.		sp.		sp.		sp.	
System*	Sample Location	Sample Number	QC Code	Total Count	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03562CH	REAL	920	0		640	69.57	0		0		0		0		0		0		0		0	
GWR	BI017192	BI03563CH	REAL	680	0		560	82.35	0		0		0		0		0		0		0		0	
GWR	BI017192	BI03564CH	REAL	880	0		560	63.64	0		40	4.55	0		0		0		0		0		0	
GWR	BI017292	BI03565CH	REAL	1520	40	2.63	400	26.32	0		120	7.89	0		0		0		0		0		0	
GWR	BI017292	BI03566CH	REAL	1280	80	6.25	200	15.63	0		40	3.13	0		0		0		0		0		0	
GWR	BI017292	BI03567CH	REAL	1480	0		560	37.84	0		0		0		0		0		0		0		0	
GWR	BI017392	BI03568CH	REAL	4040	320	7.92	2560	63.37	0		0		0		0		0		0		0		0	
GWR	BI017392	BI03569CH	REAL	2520	400	15.87	1280	50.79	0		0		0		0		0		0		0		0	
GWR	BI017392	BI03570CH	REAL	1760	480	27.27	760	43.18	0		0		0		0		0		0		0		0	
GWR	BI017692	BI03571CH	REAL	6880	1360	20.36	2560	38.32	0		0		0		0		0		0		0		0	
GWR	BI017692	BI03572CH	REAL	10440	1040	9.96	3720	35.63	0		0		0		0		0		0		0		0	
GWR	BI017692	BI03573CH	REAL	12880	1560	12.11	6080	47.20	0		0		0		0		0		0		0		0	
GWR	BI017692	BI03574CH	DUP	8720	240	2.75	3360	38.53	80	0.92	0		0		0		0		0		0		0	
GWR	BI017692	BI03575CH	DUP	8160	1360	16.67	2800	34.31	40	0.49	0		0		0		0		0		0		0	
GWR	BI017692	BI03576CH	DUP	7800	1040	13.33	1560	20.00	0		0		0		0		0		0		0		0	
MR	BI017792	BI03577CH	REAL	15320	80	0.52	360	2.35	800	5.22	0		0		0		0		0		0		40	0.26
MR	BI017792	BI03578CH	REAL	15720	80	0.51	280	1.78	1480	9.41	0		0		40	0.25	160	1.02	0		80	0.51	0	
MR	BI017792	BI03579CH	REAL	9760	80	0.82	1000	10.25	760	7.79	0		0		0		0		0		120	1.23	0	
MR	BI017892	BI03580CH	REAL	19320	1760	9.11	4720	24.43	200	1.04	80	0.41	0		0		0		0		0		0	
MR	BI017892	BI03581CH	REAL	12744	2320	18.20	1024	8.04	520	4.08	0		0		0		0		0		0		0	
MR	BI017892	BI03582CH	REAL	27280	1120	4.11	4480	16.42	2440	8.94	320	1.17	200	0.73	0		0		0		80	0.29	0	
SL	BI018192	BI03583CH	REAL	4640	280	6.03	400	8.62	0		0		0		0		0		0		0		0	
SL	BI018192	BI03584CH	REAL	1480	160	10.81	400	27.03	0		80	5.41	0		0		0		0		0		0	
SL	BI018192	BI03585CH	REAL	5320	80	1.50	680	12.78	0		0		0		0		0		0		120	2.26	0	
SL	BI018292	BI03586CH	REAL	760	0		80	10.53	0		40	5.26	0		0		0		0		0		0	
SL	BI018292	BI03587CH	REAL	520	0		120	23.08	0		0		0		0		0		0		0		0	
SL	BI018292	BI03588CH	REAL	240	0		0		0		0		0		0		0		0		0		0	
SL	BI018392	BI03589CH	REAL	1960	200	10.20	400	20.41	0		0		0		0		0		40	2.04	40	2.04	0	
SL	BI018392	BI03590CH	REAL	2200	0		840	38.18	0		0		0		0		0		0		0		0	
SL	BI018392	BI03591CH	REAL	680	80	11.76	40	5.88	0		0		0		0		0		0		0		0	
SL	BI018492	BI03592CH	REAL	560	120	21.43	160	28.57	0		0		0		0		0		0		0		0	
SL	BI018492	BI03593CH	REAL	200	0		40	20.00	0		0		0		0		0		0		0		0	
SL	BI018492	BI03594CH	REAL	80	0		0		0		40	50.00	0		0		0		0		0		0	

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-9
Sampling Round 2 - Detected Species Percentages

				ORDER →	Diptera		Diptera		Diptera		Lymnophila		Bivalvia		Diptera		Diptera		Diptera		Diptera		Diptera		Bivalvia	
				FAMILY →	Chironomidae		Chironomidae		Chironomidae		Physidae		Sphaeriidae		Chironomidae		Chironomidae		Chironomidae		Chironomidae		Chironomidae		Sphaeriidae	
				GENUS →	Parametriocnemus		Paratanytarsus		Phaenopsectra		Physella		Pisidium		Polypedilum		Procladius		Pseudochironomus		Pseudochironomus		Rheotanytarsus		Sphaerium	
				SPECIES →	sp.		sp.		sp.		sp.		sp.		sp.		sp.		fulviventris		sp.		sp.		striatum	
System*	Sample Location	Sample Number	QC Code	Total Count	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03562CH	REAL	920	0		0		0		0		0		0		80	8.70	0		0		0		0	
GWR	BI017192	BI03563CH	REAL	680	0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017192	BI03564CH	REAL	880	0		0		0		0		0		0		80	9.09	0		0		0		0	
GWR	BI017292	BI03565CH	REAL	1520	0		0		0		0		0		0		240	15.79	0		0		0		0	
GWR	BI017292	BI03566CH	REAL	1280	0		0		0		0		0		0		840	65.63	0		0		0		0	
GWR	BI017292	BI03567CH	REAL	1480	0		0		0		0		0		0		80	5.41	0		0		0		0	
GWR	BI017392	BI03568CH	REAL	4040	0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017392	BI03569CH	REAL	2520	0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017392	BI03570CH	REAL	1760	0		0		0		0		0		0		0		0		0		0		0	
GWR	BI017692	BI03571CH	REAL	6880	0		0		120	1.80	0		0		0		560	8.38	0		0		0		0	
GWR	BI017692	BI03572CH	REAL	10440	160	1.53	0		0		0		0		0		1120	10.73	0		0		0		0	
GWR	BI017692	BI03573CH	REAL	12880	120	0.93	0		0		0		0		0		880	6.83	0		0		0		0	
GWR	BI017692	BI03574CH	DUP	8720	1200	13.76	0		80	0.92	0		0		0		2080	23.85	0		0		0		0	
GWR	BI017692	BI03575CH	DUP	8160	280	3.43	0		0		0		0		0		960	11.76	0		200	2.45	0		0	
GWR	BI017692	BI03576CH	DUP	7800	320	4.10	0		0		0		0		0		640	8.21	0		80	1.03	0		0	
MR	BI017792	BI03577CH	REAL	15320	2080	13.58	80	0.52	80	0.52	0		0		0		0		0		480	3.13	0		0	
MR	BI017792	BI03578CH	REAL	15720	2320	14.76	80	0.51	240	1.53	40	0.25	0		0		0		0		880	5.60	0		0	
MR	BI017792	BI03579CH	REAL	9760	640	6.56	0		0		40	0.41	0		280	2.87	0		0		480	4.92	0		0	
MR	BI017892	BI03580CH	REAL	19320	160	0.83	0		480	2.48	0		0		0		480	2.48	0		2240	11.59	0		0	
MR	BI017892	BI03581CH	REAL	12744	640	5.02	0		80	0.63	0		0		0		1360	10.67	0		240	1.88	0		0	
MR	BI017892	BI03582CH	REAL	27280	960	3.52	0		80	0.29	80	0.29	0		0		560	2.05	0		720	2.64	0		0	
SL	BI018192	BI03583CH	REAL	4640	0		0		0		0		0		0		40	0.86	0		80	1.72	0		2960	63.79
SL	BI018192	BI03584CH	REAL	1480	0		0		0		0		0		0		40	2.70	80	5.41	0		0		0	
SL	BI018192	BI03585CH	REAL	5320	0		0		0		0		0		0		40	0.75	0		320	6.02	0		2720	51.13
SL	BI018292	BI03586CH	REAL	760	0		0		0		0		0		0		0		0		0		40	5.26	40	5.26
SL	BI018292	BI03587CH	REAL	520	0		0		0		0		0		0		80	15.38	0		0		0		0	
SL	BI018292	BI03588CH	REAL	240	0		0		0		0		40	16.67	0		0		0		0		0		40	16.67
SL	BI018392	BI03589CH	REAL	1960	0		0		0		0		0		0		240	12.24	0		0		0		0	
SL	BI018392	BI03590CH	REAL	2200	0		0		0		0		0		0		160	7.27	0		0		80	3.64	0	
SL	BI018392	BI03591CH	REAL	680	0		0		0		0		0		0		40	5.88	0		0		0		0	
SL	BI018492	BI03592CH	REAL	560	0		0		0		0		0		0		0		0		0		0		0	
SL	BI018492	BI03593CH	REAL	200	0		0		0		0		0		0		0		0		0		0		0	
SL	BI018492	BI03594CH	REAL	80	0		0		0		0		0		0		0		0		0		0		0	

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-9
Sampling Round 2 - Detected Species Percentages

			ORDER ->	Diptera		Diptera		Diptera		Diptera	
			FAMILY ->	Chironomidae		Chironomidae		Chironomidae		Chironomidae	
			GENUS ->	Tanypus		Tanytarsus		Thienemannimyia		Xenochironomus	
			SPECIES ->	sp.		sp.		sp.		sp.	
System*	Sample Location	Sample Number	QC Code	Total Count	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent	Species Count	Species Percent
GWR	BI017192	BI03562CH	REAL	920	0		0		0		0	
GWR	BI017192	BI03563CH	REAL	680	0		0		0		0	
GWR	BI017192	BI03564CH	REAL	880	0		0		0		0	
GWR	BI017292	BI03565CH	REAL	1520	0		0		0		0	
GWR	BI017292	BI03566CH	REAL	1280	0		0		0		0	
GWR	BI017292	BI03567CH	REAL	1480	0		0		0		0	
GWR	BI017392	BI03568CH	REAL	4040	0		0		0		0	
GWR	BI017392	BI03569CH	REAL	2520	0		0		0		0	
GWR	BI017392	BI03570CH	REAL	1760	0		0		0		0	
GWR	BI017692	BI03571CH	REAL	6880	0		0		0		0	
GWR	BI017692	BI03572CH	REAL	10440	80	0.77	0		0		0	
GWR	BI017692	BI03573CH	REAL	12880	0		0		0		0	
GWR	BI017692	BI03574CH	DUP	8720	0		0		80	0.9174	0	
GWR	BI017692	BI03575CH	DUP	8160	0		0		0		0	
GWR	BI017692	BI03576CH	DUP	7800	0		0		80	1.0256	0	
MR	BI017792	BI03577CH	REAL	15320	0		0		720	4.6997	0	
MR	BI017792	BI03578CH	REAL	15720	0		0		3120	19.847	0	
MR	BI017792	BI03579CH	REAL	9760	0		0		2600	26.639	0	
MR	BI017892	BI03580CH	REAL	19320	0		0		160	0.8282	0	
MR	BI017892	BI03581CH	REAL	12744	0		0		400	3.1387	240	1.8832
MR	BI017892	BI03582CH	REAL	27280	0		0		480	1.7595	160	0.5865
SL	BI018192	BI03583CH	REAL	4640	0		0		0		0	
SL	BI018192	BI03584CH	REAL	1480	0		0		0		0	
SL	BI018192	BI03585CH	REAL	5320	0		40	0.75	0		0	
SL	BI018292	BI03586CH	REAL	760	0		0		0		0	
SL	BI018292	BI03587CH	REAL	520	0		0		40	7.6923	0	
SL	BI018292	BI03588CH	REAL	240	0		0		0		0	
SL	BI018392	BI03589CH	REAL	1960	0		0		0		0	
SL	BI018392	BI03590CH	REAL	2200	0		0		0		0	
SL	BI018392	BI03591CH	REAL	680	0		0		0		0	
SL	BI018492	BI03592CH	REAL	560	0		0		0		0	
SL	BI018492	BI03593CH	REAL	200	0		0		0		0	
SL	BI018492	BI03594CH	REAL	80	0		0		0		0	

* GWR = Great Western Reservoir MR = Mower Reservoir SL = Standley Lake

Table 4-10
Aquatic Receptor Reasonable Maximum Exposure Point Activities
(pCi/g)

IHSS	^{241}Am Depth (in.)	Min.	Max.	Ave.	RME	$^{239/240}Pu$ Depth	Min.	Max.	Ave.	RME
200-Great Western Reservoir	Reservoir									
	0-12	0.00	0.206	0.043	0.206	0-12	0.00	3.30	0.267	3.3
	> 12	-0.004	1.016	0.237	1.016	> 12	-0.002	4.03	0.729	4.03
	Stream	0.001	0.061	0.017	0.061	Stream	0.00	0.55	0.156	0.55
201-Standley Lake	Lake									
	0-12	0.00	0.107	0.017	0.107	0-12	-0.015	0.553	0.033	0.553
	Stream	0.001	0.082	0.022	0.082	Stream	-0.007	0.47	0.082	0.47
202-Mower Reservoir	Reservoir									
	0-12	0.008	0.093	0.049	0.093	0-12	0.031	0.488	0.291	0.488
	Stream	0.021	0.046	0.03	0.046	Stream	0.046	0.171	0.091	0.171

= Selected RME for exposure dose calculation.

Table 4-11
Aquatic Receptor Exposure Dose

IHSS	Exposure Point Activity (pCi/g)		Receptor Dose (mG x 1h)					
			Benthic Macroinvertebrate[a]		Fish[a]		Fish Egg[b]	
	^{241}Am	$^{239/240}Pu$	^{241}Am	$^{239/240}Pu$ [c]	^{241}Pu	$^{239/240}Pu$ [c]	Am^{241}	$Pu^{239/240}$ [c]
200-Great Western Reservoir	1.016	4.03	0.0027	0.0202	0.0027	0.0202	0.0027	0.0202
201-Standley Lake	0.107	0.553	0.00028	0.00138	0.00028	0.00138	0.00028	0.00138
202-Mower Reservoir	0.093	0.488	0.00024	0.0012	0.00024	0.0012	0.00024	0.0012

[a]An internal exposure dose was calculated for the benthic macroinvertebrate and fish receptors.
[b]An external exposure dose was calculated for the fish eggs.
[c]Since data (sediment analytical results) are presented as total concentrations for both ^{239}Pu and ^{240}Pu (combined), a conservative assumption of 100 percent of the detected concentration was available as ^{239}Pu, and ^{240}Pu (refer to Attachment text for methods was evaluated).

Table 4-12
Average Energies and Bioconcentration Factors of The Pcocs

Element	Biological Concentration Factor[a]	Radiological Half-Life	Average Alpha and Alpha Recoil (MeV)
^{239}Pu	30	2.41E+04 n	5.23E+00
^{240}Pu	30	6.54E+04 n	5.24E+00
^{241}Am	30	458 n	5.57E+00

[a]The biological concentration factor (BCF) is the ratio of the concentration of the contaminant in freshwater fish to the concentration in water at steady-state conditions. Most BCFs were taken from IAEA Report No. 57 (1982)
[b]All average energies were obtained from ICRP Report No. 38

Table 4-13
Reproductive Effects in Fish and Invertebrates in Natural Populations Exposed to Chronic Irradiation

Organism and Life Stage Exposed	Exposure Regime	Observation	Reference
Fish *Gambusia affinis* (mosquitofish)	Dose rate ≥ 10 mGy d^{-1} falling to 3.5, 1.8 and 0.6 Mgy d^{-1} 1965, 1971, 1973, and 1975, respectively	Greater brood size and embryo mortality in fish	Blaylock 1969; Trabalka and Allen 1977; Blaylock and Frank 1980
Rutilus rutilus all life stages (Roach)	Dose rate 7-15 mGy d^{-1}	Lower fecundity and delay in spawning	Voronina et al. 1974; Peshkov et al. 1978
Invertebrates *Physa heterstropha* all stages (pond snail)	Dose rate 6.5 mGy d^{-1}	Egg-capsule production reduced, but with more eggs per capsule, production rate comparable to controls	Cooley 1973a

Table 4-14
Reproductive Effects in Fish Exposed to Chronic Irradiation Under Laboratory Conditions

Organism and Life Stage Exposed	Exposure Regime	Observation	Reference
Fish *Oncorhynchus tschawytscha* embryos (chinook salmon)	5.0 -475 mGy d^{-1} for 80 d	Gonadal development of smolts was retarded at ≥ 95 mGy d^{-1}	Bonham and Donaldson 1972
Poecilia reticulata 0-3-d neonates to adults	100-410 mGy d^{-1} for 17 d	Male courtship activity reduced	Erickson 1973
Poecilia reticulata 0-3-d neonates to adults	40.8-305 mGy d^{-1}	Infertile at 40.8 and 96 mGy d^{-1} but fecundity unaffected	Purdom and Woodhead 1973
Poecilia reticulata 0-3-d neonates to adults	40.8-305 mGy d^{-1} up to 988 d	Fecundity reduced to 57, 52 and 3.5% of controls at 40.8, 96 and 305 mGy d^{-1}, respectively; smaller brood size all doses	Woodhead 1977
Oryzias Latipes adult males (medaka)	12-800 mGy d^{-1} for 60-120 d	Dose rates ≥ 65 mGy d^{-1} for 60 d increased sterility	Hyodo-Taguchi 1980
Ameca splendes young adults	185 mGy d^{-1} up to 244 d	Complete sterility after 190 d	Rackham and Woodhead 1984

Table 4-15
Physiological and Histological Changes in Fish and Invertebrates Exposed to Chronic Irradiation Under Laboratory Conditions

Organism and Life Stage Exposed	Exposure Regime	Observation	Reference
Fish *Salmo gairdneri* embryos (rainbow trout)	2 and 20 Mgy d^{-1}	Lowered antibodies to *Chondrococcus columaris* disease in juveniles/yearlings	Strand et al. 1973
Gambusia affinis adult (mosquito fish)	120-130 mGy d^{-1}	No hemopoietic damage after 37 d	Cosgrove et al. 1975
	360 or 720 mGy d^{-1}	Mile hemopoietic atrophy in kidney and spleen in some fish after 128 d	
Gambusia affinis adult (mosquito fish)	312-1300 m Gd^{-1} 40 d	Testis atrophy at all dose rates; damage to other tissues not observed	Cosgrove and Blaylock 1973
Poecilia reticulata 0-3-d neonates to adult (guppy)	40.8-305 mGy d^{-1} up to 974 d	Oogenesis affected at all dose rates; damage appears earlier as dose rate increases	Woodhead 1977
Oryzias latipes adult males (medaka)	12-800 mGy d^{-1} for 30 d	Severe depletion of spermatogonia at ≥ 100 mGy d^{-1}	Hyodo-Taguchi and Egami 1977
Oryzia latipes adult males (medaka)	12-800 mGy d^{-1} for 120 d	Depletion of spermatogonia at ≥ 148 mGy d^{-1}	Hyodo-Taguchi 1980
Ameca splendes young adults	185 mGy d^{-1} up to 244 d	Spermatogenesis more radiosensitive than oogenesis	Rackham and Woodhead 1984
Invertebrates *Physa heterostropha* adult (pond snail)	240-1,200 mGy d^{-1} for 98 d	Partial atrophy of gonads in some snails at 1,200 mGy d^{-1}, but not at lower dose rates	Cooley 1973b

Table 4-16
Hazard Quotients for Aquatic PCOCs

	Concentration Comparison Hazard Quotient				Dose Comparison Hazard Quotient		
				IHSS 200-Great Western Reservoir			
Pu^{239}	4.03/5 n	10^5 pCi/g	=	8.06 n 10^{-6}	0.0202/0.4 mGy/h	=	0.0505
Pu^{240}	4.03/5 n	10^5 pCi/g	=	8.06 n 10^{-6}	0.0202/0.4 mGy/h	=	0.0505
Am^{241}	1.016 /5 n	10^4 pCi/g	=	2.03 x 10^{-5}	0.0027/0.4 mGy/h	=	0.00675
				Hazard Index = 3.6 n 10^{-5}			**Hazard Index = 1.07 n 10^{-1}**
				IHSS 201-Standley Lake			
Pu^{239}	0.553/5 n	10^5 pCi/g	=	1.106 n 10^{-6}	0.00138/0.4 mGy/h	=	0.00345
Pu^{240}	0.553/5 n	10^5 pCi/g	=	1.106 n 10^{-6}	0.00138/0.4 mGy/h	=	0.00345
Am^{241}	0.107/5 n	10^4 pCi/g	=	2.14 n 10^{-6}	0.00028/0.4 mGy/h	=	0.0007
				Hazard Index = 4.35 n 10^{-6}			**Hazard Index = 7.6 n 10^{-3}**
				IHSS 202-Mower Reservoir			
Pu^{239}	0.488/5 n	10^5 pCi/g	=	9.76 n 10^{-7}	0.0012/0.4 mGy/h	=	0.003
Pu^{240}	0.488/5 n	10^5 pCi/g	=	9.76 n 10^{-7}	0.0012/0.4 mGy/h	=	0.003
Am^{241}	0.093/5 n	10^4 pCi/g	=	1.86 n 10^{-6}	0.0024/0.4 mGy/h	=	0.0006
				Hazard Index = 2.13 n 10^{-5}			**Hazard Index = 6.6 n 10^{-3}**

Hazard Index = Sum of the Receptor Hazard Quotients by IHSS. A Hazard Quotient and Index value below 1, indicates no risk.

Table 4-17

Summary of Aquatic Bioassay Results for OU3

	Bioassay Results (% survival)		
	Sediment	Surface Water	
Location	Hyallela Azteca	Ceriodaphnia	Fathead Minnow
Mower Reservoir			
SED01392	96 percent surv.*	89 (8/9)	95 (38/40)
SED15192	91 percent surv.	100 (9/9)	97.3 (37/38)
SED15292	94 percent surv.	100 (10/10)	97.3 (37/38)
Woman Creek			
SED02092	93 percent surv.*	Data not available	97.5 (39/40)
Big Dry Creek			
SED02592	93 percent surv.*	100** (10/10)	100 (40/40)
Walnut Creek			
SED00392	76 percent surv.*	100 (10/10)	97.5 (39/40)

* A statistically significant difference between treated vs. control organism weight was observed at the termination of the test.
** A statistically significant difference between treated vs. control organisms (ceriodaphnia) reproduction rate was observed.

BENTHIC MACROINVERTEBRATE AND PERIPHYTON DATA

OU3 AQUATIC POTENTIAL COC EVALUATION

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Versar Inc.
ESM Operations

8 December 1992

COPY

Beth Montano
EG&G Rocky Flats
Sample Management Office
Buildi..g 80
P.O. Box 464
Golden, Colorado 80402-0464

Dear Ms. Montano:

Versar has completed the analysis of all the periphyton samples and the first 24 benthic samples recently sent us by Dick Moos at CH2M Hill. Enclosed is a hard copy of the data, an ASCII file, copies of our chain-of-custody records, and a description of the database. The benthic abundance, periphyton abundance, and periphyton biomass data are contained in the files named BENTHIC.TXT, PERIPH_C.TXT, and PERIPH_B.TXT, respectively.

Because all of the periphyton samples are now completed, we generated summary tables of the results for your convenience (see attached Tables 1 and 2). In these samples we found a total of 118 species. Most of the algal species were diatoms (78 species); 14 were green algae (Chlorophyta), and five were blue-green algae (Cyanophyta, Table 1). For sample numbers BIO3650CH, 51, 52, 56, 57, and 58 the filamentous blue-green species, *Schizothrix calciola* was most abundant. The centric diatom, *Cocconeis placentual*, was the most abundant periphyton species in sample numbers 53, 54, and 55. These three samples contained fewer species (ranging from 9 to 17 species) than the remaining samples, which contained 39 to 54 species (Table 2). Lowest total abundance (804 cells/mm^2) was observed in sample number 53, whereas more than 7,000 cells/mm^2 were found in samples numbers 51, 52, and 57 (Table 2). Total abundances for samples 50, 54, 55, 56, and 58 were similar, ranging from 2,753 to 4,572 cells/mm^2.

We are also submitting the data for 24 benthic samples. Now that we have received the signed purchase order for the remaining samples, we will be completing the additional 54 samples within the next month. After this analysis is complete, Lisa Scott will submit a table of functional feeding groups by taxa, a brief description of the results, and a tabular summary of the data to assist EG&G and your consultants in data interpretation. Since we are currently providing you with a partial data submittal for the benthic samples, we felt this information would be more useful when you receive the entire benthic data set.

Please let me know if you have any questions or comments.

Sincerely,

Fred Pinkney
(Ecological Sciences and Analysis)

FP/sg
74\ROCKY.PER\7799-L
Enclosures

cc: William Meise (QuantaLex, Inc.)
File: 1974-002

9200 RUMSEY ROAD • COLUMBIA, MARYLAND 21045-1934 • TELEPHONE: (410) 964-9200 FAX (410) 964-5155

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Table 1. Summary of algal abundance (#'s/mm^2) for the nine Rocky Flats periphyton samples

	Sample Number								
	BIO 3650 CH	BIO 3652 CH	BIO 3653 CH	BIO 3654 CH	BIO 3655 CH	BIO 3656 CH	BIO 3657 CH	BIO 3658 CH	BIO 3659 CH
Blue Greens (Cyanophyta)									
Anabaina sp A	0.0	0.0	0.0	0.0	0.0	0.0	76.0	0.0	0.0
Anacystis montana	0.0	219.5	0.0	88.3	0.0	0.0	0.0	0.0	0.0
Nostoc sp A	0.0	175.6	0.0	7.2	0.0	0.0	0.0	0.0	65.4
Schizothrix calciola	3505.7	5887.0	5514.0	68.0	547.5	485.3	2085.5	3240.3	1573.9
unident blue green coclods	0.0	0.0	0.0	0.0	0.0	58.0	0.0	0.0	0.0
Green Algae (Chlorophyta)									
Ankistrodesmus sp A	0.0	0.0	11.6	0.0	0.0	0.0	0.0	0.0	0.0
Cosmarium sp A	0.0	0.0	11.6	1.4	0.0	7.2	0.0	8.2	0.0
Eurastrum sp A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0
Mougeotia sp A	0.0	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pediastrum duplex	0.0	70.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scenedesmus ecornis	0.0	0.0	0.0	0.0	9.5	0.0	0.0	0.0	0.0
Scenedesmus quadricauda	10.8	0.0	0.0	0.0	0.0	0.0	0.0	65.8	0.0
Stegeoclonium lubricum	51.4	0.0	0.0	0.0	847.5	539.7	13.1	238.5	65.4
Staurastrum quadricuspidatum	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0
Staurastrum sp A	0.0	0.0	0.0	0.0	0.0	3.6	2.6	0.0	0.0
Staurastrum sp B	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.0
Ulothrix sp A	0.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
unident green cocoid	0.0	0.0	11.6	0.0	0.0	0.0	0.0	0.0	16.4
unident flagellated green	0.0	0.0	5.8	0.0	0.0	0.0	0.0	0.0	0.0
Yellow Greens (Chrysophyta)									
Dinobryon sp A	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	0.0
Other Species									
Trachelomonas sp A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.4	0.0
Diatoms (Bacillariophyta)									
Achnanthes lanceolata v. dubia	0.0	0.0	0.0	0.0	0.0	0.0	4.4	14.9	0.0
Achnanthes microcephala	32.1	29.9	263.4	0.0	0.0	0.0	0.0	0.0	0.0
Achnanthes minutissima	281.0	485.0	587.9	8.9	8.6	0.0	540.5	408.9	1036.5
Achnanthes pinnata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
Achnanthes sp	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
Amphipleura pellucida	2.0	6.0	32.9	0.0	0.0	0.0	39.7	223.0	79.2
Amphora ovalis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
Amphora perpusilla	0.0	6.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0
Amphora submontana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
Amphora turgida	0.0	0.0	0.0	0.0	0.0	0.0	6.6	14.9	7.5
Amphora veneta	0.0	0.0	4.7	28.1	120.2	136.0	11.0	44.6	11.3

Table 1. Continued

	Sample Number								
	BIO 3650 CH	BIO 3652 CH	BIO 3653 CH	BIO 3654 CH	BIO 3655 CH	BIO 3656 CH	BIO 3657 CH	BIO 3658 CH	BIO 3659 CH
Anomoeoneis vitrea	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Asterionella formosa	2.0	12.0	0.0	0.0	0.0	0.0	6.6	44.6	3.8
Caloneis bacillum	0.0	0.0	4.7	0.0	0.0	0.0	2.2	0.0	0.0
Cocconeis placentula v. euglypta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5
Cocconeis placentula v. lineata	0.0	0.0	0.0	565.4	1872.4	1300.6	0.0	0.0	3.8
Cyclotella kuetzingiana	4.0	12.0	9.4	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella meneghiniana	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella ocellata	2.0	24.0	28.2	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella pseudostelligera	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclotella stelligera	8.0	18.0	32.9	0.0	0.0	0.0	0.0	0.0	0.0
Cymatopleura solea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9	0.0
Cymbella affinis	80.3	56.9	103.5	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella cistula	0.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella microcephala	130.5	302.4	696.1	0.0	0.0	3.3	24.3	0.0	37.7
Cymbella microcephala v. crassa	2.0	9.0	32.9	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella minuta	20.1	32.9	32.9	0.0	0.0	0.0	4.4	0.0	15.1
Cymbella minuta v. silesiaca	2.0	18.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella prostrata v. auerswaldii	0.0	0.0	9.4	0.0	0.0	0.0	4.4	14.9	0.0
Cymbella sinuata	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cymbella tumida	0.0	3.0	0.0	0.0	0.0	0.0	4.4	0.0	11.3
Denticula elegans	0.0	3.0	0.0	7.7	0.0	0.0	0.0	0.0	0.0
Diploneis puella	2.0	6.0	4.7	0.0	0.0	0.0	0.0	0.0	7.5
Entomoneis alata	2.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
Epithemia adnata	0.0	0.0	0.0	1.3	4.3	0.0	0.0	0.0	0.0
Epithemia argus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
Epithemia sorex	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0
Epithemia turgida	0.0	0.0	0.0	12.8	141.7	149.3	0.0	7.4	0.0
Fragilaria crotonensis	0.0	0.0	0.0	0.0	0.0	0.0	97.1	349.4	49.0
Fragilaria crotonensis v. oregona	20.1	12.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0
Fragilaria pinnata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1814.0	90.5
Fragilaria pinnata v. lancettula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.8	0.0
Fragilaria vaucheriae	4.0	9.0	80.0	0.0	0.0	0.0	0.0	22.3	26.4
Gomphonema acuminatum	4.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema affine	82.3	89.8	61.1	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema clevei	0.0	0.0	0.0	1.3	0.0	0.0	136.8	96.6	158.3
Gomphonema gracile	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema grunowii	54.2	68.9	28.2	0.0	0.0	0.0	0.0	0.0	0.0
Gomphonema olivaceoides v. hutchinsoniana	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
Gomphonema parvulum	148.5	41.9	155.2	0.0	0.0	3.3	114.7	81.8	165.8
Gomphonema subclavatum	10.0	6.0	18.8	0.0	0.0	0.0	17.6	22.3	11.3
Gomphonema truncatum	22.1	12.0	23.5	0.0	0.0	0.0	0.0	0.0	0.0
Gyrosigma scalproides	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Melosira ambigua	32.1	50.9	32.9	0.0	0.0	0.0	6.6	171.0	7.5
Melosira granulata	0.0	3.0	0.0	0.0	0.0	0.0	8.8	44.6	0.0
Melosira italica v. tenuissima	4.0	24.0	0.0		0.0	0.0	0.0	29.7	0.0
Me [redacted] rians	0.0	0.0	0.0		0.0	0.0	2.2	0.0	26.4

Table 1. Continued

	Sample Number								
	BIO 3650 CH	BIO 3652 CH	BIO 3653 CH	BIO 3654 CH	BIO 3655 CH	BIO 3656 CH	BIO 3657 CH	BIO 3658 CH	BIO 3659 CH
Navicula cancellata	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	3.8
Navicula capitata	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Navicula cryptocephala	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5
Navicula decussis	0.0	0.0	0.0	0.0	0.0	0.0	8.8	7.4	3.8
Navicula lanceolata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
Navicula menisculus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	0.0
Navicula pupula	0.0	0.0	0.0	0.0	0.0	0.0	4.4	7.4	0.0
Navicula pupula v. mutata	0.0	0.0	0.0	0.0	0.0	0.0	4.4	7.4	11.3
Navicula rhynchocephala v. germainii	0.0	0.0	4.7	0.0	0.0	0.0	4.4	0.0	7.5
Navicula salinarum v. intermedia	0.0	9.0	4.7	0.0	0.0	0.0	4.4	0.0	3.8
Navicula subhamulata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
Nitzschia acicularis	2.0	6.0	4.7	3.8	0.0	0.0	0.0	14.9	0.0
Nitzschia admissa	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0
Nitzschia bacata	0.0	9.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0
Nitzschia clausii	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0
Nitzschia communis v. hyalina	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia dissipata	0.0	3.0	9.4	0.0	0.0	0.0	2.2	7.4	0.0
Nitzschia dissipata v. media	0.0	6.0	14.1	0.0	0.0	0.0	4.4	0.0	0.0
Nitzschia frustulum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	11.3
Nitzschia frustulum v. subsalina	0.0	3.0	4.7	2.6	0.0	0.0	0.0	0.0	0.0
Nitzschia gracilis	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitzschia hungarica	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0
Nitzschia kuetzingiana	20.1	41.9	28.2	5.1	0.0	6.6	8.8	22.3	15.1
Nitzschia palea	2.0	3.0	0.0	0.0	0.0	0.0	2.2	14.9	3.8
Nitzschia paleacea	0.0	0.0	0.0	0.0	0.0	33.2	0.0	0.0	0.0
Nitzschia subtilis	6.0	12.0	0.0	0.0	0.0	0.0	0.0	22.3	3.8
Pleurosigma gracile	0.0	0.0	0.0	0.0	0.0	3.3	2.2	0.0	0.0
Rhopalodia gibba	0.0	3.0	0.0	1.3	0.0	6.6	0.0	0.0	11.3
Skeletonema potamos	4.0	12.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0
Stephanodiscus astraea	2.0	3.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0
Stephanodiscus minutus	2.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Surirella minuta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
Surirella suecica	0.0	0.0	0.0	0.0	0.0	0.0	2.2	14.9	0.0
Synedra delicatissima v. angustissima	0.0	0.0	4.7	0.0	0.0	0.0	2.2	0.0	3.8
Synedra minuscula	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5
Synedra pulchella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
Synedra rumpens	0.0	3.0	0.0	0.0	0.0	0.0	4.4	14.9	18.8
Synedra rumpens v. familiaris	0.0	0.0	9.4	0.0	0.0	0.0	0.0	14.9	0.0
Synedra tenera	0.0	6.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0
Synedra ulna	0.0	3.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0

Table 2. Summary of species diversity, abundance (total #'s/mm^2), and biomass for the nine Rocky Flats periphyton samples

	Sample Number								
	BIO 3650 CH	BIO 3651 CH	BIO 3652 CH	BIO 3653 CH	BIO 3654 CH	BIO 3655 CH	BIO 3656 CH	BIO 3657 CH	BIO 3658 CH
DIVERSITY									
Number of green species	3.0	6.0	5.0	5.0	4.0	5.0	5.0	6.0	4.0
Number of diatom species	36.0	48.0	35.0	11.0	5.0	12.0	36.0	39.0	37.0
Total number of species	39.0	54.0	40.0	16.0	9.0	17.0	41.0	45.0	41.0
# TOTAL ABUNDANCE									
Number of cells/mm^2	4,571.5	8,046.9	7,906.1	804.5	3,556.5	2,752.7	3,282.9	7,294.7	3,605.6
BIOMASS									
Dry weight g/m^2	51.2	65.7	54.8	31.6	45.6	62.1	85.4	130.6	83.4
Ash free dry weight g/m^2	5.9	7.8	6.6	3.6	5.1	7.0	9.2	13.9	9.3

Standley Lake / Periphyton

Species	BI03656CH	BI03657CH	BI03658CH
Achnanthes lanceolata v. dubia	4	15	
Achnanthes minutissima	541	409	1037
Achnanthes pinnata		7	
Achnanthes sp		7	
Amphipleura pellucida	40	223	79
Amphora ovalis		7	
Amphora perpusilla	2		
Amphora submontana		7	
Amphora turgida	7	15	8
Amphora veneta	11	45	11
Anabaina sp A	76		
Asterionella formosa	7	45	4
Caloneis bacillum	2		
Cocconeis placentula v. euglypta			8
Cocconeis placentula v. lineata			4
Cosmarium sp A		8	
Cymatopleura solea		15	
Cymbella microcephala	24		38
Cymbella minuta	4		15
Cymbella prostrata v. auerswaldii	4	15	
Cymbella tumida	4		11
Dinobryon sp A	3		
Diploneis puella			8
Entomoneis alata		7	
Epithemia argus		7	
Epithemia turgida		7	
Eurastrum sp A		8	
Fragilaria crotonensis	97	349	49
Fragilaria pinnata		1814	91
Fragilaria pinnata v. lancettula		82	
Fragilaria vaucheriae		22	26
Gomphonema clevei	137	97	158
Gomphonema parvulum	115	82	166
Gomphonema subclavatum	18	22	11
Melosira ambigua	7	171	8
Melosira granulata	9	45	
Melosira italica v. tenuissima		30	
Melosira varians	2		26
Navicula canalis	4		4
Navicula cryptocephala			8
Navicula decussis	9	7	4
Navicula lanceolata		7	
Navicula menisculus		7	
Navicula pupula	4	7	
Navicula pupula v. mutata	4	7	11
Navicula rhynchocephala v. germainii	4		8
Navicula salinarum v. intermedia	4		4
Navicula subhamulata			4
Nitzschia acicularis		15	
Nitzschia admissa	2		
Nitzschia dissipata	2	7	

Standley Lake / Periphyton

Species	BI03656CH	BI03657CH	BI03658CH
Nitzschia dissipata v. media	4		
Nitzschia frustulum		7	11
Nitzschia hungarica	2		
Nitzschia kuetzingiana	9	22	15
Nitzschia palea	2	15	4
Nitzschia subtilis		22	4
Nostoc sp A			65
Pleurosigma gracile	2		
Rhopalodia gibba			11
Scenedesmus quadricauda		66	
Schizothrix calciola	2086	3240	1574
Staurastrum sp A	3		
Stegeoclonium lubricum	13	239	65
Surirella minuta			4
Surirella suecica	2	15	
Synedra delicatissima v. angustissima	2		4
Synedra minuscula			8
Synedra pulchella			4
Synedra rumpens	4	15	19
Synedra rumpens v. familiaris		15	
Synedra ulna	4		
Trachelomonas sp A		16	
unident green cocoid			16

Order	Family	Species	Total Number of Species
		Entomoneis alata	7
		unident green cocoid	16
Centrales			
	Coscinodiscaceae		
		Melosira ambigua	186
		Melosira granulata	54
		Melosira italica v. tenuissima	30
		Melosira varians	28
etophorales			
	Chaetophoraceae		
		Stegeoclonium lubricum	317
Chlorococcales			
	Scenedesmaceae		
		Scenedesmus quadricauda	66
Euglenoles			
	Euglenaccae		
		Trachelomonas sp A	16

Order	Family	Species	Total Number of Species
Nostocales			
	Nostocaceae		
		Anabaina sp A	76
Ochromonadales			
	Dinobryaceae		
		Dinobryon sp A	3
Oscillatoriales			
	Oscillatoriaceae		
		Schizothrix calciola	6900
Pennales			
	Achnanthaceae		
		Achnanthes lanceolata v. dubia	19
		Achnanthes minutissima	1987
		Achnanthes pinnata	7
		Achnanthes sp	7
		Cocconeis placentula v. euglypta	8
		Cocconeis placentula v. lineata	4
	Cymbellaceae		
		Cymbella microcephala	62
		Cymbella minuta	19
		Cymbella prostrata v. auerswaldii	19

Order	Family	Species	Total Number of Species
Pennales			
	Cymbellaceae		
		Cymbella tumida	15
	Dostocaceae		
		Nostoc sp A	65
	Epithemiaceae		
		Epithemia argus	7
		Epithemia turgida	7
		Rhopalodia gibba	11
	Fragilariaceae		
		Asterionella formosa	56
		Fragilaria crotonensis	495
		Fragilaria pinnata	1905
		Fragilaria pinnata v. lancettula	82
		Fragilaria vaucheriae	48
		Synedra delicatissima v. angustissima	6
		Synedra minuscula	8
		Synedra pulchella	4
		Synedra rumpens	38
		Synedra rumpens v. familiaris	15
		Synedra ulna	4

Order	Family	Species	Total Number of Species
Pennales			
	Gomphonemaceae		
		Gomphonema clevei	392
		Gomphonema parvulum	363
		Gomphonema subclavatum	51
	Naviculaceae		
		Amphipleura pellucida	342
		Amphora ovalis	7
		Amphora perpusilla	2
		Amphora submontana	7
		Amphora turgida	30
		Amphora veneta	67
		Caloneis bacillum	2
		Diploneis puella	8
		Navicula canalis	8
		Navicula cryptocephala	8
		Navicula decussis	20
		Navicula lanceolata	7
		Navicula menisculus	7
		Navicula pupula	11
		Navicula pupula v. mutata	22
		Navicula rhynchocephala v. germainii	12
		Navicula salinarum v. intermedia	8

Order	Family	Species	Total Number of Species
Pennales			
	Naviculaceae		
		Navicula subhamulata	4
		Pleurosigma gracile	2
	Nitzschiaceae		
		Nitzschia acicularis	15
		Nitzschia admissa	2
		Nitzschia dissipata	9
		Nitzschia dissipata v. media	4
		Nitzschia frustulum	18
		Nitzschia hungarica	2
		Nitzschia kuetzingiana	46
		Nitzschia palea	21
		Nitzschia subtilis	26
	Surirellaceae		
		Cymatopleura solea	15
		Surirella minuta	4
		Surirella suecica	17
Zygnematales			
	Desmidiaceae		
		Cosmarium sp A	8
		Eurastrum sp A	8

Order	Family	Species	Total Number of Species
Zygnematales			
	Desmidiaceae		
		Staurastrum sp A	3

Great Western Reservoir / Periphyton

Species	BI03650CH	BI03651CH	BI03652CH
Achnanthes microcephala	32	30	263
Achnanthes minutissima	281	485	588
Amphipleura pellucida	2	6	33
Amphora perpusilla		6	
Amphora veneta			5
Anacystis montana		220	
Ankistrodesmus sp A			12
Anomoeoneis vitrea	4		
Asterionella formosa	2	12	
Caloneis bacillum			5
Cosmarium sp A			12
Cyclotella kuetzingiana	4	12	9
Cyclotella meneghiniana	2		
Cyclotella ocellata	2	24	28
Cyclotella pseudostelligera	4		
Cyclotella stelligera	8	18	33
Cymbella affinis	80	57	104
Cymbella cistula		9	
Cymbella microcephala	131	302	696
Cymbella microcephala v. crassa	2	9	33
Cymbella minuta	20	33	33
Cymbella minuta v. silesiaca	2	18	5
Cymbella prostrata v. auerswaldii			9
Cymbella sinuata		3	
Cymbella tumida		3	
Denticula elegans		3	
Diploneis puella	2	6	5
Entomoneis alata	2		
Fragilaria crotonensis v. oregona	20	12	5
Fragilaria vaucheriae	4	9	80
Gomphonema acuminatum	4	9	
Gomphonema affine	82	90	61
Gomphonema gracile	2		
Gomphonema grunowii	54	69	28
Gomphonema parvulum	149	42	155
Gomphonema subclavatum	10	6	19
Gomphonema truncatum	22	12	24
Gyrosigma scalproides		3	
Melosira ambigua	32	51	33
Melosira granulata		3	
Melosira italica v. tenuissima	4	24	
Mougeotia sp A		18	
Navicula capitata		3	
Navicula rhynchocephala v. germainii			5
Navicula salinarum v. intermedia		9	5
Nitzschia acicularis	2	6	5
Nitzschia bacata		9	
Nitzschia communis v. hyalina		3	
Nitzschia dissipata		3	9
Nitzschia dissipata v. media		6	14
Nitzschia frustulum v. subsalina		3	5

Great Western Reservoir / Periphyton

Species	BI03650CH	BI03651CH	BI03652CH
Nitzschia gracilis	2		
Nitzschia kuetzingiana	20	42	28
Nitzschia palea	2	3	
Nitzschia subtilis	6	12	
Nostoc sp A		176	
Pediastrum duplex		70	
Rhopalodia gibba		3	
Scenedesmus quadricauda	11		
Schizothrix calciola	3506	5887	5514
Skeletonema potamos	4	12	5
Stegeoclonium lubricum	51		
Stephanodiscus astraea	2	3	5
Stephanodiscus minutus	2	3	
Synedra delicatissima v. angustissima			5
Synedra rumpens		3	
Synedra rumpens v. familiaris			9
Synedra tenera		6	5
Synedra ulna		3	
Ulothrix sp A		180	
unident flagellated green			6
unident green cocoid			12

Order	Family	Species	Total Number of Species
		Entomoneis alata	2
		unident flagellated green	6
		unident green cocoid	12
Centrales			
		Skeletonema potamos	21
	Coscinodiscaceae		
		Cyclotella kuetzingiana	25
		Cyclotella meneghiniana	2
		Cyclotella ocellata	54
		Cyclotella pseudostelligera	4
		Cyclotella stelligera	59
		Melosira ambigua	116
		Melosira granulata	3
		Melosira italica v. tenuissima	28
		Stephanodiscus astraea	10
		Stephanodiscus minutus	5

Order	Family	Species	Total Number of Species
Chaetophorales			
	Chaetophoraceae		
		Stegeoclonium lubricum	51
Chlorococcales			
	Hydrodictyaceae		
		Pediastrum duplex	70
	Oocystoceae		
		Ankistrodesmus sp A	12
	Scenedesmaceae		
		Scenedesmus quadricauda	11
Chroococcales			
	Chroococcaceae		
		Anacystis montana	220
Oscillatoriales			
	Oscillatoriaceae		
		Schizothrix calciola	14907
Pennales			
	Achnanthaceae		
		Achnanthes microcephala	325
		Achnanthes minutissima	1354

Order	Family	Species	Total Number of Species
Pennales			
	Cymbellaceae		
		Cymbella affinis	241
		Cymbella cistula	9
		Cymbella microcephala	1129
		Cymbella microcephala v. crassa	44
		Cymbella minuta	86
		Cymbella minuta v. silesiaca	25
		Cymbella prostrata v. auerswaldii	9
		Cymbella sinuata	3
		Cymbella tumida	3
	Dostocaceae		
		Nostoc sp A	176
	Epithemiaceae		
		Denticula elegans	3
		Rhopalodia gibba	3
	Fragilariaceae		
		Asterionella formosa	14
		Fragilaria crotonensis v. oregona	37
		Fragilaria vaucheriae	93
		Synedra delicatissima v. angustissima	5
		Synedra rumpens	3

Order	Family	Species	Total Number of Species
Pennales			
	Fragilariaceae		
		Synedra rumpens v. familiaris	9
		Synedra tenera	11
		Synedra ulna	3
	Gomphonemaceae		
		Gomphonema acuminatum	13
		Gomphonema affine	233
		Gomphonema gracile	2
		Gomphonema grunowii	151
		Gomphonema parvulum	346
		Gomphonema subclavatum	35
		Gomphonema truncatum	48
	Naviculaceae		
		Amphipleura pellucida	41
		Amphora perpusilla	6
		Amphora veneta	5
		Anomoeoneis vitrea	4
		Caloneis bacillum	5
		Diploneis puella	13
		Gyrosigma scalproides	3
		Navicula capitata	3

Order	Family	Species	Total Number of Species
Pennales			
	Naviculaceae		
		Navicula rhynchocephala v. germainii	5
		Navicula salinarum v. intermedia	14
	Nitzschiaceae		
		Nitzschia acicularis	13
		Nitzschia bacata	9
		Nitzschia communis v. hyalina	3
		Nitzschia dissipata	12
		Nitzschia dissipata v. media	20
		Nitzschia frustulum v. subsalina	8
		Nitzschia gracilis	2
		Nitzschia kuetzingiana	90
		Nitzschia palea	5
		Nitzschia subtilis	18
Ulotricholes			
	Ulotrichaceae		
		Ulothrix sp A	180
Zygnematales			
	Desmidiaceae		
		Cosmarium sp A	12

Order	Family	Species	Total Number of Species
Zygnematales			
	Zygnemataceae		
		Mougeotia sp A	18

Mower Reservoir / Periphyton

Species	BI03653CH	BI03654CH	BI03655CH
Achnanthes minutissima	9	9	
Amphora veneta	28	120	136
Anacystis montana	88		
Cocconeis placentula v. lineata	565	1872	1301
Cosmarium sp A	1		7
Cymbella microcephala			3
Denticula elegans	8		
Epithemia adnata	1	4	
Epithemia sorex			10
Epithemia turgida	13	142	149
Gomphonema clevei	1		
Gomphonema parvulum			3
Nitzschia acicularis	4		
Nitzschia bacata			3
Nitzschia clausii			3
Nitzschia frustulum v. subsalina	3		
Nitzschia kuetzingiana	5		7
Nitzschia paleacea			33
Nostoc sp A	7		
Pleurosigma gracile			3
Rhopalodia gibba	1		7
Scenedesmus ecornis		10	
Schizothrix calciola	68	548	485
Staurastrum quadricuspidatum	1		
Staurastrum sp A			4
Staurastrum sp B		5	
Stegeoclonium lubricum		848	540
unident blue green cociods			58

Order	Family	Species	Total Number of Species
		unident blue green cociods	58
Chaetophorales			
	Chaetophoraceae		
		Stegeoclonium lubricum	1388
Chlorococcales			
	Scenedesmaceae		
		Scenedesmus ecornis	10
Chroococcales			
	Chroococcaceae		
		Anacystis montana	88
Oscillatoriales			
	Oscillatoriaceae		
		Schizothrix calciola	1101
Pennales			
	Achnanthaceae		
		Achnanthes minutissima	18
		Cocconeis placentula v. lineata	3738

Order	Family	Species	Total Number of Species
Pennales			
	Cymbellaceae		
		Cymbella microcephala	3
	Dostocaceae		
		Nostoc sp A	7
	Epithemiaceae		
		Denticula elegans	8
		Epithemia adnata	5
		Epithemia sorex	10
		Epithemia turgida	304
		Rhopalodia gibba	8
	Gomphonemaceae		
		Gomphonema clevei	1
		Gomphonema parvulum	3
	Naviculaceae		
		Amphora veneta	284
		Pleurosigma gracile	3
	Nitzschiaceae		
		Nitzschia acicularis	4
		Nitzschia bacata	3
		Nitzschia clausii	3

Order	Family	Species	Total Number of Species
Pennales			
	Nitzschiaceae		
		Nitzschia frustulum v. subsalina	3
		Nitzschia kuetzingiana	12
		Nitzschia paleacea	33
Zygnematales			
	Desmidiaceae		
		Cosmarium sp A	8
		Staurastrum quadricuspidatum	1
		Staurastrum sp A	4
		Staurastrum sp B	5

BIOASSAY RESULTS FOR SURFACE WATER AND SEDIMENT

OU3 AQUATIC POTENTIAL COC EVALUATION

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The SeaCrest Group
An Environmental Services Company

October 10, 1992

Dr. Richard Moos
CH_2M Hill
6060 South Willow Drive
Greenwood Village, Colorado 80111-51423

COPY

Dear Dick:

I am pleased to submit the results of the chronic biomonitoring tests for the Rocky Flats sediment and water samples collected during September 1992. NO effects were seen in the fathead minnow tests, however, several of the sediment samples had effects on the *Hyalella*. Similarly, one of the water samples had an effect on the *Ceriodaphnia*. I would need to see water and sediment chemistry data to suggest what might be causing an impact.

Please feel free to contact me if you have any questions.

Sincerely,

Ken Fucik

enclosure

325 Interlocken Parkway, Suite 205 • Broomfield, Colorado 80021 • 303/438-0970 • FAX: 303/438-0971
• Locations in Texas, Colorado, and Virginia •

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AQUATIC AND SEDIMENT CHRONIC BIOMONITORING RESULTS FROM EG&G'S ROCKY FLATS PLANT

Submitted to:

Dr. Richard Moos
CH_2M Hill
6060 South Willow Drive
Greenwood Village, Colorado 80111-51423

Submitted by:

The Seacrest Group
325 Interlocken Parkway
Suite 205
Broomfield, Colorado 80021
(303) 438-0970

September 30, 1992

T.H.E. LABORATORIES, INC.
QA/QC CHECKLIST
REPORT/ANALYSIS REVIEW RECORD

Client ROCKY FLATS **Date submitted** 10-12-92

Project number 537092, 535492, 535142 **Sample type** Comp

Project manager Ken Fuaik **Analyst** Michelle Highsmith, Karen Christensen, Lori Wankert, Don Darling, Dan Fink

QA/QC Item	Yes	No	Reviewer	Date
1. Samples shipped on ice, no obvious tampering, sample integrity met.	✓	—	mjt	10-12
2. Samples logged in, chain of custody complete, project number assigned.	✓	—	mjt	10-12
3. Test begun within 36 hours after collection.	✓	—	mjt	10-12
4. Equipment calibrated and working properly.	✓	—	mjt	10-12
5. Lab sheet complete and test guidelines met.	✓	—	mjt	10-12
6. Summary sheet complete and matches lab data sheet.	✓	—	mjt	10-12
7. Calculations checked.	✓	—	[illegible]	10/12
8. Commentary reviewed and resolved.	✓	—	KF	10/12
9. QA/QC deficiencies addressed and resolved.	✓	—	KF	10/12

All requirements for tests and QA/QC have been reviewed and approved.

[signature] Project Manager

10/12/92 Date

INTRODUCTION

EG&G's Rocky Flats Plant performs whole effluent toxicity tests on various surface waters on the plant property. The purpose of this testing is to monitor water quality of the surface waters on the plant property. During August 1992, an additional series of tests were conducted to measure the possible chronic toxicity associated with the sediments and surface waters in the vicinity of the plant. The aquatic biomonitoring tests used *Ceriodaphnia* sp., an invertebrate, and fathead minnows (*Pimephales promelas*). These biomonitoring procedures followed the protocols outlined in Peltier and Weber (1985). These test procedures are consistent with the Colorado Water Quality Control Division and Environmental Protection Agency Region VIII guidelines for biomonitoring. The sediment toxicity tests used the amphipod, *Hyalella azteca*, in 28 day exposures. These tests followed ASTM Method E1383-90 as described in Nelson et al (1990). The results of the biomonitoring tests are presented in the following sections.

MATERIALS AND METHODS

Grab sediment samples were collected in on August 13, 1992. Water samples were collected on August 10, 12, and 14 or on August 31 and September 2 and 3, 1992. Sampling times and locations are summarized in Table 1. These samples were delivered to the lab within 24 hours of their collection.

All samples were delivered to Seacrest's lab in ice chests where they were refrigerated at 4°C until testing. Chain of custody forms showing collection and lab arrival times for each sampling period are provided in Appendix 1.

Prior to testing, water samples were analyzed for hardness, alkalinity, conductivity, ammonia, pH, and dissolved oxygen. Hardness and alkalinity were determined titrimetrically. Ammonia was also measured with an Orion ion selective electrode. Methods followed those described in APHA (1985). Conductivity, dissolved oxygen, and pH were measured with probes after calibration of instruments.

Five dilutions of each effluent sample and a control were used for testing the *Ceriodaphnia* sp. and fathead minnows. Effluent dilutions used included 100%, 75%, 50%, 25%, and 12% concentrations. Reconstituted water was used as the source of dilution water and a control.

Less than 24 hour old *Ceriodaphnia* and up to seven day old minnows were used. The organisms came from Seacrest's in-house cultures. In house animals are tested monthly in a reference toxicant test using sodium dodecyl sulfate.

Table 1. Summary of sample collection times and station designations.

STATION	DATE OF COLLECTION	STATION ACRONYM
BIO3810CH	8/10-14/92	SED 15292
BIO3808CH	8/10-14/92	SED 15192
BIO3812CH	8/10-14/92	SED 01392
BIO3806CH	8/10-14/92	SED 02092
BIO3802CH	8/10-14/92	SED 02592
BIO3804CH	8/10-14/92	SED 00392
BIO3813CH	8/13/92	SED REF92

Both the *Ceriodaphnia* and the fathead minnows were exposed to the water samples for 7 days. The exposure medium was replaced after each 24 hour period and the number of surviving organisms counted and recorded. Neonates born in each 24 hour period were also counted in the ceriodaph test. Routine measurements of pH, temperature, and dissolved oxygen were made for each 24 hour period prior to and after water was changed. Tests were run in an environmental chamber programmed for a 16 hr light/8 hr dark cycle and maintained at 25°C. At the end of the seven day exposure, surviving fish were sacrificed and dried in an oven at approximately 105°C for two hours.

The amphipods in the sediment tests were obtained from either in-house cultures or a commercial supplier. All animals used in the test were approximately 5 mm in size. Four replicates of each sample were tested with 20 animals in each replicate. Four hundred grams of sediment were used in each exposure chamber which consisted of plastic containers approximately 20 cm x 10 cm x 7.5 cm in size. A reference test was conducted using a clean sand substrate. The sediment samples were screened through a #14 mesh screen prior to the tests to remove indigenous macroinvertebrates. Water was changed every other day while readings for temperature, dissolved oxygen, pH, and conductivity were taken daily. The animals were fed every other day. Organisms were initially fed Tetramin flakes but beginning on Day 22 were fed 1 ml of rabbit chow which had been dissolved in distilled water after blending.

At the end of the exposure period, animals were removed from sediments by screening through the #14 mesh. Animals in the reference sand were removed by the addition of alcohol which caused the animals to float to the surface. Animals were preserved in alcohol until adult and larval animals could be counted. Adult animals were then dried for two hours at 105°C and weighed.

The TOXSTAT data package was used to determine statistically significant differences between control and exposed organisms (Gulley et al 1989). Results were calculated for measures of toxicity, growth, and reproduction.

Deviations from Test Protocols

Three of the samples (SED 15192, SED 01392, and SED 15292) arrived in the lab with pH's which exceeded 10 s.u. Because these levels were expected to be toxic to the organisms, hydrochloric acid was used to adjust the pH to approximately 8 s.u. This adjustment was required for subsequent water samples collected during the period of the chronic test.

RESULTS

Sediment Toxicity Tests

Results for the amphipod exposures are summarized in Table 2. Raw test data and biological observations are included in Appendix 2. Evidence of growth

Table 2. Summary of *Hyalella azteca* sediment exposure results. Statistically significant differences are indicated by an asterisk.

STATION	% SURVIVAL	AVERAGE WEIGHT	SIGNIFICANCE
Sand Control	85	0.30	
SEDREF 92	81	0.30	n.s.
SED 01392	96	0.21	*
SED 15292	94	0.23	n.s.
SED 15192	91	0.23	n.s.
SED 02092	93	0.16	*
SED 00392	76	0.18	*
SED 02592	93	0.21	*

was obvious by day 4 of the exposure as molted carapaces began to be observed floating in the water. Most of the mortality appeared to occur in the early stages of the test (i.e. through day 6) although dead animals continued to be found at least through day 12. Mating animals were seen as early as day 4 but the majority of this activity appeared to occur beginning with day 19. While some reproduction was evident in each of the sediments, on the whole, new births were minimal in all samples.

Survival was good in most of the samples and generally ranged from 76-96%. The reference sand had an 85% survival with a reference sediment (SED REF92) producing an 81% survival. The lowest number of survivors was measured at station SED 00392. Dunnett's Test was used to determine that there was no statistical difference in survival between the control and reference sediments and the exposed sediments.

Average weights were similar in the sand and reference sediment test and represented the highest numbers for the test. Most of the other samples had similar weights in an intermediate range with the lowest weights being recorded at SED 00392 and SED 02092. Dunnett's Test found that animals from four of the sites had weights significantly lower than that found in animals from either the control or reference sediments.

Fathead Minnow Test Results

The results of the fish chronic exposures are summarized in Table 3 with lab data sheets being provided in Appendix 3. None of the samples produced a toxic effect on the fish as 93% or better of the animals survived in all exposures in all tests. Similarly, no statistically significant effects were noted for growth as most of the samples had average weights in the 100% effluent that met or exceeded control weights. The control fish in the BIO 3808CH sample had a weight of 0.23 mg/l which is less than the required 0.25 mg/l average. However, the highest weights for this test were obtained in the 100% effluent which would indicate that no chronic effects were being detected.

***Ceriodaphnia* Test Results**

Ceriodaphnia test results are summarized in Table 4 and in data sheets in Appendix 4. A second water collection was made beginning on August 31 for sites at SED 00392, SED 02092, and SED 01392. The second collection was made because the original samples had control reproductive rates which failed to meet test requirements. In two samples, control births averaged approximatley 14 neonates per female (SED 00392 and SED 01392) where 15 is the generally accepted standard. A third sample (SED 02092) produced only 10 neonates. Unfortunately, high mortalities and low birth rates were measured in all control and exposure samples of the second set of waters. This problem was thought to be due to a contaminant in the food supply. Accordingly, only data from the early August collections were considered in the data analysis.

Table 3. Summary of fathead minnow test results. Forty fish were exposed at each concentration. An asterisk denotes a statistically significant difference between the control and exposed organisms.

Concentration	No. Alive	Ave. wt. (mg)	Min.	Max.	Sig.
SED 02592					
Control	40	0.29	0.26	0.36	
100%	40	0.36	0.33	0.39	
SED 00392					
Control	40	0.30	0.21	0.38	
100%	39	0.39	0.35	0.44	
SED 02092					
Control	40	0.32	0.29	0.38	
100%	39	0.45	0.45	0.50	
SED 15192					
Control	38	0.23	0.20	0.28	
100%	37	0.31	0.22	0.36	
SED 15292					
Control	38	0.25	0.23	0.28	
100%	37	0.28	0.24	0.30	
SED 01392					
Control	38	0.35	0.32	0.41	
100%	40	0.30	0.28	0.33	

Table 4. Summary of *Ceriodaphnia* test results for the control and 100% concentration. Statistically significant differences are indicated by an asterisk.

Concentration	No. Surviving	Mean Births	Min.	Max.	Sig.
SED 02592					
Control	10	15.0	11	21	
100%	10	8.6	5	13	*
SED 00392					
Control	10	14.2	10	18	
100%	10	11.3	0	16	
SED 02092[1]					
Control	9	10.4	4	13	
100%	8	8.3	3	12	
SED 15192					
Control	9	15.8	10	19	
100%	9	15.8	9	22	
SED 15292					
Control	10	16.0	9	21	
100%	10	16.5	12	22	
SED 01392					
Control	8	13.5	2	24	
100%	9	13.7	3	22	

[1]data is not acceptable due to low control reproduction

Given these factors, five of the samples were considered for analysis. The SED 02092 was not analyzed for the ceriodaphs because the control reproduction was too low. The other two samples which had control births averaging approximately 14 neonates were included since the other three samples had control births averaging greater than 15 organisms; all tests were run at the same time; and all of the animals came from the same batch so that if all controls were averaged for all tests, greater than 15 neonates was obtained.

In the five samples, no significant mortality was measured in any of the samples. Survival in the 100% effluent of all of the samples ranged from 80-100%. Average numbers of births was similar in each of the exposures between the control and exposed organisms except in the SED 02592 sample where Bonferroni's T-Test was used to determine that the controls and 100% exposure had statistically different reproductive rates.

DISCUSSION

Low level chronic effects were seen only in the invertebrate exposures as the fish were not affected by the waters. The source of the contaminant which led to the measured effects is unknown at this time. However, it is known that ceriodaphs and the amphipod are more sensitive to trace metals than are the fish. The fact that more effects were noted in the amphipod test suggest than in the ceriodaphs suggest that the contaminant is probably bound up in the sediments as opposed to being dissolved in the water column. Additional data would be required to determine whether this is in fact the case.

The test results with the sediments seem to correlate fairly well with biological observations made on the sediments during processing. The soils in which impacts were measured consisted of either clays or sandy soils which had few visible macroinvertebrates or were characterized by the presence of chironomids. Chironomids are known to populate contaminated areas. SED 15192 and SED 15292, where no effects were noted, appeared to have high organic content and had chironomids and snails present. This might suggest that some of the differences in average weights could be explained by differences in the organic content of the sediments, especially since the reference sediment was rich in organic matter. However, the control sediment was made up of coarse grained sand and still produced the highest average weights. Therefore, it would appear that the measured effects were real and not due to environmental factors associated with grain size.

REFERENCES

APHA/AWWA/WPCF. 1985. Standard methods for the examination of water and wastewater. 16th Edition. American Public Health Association. 1268 pp.

Nelson, M.K., C.G. Ingersoll, and F.J. Dwyer. 1990. Standard Guide for Conducting Sediment Toxicity Tests with Freshwater Invertebrates. ASTM Committee E-47 on Biological Effects and Environmental Fate, Method E 1383-90. Annual Book of ASTM Standards, Vol. 14.02.

Weber, C.I. *et al.* 1989. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms. Second Edition. EPA 600/4-89/001. 249 pp.

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Appendix 1. Chain of Custody Forms

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535192

CONTR. CH2M Hill SAMPLERS K. Kling, [redacted] Hope PROJECT # 1108 [redacted]-003

SITE CONTACT/PHONE

LAB/LOCATION THE

C-O-C NUMBER ~~THE 001~~ KF THE0001

EG&G ROCKY FLATS, CHAIN OF CUSTODY

DATE/TIME		SAMPLE NUMBER	LOCATION	CONTAINER TYPE	NUMBER OF CONTAINERS	MEDIA SOIL(S) WATER (W)	FILTERED=F POT DISS=P	TURN AROUND RUSH =R	OUT OF SPEC REPORTS	COOLED TO 4 C	HCl	NAOH	HNO3	H2SO4	Chronic Tox	Bioassay	Fish/Citro
8/10/92	10:15	B103810CH	SED15292	1 gallon poly	3	W				✓							✓
8/10/92	0955	B103808CH	SED15192	1 gallon poly	3	W				✓							✓
8/10/92	0930	B103812CH	SED01392	1 gallon poly	3	W				✓							✓
8/10/92	1120	B103806CH	SED02092	1 gallon poly	3	W				✓							✓
8/10/92	1300	B103802CH	SED02592	1 gallon poly	3	W				✓							✓
8/10/92	1330	B103804CH	SED00392	1 gallon poly	3	W				✓							✓

BOTTLE CODES

PRESERVATIVE

RELINQUISHED BY	DATE/TIME		RECEIVED BY	DATE/TIME	
Karmen Kling	8/10/92	1415	[signature]	8/10/92	1415

LABORATORY USE ONLY	Y	N
PCKG REC'D/CUSTODY SEALS INTACT		
SAMPLE LABELS/COCs AGREE		
TEMPERATURE WITHIN SPECIFICATION _____C		
CORRECTED COPY ATTACHED		
PROBLEMS OR DISCREPANCIES		

REMARKS

SHIPMENT METHOD

T.H.E. LABORATORIES, INC.
325 Interlocken Parkway
Suite 205
Broomfield, Colorado 80021

SAMPLE RECEIPT FORM

	Temp	pH
B10 3810CH-	9.5	10.6
B10 3808CH-	11.0	10.7
B10 3812CH-	12.5	10.3
B10 3806CH-	11.0	8.3
B10 3802CH	14°C	8.5
B10 3804CH	15°C	8.5

Project Number _____

Date/Initials 8-10-92 DR

SAMPLES WERE:

1. Shipped or ~~Hand Delivered~~
   NOTES:

2. Airbill Present NOTES:	Y	N	(NA)
3. Ambient or (Chilled) NOTES:			
4. Cooler Received Broken/Leaking NOTES:	Y		(N)
5. Sample Received Broken/Leaking (Improperly Sealed) NOTES:	Y		(N)
6. Samples Properly Preserved NOTES:	(Y)		N
7. Received Within Holding Times NOTES:	(Y)		N

COC TAPE WAS:

1. Present on Outer Package	Y	(N)
2. Unbroken on Outer Package	Y	(N)
3. Present on Sample	(Y)	N
4. Unbroken on Sample	(Y)	N

COC RECORD WAS:

1. Present Upon Receipt of Sample	(Y)	N

CH2M HILL TRANSMITTAL

TO T.H.E. Laboratories
325 Interlocken Parkway
Suite 205
Broomfield, Co 80021

FROM Karmen Klima
CH2M Hill
P.O. Box 22508
Denver, Co 80222

ATTN Ken Fucik

DATE 8/10/92

RE

PROJECT NUMBER DEN 30181.XL.03

WE ARE SENDING YOU

☐ ATTACHED ☐ UNDER SEPARATE COVER VIA

☐ SHOP DRAWINGS ☐ DOCUMENTS ☐ TRACINGS

☐ PRINTS ☐ SPECIFICATIONS ☐ CATALOGS

☐ COPY OF LETTER ☒ Water Samples to be used ~~for~~ for Chronic Toxicity Bioassays

QUANTITY	DESCRIPTION
3	3-1gallon bottles of water : sample # B1D3810 CH from SED15292
3	" " " : sample # B1D3808CH from SED15192
3	" " " : sample # B1D3812CH from SED01392
3	" " " : sample # B1D3801CH from SED02C92
3	" " " : sample # B1D3802CH from SED02592
3	" " " : sample # B1D3804CH from SED00392

IF MATERIAL RECEIVED IS NOT AS LISTED, PLEASE NOTIFY US AT ONCE

REMARKS

COPY TO

REV 1/97 FORM 6

CONTRACTOR CH2M Hill SAMPLERS Carmen Klima, Steve Hope, R. SHELDEN PROJECT # 110852-0113

SITE CONTACT/PHONE Dick Moos (303) 771-0900 LAB/LOCATION T.H.E. Laboratories

C-O-C NUMBER ~~THE002~~ THE0002

EG&G ROCKY FLATS, CHAIN OF CUSTODY

DATE/TIME		SAMPLE NUMBER	LOCATION	CONTAINER TYPE	NUMBER OF CONTAINERS	MEDIA SOIL(S) WATER (W)	FILTERED=F POT DISS=P	TURN AROUND RUSH =R	OUT OF SPEC REPORTS	COOLED TO 4 C	HCl	NAOH	HNO3	H2SO4	Chronic Tox	Bioassay	FISH/Cerio
8/12/92	1255	B103810CH	SED15292	1gallon poly	2	W				✓							✓
8/12/92	1330	B103808CH	SED15792	1gallon poly	2	W				✓							✓
8/12/92	1405	B103812CH	SED01392	1gallon poly	2	W				✓							✓
8/12/92	1520	B103806CH	SED02092	1gallon poly	2	W				✓							✓
8/12/92	1600	B103802CH	SED02592	1gallon poly	2	W				✓							✓
8/12/92	1630	B103804CH	SED00392	1gallon poly	2	W				✓							✓

BOTTLE CODES

PRESERVATIVE

RELINQUISHED BY	DATE/TIME		RECEIVED BY	DATE/TIME	
Steve Hope	8/12/92	1700	[illegible]	8-12-92	1700

LABORATORY USE ONLY	Y	N
PCKG REC'D/CUSTODY SEALS INTACT		
SAMPLE LABELS/COCs AGREE		
TEMPERATURE WITHIN SPECIFICATION _____C		
CORRECTED COPY ATTACHED		
PROBLEMS OR DISCREPANCIES		

REMARKS

SHIPMENT METHOD

CH2M HILL TRANSMITTAL

TO T.H.E. Laboratories
325 Interlocken Pkwy, Ste 205
Broomfield, CO 80021

FROM Karmen Klima
CH2M Hill
P.O. Box 22508
Denver, CO 80222

ATTN Ken Fucik

DATE 8/12/92

RE transfer of surface water samples for chronic toxicity testing.

PROJECT NUMBER DEN 30181.X1.03

WE ARE SENDING YOU

- ☐ ATTACHED
- ☐ UNDER SEPARATE COVER VIA
- ☐ SHOP DRAWINGS
- ☐ DOCUMENTS
- ☐ TRACINGS
- ☐ PRINTS
- ☐ SPECIFICATIONS
- ☐ CATALOGS
- ☐ COPY OF LETTER
- ☒ 12 - 1 gallon containers of surface water for Day 3 of the chronic tox. bioassays for Fish & Cerodaf

QUANTITY	DESCRIPTION
2	1 gallon containers of water: Sample #B103810CH: location #SED15292
2	1 gallon containers of water: Sample #B103808CH: location #SED15192
2	1 gallon containers of water: Sample #B103812CH: location #SED01392
2	1 gallon containers of water: sample #B103806CH location #SED02092
2	1 gallon containers of water: sample #B103802CH: location #SED02592
2	1 gallon containers of water: sample #B103804CH: location #SED00392

Steve Hope

IF MATERIAL RECEIVED IS NOT AS LISTED, PLEASE NOTIFY US AT ONCE

REMARKS

COPY TO

REV 1/87 FORM 6

T.H.E. LABORATORIES, INC.
325 Interlocken Parkway
Suite 205
Broomfield, Colorado 80021

SAMPLE RECEIPT FORM

Project Number 535192

Date/Initials 8/12/92 DD

SAMPLES WERE:

1. Shipped or (Hand Delivered)
   NOTES:

2. Airbill Present — Y N (NA)
   NOTES:

3. Ambient or (Chilled)
   NOTES:

	3802	3804	3806	3808	3810	3812
Temp	11.9	12.4	10.7	9.9	11.3	10.4
pH	8.0	8.3	8.2	10.4	10.4	10.1

radiation - no date

4. Cooler Received Broken/Leaking — Y (N)
   NOTES:

5. Sample Received Broken/Leaking (Improperly Sealed) — Y (N)
   NOTES:

6. Samples Properly Preserved — (Y) N
   NOTES:

7. Received Within Holding Times — (Y) N
   NOTES:

COC TAPE WAS:

1. Present on Outer Package — Y (N)

2. Unbroken on Outer Package — Y N

3. Present on Sample — (Y) ~~(N)~~ DD 8/12/92

4. Unbroken on Sample — (Y) N

COC RECORD WAS:

1. Present Upon Receipt of Sample — (Y) N

CONTR Cham Hill SAMPLERS Karmen [illegible]ma, Steve Hope. R. Shelvin PROJECT 1108[illegible]-00

SITE CONTACT/PHONE Dick Moss (303) 771-0900 LAB/LOCATION THE Laboratories

C-O-C NUMBER ~~THE003~~ KK THE0003

EG&G ROCKY FLATS, CHAIN OF CUSTODY

DATE/TIME		SAMPLE NUMBER	LOCATION	CONTAINER TYPE	NUMBER OF CONTAINERS	MEDIA SOIL(S) WATER (W)	FILTERED-F POT DISS-P	TURN AROUND RUSH-R	OUT OF SPEC REPORTS	COOLED TO 4 C	HCl	NAOH	HNO3	H2SO4		Chronic Tox	Bioassay	Sediment	~~Sed Dry~~ KK	Chronic
8/13/92	1240	B103809CH	SED15292	4L poly	2	S				✓									✓	
8/13/92	1155	B103807CH	SED15192	4L poly	2	S				✓									✓	
8/13/92	11:20	B103811CH	SED01392	4L poly	2	S				✓									✓	
8/13/92	16:10	B103805CH	SED02092	4L poly	2	S				✓									✓	
8/13/92	1405	B103801CH	SED02592	4L poly	2	S				✓									✓	
8/13/92	1515	B103803CH	SED00392	4L poly	2	S				✓									✓	
8/13/92	10:00	B103813CH	SEDREF92	4L poly	2	S				✓									✓	

BOTTLE CODES

PRESERVATIVE

RELINQUISHED BY	DATE/TIME		RECEIVED BY	DATE/TIME	
Steve Hope	8/13/92	1703	Don Darling	8/13/92	1703

LABORATORY USE ONLY	Y	N
PCKG REC'D/CUSTODY SEALS INTACT		
SAMPLE LABELS/COCs AGREE		
TEMPERATURE WITHIN SPECIFICATION _____C		
CORRECTED COPY ATTACHED		
PROBLEMS OR DISCREPANCIES		

REMARKS

SHIPMENT METHOD

CH2M HILL TRANSMITTAL

TO THE Laboratories

FROM Karmen Klima
CH2M Hill
P.O. Box 22505
Denver, Co 80222

ATTN Ken Fucik

DATE 8/13/92

RE Sediment Chronic Tox Bioassay

PROJECT NUMBER 110852-003

WE ARE SENDING YOU

- ☐ ATTACHED
- ☐ UNDER SEPARATE COVER VIA
- ☐ SHOP DRAWINGS
- ☐ DOCUMENTS
- ☐ TRACINGS
- ☐ PRINTS
- ☐ SPECIFICATIONS
- ☐ CATALOGS
- ☐ COPY OF LETTER
- ☒ Sediment Samples for Chronic Tox Bioassays

QUANTITY	DESCRIPTION
2	2 - 4 Liter containers of sediment; sample # B103809CH; Location = SED1529.2
2	2 - 4 Liter containers of sediment; sample # B103807CH; Location = SED1519.2
2	2 - 4 Liter containers of sediment; sample # B103811CH; Location = SED01392
2	2 - 4 Liter containers of sediment; sample # B103805CH; Location = ~~SED01392~~ SED02[illegible]
2	2 - 4 Liter containers of sediment; sample # B103801CH; Location = SED02592
2	2 - 4 Liter containers of sediment; sample # B103803CH; Location = SED0039.2
2	2 - 4 Liter containers of sediment; sample # B103813CH Location = SEDREF[illegible]

IF MATERIAL RECEIVED IS NOT AS LISTED, PLEASE NOTIFY US AT ONCE

REMARKS

COPY TO

REV 1/87 FORM 6

T.H.E. LABORATORIES, INC.
325 Interlocken Parkway
Suite 205
Broomfield, Colorado 80021

SAMPLE RECEIPT FORM

Project Number 535492

Date/Initials 8/13/92 DD

SAMPLES WERE:

1. Shipped or (Hand Delivered)
   NOTES: radiation - none detected

2. Airbill Present — Y N (NA)
   NOTES:

3. Ambient or (Chilled)
   NOTES:

	3801	3803	3805	3807	3809	3811	3813
Temp	19.9	21.9	24.2		18.9	18.0	19.6
pH	7.8	7.1	7.7		8.0	6.9	7.0

4. Cooler Received Broken/Leaking — Y (N)
   NOTES:

5. Sample Received Broken/Leaking (Improperly Sealed) — Y (N)
   NOTES:

6. Samples Properly Preserved — (Y) N
   NOTES:

7. Received Within Holding Times — (Y) N
   NOTES:

COC TAPE WAS:

1. Present on Outer Package — Y (N)
2. Unbroken on Outer Package — Y N
3. Present on Sample — (Y) N
4. Unbroken on Sample — (Y) N

COC RECORD WAS:

1. Present Upon Receipt of Sample — (Y) N

CONTRACTOR CH2M Hill SAMPLERS Karmen Klima, Steve Hope PROJECT # 110852-003

SITE CONTACT/PHONE Dick Moos (303) 771-0400 LAB/LOCATION T.H.E. Laboratories

C-O-C NUMBER ~~THE 004~~ THE0004

EG&G ROCKY FLATS, CHAIN OF CUSTODY

DATE/TIME		SAMPLE NUMBER	LOCATION	CONTAINER TYPE	NUMBER OF CONTAINERS	MEDIA SOIL(S) WATER (W)	FILTERED=F POT DISS=P	TURN AROUND RUSH=R	OUT OF SPEC REPORTS	COOLED TO 4 C	HCl	NAOH	HNO3	H2SO4	Chronic Tox	Bioassay	Day 5
8/14/92	0630	B103810CH	SED15292	1gallon poly	2	W				✓							✓
8/14/92	0620	B103808CH	SED15792	1gallon poly	2	W				✓							✓
8/14/92	0600	B103812CH	SED01392	1gallon poly	2	W				✓							✓
8/14/92	0845	B103806CH	SED02092	1gallon poly	2	W				✓							✓
8/14/92	0815	B103802CH	SED02592	1gallon poly	2	W				✓							✓
8/14/92	0730	B103804CH	SED00392	1gallon poly	2	W				✓							✓
~~S~~ KK																	

BOTTLE CODES

PRESERVATIVE

RELINQUISHED BY	DATE/TIME		RECEIVED BY	DATE/TIME	
Karmen Klima	8/13/92	0915	Michael Hyhmet	8/14/92 (mon 8/14)	0915

LABORATORY USE ONLY	Y	N
PCKG REC'D/CUSTODY SEALS INTACT		
SAMPLE LABELS/COCs AGREE		
TEMPERATURE WITHIN SPECIFICATION _____C		
CORRECTED COPY ATTACHED		
PROBLEMS OR DISCREPANCIES		

REMARKS

SHIPMENT METHOD

CH2M HILL TRANSMITTAL

TO THE Laboratories
325 Interlocken ste 205
Broomfield CO 80021

FROM Karmen Klima
CH2M Hill
P.O. Box [illegible]
Denver, CO [illegible]

ATTN Ken Fuck

DATE

RE Samples for Day 5 of Chronic Tox. Bioassays

PROJECT NUMBER 110852-003 (DEN3015[illegible]

WE ARE SENDING YOU

- ☐ ATTACHED
- ☐ UNDER SEPARATE COVER VIA
- ☐ SHOP DRAWINGS
- ☐ DOCUMENTS
- ☐ TRACINGS
- ☐ PRINTS
- ☐ SPECIFICATIONS
- ☐ CATALOGS
- ☐ COPY OF LETTER
- ☒ Surface Water samples (2 gallons) for Chronic exposure bioassay

QUANTITY	DESCRIPTION
2	2-~~4 Liter~~ 1 Gallon containers of surface water: sample # B103810CH: location: SED15[illegible]
2	2-1 Gallon containers of surface water: sample # B103808CH: location SED15[illegible]
2	2-1 Gallon containers of surface water: sample # B103812CH: location SED[illegible]
2	2-1 Gallon containers of surface water: sample # B103806CH: location SED[illegible]
2	2-1 Gallon containers of surface water: sample # B103802CH: location SED[illegible]
2	2-1 Gallon containers of surface water: sample # B103804CH: location SED[illegible]
	Karmen Klima

IF MATERIAL RECEIVED IS NOT AS LISTED, PLEASE NOTIFY US AT ONCE

REMARKS

COPY TO

REV 1/87 FORM 6

T.H.E. LABORATORIES, INC.
325 Interlocken Parkway
Suite 205
Broomfield, Colorado 80021

SAMPLE RECEIPT FORM

Project Number 535192

Date/Initials 8/18/92 MOM

SAMPLES WERE:

1. Shipped or (Hand Delivered)
   NOTES:

2. Airbill Present (Y) N (NA)
   NOTES:

		pH	Temp
B103	B02 CH	8.1	13.8
	B04	8.2	13.2
	B0C	8.1	15.4
	B08	10.4	10.6
	B10	10.5	11.8
	B12	10.0	10.4

3. Ambient or (Chilled)
   NOTES:

4. Cooler Received Broken/Leaking Y (N)
   NOTES:

5. Sample Received Broken/Leaking (Improperly Sealed) Y (N)
   NOTES:

6. Samples Properly Preserved Y (N) 10.4 - 15.4°C collected earlier in the morning
   NOTES:

7. Received Within Holding Times (Y) N
   NOTES:

COC TAPE WAS:

1. Present on Outer Package Y (N)

2. Unbroken on Outer Package Y N

3. Present on Sample (Y) N

4. Unbroken on Sample (Y) N

COC RECORD WAS:

1. Present Upon Receipt of Sample (Y) N

Appendix 2. Amphipod Data Sheets

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Stam 8-21-92
9-17-92

Sample	Sample #	Location	Rep #1	Rep #2	Rep #3	Rep #4
A	B103801CH	SED02592	400.04	400.07	400.01	400.03
B	B103803 CH	SED 00392	400.09	400.04	400.02	400.00
C	B103805 CH	SED 02092	400.00	400.01	400.00	400.01
D	B103807 CH	SED 15192	400.02	400.02	399.59	399.19
E	B103809 CH	SED 15292	400.01	400.00	400.00	400.00
F	B103811 CH	SED 01392	400.00	400.00	400.00	400.00
G	B103813 CH	SED RGF92	400.00	400.00	400.00	400.00
H	Sand	Sand	400.09	400.02	400.01	400.03

400 grams sediment and 1000 ml Recon mixed and run thru #14 mesh screen set over night.

A - clayey soil, about a dozen chironomids sifted out of the 4 samples

B - sandy clay soil, chironomids present

C - sandy soil, not ~~many~~ any bugs present

D - Highly organic soil - snail shells, ~~chironomids~~ chironomids present, plant debris prevalent

E - similar to D, snail present

F - similar to E

G Reference sample - highly organic

H - Sand - washed once - no organisms present

DAY 4: G1 - 2 dead; saw 2 alive
G2 - 5 dead; saw 2 alive
H3 - 1 dead
H4 - 1 dead | pair mating
F2 - 1 dead
C1 - 1 skin (shell)
A1 - 1 skin
D3 - 1 dead

DAY 5: G2 - 2 dead (1 floating)
F2 - 1 skin
C4 - 1 dead (floating)
C1 - 1 skin
B4 - 2 skins

Day 6 C-1 - 1 dead
G-1 ~~G-2 dead~~ now 9/24 3 dead +1 dead
G-4 - 2 dead +1 dead
G-2 - 1 dead
E-4 - 1 shell, 1 dead
E-2 - 1 dead
F-4 - 1 shell
B-3 - 1 shell
B4 - 1 dead, 1 shell
B1 - 1 dead
D1 - 1 dead

Day 7 F4 - 1 shell
H1 - 1 shell
H3 - 1 shell
G1 - 1 shell
G3 - 1 skin
C4 - 1 dead
G-4 - 1 shell
C3 - 1 pair mating
C1 - 1 pair mating

DAY 7: B1 - 1 skin and 1 in process of dropping its skin
B2 - 1 dead
B4 - 1 dead
B3 - 1 dead

DAY 8: F3 - 1 skin
F4 - 1 skin
H-1 - 1 shell
E3 - 1 skin
H3 - 1 skin
G3 - 1 dead; 1 skin
C1 - 6 shells 1 dead
C2 - 2 shells
C3 - 3 shells; 1 pr mating

DAY 9: E2 - 2 skins
F4 - 2 skins
F1 - 1 shell
F2 - 3 skins
H4 - 1 dead; 1 pair mating; 1 skin
G3 - 3 skins
C4 - 1 skin
C3 - 4 skins; pair mating
A3 - 2 skins
A4 - 1 skin
D4 - 2 skins
C1 - 1 molt
A2 - 1 shell
B1 - 1 dead
B2 - 2 dead; 3 skins
B3 - 1 skin

DAY 10: E1 - 2 shells
E2 - 1 shell
F2 - 1 shell
F1 - 1 shell
H2 - 1 shell
H3 - 1 dead, 1 shell
C1 - 1 shell
C4 - 2 shells
A2 - 3 shells
G1 - 2 shells
G2 - 1 shell
D1 - 2 shells
D4 - 1 shell
B1 - 3 shells
B3 - 2 shells

DAY 11: F1 - 1 skin
F3 - 1 skin
F2 - 2 skins
E2 - 1 skin
F4 - 2 skins
H4 - 1 skin
E4 - 2 skins
H3 - 1 dead; 2 skins; 1 pair mating
G3 - 1 skin
H1 - 2 skins
H2 - 2 skins
~~H3 - 2 skins~~ DD 8/31/92
G4 - 4 skins
G1 - 2 skins
C1 - 1 skin; 1 pair mating
C4 - 2 skins
C3 - 4 skins, 1 pair mating
C2 - 3 skins
A4 - 1 dead; 1 skin
B2 - 1 skin
D4 - 2 skins
B1 - 2 skins
A1 - 2 skins

DAY 12: F3 - 1 skin
F2 - 1 skin
E4 - 2 skins
H4 - 1 skin
H2 - 1 skin
H3 - 3 skins
G2 - 1 skin
G3 - 1 skin
G1 - 3 skins
G4 - 3 skins
C1 - 1 skin
C2 - 1 skin; 1 pair mating
C3 - 2 skins; 1 pair mating
C4 - 2 skins
A1 - 1 skin
B1 - 3 skins
B2 - 1 dead
B3 - 2 skins

(cont) pg 5

DAY 13

F2 1 shell
F3 - 1 shell
E3 - 2 shells
E4 - 1 shell, 1 pr mating
H1 - 2 shells
H2 - 1 shell
G1 - 1 shell
G4 - 7 shells
G2 - 1 shell
G3 - 1 shell

C2 - 1 pair mating, 1 shell
A2 - 1 shell
A4 - 1 shell
D1 - 2 shells
B2 - 1 shell
B4 - 2 shells

DAY 14

E4 - 1 shell
E3 - 3 shells
H1 - 1 shell
H2 - 1 pair mating
C3 - 1 pair mating
C1 - 1 pair mating, 2 shells
~~C4 - 1 shell~~ and D3
G4 - 1 dead, 1 pr mating

C3 - 2 shells
B1 - 1 shell

DAY 15

F1 - 1 shell
F4 - 1 shell
F2 - 1 shell
G1 - 1 shell
G2 - 1 shell
G3 - 1 shell
C2 - 1 shell
C4 - 1 shell
C2 - 1 pr mating

E1 - 1 shell
E2 - 1 shell
H4 - 1 shell
H3 - 1 shell
H2 - 2 shells
A4 - 3 shells
B3 - 1 shell
D4 - 1 shell

Day 16

E-2 Mating pair
C - all many eccentrics present
G-3 2 shells
G-4 1 shell

Day 17

F1 - 1 shell
F3 - 2 shells
E2 - 1 shell
G1 - 1 shell, 1 pr mating
G2 - 1 shell
G4 - 1 shell, 1 pr mating
H1 - 2 shells
H3, H1 - 1 shell
H2 - 2 shells

C2 - 2 shells 1 pr mating
C3 - 1 shell
A4 - 1 shell
B1 - 1 shell
B3 - 2 shells
D3 - 1 shell

E4 - 1 shell
H2 - 1 pair mating
C4 - 1 pair mating

DAY 19

F4 - 1 shell
E2 - 1 shell
E4 - 4 shells
E3 - 1 shell
B3 - 2 shells
B2 - 1 shell
D1 - 1 shell
D4 - 1 pair mating; 1 shell
G1 - 1 shell
G4 - 2 pairs mating; 7 shells
G3 - 3 shells
G2 - 1 shell
C4 - 1 pair mating
H1 - 1 " " 2 shells
H3 - 1 " " 1 "
H2 - 1 " " 2 "

Day 20

H-1 1 shell
H-3 1 shell

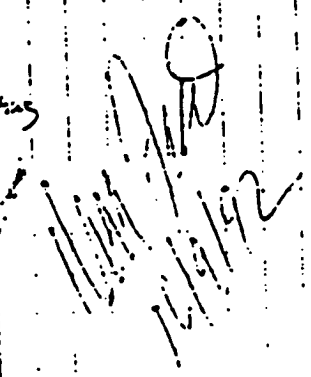
Day 21

D-4 Mating pair
E-4 Mating pair
E-3 1 shell
G-3 1 shell
C-1 Mating Pair
C-2 2 shell
C-3 2 mating pairs
C-4 2 Mating Pair
H3 1 pair mating; 1 shell
H4 2 pair mating
H2 2 pair mating

Day 22

E4 - 1 pr mating
B4 1 shell
B-1 1 mating pair
B-2 1 " " 1 shell
H1 1 " "
H4 1 " "
H-3 1 " "

G-1 - much mating



D1 - 1 floater
D2 - 1 shell, 1 pr mating
E1 - 1 pr mating
E3 3 shells
E2 - 2 shells
E4 - 2 pr mating, 1 shell
B1 - 1 shell
B2 - 1 shell
B3 - 1 shell, 1 pr mating
C1 - 1 shell, 2 pr mating
C4 - 1 shell
C3 - 1 pr mating
A4 - 1 pr mating
H1 - 2 shells
H2 - 2 shells
H4 - 5 shells
H3 - 1 shell, 1 pr mating
G1 - 2 pr mating
G2 - 2 shells
G3 3 shells
G4 - 1 shell
F1 - 1 shell
F2 - 1 shell
F4 - 1 shell

DAY 24
E1 - 2 shells
E2 - 4 shells
D2 - 1 shell
B2 - 1 shell
C1 - 2 shells
H3 - 1 shell
H4 - 1 shell
H2 - 1 pr mating
G1 - 2 shells
G2 - 1 shell

DAY 25
E1 - 3 shells
E3 1 dead, 1 shell
E4 - 1 pr mating
D4 - 4 shells, 1 floater (alive)
D2 - 1 shell
B3 - very active
B1 - 1 shell
B3 - 1 pr mating
H1 - 1 shell
H2 - 1 shell
E1 - 2 shells
E2 - 2 shells
D1 - 1 floater (dead)
D4 - 1 shell
B-3 - 2 shells
H1 - 1 floater (alive)
G1 - 2 shells, 1 pr mating
C-1 - 1 shell 3 mating pr
F4 - 2 shells
G-3 1 shell
G-4 1 mating pair

DAY 27
E1 - 1 pr mating
E4 - 1 shell
E2 - 1 floater (dead), 1 shell
D4 - 1 shell
B1 - 2 shells
B4 - 1 shell
B3 - 1 shell
C1 - 2 pr mating
C3 - 1 dead, 1 pr mating
C1-C4 - all showed much activity
H1 - 1 shell, 1 floater (alive)
H3 - 1 shell
H4 - 1 pr mating
A1-A4 - too cloudy to see anything
G4 - 1 pr mating
F1 - 1 shell
F2 - 1 shell
F4 - 1 shell
H4 - 1 shell
A4 - 1 shell
C1 - 2 shells 1 pr mating
C4 - 2 pr mating
C1-4 - all showed much activity
F2 - 1 shell
F3, F4 - 1 shell
G1 - 1 shell
G4 - 1 floater (alive)
G2 - 1 shell
E1 - 1 shell, 1 pr mating
E3 - 1 shell
D2 - 1 pr mating
B4 - 1 shell
C1 - 1 pr mating
C4 - 1 pr mating
H1 - 2 shell
A1-A4 - too cloudy to see
G1 - 1 floater Alive
G-4 - 2 shells
D2-3 shells
G3 - 1 shell
H2 - 1 shell
H3 - 1 shell

	1	2	3	4	FED 5	6	7	FED 8	9	FED 10	11	FED 12	13	FI
TEMP		20.3/20.7												
A	20.6	22.5/20.6	20.0	20.1 20.5	20.1	20.1 20.4	19.7	20.5 20.9	20.9	21.0 20.4	21.0	21.0 20.3	21.0	20.8
B	20.8	20.2/20.3	19.8	19.2 20.4	19.5	19.3 19.6	19.1	19.2 19.1	20.6	20.4 20.1	20.0	20.1 20.2	20.3	19.9
C	20.4	19.6/20.1	19.7	20.0 20.3	20.0	20.1 20.1	19.6	20.4 19.9	20.3	20.7 20.9	20.8	20.9 20.7	20.9	20.5
D	20.6	19.9/20.1	20.0	19.9 20.6	19.7	20.3 20.3	19.8	20.1 19.8	20.7	21.0 20.5	21.0	20.9 20.7	21.1	20.8
E	19.7	19.8/20.1	19.8	19.6 20.0	19.7	19.9 20.3	19.5	19.5 19.4	20.4	20.0 20.4	20.7	20.9 20.4	20.5	20.6
F	20.9	20.7/20.8	20.8	20.2 20.2	20.1	20.7 20.8	19.6	19.5 19.5	20.4	20.7 20.4	20.7	20.9 20.5	20.6	21.2
G	19.6	20.9/20.8	20.9	19.9 20.6	20.2	20.3 20.3	20.0	20.2 19.9	20.9	20.9 20.1	20.6	21.0 20.6	20.6	20.6
H	19.3	20.5/20.2	20.9	19.6 20.3	19.7	19.9 20.4	19.7	19.9 19.6	20.9	20.4 20.3	20.6	20.3 20.1	20.5	20.6
DO		4.4/5.8												
A	4.7	6.4/7.1	4.6	3.9 5.6	4.5	4.3 5.5	4.8	4.8 6.0	4.1	4.9 6.3	4.4	4.1 5.4	4.0	4.0
B	4.3	3.9/5.6	3.8*	6.4 6.5	6.6	6.4 6.7	5.4	6.7 7.0	6.4	6.8 7.0	6.5	6.4 6.5	5.8	5.9
C	5.9	5.6/6.4	5.3	5.4 6.1	5.8	5.4 6.2	5.8	6.0 6.7	5.4	6.7 7.1	5.4	5.1 6.2	5.1	4.8
D	3.8*	6.7/6.9	3.8*	6.0 6.3	6.4	5.6 6.3	5.0	6.9 7.2	6.7	6.7 7.2	6.4	5.7 6.4	6.0	5.8
E	4.2	3.9/5.2	4.2	4.3 5.4	4.3	3.8 6.1	4.4	4.3 5.5	4.4	4.3 6.0	3.9	3.3 5.2	4.1	3.8
F	4.2	3.8/5.3	3.7*	6.4 6.6	6.5	5.9 6.5	4.6	6.6 6.8	6.0	6.8 7.3	4.9	5.9 6.3	6.0	5.3
G	4.5	3.8/5.4	3.3*	6.3 6.5	6.0	5.6 6.2	6.4	6.6 6.9	6.5	6.0 6.9	4.0	6.2 6.4	5.8	5.6
H	7.1	6.6/7.1	6.4	5.9 6.5	6.2	5.8 6.3	6.0	6.0 6.5	5.4	16.0 7.0	4.9	4.9 6.1	5.2	5.2
pH		7.6/7.9												
A	7.6	8.4/8.5	7.6	7.5 7.8	7.6	7.5 7.8	7.7	7.6 7.9	7.5	7.5 7.7	7.6	7.5 7.8	7.5	7.6
B	7.6	7.5/7.8	7.5	8.1 8.2	8.0	8.0 8.2	7.9	8.1 8.3	8.1	8.1 8.2	8.2	8.1 8.2	8.0	8.1
C	7.9	7.8/8.1	7.8	7.7 7.9	7.8	7.6 7.9	7.7	7.7 8.0	7.7	7.6 7.8	7.6	7.4 7.7	7.3	7.6
D	7.5	8.1/8.3	7.6	8.1 8.2	8.1	7.9 8.1	8.0	8.1 8.3	8.1	8.1 8.2	8.1	8.0 8.1	8.0	8.2
E	7.7	7.7/7.9	7.7	7.5 7.8	7.6	7.5 7.7	7.7	7.7 7.9	7.7	7.5 7.8	7.6	7.6 7.9	7.7	7.7
F	7.3	7.3/7.5	7.4	8.3 8.3	8.2	8.2 8.3	8.1	8.3 8.3	8.3	8.3 8.3	8.1	8.2 8.3	8.1	8.2
G	7.1	7.2/7.4	7.3	8.4 8.4	8.5	8.6 8.6	8.4	8.4 8.4	8.3	8.3 8.3	8.1	8.3 8.3	8.0	8.2
H	8.3	8.1/8.3	7.9	7.8 8.0	7.8	7.7 7.9	7.8	7.8 8.0	7.6	7.6 7.8	7.5	7.4 7.8	7.5	7.6
Conduct		/651												
A	621	/665		673 649	664	691 668	675	705 670	705	679 642	698	719 663	678	715
B	650	/636		655 647	659	662 652	692	731 688	738	737 643	687	709 657	681	729
C	570	/582		623 620	644	647 643	642	653 646	646	652 632	655	655 631	639	667
D	563	/621		667 651	683	659 648	701	715 677	741	720 651	701	738 672	697	761
E	560	/612		615 622	642	674 661	648	670 675	708	692 635	717	718 659	668	720
F	631	/610		643 645	668	692 672	689	703 678	762	739 663	758	764 695	748	806
G	576	/542		591 609	663	671 658	711	746 717	789	777 688	803	830 679	741	783
H	660	/665		646 637	641	673 664	643	638 669	691	649 630	675	674 645	633	656

* D on air beginning 8/21 off 8/22 mon
1 dead floater H4 8/22 MON
1 dead picked from sed. E2, C1 8/22/MON
water change consisted of removing approximately 4 gallons water 8/22 mon
Fed 15-20 small flakes of Tetramin 8/22 mon
* B, D, F, G aerated beginning 8/23 MON
** E aerated beginning 9-4-92 MON

after 8/22 fed every other

A	21.0	20.0	19.7	20.1	20.0	19.8	19.8	20.0	19.8	19.8	20.0	20.2	20.0	20.2	20.0	20.0	20.2	20.0	19.9	
B	20.6	19.7	19.6	19.1	20.0	19.8	20.0	20.0	20.2	19.3	19.2	19.9	19.9	20.0	20.0	19.9	19.8	19.3	19.8	
C	20.7	19.8	19.5	19.9	20.1	19.9	20.0	20.0	19.8	19.8	20.2	20.0	19.8	20.2	20.2	20.3	20.2	20.2	19.9	19.8
D	20.8	20.5	19.6	20.6	20.7	20.5	20.2	20.2	20.0	20.1	19.7	19.6	20.1	20.0	20.2	20.2	20.1	20.0	20.0	19.9
E	20.8	20.0	19.6	20.2	20.1	19.5	20.0	20.3	20.2	19.9	20.0	19.8	19.0	19.7	20.2	19.9	19.8	19.9	19.5	19.8
F	20.5	20.0	19.7	19.5	20.4	20.4	19.9	20.1	20.1	20.0	19.9	19.9	19.9	20.0	20.0	20.2	20.0	20.0	20.1	19.9
G	20.8	19.9	19.7	20.2	20.0	19.8	19.9	19.7	19.9	19.7	20.0	20.1	19.9	20.6	21.0	20.8	20.6	20.2	20.5	20.3
H	21.0	20.0	19.9	19.7	20.1	20.0	20.0	20.0	19.9	19.8	20.2	19.9	20.0	20.1	20.0	20.0	19.8	20.0	19.5	
A	3.9	4.0	4.1	9.2	4.7	5.0	4.9	4.6	4.8	4.2	4.6	4.5	4.2	4.4	5.4	4.1	4.0	4.7	4.3	4.2
B	6.5	6.5	6.5	7.1	6.0	6.6	5.9	6.8	7.1	6.7	6.7	6.6	5.2	6.0	6.9	6.2	6.6	6.7	6.4	5.8
C	4.5	5.1	4.6	4.8	4.8	4.4	4.6	5.6	5.8	4.0	4.5	4.7	4.2	4.7	5.9	4.4	4.2	5.4	4.5	4.5
D	6.0	6.4	6.4	6.4	6.2	5.6	5.0	4.4	4.9	5.5	5.3	5.3	5.9	5.8	6.5	5.8	6.3	6.4	5.9	5.7
E	3.6	4.7	4.8	5.4	6.2	6.5	5.7	5.8	6.6	5.9	5.1	5.5	5.6	5.5	6.6	5.9	5.4	5.9	4.5	5.5
F	6.9	6.5	6.6	6.2	5.6	6.4	5.8	6.7	6.4	6.0	6.7	6.6	6.6	5.3	5.9	6.2	5.0	6.3	6.4	6.3
G	6.8	6.5	6.4	6.4	6.2	6.1	5.8	5.0	6.4	5.6	6.2	6.2	6.4	5.9	6.1	6.0	6.0	6.1	5.7	5.7
H	5.5	5.4	6.1	6.0	5.9	6.1	5.0	6.0	6.4	5.1	5.0	6.3	5.0	6.5	5.8	4.9	5.1	5.6	4.7	4.9
A	7.8	7.6	7.7	7.6	7.6	7.7	7.6	7.6	7.6	7.7	7.7	7.7	7.6	7.6	7.8	7.7	7.5	7.6	7.1	7.7
B	8.2	8.2	8.2	8.3	8.3	8.3	8.1	8.3	8.4	8.4	8.4	8.3	8.0	8.3	8.4	8.3	8.3	8.3	8.3	8.2
C	7.7	7.6	7.6	7.6	7.5	7.6	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.7	7.6	7.3	7.5	7.5	7.6
D	8.3	8.1	8.6	8.5	8.5	8.4	8.4	8.5	8.4	8.6	8.5	8.4	8.5	8.5	8.4	8.5	8.4	8.4	8.4	8.5
E	7.8	8.5	8.3	8.5	8.6	8.6	8.5	8.6	8.5	8.6	8.4	8.4	8.6	8.6	8.6	8.5	8.5	8.5	8.3	8.5
F	8.3	8.3	8.3	8.1	8.2	8.3	8.2	8.3	8.3	8.3	8.4	8.3	8.4	8.1	8.2	8.2	8.0	8.2	8.3	8.3
G	8.2	8.5	8.3	8.1	8.2	8.2	8.1	8.1	8.3	8.2	8.3	8.3	8.3	8.2	8.3	8.2	8.1	8.1	8.2	8.1
H	7.7	7.7	7.1	7.6	7.6	7.7	7.4	7.5	7.6	7.4	7.6	7.6	7.5	7.4	7.6	7.5	7.3	7.4	7.6	7.6
A	665	692	633	689	717	683	677	678	657	676	685	660	651	643	623	664	677	661	708	706
B	679	641	631	695	733	678	693	709	679	658	673	657	653	638	621	662	674	657	708	751
C	634	604	577	641	661	654	642	660	636	641	651	633	604	592	585	621	625	618	656	656
D	750	~~608~~	~~627~~	801	855	807	834	873	815	867	936	843	892	878	771	864	927	831	912	957
E	698	693	647	753	817	751	798	856	727	795	896	842	853	876	721	837	890	823	949	965
F	795	793	697	786	780	717	775	746	694	746	761	725	749	793	691	746	764	742	771	778
G	735	721	696	736	821	735	747	795	801	819	846	788	738	740	697	732	747	713	770	783
H	630	589	575	625	649	634	630	628	609	612	668	605	587	585	576	602	607	605	638	635

day with 1 ml of dissolved rabbit chow (14 g rabbit pellets in 1 l.tr D.I.)
5 minutes in blender

A1	1.1217	1.1171	0.0046	18 + 1 young	0.26		
A2	1.1104	1.1063	0.0041	19	0.22	0.21	43%
A3	1.1132	1.1096	0.0036	20	0.18		
A4	1.1143	1.1110	0.0033	17 + 1 young	0.19		
	1.1234	1.1205	0.0029	17	0.17		
B2	1.1119	1.1099	0.0020	14	0.14	0.18	76%
B3	1.1339	1.1301	0.0038	16	0.24		
B4	1.1114	1.1089	0.0025	14	0.19		
C1	1.1122	1.1076	0.0046	20	0.23		
C2	1.1006	1.0991	0.0015	16 - determining, not preserved well	0.09	0.16	73%
C3	1.1097	1.1067	0.0030	20	0.15		
C4	1.1157	1.1125	0.0032	18 + 1 young	0.18		
D1	1.1148	1.1099	0.0049	18	0.27		
D2	1.1086	1.1048	0.0038	18	0.21	0.23	91%
D3	1.1075	1.1038	0.0037	17	0.22		
D4	1.1154	1.1109	0.0045	20 + 1 young	0.23		
E1	1.0978	1.0954	0.0024	18 - determining, not preserved well	0.13		
E2	1.1016	1.0971	0.0045	18	0.25	0.23	94%
E3	1.1059	1.1008	0.0051	19	0.27		
E4	1.1096	1.1042	0.0054	20	0.27		
F1	1.1106	1.1067	0.0039	17	0.23		
F2	1.1088	1.1045	0.0043	20 + 1 young	0.22	0.21	96%
F3	1.1047	1.1018	0.0029	20 + 4 young	0.15		
F4	1.1078	1.1032	0.0046	20	0.23		
G1	1.1153	1.1098	0.0055	14	0.39		
2	1.1004	1.0980	0.0024	12	0.20	0.30	81%
G3	1.1107	1.1050	0.0057	19	0.30		
G4	1.1198	1.1141	0.0057	20	0.29		
H1	1.1194	1.1138	0.0056	19	0.29		
H2	1.1060	1.1004	0.0056	19 + 1 young	0.29	0.30	
H3	1.1141	1.1092	0.0049	16	0.31		55%
H4	1.1196	1.1154	0.0042	14 + 4 young	0.30		
Pretest	1.0919	1.0891	0.0028	20	0.14		

Oven Temp 208°F

test sediments samples were preserved in 70% isopropyl alcohol until all sediments could be sifted through. Hyalella were dried in oven for two hours, then weighed.

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rocky flats sediments
File: rocky.000 Transform: NO TRANSFORMATION

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	sand	4	0.290	0.310	0.298
2	sedref92	4	0.200	0.390	0.295
3	sed01392	4	0.150	0.230	0.208
4	sed15292	4	0.130	0.270	0.230
5	sed15192	4	0.210	0.270	0.233
6	sed02092	4	0.090	0.230	0.163
7	sed00392	4	0.140	0.240	0.183
8	sed02592	4	0.180	0.260	0.213

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORMATION

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
	sand	0.000	0.010	0.005
	sedref92	0.006	0.078	0.039
3	sed01392	0.001	0.039	0.019
4	sed15292	0.005	0.067	0.034
5	sed15192	0.001	0.026	0.013
6	sed02092	0.003	0.059	0.029
7	sed00392	0.002	0.042	0.021
8	sed02592	0.001	0.036	0.018

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORMATION

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	7	0.065	0.009	4.500
Within (Error)	24	0.058	0.002	
Total	31	0.123		

Critical F value = 2.42 (0.05,7,24)
Since F > Critical F REJECT Ho:All groups equal

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	sand	4	14.000	19.000	17.000
2	sedref92	4	12.000	20.000	16.250
3	sed01392	4	17.000	20.000	19.250
4	sed15292	4	18.000	20.000	18.750
5	sed15192	4	17.000	20.000	18.250
6	sed02092	4	16.000	20.000	18.500
7	sed00392	4	14.000	17.000	15.250
8	sed02592	4	17.000	20.000	18.500

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORM

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

	IDENTIFICATION	VARIANCE	SD	SEM
1	sand	6.000	2.449	1.225
2	sedref92	14.917	3.862	1.931
3	sed01392	2.250	1.500	0.750
4	sed15292	0.917	0.957	0.479
5	sed15192	1.583	1.258	0.629
6	sed02092	3.667	1.915	0.957
7	sed00392	2.250	1.500	0.750
8	sed02592	1.667	1.291	0.645

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORM

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	7	54.719	7.817	1.881
Within (Error)	24	99.750	4.156	
Total	31	154.469		

Critical F value = 2.42 (0.05,7,24)

Since F < Critical F FAIL TO REJECT Ho:All groups equal

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	sand	17.000	17.000		
2	sedref92	16.250	16.250	0.520	
3	sed01392	19.250	19.250	-1.561	
4	sed15292	18.750	18.750	-1.214	
5	sed15192	18.250	18.250	-0.867	
6	sed02092	18.500	18.500	-1.041	
7	sed00392	15.250	15.250	1.214	
8	sed02592	18.500	18.500	-1.041	

Dunnett table value = 2.48 (1 Tailed Value, P=0.05, df=24,7)

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORM

DUNNETTS TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	sand	4			
2	sedref92	4	3.575	21.0	0.750
3	sed01392	4	3.575	21.0	-2.250
4	sed15292	4	3.575	21.0	-1.750
5	sed15192	4	3.575	21.0	-1.250
6	sed02092	4	3.575	21.0	-1.500
7	sed00392	4	3.575	21.0	1.750
8	sed02592	4	3.575	21.0	-1.500

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORMATION

DUNNETTS TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	sand	0.298	0.298		
2	sedref92	0.295	0.295	0.079	
3	sed01392	0.208	0.208	2.846	*
4	sed15292	0.230	0.230	2.135	
5	sed15192	0.233	0.233	2.055	
6	sed02092	0.163	0.163	4.269	*
7	sed00392	0.183	0.183	3.637	*
8	sed02592	0.213	0.213	2.688	*

Dunnett table value = 2.48 (1 Tailed Value, P=0.05, df=24,7)

rocky flats sediments
File: rocky.000 Transform: NO TRANSFORMATION

DUNNETTS TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	sand	4			
2	sedref92	4	0.078	26.4	0.003
3	sed01392	4	0.078	26.4	0.090
4	sed15292	4	0.078	26.4	0.068
5	sed15192	4	0.078	26.4	0.065
6	sed02092	4	0.078	26.4	0.135
7	sed00392	4	0.078	26.4	0.115
8	sed02592	4	0.078	26.4	0.085

Appendix 3. Fathead Minnow Data Summary Sheets

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COLORADO - CDPS WET TEST REPORT FORM - CHRONIC

① SED02592

PERMITTEE: Rocky Flats CDPS NO. CO-00 OUTFALL: B10 3502 C 14

TEST SPECIES: Fathead Minnows AGE: 4 days RECEIVING WATER USED FOR DILUTION? YES/(NO)

TEST RESULTS: CONTROL MORTALITY: 0 % CONTROL PERFORMANCE: ^ 20%

CONC. WITH STAT. SIG.: MORTALITY: None % REPRODUCTION N/A % GROWTH None %

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	1300 AM/(PM) 8/10/92	BEGINNING	1615 AM/(PM) 8/10/92
NO. 2	1600 AM/(PM) 8/12/92	ENDING	1405 AM/(PM) 8/17/92
NO. 3	0815 (AM)/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED? YES/(NO)	

DILUTIONS (% EFFLUENT)

MEASUREMENTS		CONTROL(0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY:	1	100	100	100	100	100	100
	2	100	100	100	100	100	98
	3	100	100	100	100	100	95
	4	100	100	98	100	100	95
	5	100	100	98	100	100	95
	6	100	100	98	100	100	95
	7	100	100	98	100	100	95
MEAN 3 BROOD TOTAL:		NA	NA	NA	NA	NA	NA
7 DAY MEAN DRY WEIGHT:		0.29	0.36	0.37	0.36	0.33	0.32 mg
D.O., MG/L	MAX/MIN:	6.7/4.0	6.8/4.1	6.4/4.0	6.5/3.8	6.5/3.9	6.5/3.5
TEMP °C	MAX/MIN:	25.2/24.1	25.4/24.0	25.2/24.1	25.2/24.1	25.2/24.1	25.2/24.1
PH	MAX/MIN:	8.4/7.7	8.1/7.5	8.2/7.5	8.3/7.6	8.3/7.6	8.4/7.7

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 91 RECON/LAB WATER: 187

SALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 60 RECON/LAB WATER: 111

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/(NO)

LABORATORY: T.H.E. LABORATORIES, INC. ANALYST: Dan Fak 1/1/91

Fred 10/5/92

COLORADO - CDPS WET TEST REPORT FORM - CHRONIC

(2) SED 00392

PERMITTEE: Rocky Flats CDPS NO. CO-00 OUTFALL: B103504CH

TEST SPECIES: Fathead Minnows AGE: 4 days RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: 10 % CONTROL PERFORMANCE: 0.90

CONC. WITH STAT. SIG.: MORTALITY: NA % REPRODUCTION NA % GROWTH NA %

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE	
NO. 1	1330 AM/PM	8/10/92	BEGINNING 1625 AM/PM	8/10/92
NO. 2	1630 AM/PM	8/12/92	ENDING 1420 AM/PM	8/17/92
NO. 3	0730 AM/PM	8/14/92	SPECIAL CONDITION: SAMPLE AERATED? YES/NO	

DILUTIONS (% EFFLUENT)

MEASUREMENTS		CONTROL(0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY:	1	100	100	100	100	100	100
	2	100	100	100	100	100	100
	3	100	100	100	100	100	100
	4	100	100	100	100	100	100
	5	100	100	100	100	100	100
	6	100	100	100	100	100	100
	7	100	98	100	100	100	100
MEAN 3 BROOD TOTAL:		NA	NA	NA	NA	NA	NA
7 DAY MEAN DRY WEIGHT:		0.30	0.39	0.32	0.31	0.31	0.32 mg
D.O., MG/L	MAX/MIN:	6.9/4.6	6.7/3.8	6.5/3.9	6.7/4.0	6.7/4.1	6.8/4.2
TEMP °C	MAX/MIN:	25.4/24.1	25.2/24.2	25.2/24.0	25.3/24.0	25.3/24.0	25.4/24.0
PH	MAX/MIN:	8.4/7.9	8.4/8.1	8.4/8.2	8.4/7.9	8.4/7.8	8.3/7.7

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 202 RECON/LAB WATER: 187

SALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 218 RECON/LAB WATER: 111

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: T.H.E. LABORATORIES, INC. ANALYST: Dan Fak 1/1/91

10/8/92

SED02092

COLORADO - CDPS WET TEST REPORT FORM - CHRONIC

PERMITTEE: Rocky Flats CDPS NO. CO-00 _____ OUTFALL: (3) B10380611

TEST SPECIES: Fathead Minnows AGE: 4 days RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: 0 % CONTROL PERFORMANCE: OK

CONC. WITH STAT. SIG.: MORTALITY: None % REPRODUCTION 1.14 % GROWTH None %

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	1120 AM/PM 8/10/92	BEGINNING	1635 AM/PM 8/10/92
NO. 2	1520 AM/PM 8/12/92	ENDING	1430 AM/PM 8/17/92
NO. 3	0845 AM/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED?	YES/NO

DILUTIONS (% EFFLUENT)

MEASUREMENTS	CONTROL (0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY: 1	100	100	100	100	100	100
2	100	100	100	100	100	100
3	100	100	100	100	100	100
4	100	100	98	100	100	100
5	100	98	98	100	100	100
6	100	98	98	100	100	100
7	100	98	98	100	98	98
MEAN 3 BROOD TOTAL:	NA	NA	NA	NA	NA	NA
7 DAY MEAN DRY WEIGHT:	0.32	0.45	0.48	0.43	0.38	0.31
D.O., MG/L MAX/MIN:	6.8 / 4.8	6.2 / 3.8	6.3 / 4.0	6.3 / 3.8	6.5 / 4.0	6.6 / 3.9
TEMP °C MAX/MIN:	26.0 / 24.1	26.0 / 24.1	26.0 / 24.1	26.0 / 24.0	26.0 / 24.2	26.0 / 24.1
PH MAX/MIN:	8.4 / 8.0	8.4 / 8.0	8.4 / 8.0	8.3 / 7.9	8.3 / 7.8	8.3 / 7.8

HARDNESS (x̄) MG/L RECEIVING WATER: NA EFFLUENT: 217 RECON/LAB WATER: 187

ALKALINITY (x̄) MG/L RECEIVING WATER: NA EFFLUENT: 188 RECON/LAB WATER: 111

T. AMMONIA as N (x̄) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: T.H.E. LABORATORIES, INC. ANALYST: Dan Fink 11/1/91

10/6/92

COLORADO - CDPS WET TEST REPORT FORM - CHRONIC

@ SED 15192

PERMITTEE: Rocky Flats CDPS NO. CO-00 OUTFALL: B103/108CH

TEST SPECIES: Fathead Minnows AGE: 4 days RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: 5 % CONTROL PERFORMANCE: 0.23

CONC. WITH STAT. SIG.: MORTALITY: None % REPRODUCTION NA % GROWTH None %

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE	
NO. 1	0955 AM/PM	8/10/92	BEGINNING 1320 AM/PM	8/11/92
NO. 2	1330 AM/PM	8/12/92	ENDING 1340 AM/PM	8/18/92
NO. 3	0620 AM/PM	8/14/92	SPECIAL CONDITION: SAMPLE AERATED? YES/NO	

DILUTIONS (% EFFLUENT)

MEASUREMENTS	CONTROL(0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY: 1	100	98	100	100	100	100
2	100	98	98	100	100	100
3	100	98	98	100	100	100
4	100	95	98	100	98	98
5	100	93	98	98	98	98
6	100	93	98	98	98	98
7	95	93	95	98	98	95
MEAN 3 BROOD TOTAL:	NA	NA	NA	NA	NA	NA
7 DAY MEAN DRY WEIGHT:	0.23	0.31	0.30	0.29	0.29	0.26
D.O., MG/L MAX/MIN:	7.2/4.4	7.0/4.8	7.0/4.6	7.0/4.2	7.0/4.7	7.1/4.5
TEMP °C MAX/MIN:	25.8/24.0	26.0/24.0	25.7/24.0	25.5/24.1	25.5/24.1	25.8/24.1
PH MAX/MIN:	8.4/7.9	8.1/7.6	8.2/7.8	8.3/7.8	8.3/8.0	8.4/8.0

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 68 RECON/LAB WATER: 187

SALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 57 RECON/LAB WATER: 111

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: T.H.E. LABORATORIES, INC. ANALYST: Dan Fink 1/1/91

pH adjusted from 10.7 to 8.0

10/8/92

COLORADO - CDPS WET TEST REPORT FORM - CHRONIC

(5) SED 15292

PERMITTEE: Rocky Flats CDPS NO. CO-00_____ OUTFALL: B10381004

TEST SPECIES: Fathead Minnows AGE: 4 days RECEIVING WATER USED FOR DILUTION? YES/(NO)

TEST RESULTS: CONTROL MORTALITY: < 5 % CONTROL PERFORMANCE: 1.25

CONC. WITH STAT. SIG.: MORTALITY: 100 % REPRODUCTION N/A % GROWTH 100 %

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	1015 (AM)/PM 8/10/92	BEGINNING	1255 AM/(PM) 8/11/92
NO. 2	1255 AM/(PM) 8/12/92	ENDING	1350 AM/(PM) 8/18/92
NO. 3	0630 (AM)/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED?	YES/(NO)

MEASUREMENTS		DILUTIONS (% EFFLUENT)					
		CONTROL (0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY:	1	100	100	100	100	100	100
	2	100	100	100	100	100	100
	3	100	98	100	95	100	100
	4	100	95	100	95	100	100
	5	98	93	100	95	100	100
	6	95	93	100	93	100	100
	7	95	93	98	93	100	100
MEAN 3 BROOD TOTAL:		NA	NA	NA	NA	NA	NA
7 DAY MEAN DRY WEIGHT:		0.25	0.28	0.31	0.31	0.27	0.28 mg
D.O., MG/L	MAX/MIN:	7.2/4.2	7.0/3.8	7.0/3.8	7.0/4.0	7.1/4.3	7.1/4.1
TEMP °C	MAX/MIN:	25.2/24.2	25.5/24.0	25.2/24.1	25.1/24.0	25.1/24.0	25.2/24.0
PH	MAX/MIN:	8.4/7.8	7.9/7.3	8.1/7.4	8.2/7.6	8.3/7.7	8.3/7.7

HARDNESS (x̄) MG/L RECEIVING WATER: NA EFFLUENT: 62 RECON/LAB WATER: 187

ALKALINITY (x̄) MG/L RECEIVING WATER: NA EFFLUENT: 53 RECON/LAB WATER: 111

T. AMMONIA as N (x̄) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/(NO)

LABORATORY: T.H.E. LABORATORIES, INC. ANALYST: Dan Fink 11/1/91

pH adjusted from 10.6 to 7.6

Dan Fink 10/8/92

COLORADO - CDPS WET TEST REPORT FORM - CHRONIC

SED 01342

PERMITTEE: Rocky Flats CDPS NO. CO-00 OUTFALL: B1035120H

TEST SPECIES: Fathead Minnows AGE: 4 days RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: 5 % CONTROL PERFORMANCE: 0.35

CONC. WITH STAT. SIG.: MORTALITY: >100 % REPRODUCTION >100 % GROWTH >100 %

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	0930 AM/PM 8/10/92	BEGINNING	1340 AM/PM 8/11/92
NO. 2	1405 AM/PM 8/12/92	ENDING	1405 AM/PM 8/18/92
NO. 3	0600 AM/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED?	YES/NO

DILUTIONS (% EFFLUENT)

MEASUREMENTS		CONTROL(0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY:	1	100	100	100	98	98	100
	2	100	100	100	98	98	100
	3	100	100	98	98	95	98
	4	100	100	98	98	95	98
	5	100	100	98	95	95	98
	6	98	100	98	93	95	98
	7	95	100	98	90	95	95
MEAN 3 BROOD TOTAL:		NA	NA	NA	NA	NA	NA
7 DAY MEAN DRY WEIGHT:		0.35	0.30	0.33	0.33	0.32	0.34 mg
D.O., MG/L	MAX/MIN:	7.2 / 4.0	7.0 / 4.0	7.0 / 3.9	7.0 / 4.0	7.0 / 3.8	7.1 / 3.9
TEMP °C	MAX/MIN:	25.3 / 24.1	25.8 / 24.1	25.6 / 24.1	25.4 / 24.2	25.4 / 24.1	25.4 / 24.1
PH	MAX/MIN:	8.4 / 7.9	8.2 / 7.5	8.2 / 7.5	8.3 / 7.7	8.4 / 7.7	8.4 / 7.7

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 68 RECON/LAB WATER: 187

SALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 64 RECON/LAB WATER: 111

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: T.H.E. LABORATORIES, INC. ANALYST: Dan Fink 1/1/91

10/6/92

Appendix 4. *Ceriodaphnia Data Summary Sheets*

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PERMITTEE: Rocky Flats CH2M Hill CDPS NO. CO-00 OUTFALL: Bio 38120

TEST SPECIES: Ceriodaphnia AGE: <24hrs RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: 20 % CONTROL PERFORMANCE: 15

CONC. WITH STAT. SIG.: MORTALITY: N/A % REPRODUCTION N/A % GROWTH 1.91

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	9:30 AM/PM 8/10/92 *	BEGINNING	13:40 AM/PM 8/11/92
NO. 2	14:05 AM/PM 8/12/92 *	ENDING	13:40 AM/PM 8/18/92
NO. 3	06:00 AM/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED?	YES/NO

DILUTIONS (% EFFLUENT)

MEASUREMENTS	CONTROL(0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY: 1	100	100	100	100	100	100
2	100	90	100	100	100	100
3	100	90	100	100	100	100
4	90	90	100	100	100	100
5	90	90	100	100	90	100
6	90	90	100	100	~~50~~ 60	80
7	80	90	100	100	~~50~~ 60	80
MEAN 3 BROOD TOTAL:	13.5 KF 13.5	13.7 KF 14	KF 15 14.5	15.5	KF 11	KF 12 11.5
7 DAY MEAN DRY WEIGHT:	NA	NA	NA	NA	NA	NA
D.O., MG/L MAX/MIN:	7.5/5.2	8.1/6.0	8.1/6.2 6.1	7.9/6.0	7.8/6.0	7.7/6.0
TEMP °C MAX/MIN:	26.0/21.8	27.4/22.4	27.0/22.7	26.9/22.7	26.4/22.8	26.8/22.9
PH MAX/MIN:	8.2/7.5	8.4/7.6	8.3/7.7	8.2/7.7	8.2/7.8	8.2/7.8

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 68 RECON/LAB WATER: 94

ALKALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 64 RECON/LAB WATER: 64

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: THE Laboratories Inc. ANALYST: Lori Wenkert, Karen Christensen, Michelle Highsmith 1/1/91

* No. 1 pH adjusted from 10.3 to 8.0 on 8-10-92
* No 2 pH adjusted from 9.8 to 8.4 on 8-13-92

PERMITTEE: Rocky Flats CH_M Hill CDPS NO. CO-00 OUTFALL: Bio 3810

TEST SPECIES: Ceriodaphnia AGE: <24hrs. RECEIVING WATER USED FOR DILUTION? YES

TEST RESULTS: CONTROL MORTALITY: 0 % CONTROL PERFORMANCE: Acc

CONC. WITH STAT. SIG.: MORTALITY: Lost % REPRODUCTION Lost % GROWTH Lost

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	10:15 AM/PM 8/10/92 *	BEGINNING	13:00 AM/PM 8/11/92
NO. 2	12:55 AM/PM 8/12/92 *	ENDING	13:00 AM/PM 8/18/92
NO. 3	6:30 AM/PM 8/14/92 *	SPECIAL CONDITION: SAMPLE AERATED?	YES/NO

MEASUREMENTS		DILUTIONS (% EFFLUENT) CONTROL(0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY:	1	100	100	100	100	100	100
	2	100	100	100	100	100	100
	3	100	100	90	100	100	100
	4	100	100	90	100	100	100
	5	100	100	90	100	100	100
	6	100	100	90	100	100	100
	7	100	100	90	100	100	100
MEAN 3 BROOD TOTAL:		16.0	LF 16.5	MF 15.8	KF 18.1	KF 17.4	18.2
7 DAY MEAN DRY WEIGHT:		NA	NA	NA	NA	NA	NA
D.O., MG/L MAX/MIN:		7.9/5.5	8.0/5.5	7.8/5.7	7.8/5.6	7.7/5.8	7.8/5.5
TEMP °C MAX/MIN:		24.1/22.0	26.4/20.2	25.6/20.2	25.5/20.2	25.5/20.3	25.5/20.3
PH MAX/MIN:		8.2/7.7	8.0/7.5	8.0/7.6	8.0/7.6	8.2/7.5	8.2/7.5

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 62 RECON/LAB WATER: 94

ALKALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 53 RECON/LAB WATER: 64

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES

LABORATORY: T.H.E. LABORATORIES, INC. ANALYST: Lori Weikert, Karen Christensen, Michelle Highsmith 1/1/..

* No. 1 pH adjusted from 10.6 to 7.6 on 8-10-92
* No. 2 pH adjusted from 10.0 to 7.8 on 8-13-92
* No. 3 pH adjusted from 10.5 to 7.9 on 8-15-92

PERMITTEE: Rocky Flats CH2M Hill CDPS NO. CO-00 _____ OUTFALL: Bio38066

TEST SPECIES: Ceriodaphnia AGE: <24hrs. RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: [illegible] % CONTROL PERFORMANCE: [illegible]

CONC. WITH STAT. SIG.: MORTALITY: None % REPRODUCTION None % GROWTH [illegible]

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	11:20 AM/PM 8/10/92	BEGINNING	16:15 AM/PM 8/10/92
NO. 2	15:20 AM/PM 8/12/92	ENDING	16:15 AM/PM 8/17/92
NO. 3	08:45 AM/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED?	YES/NO

DILUTIONS (% EFFLUENT)

MEASUREMENTS	CONTROL(0%)	100 %	75 %	50 %	25 %	12
% SURVIVAL FOR DAY: 1	100	100	100	100	100	100
2	100	100	100	100	100	100
3	100	100	100	90	90	100
4	100	100	100	90	90	100
5	100	90	100	90	90	90
6	90	80	100	90	90	90
7	90	80	100	90	90	80
MEAN 3 BROOD TOTAL:	10.4	8.3	10.1	12.4	11.4	[illegible]
7 DAY MEAN DRY WEIGHT:	NA	NA	NA	NA	NA	NA
D.O., MG/L MAX/MIN:	7.9/6.1	7.8/6.3	7.6/6.3	7.7/5.7	7.8/6.1	7.9/6.5
TEMP °C MAX/MIN:	27.6/22.9	27.6/22.4	27.1/23.1	26.9/23.3	27.3/23.4	26.8/23.4
PH MAX/MIN:	8.7/7.8	8.5/8.2	8.4/8.2	8.4/8.1	8.4/8.0	8.4/8.0

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 217 RECON/LAB WATER: 94

ALKALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 188 RECON/LAB WATER: 64

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: THE Laboratories, Inc. ANALYST: Lori Wenkert, Karen Christensen 1/1/91

Michelle Highsmith

[illegible] control reproduction

[illegible] 10/8/92

PERMITTEE: Rocky Flats-CH, M Hill CDPS NO. CO-00 OUTFALL: Bio3804c

TEST SPECIES: Ceriodaphnia AGE: 24hrs RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: 10 % CONTROL PERFORMANCE: GOOD

CONC. WITH STAT. SIG.: MORTALITY: 100 % REPRODUCTION 100 % GROWTH 100

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	13:30 AM/PM 8/10/92	BEGINNING	16:15 AM/PM 8/10/92
NO. 2	16:30 AM/PM 8/12/92	ENDING	16:15 AM/PM 8/17/92
NO. 3	7:30 AM/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED?	YES/NO

MEASUREMENTS		DILUTIONS (% EFFLUENT)					
		CONTROL (0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY:	1	20 100	20 100	20 100	20 100	20 100	26 100
	2	100	100	100	100	100	100
	3	100	100	100	100	80	100
	4	100	100	90	100	80	100
	5	100	100	90	100	80	100
	6	100	100	90	100	70	100
	7	90	100	80	100	70	100
MEAN 3 BROOD TOTAL:		14.2	11.3	~~10.5~~ 10.3	15.2	13.1	11.1
7 DAY MEAN DRY WEIGHT:		NA	NA	NA	NA	NA	NA
D.O., MG/L	MAX/MIN:	7.5/6.0	8.0/5.9	7.9/6.0	7.9/6.0	7.8/6.1	7.7/6.2
TEMP °C	MAX/MIN:	26.2/22.3	25.7/22.9	25.8/23.4	26.0/23.5	26.1/23.7	26.0/23.7
PH	MAX/MIN:	8.2/~~7.7~~ 7.68	8.6/8.2	8.5/8.3	8.4/8.1	8.4/8.0	8.4/8.0

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 202 RECON/LAB WATER: 94

ALKALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 218 RECON/LAB WATER: 64

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: T.H.E. LABORATORIES, INC. ANALYST: Lori Wenkert, Karen Christensen, Michelle Highsmith 1/1,..

PERMITTEE: CH_2M Hill Rocky Flats CDPS NO. CO-00 OUTFALL: Bio 38026

TEST SPECIES: Ceriodaphnia AGE: <24hrs RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: 0 % CONTROL PERFORMANCE: 15

CONC. WITH STAT. SIG.: MORTALITY: >100 % REPRODUCTION 100 % GROWTH >100 %

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	13:00 AM/PM 8/10/92	BEGINNING	16:00 AM/PM 8/10/92
NO. 2	16:00 AM/PM 8/12/92	ENDING	16:00 AM/PM 8/17/92
NO. 3	8:15 AM/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED?	YES/NO

DILUTIONS (% EFFLUENT)

MEASUREMENTS	CONTROL(0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY: 1	100	100	100	100	100	100
2	100	100	100	100	100	100
3	100	100	100	100	100	100
4	100	100	100	100	100	100
5	100	100	100	100	100	100
6	100	100	100	100	90	100
7	100	100	100	100	40	100
MEAN 3 BROOD TOTAL:	15.0	KF 9.6	13.3	KF KF 14.5	KF 13.7	KF 15.7
7 DAY MEAN DRY WEIGHT:	NA	NA	NA	NA	NA	NA
D.O., MG/L MAX/MIN:	7.6 / 6.0	7.7 / 5.5	7.7 / 5.7	7.6 / 5.9	7.7 / 5.3	7.8 / 5.5
TEMP °C MAX/MIN:	26.1 / ~~22.9~~ 22.3	25.8 / 22.2	26.0 / 22.2	25.9 / 22.6	26.0 / 22.7	26.0 / 22.8
PH MAX/MIN:	8.3 / 7.7	8.1 / 7.5	8.2 / 7.5	8.2 / 7.6	8.2 / 7.7	8.3 / 7.7

~~mt~~ 9-30-92

HARDNESS ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 91 RECON/LAB WATER: 94

ALKALINITY ($\bar{x}$) MG/L RECEIVING WATER: NA EFFLUENT: 60 RECON/LAB WATER: 61

T. AMMONIA as N ($\bar{x}$) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: THE Laboratories, Inc ANALYST: Lori Wenkert Karen Christensen 1/1/91

Michelle Highsmith

PERMITTEE: Rocky Flats CH2M Hill CDPS NO. CO-00 OUTFALL: 8i038c.

TEST SPECIES: Ceriodaphnia AGE: <24hrs. RECEIVING WATER USED FOR DILUTION? YES/NO

TEST RESULTS: CONTROL MORTALITY: 10 % CONTROL PERFORMANCE: [illegible]

CONC. WITH STAT. SIG.: MORTALITY: [illegible] % REPRODUCTION [illegible] % GROWTH [illegible]

SAMPLE TYPE: GRAB/COMPOSITE TEST:

	TIME & DATE		TIME & DATE
NO. 1	9:55 AM/PM 8/10/92 *	BEGINNING	14:10 AM/PM 8/11/92
NO. 2	13:30 AM/PM 8/12/92 +	ENDING	14:10 AM/PM 8/18/92
NO. 3	6:20 AM/PM 8/14/92	SPECIAL CONDITION: SAMPLE AERATED?	YES/NO

DILUTIONS (% EFFLUENT)

MEASUREMENTS	CONTROL(0%)	100 %	75 %	50 %	25 %	12 %
% SURVIVAL FOR DAY: 1	100	100	100	100	100	100
2	100	100	100	100	100	100
3	100	90	100	100	100	100
4	100	90	100	100	80	100
5	100	90	100	100	80	100
6	90	90	100	100	80	100
7	90	90	100	100	80	100
MEAN 3 BROOD TOTAL:	16 15.8	16 15.8	13.5	18.0	17.1	19.1
7 DAY MEAN DRY WEIGHT:	NA	NA	NA	NA	NA	NA
D.O., MG/L MAX/MIN:	7.5/5.6	8.3/5.6	8.2/6.3	8.0/6.1	7.8/6.4	7.6/6.4
TEMP °C MAX/MIN:	26.4/22.4	25.2/22.4	25.4/22.5	25.3/22.7	25.5/22.6	26.1/22.8
PH MAX/MIN:	8.2/7.6	8.1/7.5	8.1/7.7	8.2/7.7	8.2/7.8 7.8	8.2/7.8

HARDNESS (x̄) MG/L RECEIVING WATER: NA EFFLUENT: 68 RECON/LAB WATER: 94 mm 9-30-92

ALKALINITY (x̄) MG/L RECEIVING WATER: NA EFFLUENT: 57 RECON/LAB WATER: 64

T. AMMONIA as N (x̄) MG/L INITIAL EFFLUENT: ND FINAL EFFLUENT: ND

T. RESIDUAL CHLORINE, MG/L 100%: ND SAMPLE DECHLORINATED BEFORE TEST? YES/NO

LABORATORY: THE Laboratories, Inc. ANALYST: Lori Wenkert Karen Christensen 1/1/..

No. 1 pH adjusted from 10.7 to 8.0 on 8-10-92
No 2 pH adjusted from 9.9 to 7.9 on 8-13-92

Michelle Highsmith

rocky flats cerios 3802
File: rocky.000 Transform: NO TRANSFORMATION

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	control	10	11.000	21.000	15.000
2	12	10	3.000	19.000	13.900
3	25	9	0.000	19.000	12.667
4	50	10	5.000	19.000	14.500
5	75	10	10.000	18.000	13.300
6	100	10	5.000	13.000	8.600

rocky flats cerios 3802
File: rocky.000 Transform: NO TRANSFORMATION

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
1	control	12.222	3.496	1.106
2	12	22.767	4.771	1.509
	25	31.500	5.612	1.871
	50	26.722	5.169	1.635
	75	8.456	2.908	0.920
6	100	6.267	2.503	0.792

rocky flats cerios 3802
File: rocky.000 Transform: NO TRANSFORMATION

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	5	266.100	53.220	3.001
Within (Error)	53	939.900	17.734	
Total	58	1206.000		

Critical F value = 2.45 (0.05,5,40)
Since F > Critical F REJECT Ho:All groups equal

rocky flats cerios 3802
File: rocky.000 Transform: NO TRANSFORMATION

BONFERRONI T-TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	control	15.000	15.000		
2	12	13.900	13.900	0.584	
3	25	12.667	12.667	1.206	
4	50	14.500	14.500	0.265	
5	75	13.300	13.300	0.903	
6	100	8.600	8.600	3.398	*

Bonferroni T table value = 2.40 (1 Tailed Value, P=0.05, df=50,5)

rocky flats cerios 3802
File: rocky.000 Transform: NO TRANSFORMATION

BONFERRONI T-TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	control	10			
2	12	10	4.527	30.2	1.100
3	25	9	4.652	31.0	2.333
4	50	10	4.527	30.2	0.500
5	75	10	4.527	30.2	1.700
6	100	10	4.527	30.2	6.400

rocky flats cerios 3804
File: rocky.000 Transform: NO TRANSFORMATION

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 1 of 2

GRP	IDENTIFICATION	N	MIN	MAX	MEAN
1	control	10	10.000	18.000	14.200
2	12	10	3.000	17.000	11.100
3	25	7	9.000	16.000	12.857
4	50	10	11.000	20.000	15.200
5	75	9	1.000	16.000	10.333
6	100	10	0.000	16.000	11.300

rocky flats cerios 3804
File: rocky.000 Transform: NO TRANSFORMATION

SUMMARY STATISTICS ON TRANSFORMED DATA TABLE 2 of 2

GRP	IDENTIFICATION	VARIANCE	SD	SEM
1	control	7.289	2.700	0.854
2	12	18.100	4.254	1.345
	25	5.810	2.410	0.911
	50	7.511	2.741	0.867
	75	21.750	4.664	1.555
6	100	23.789	4.877	1.542

rocky flats cerios 3804
File: rocky.000 Transform: NO TRANSFORMATION

ANOVA TABLE

SOURCE	DF	SS	MS	F
Between	5	178.925	35.785	2.488
Within (Error)	50	719.057	14.381	
Total	55	897.982		

Critical F value = 2.45 (0.05,5,40)
Since F > Critical F REJECT Ho:All groups equal

rocky flats cerios 3804
File: rocky.000 Transform: NO TRANSFORMATION

BONFERRONI T-TEST - TABLE 1 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	TRANSFORMED MEAN	MEAN CALCULATED IN ORIGINAL UNITS	T STAT	SIG
1	control	14.200	14.200		
2	12	11.100	11.100	1.828	
3	25	12.857	12.857	0.719	
4	50	15.200	15.200	-0.590	
5	75	10.333	10.333	2.219	
6	100	11.300	11.300	1.710	

Bonferroni T table value = 2.40 (1 Tailed Value, P=0.05, df=50,5)

rocky flats cerios 3804
File: rocky.000 Transform: NO TRANSFORMATION

BONFERRONI T-TEST - TABLE 2 OF 2 Ho:Control<Treatment

GROUP	IDENTIFICATION	NUM OF REPS	Minimum Sig Diff (IN ORIG. UNITS)	% of CONTROL	DIFFERENCE FROM CONTROL
1	control	10			
2	12	10	4.077	28.7	3.100
3	25	7	4.493	31.6	1.343
4	50	10	4.077	28.7	-1.000
5	75	9	4.189	29.5	3.867
6	100	10	4.077	28.7	2.900

MEMORANDUM

CH2M HILL

TO: Mike Guillaume/EG&G
Karen Wiemelt/CH2M HILL
Greg Williams/IT Corporation
Karmen Klima/CH2M HILL
Robert Sheldon/CH2M HILL
Hany Malek/CH2M HILL

FROM: Dick Moos/CH2M HILL

DATE: September 18, 1992

SUBJECT: Rerun of Toxicity Samples

PROJECT: DEN30181.X1

The results from the chronic toxicity tests with the zooplankton *Ceriodaphnia,* started on August 10, 1992, revealed that the control groups of organisms did not exhibit the reproduction rate required for a successful test in three of the seven runs. This is not common, but it does happen. For some reason, the test organisms were not as viable as required to meet the test specifications.

The chronic toxicity tests with *Ceriodaphnia* was repeated during the week of September 1 through 4 for the three runs (locations) that were affected; Walnut Creek, Woman Creek, and one station on Mower Reservoir. There was no unusual weather during the 2 weeks between the original runs and the reruns. In situ water quality data were collected during both the original and repeat sampling events, and will be reviewed to assess the comparability of the two time periods. At this time, we think the reruns will be comparable.

The chronic tests with fathead minnows were completed with no problems, and the sediment toxicity tests with *Hyalella* are still ongoing.

MEMORANDUM CH2MHILL

TO: Michael Guillaume/EG&G
Fred Harrington/EG&G

COPIES: Karen Weimelt/CH2M HILL
Dick Moos/CH2M HILL
Karmen Klima/CH2M HILL
Gregg Williams/IT Corp.

COPY

FROM: Trudy Steidl Pulley/CH2M HILL

DATE: January 7, 1993

SUBJECT: Rocky Flats OU3 Toxicity Bioassay Studies

PROJECT: DEN30181.X1.03

In reviewing the data received from Seacrest Laboratories (formerly T.H.E. Laboratories), several inconsistencies were found which directly relate to the acceptability of the data for purposes of a risk assessment. Some of the problems could be rectified with additional information from the laboratory, however others occurred in the testing procedure making the results questionable.

A. SEDIMENT

1. Test organisms used did not come from the same source. It was reported that test organisms came either from in-house cultures or from a commercial supplier. It is generally accepted procedure that all test animals come from the same source to insure that they are as equivalent as possible in age, genetic history and quality. Additional information concerning the reasons why animals from more than one source were used in the same tests would be beneficial.

2. The feeding regime was changed at day 22 of the test. The recommended food for Hyalella azteca in the procedures used was rabbit chow dissolved in deionized water. Tetramin flakes were fed through the 22nd day at which point the food was changed to rabbit chow for the remainder of the test. This change in food probably would not have significant effects on the test results, however it would be helpful to receive information on why the food was changed towards the end of the test and why rabbit chow was not used from the initiation of the test.

B. WATER-FATHEAD MINNOWS

1. Raw statistics were not included in the report for any of the samples tested. No statistical significance was reported for the results of the tests, however without the raw statistics we do not know what level of confidence, i.e. 90%, 95%, or 99% was used as the determination of significance. Additional information on the statistics and the associated p-values ($p=0.05$ is equivalent to a confidence level of 95%) should be provided with the final report.

C. WATER-CERIODAPHNIA

1. Control reproductive rates were below acceptable limits of 15 young per daphnid in 3 of the 6 control samples and minimum reproductive rates were unusually low in all control samples. These rates are unacceptable for use as a control against which toxicity in field collected samples could be compared. Due to this problem, the laboratory requested that we collect a second set of samples to conduct new ceriodaphnia toxicity bioassays. Results for this set of samples were never reported since control problems occurred in all samples. Instead, the laboratory reported the first set of samples and averaged all control reproductive rates in order to achieve the required 15 young per daphnid. These data are not acceptable for either qualitative or quantitative use. If the problem was in the food, then animals exposed to field collected waters would have the same decrease in reproductive rates as the control animals and thus additional toxicity was added to the tests. Judging by the overall survival rates in the tests, the toxicity is more likely to be chronic rather than acute in which case effects are observed as decreased reproduction. Based on the data presented, no conclusions can be drawn from the ceriodaphnia bioassays as to the nature of toxicity.

2. Statistics were included in the report for only 2 of the 6 samples. The level of significance reported for these samples was 95% ($p= 0.05$) which is acceptable. The statistical calculations and associated p-values for all samples tested should be included in the final report and it would be beneficial to have this additional information supplied.

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B. WATER-FATHEAD MINNOWS

1. Raw statistics were not included in the report for any of the samples tested. No statistical significance was reported for the results of the tests, however without the raw statistics we do not know what level of confidence, i.e. 90%, 95%, or 99% was used as the determination of significance. Additional information on the statistics and the associated p-values (p=0.05 is equivalent to a confidence level of 95%) should be provided with the final report.

C. WATER-CERIODAPHNIA

1. Control reproductive rates were below acceptable limits of 15 young per daphnid in 3 of the 6 control samples and minimum reproductive rates were unusually low in all control samples. These rates are unacceptable for use as a control against which toxicity in field collected samples could be compared. Due to this problem, the laboratory requested that we collect a second set of samples to conduct new ceriodaphnia toxicity bioassays. Results for this set of samples were never reported since control problems occurred in all samples. Instead, the laboratory reported the first set of samples and averaged all control reproductive rates in order to achieve the required 15 young per daphnid. These data are not acceptable for either qualitative or quantitative use. If the problem was in the food, then animals exposed to field collected waters would have the same decrease in reproductive rates as the control animals and thus additional toxicity was added to the tests. Judging by the overall survival rates in the tests, the toxicity is more likely to be chronic rather than acute in which case effects are observed as decreased reproduction. Based on the data presented, no conclusions can be drawn from the ceriodaphnia bioassays as to the nature of toxicity.

2. Statistics were included in the report for only 2 of the 6 samples. The level of significance reported for these samples was 95% (p= 0.05) which is acceptable. The statistical calculations and associated p-values for all samples tested should be included in the final report and it would be beneficial to have this additional information supplied.

LOCATION CODE	SAMPLE NUMBER	SAMPLE DATE	TEST GROUP CODE	CHEMICAL NAME	ANALYSIS DATE	NEW RESULT	ADJ RESULT	UNITS	NEW DETECT LIMIT	QUALIFIER
SED00392	SD06001CH	7/10/92	METALS	ALUMINUM	8/04/92	4710.000	4710.000	MG/KG	200.000	
SED00392	SD06001CH	7/10/92	METALS	ARSENIC	8/14/92	7.800	7.800	MG/KG	10.000	
SED00392	SD06001CH	7/10/92	METALS	BARIUM	8/04/92	109.000	109.000	MG/KG	200.000	
SED00392	SD06001CH	7/10/92	METALS	BERYLLIUM	8/04/92	.490	.490	MG/KG	5.000	
SED00392	SD06001CH	7/10/92	METALS	CADMIUM	8/04/92	.770	.770	MG/KG	5.000	
SED00392	SD06001CH	7/10/92	METALS	CALCIUM	8/04/92	6230.000	6230.000	MG/KG	5000.000	
SED00392	SD06001CH	7/10/92	METALS	CESIUM	8/04/92	19.900	19.900	MG/KG	1000.000	
SED00392	SD06001CH	7/10/92	METALS	CHROMIUM	8/04/92	5.800	5.800	MG/KG	10.000	
SED00392	SD06001CH	7/10/92	METALS	COBALT	8/04/92	7.300	7.300	MG/KG	50.000	
SED00392	SD06001CH	7/10/92	METALS	COPPER	8/04/92	37.800	37.800	MG/KG	25.000	
SED00392	SD06001CH	7/10/92	METALS	IRON	8/04/92	14700.000	14700.000	MG/KG	100.000	
SED00392	SD06001CH	7/10/92	METALS	LEAD	8/12/92	91.400	91.400	MG/KG	3.000	
SED00392	SD06001CH	7/10/92	METALS	LITHIUM	8/04/92	5.500	5.500	MG/KG	100.000	
SED00392	SD06001CH	7/10/92	METALS	MAGNESIUM	8/04/92	1750.000	1750.000	MG/KG	5000.000	
SED00392	SD06001CH	7/10/92	METALS	MANGANESE	8/04/92	1120.000	1120.000	MG/KG	15.000	
SED00392	SD06001CH	7/10/92	METALS	MERCURY	7/28/92	.140	.140	MG/KG	.200	
SED00392	SD06001CH	7/10/92	METALS	MOLYBDENUM	8/04/92	1.600	1.600	MG/KG	200.000	
SED00392	SD06001CH	7/10/92	METALS	NICKEL	8/04/92	13.100	13.100	MG/KG	40.000	
SED00392	SD06001CH	7/10/92	METALS	POTASSIUM	8/04/92	1090.000	1090.000	MG/KG	5000.000	
SED00392	SD06001CH	7/10/92	METALS	SILVER	8/04/92	1.900	1.900	MG/KG	10.000	
SED00392	SD06001CH	7/10/92	METALS	SODIUM	8/04/92	51.500	51.500	MG/KG	5000.000	
SED00392	SD06001CH	7/10/92	METALS	STRONTIUM	8/04/92	33.900	33.900	MG/KG	200.000	
SED00392	SD06001CH	7/10/92	METALS	VANADIUM	8/04/92	19.800	19.800	MG/KG	50.000	
SED00392	SD06001CH	7/10/92	METALS	ZINC	8/04/92	495.000	495.000	MG/KG	20.000	
SED00392	SD06001CH	7/10/92	RADIONUCLIDES	AMERICIUM-241	1/12/93	.042	.042	PCI/G	.005	
SED00392	SD06001CH	7/10/92	RADIONUCLIDES	GROSS ALPHA	11/20/92	8.300	8.300	PCI/G	2.900	
SED00392	SD06001CH	7/10/92	RADIONUCLIDES	GROSS BETA	11/20/92	25.000	25.000	PCI/G	5.400	
SED00392	SD06001CH	7/10/92	RADIONUCLIDES	PLUTONIUM-239/240	11/17/92	.006	.006	PCI/G	.002	J
SED00392	SD06001CH	7/10/92	RADIONUCLIDES	URANIUM-233/234	1/15/93	.620	.620	PCI/G	.015	
SED00392	SD06001CH	7/10/92	RADIONUCLIDES	URANIUM-235	1/15/93	.064	.064	PCI/G	.009	J
SED00392	SD06001CH	7/10/92	RADIONUCLIDES	URANIUM-238	1/15/93	.730	.730	PCI/G	.015	B
SED01392	SD00391WCU3	7/08/92	METALS	ALUMINUM	8/20/92	10600.000	10600.000	MG/KG	40.000	
SED01392	SD00391WCU3	7/08/92	METALS	ARSENIC	7/22/92	5.100	5.100	MG/KG	2.000	
SED01392	SD00391WCU3	7/08/92	METALS	BARIUM	8/20/92	84.300	84.300	MG/KG	40.000	
SED01392	SD00391WCU3	7/08/92	METALS	BERYLLIUM	8/20/92	.410	.410	MG/KG	1.000	B
SED01392	SD00391WCU3	7/08/92	METALS	CALCIUM	8/20/92	6480.000	6480.000	MG/KG	1000.000	
SED01392	SD00391WCU3	7/08/92	METALS	CESIUM	7/28/92	2.000	2.000	MG/KG	200.000	B
SED01392	SD00391WCU3	7/08/92	METALS	CHROMIUM	8/20/92	16.900	16.900	MG/KG	2.000	

LOCATION CODE	SAMPLE NUMBER	SAMPLE DATE	TEST GROUP CODE	CHEMICAL NAME	ANALYSIS DATE	NEW RESULT	ADJ RESULT	UNITS	NEW DETECT LIMIT	QUALIFIER
SED01392	SD00391WCU3	7/08/92	METALS	COBALT	8/20/92	7.500	7.500	MG/KG	10.000	B
SED01392	SD00391WCU3	7/08/92	METALS	COPPER	8/20/92	9.700	9.700	MG/KG	5.000	
SED01392	SD00391WCU3	7/08/92	METALS	IRON	8/20/92	15200.000	15200.000	MG/KG	20.000	
SED01392	SD00391WCU3	7/08/92	METALS	LEAD	8/05/92	16.300	16.300	MG/KG	1.000	
SED01392	SD00391WCU3	7/08/92	METALS	LITHIUM	8/20/92	7.200	7.200	MG/KG	20.000	B
SED01392	SD00391WCU3	7/08/92	METALS	MAGNESIUM	8/20/92	2510.000	2510.000	MG/KG	1000.000	
SED01392	SD00391WCU3	7/08/92	METALS	MANGANESE	8/20/92	334.000	334.000	MG/KG	3.000	
SED01392	SD00391WCU3	7/08/92	METALS	NICKEL	8/20/92	15.000	15.000	MG/KG	8.000	
SED01392	SD00391WCU3	7/08/92	METALS	POTASSIUM	8/20/92	1210.000	1210.000	MG/KG	1000.000	
SED01392	SD00391WCU3	7/08/92	METALS	SODIUM	8/20/92	193.000	193.000	MG/KG	1000.000	B
SED01392	SD00391WCU3	7/08/92	METALS	STRONTIUM	8/20/92	35.800	35.800	MG/KG	40.000	B
SED01392	SD00391WCU3	7/08/92	METALS	THALLIUM	8/04/92	.250	.250	MG/KG	2.000	B
SED01392	SD00391WCU3	7/08/92	METALS	VANADIUM	8/20/92	33.100	33.100	MG/KG	10.000	
SED01392	SD00391WCU3	7/08/92	METALS	ZINC	8/24/92	50.300	50.300	MG/KG	4.000	
SED01392	SD00391WCU3	7/08/92	RADIONUCLIDES	AMERICIUM-241	1/19/93	.046	.046	PCI/G	.008	
SED01392	SD00391WCU3	7/08/92	RADIONUCLIDES	GROSS ALPHA	10/29/92	17.000	17.000	PCI/G	2.800	
SED01392	SD00391WCU3	7/08/92	RADIONUCLIDES	GROSS BETA	10/29/92	20.000	20.000	PCI/G	5.200	
SED01392	SD00391WCU3	7/08/92	RADIONUCLIDES	PLUTONIUM-239/240	11/25/92	.069	.069	PCI/G	.002	
SED01392	SD00391WCU3	7/08/92	RADIONUCLIDES	URANIUM-233/234	12/30/92	1.000	1.000	PCI/G	.040	B
SED01392	SD00391WCU3	7/08/92	RADIONUCLIDES	URANIUM-235	12/30/92	.057	.057	PCI/G	.040	J
SED01392	SD00391WCU3	7/08/92	RADIONUCLIDES	URANIUM-238	12/30/92	.790	.790	PCI/G	.013	B
SED01392	SD06035CH	8/13/92	WATER-QUALITY	TOTAL ORGANIC CARBON	8/20/92	.870	.870	%	.050	X
SED02092	SD00454WCU3	10/30/92	METALS	ALUMINUM	12/08/92	3320.000	3320.000	MG/KG	3.700	
SED02092	SD00454WCU3	10/30/92	METALS	ARSENIC	12/08/92	4.600	4.600	MG/KG	.140	
SED02092	SD00454WCU3	10/30/92	METALS	BARIUM	12/08/92	135.000	135.000	MG/KG	.420	
SED02092	SD00454WCU3	10/30/92	METALS	BERYLLIUM	12/08/92	.220	.220	MG/KG	.160	
SED02092	SD00454WCU3	10/30/92	METALS	CADMIUM	12/08/92	3.500	3.500	MG/KG	.740	
SED02092	SD00454WCU3	10/30/92	METALS	CALCIUM	12/08/92	1850.000	1850.000	MG/KG	3.500	
SED02092	SD00454WCU3	10/30/92	METALS	CHROMIUM	12/08/92	4.400	4.400	MG/KG	.480	
SED02092	SD00454WCU3	10/30/92	METALS	COBALT	12/08/92	8.800	8.800	MG/KG	.720	
SED02092	SD00454WCU3	10/30/92	METALS	COPPER	12/08/92	37.300	37.300	MG/KG	.480	
SED02092	SD00454WCU3	10/30/92	METALS	IRON	12/08/92	16800.000	16800.000	MG/KG	.940	
SED02092	SD00454WCU3	10/30/92	METALS	LEAD	12/14/92	46.500	46.500	MG/KG	5.300	
SED02092	SD00454WCU3	10/30/92	METALS	LITHIUM	12/08/92	2.700	2.700	MG/KG	.940	
SED02092	SD00454WCU3	10/30/92	METALS	MAGNESIUM	12/08/92	1070.000	1070.000	MG/KG	5.900	
SED02092	SD00454WCU3	10/30/92	METALS	MANGANESE	12/08/92	2710.000	2710.000	MG/KG	.420	
SED02092	SD00454WCU3	10/30/92	METALS	MOLYBDENUM	12/08/92	6.700	6.700	MG/KG	1.700	

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SED02092	SD00454WCU3	10/30/92	METALS	NICKEL	12/08/92	19.200	19.200	MG/KG	3.900	
SED02092	SD00454WCU3	10/30/92	METALS	POTASSIUM	12/08/92	622.000	622.000	MG/KG	156.000	
SED02092	SD00454WCU3	10/30/92	METALS	SILICON	12/08/92	281.000	281.000	MG/KG	3.000	
SED02092	SD00454WCU3	10/30/92	METALS	SILVER	12/08/92	1.100	1.100	MG/KG	.520	
SED02092	SD00454WCU3	10/30/92	METALS	SODIUM	12/08/92	141.000	141.000	MG/KG	5.700	
SED02092	SD00454WCU3	10/30/92	METALS	STRONTIUM	12/08/92	35.200	35.200	MG/KG	.160	
SED02092	SD00454WCU3	10/30/92	METALS	VANADIUM	12/08/92	25.100	25.100	MG/KG	.660	
SED02092	SD00454WCU3	10/30/92	METALS	ZINC	12/08/92	685.000	685.000	MG/KG	.420	
SED02092	SD00454WCU3	10/30/92	RADIONUCLIDES	AMERICIUM-241	1/19/93	.010	.010	PCI/G	0.000	
SED02092	SD00454WCU3	10/30/92	RADIONUCLIDES	GROSS ALPHA	12/29/92	14.300	14.300	PCI/G	1.900	
SED02092	SD00454WCU3	10/30/92	RADIONUCLIDES	GROSS BETA	12/29/92	22.000	22.000	PCI/G	5.200	
SED02092	SD00454WCU3	10/30/92	RADIONUCLIDES	PLUTONIUM-239/240	1/19/93	.002	.002	PCI/G	.007	
SED02092	SD00454WCU3	10/30/92	RADIONUCLIDES	URANIUM-233/234	1/19/93	.819	.819	PCI/G	.019	
SED02092	SD00454WCU3	10/30/92	RADIONUCLIDES	URANIUM-235	1/19/93	.047	.047	PCI/G	0.000	
SED02092	SD00454WCU3	10/30/92	RADIONUCLIDES	URANIUM-238	1/19/93	.668	.668	PCI/G	.019	
SED02092	SD00454WCU3	10/30/92	WATER-QUALITY	% SOLIDS	12/09/92	92.800	92.800	%	.100	
SED02092	SD00454WCU3	10/30/92	WATER-QUALITY	TOTAL ORGANIC CARBON	12/07/93	.070	.070	%	.050	
SED02092	SD06002CH	7/13/92	METALS	ALUMINUM	8/04/92	5000.000	5000.000	MG/KG	200.000	
SED02092	SD06002CH	7/13/92	METALS	ARSENIC	8/14/92	6.300	6.300	MG/KG	10.000	
SED02092	SD06002CH	7/13/92	METALS	BARIUM	8/04/92	134.000	134.000	MG/KG	200.000	
SED02092	SD06002CH	7/13/92	METALS	BERYLLIUM	8/04/92	.390	.390	MG/KG	5.000	
SED02092	SD06002CH	7/13/92	METALS	CADMIUM	8/04/92	2.100	2.100	MG/KG	5.000	
SED02092	SD06002CH	7/13/92	METALS	CALCIUM	8/04/92	2220.000	2220.000	MG/KG	5000.000	
SED02092	SD06002CH	7/13/92	METALS	CHROMIUM	8/04/92	6.900	6.900	MG/KG	10.000	
SED02092	SD06002CH	7/13/92	METALS	COBALT	8/04/92	8.600	8.600	MG/KG	50.000	
SED02092	SD06002CH	7/13/92	METALS	COPPER	8/04/92	52.300	52.300	MG/KG	25.000	
SED02092	SD06002CH	7/13/92	METALS	IRON	8/04/92	12000.000	12000.000	MG/KG	100.000	
SED02092	SD06002CH	7/13/92	METALS	LEAD	8/12/92	66.800	66.800	MG/KG	3.000	
SED02092	SD06002CH	7/13/92	METALS	LITHIUM	8/04/92	5.800	5.800	MG/KG	100.000	
SED02092	SD06002CH	7/13/92	METALS	MAGNESIUM	8/04/92	2090.000	2090.000	MG/KG	5000.000	
SED02092	SD06002CH	7/13/92	METALS	MANGANESE	8/04/92	2340.000	2340.000	MG/KG	15.000	
SED02092	SD06002CH	7/13/92	METALS	MERCURY	7/28/92	.100	.100	MG/KG	.200	
SED02092	SD06002CH	7/13/92	METALS	MOLYBDENUM	8/04/92	3.600	3.600	MG/KG	200.000	
SED02092	SD06002CH	7/13/92	METALS	NICKEL	8/04/92	15.500	15.500	MG/KG	40.000	
SED02092	SD06002CH	7/13/92	METALS	POTASSIUM	8/04/92	1330.000	1330.000	MG/KG	5000.000	
SED02092	SD06002CH	7/13/92	METALS	SILVER	8/04/92	2.100	2.100	MG/KG	10.000	
SED02092	SD06002CH	7/13/92	METALS	SODIUM	8/04/92	102.000	102.000	MG/KG	5000.000	

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SED02092	SD06002CH	7/13/92	METALS	STRONTIUM	8/04/92	35.400	35.400	MG/KG	200.000	
SED02092	SD06002CH	7/13/92	METALS	VANADIUM	8/04/92	16.200	16.200	MG/KG	50.000	
SED02092	SD06002CH	7/13/92	METALS	ZINC	8/04/92	739.000	739.000	MG/KG	20.000	
SED02092	SD06002CH	7/13/92	RADIONUCLIDES	GROSS ALPHA	10/21/92	33.000	33.000	PCI/G	1.900	
SED02092	SD06002CH	7/13/92	RADIONUCLIDES	GROSS BETA	10/21/92	36.000	36.000	PCI/G	5.300	
SED02092	SD06002CH	7/13/92	RADIONUCLIDES	PLUTONIUM-239/240	1/09/93	.010	.010	PCI/G	.010	J
SED02092	SD06002CH	7/13/92	RADIONUCLIDES	URANIUM-233/234	12/28/92	.670	.670	PCI/G	.024	B
SED02092	SD06002CH	7/13/92	RADIONUCLIDES	URANIUM-235	12/28/92	.065	.065	PCI/G	.009	BJ
SED02092	SD06002CH	7/13/92	RADIONUCLIDES	URANIUM-238	12/28/92	.620	.620	PCI/G	.015	B
SED02592	SD00396WCU3	10/23/92	METALS	ALUMINUM	12/08/92	4140.000	4140.000	MG/KG	6.100	
SED02592	SD00396WCU3	10/23/92	METALS	ARSENIC	12/11/92	3.400	3.400	MG/KG	.230	
SED02592	SD00396WCU3	10/23/92	METALS	BARIUM	12/08/92	85.000	85.000	MG/KG	.690	
SED02592	SD00396WCU3	10/23/92	METALS	BERYLLIUM	12/08/92	.360	.360	MG/KG	.260	
SED02592	SD00396WCU3	10/23/92	METALS	CALCIUM	12/08/92	2030.000	2030.000	MG/KG	5.700	
SED02592	SD00396WCU3	10/23/92	METALS	CHROMIUM	12/08/92	5.000	5.000	MG/KG	.790	
SED02592	SD00396WCU3	10/23/92	METALS	COBALT	12/08/92	2.900	2.900	MG/KG	1.200	
SED02592	SD00396WCU3	10/23/92	METALS	COPPER	12/08/92	19.800	19.800	MG/KG	.790	
SED02592	SD00396WCU3	10/23/92	METALS	IRON	12/08/92	5670.000	5670.000	MG/KG	1.500	
SED02592	SD00396WCU3	10/23/92	METALS	LEAD	12/14/92	17.900	17.900	MG/KG	2.100	
SED02592	SD00396WCU3	10/23/92	METALS	LITHIUM	12/08/92	2.500	2.500	MG/KG	1.500	
SED02592	SD00396WCU3	10/23/92	METALS	MAGNESIUM	12/08/92	1000.000	1000.000	MG/KG	9.700	
SED02592	SD00396WCU3	10/23/92	METALS	MANGANESE	12/08/92	2390.000	2390.000	MG/KG	.690	
SED02592	SD00396WCU3	10/23/92	METALS	POTASSIUM	12/08/92	890.000	890.000	MG/KG	256.000	
SED02592	SD00396WCU3	10/23/92	METALS	SILICON	12/08/92	982.000	982.000	MG/KG	5.000	
SED02592	SD00396WCU3	10/23/92	METALS	SILVER	12/08/92	1.100	1.100	MG/KG	.850	
SED02592	SD00396WCU3	10/23/92	METALS	SODIUM	12/08/92	84.600	84.600	MG/KG	9.300	
SED02592	SD00396WCU3	10/23/92	METALS	STRONTIUM	12/08/92	20.600	20.600	MG/KG	.260	
SED02592	SD00396WCU3	10/23/92	METALS	VANADIUM	12/08/92	11.200	11.200	MG/KG	1.100	
SED02592	SD00396WCU3	10/23/92	METALS	ZINC	12/08/92	121.000	121.000	MG/KG	.690	
SED02592	SD00396WCU3	10/23/92	RADIONUCLIDES	AMERICIUM-241	1/11/93	.007	.007	PCI/G	0.000	J
SED02592	SD00396WCU3	10/23/92	RADIONUCLIDES	GROSS ALPHA	12/02/92	15.190	15.190	PCI/G	2.600	
SED02592	SD00396WCU3	10/23/92	RADIONUCLIDES	GROSS BETA	11/25/92	25.220	25.220	PCI/G	2.350	
SED02592	SD00396WCU3	10/23/92	RADIONUCLIDES	PLUTONIUM-239/240	1/12/93	.003	.003	PCI/G	0.000	J
SED02592	SD00396WCU3	10/23/92	RADIONUCLIDES	TRITIUM	12/01/92	82.560	82.560	PCI/L	280.000	J
SED02592	SD00396WCU3	10/23/92	RADIONUCLIDES	URANIUM-233/234	12/23/92	1.839	1.839	PCI/G	.014	
SED02592	SD00396WCU3	10/23/92	RADIONUCLIDES	URANIUM-235	12/23/92	.098	.098	PCI/G	0.000	J
SED02592	SD00396WCU3	10/23/92	RADIONUCLIDES	URANIUM-238	12/23/92	1.617	1.617	PCI/G	.029	

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SED02592	SD00396WCU3	10/23/92	WATER-QUALITY	% SOLIDS	12/09/92	56.800	56.800	%	.100	
SED02592	SD06005CH	7/09/92	METALS	ALUMINUM	8/04/92	7380.000	7380.000	MG/KG	200.000	
SED02592	SD06005CH	7/09/92	METALS	ARSENIC	8/14/92	4.500	4.500	MG/KG	10.000	
SED02592	SD06005CH	7/09/92	METALS	BARIUM	8/04/92	190.000	190.000	MG/KG	200.000	
SED02592	SD06005CH	7/09/92	METALS	BERYLLIUM	8/04/92	.540	.540	MG/KG	5.000	
SED02592	SD06005CH	7/09/92	METALS	CALCIUM	8/04/92	75000.000	75000.000	MG/KG	5000.000	
SED02592	SD06005CH	7/09/92	METALS	CHROMIUM	8/04/92	7.100	7.100	MG/KG	10.000	
SED02592	SD06005CH	7/09/92	METALS	COBALT	8/04/92	9.200	9.200	MG/KG	50.000	
SED02592	SD06005CH	7/09/92	METALS	COPPER	8/04/92	17.200	17.200	MG/KG	25.000	
SED02592	SD06005CH	7/09/92	METALS	IRON	8/04/92	14600.000	14600.000	MG/KG	100.000	
SED02592	SD06005CH	7/09/92	METALS	LEAD	8/12/92	20.800	20.800	MG/KG	3.000	
SED02592	SD06005CH	7/09/92	METALS	LITHIUM	8/04/92	7.500	7.500	MG/KG	100.000	
SED02592	SD06005CH	7/09/92	METALS	MAGNESIUM	8/04/92	2660.000	2660.000	MG/KG	5000.000	
SED02592	SD06005CH	7/09/92	METALS	MANGANESE	8/04/92	608.000	608.000	MG/KG	15.000	
SED02592	SD06005CH	7/09/92	METALS	MERCURY	7/28/92	.080	.080	MG/KG	.200	
SED02592	SD06005CH	7/09/92	METALS	MOLYBDENUM	8/04/92	1.700	1.700	MG/KG	200.000	
SED02592	SD06005CH	7/09/92	METALS	NICKEL	8/04/92	22.300	22.300	MG/KG	40.000	
SED02592	SD06005CH	7/09/92	METALS	POTASSIUM	8/04/92	1520.000	1520.000	MG/KG	5000.000	
SED02592	SD06005CH	7/09/92	METALS	SODIUM	8/04/92	114.000	114.000	MG/KG	5000.000	
SED02592	SD06005CH	7/09/92	METALS	STRONTIUM	8/04/92	92.400	92.400	MG/KG	200.000	
SED02592	SD06005CH	7/09/92	METALS	VANADIUM	8/04/92	24.200	24.200	MG/KG	50.000	
SED02592	SD06005CH	7/09/92	METALS	ZINC	8/04/92	78.000	78.000	MG/KG	20.000	
SED02592	SD06005CH	7/09/92	RADIONUCLIDES	AMERICIUM-241	1/12/93	.024	.024	PCI/G	.006	
SED02592	SD06005CH	7/09/92	RADIONUCLIDES	GROSS ALPHA	11/20/92	15.000	15.000	PCI/G	3.600	
SED02592	SD06005CH	7/09/92	RADIONUCLIDES	GROSS BETA	11/20/92	17.000	17.000	PCI/G	5.200	
SED02592	SD06005CH	7/09/92	RADIONUCLIDES	URANIUM-233/234	1/15/93	.800	.800	PCI/G	.012	
SED02592	SD06005CH	7/09/92	RADIONUCLIDES	URANIUM-235	1/15/93	.043	.043	PCI/G	.012	J
SED02592	SD06005CH	7/09/92	RADIONUCLIDES	URANIUM-238	1/15/93	.690	.690	PCI/G	.012	B
SED15192	SD06009CH	7/22/92	METALS	ALUMINUM	8/24/92	15100.000	15100.000	MG/KG	200.000	
SED15192	SD06009CH	7/22/92	METALS	ARSENIC	9/14/92	4.900	4.900	MG/KG	10.000	W
SED15192	SD06009CH	7/22/92	METALS	BARIUM	8/24/92	208.000	208.000	MG/KG	200.000	
SED15192	SD06009CH	7/22/92	METALS	BERYLLIUM	8/24/92	1.000	1.000	MG/KG	5.000	
SED15192	SD06009CH	7/22/92	METALS	CALCIUM	8/24/92	12200.000	12200.000	MG/KG	5000.000	
SED15192	SD06009CH	7/22/92	METALS	CHROMIUM	8/24/92	16.500	16.500	MG/KG	10.000	
SED15192	SD06009CH	7/22/92	METALS	COBALT	8/24/92	9.700	9.700	MG/KG	50.000	
SED15192	SD06009CH	7/22/92	METALS	COPPER	8/24/92	50.100	50.100	MG/KG	25.000	

LOCATION CODE	SAMPLE NUMBER	SAMPLE DATE	TEST GROUP CODE	CHEMICAL NAME	ANALYSIS DATE	NEW RESULT	ADJ RESULT	UNITS	NEW DETECT LIMIT	QUALIFIER
SED15192	SD06009CH	7/22/92	METALS	IRON	8/24/92	18700.000	18700.000	MG/KG	100.000	
SED15192	SD06009CH	7/22/92	METALS	LEAD	9/14/92	35.000	35.000	MG/KG	3.000	
SED15192	SD06009CH	7/22/92	METALS	LITHIUM	8/24/92	13.900	13.900	MG/KG	100.000	
SED15192	SD06009CH	7/22/92	METALS	MAGNESIUM	8/24/92	4270.000	4270.000	MG/KG	5000.000	
SED15192	SD06009CH	7/22/92	METALS	MANGANESE	8/24/92	193.000	193.000	MG/KG	15.000	
SED15192	SD06009CH	7/22/92	METALS	NICKEL	8/24/92	18.000	18.000	MG/KG	40.000	
SED15192	SD06009CH	7/22/92	METALS	POTASSIUM	8/24/92	3220.000	3220.000	MG/KG	5000.000	
SED15192	SD06009CH	7/22/92	METALS	SODIUM	8/24/92	278.000	278.000	MG/KG	5000.000	
SED15192	SD06009CH	7/22/92	METALS	STRONTIUM	8/24/92	73.700	73.700	MG/KG	200.000	W
SED15192	SD06009CH	7/22/92	METALS	VANADIUM	8/24/92	44.100	44.100	MG/KG	50.000	
SED15192	SD06009CH	7/22/92	METALS	ZINC	8/24/92	80.300	80.300	MG/KG	20.000	
SED15192	SD06009CH	7/22/92	RADIONUCLIDES	AMERICIUM-241	1/08/93	.041	.041	PCI/G	.019	
SED15192	SD06009CH	7/22/92	RADIONUCLIDES	GROSS ALPHA	10/15/92	43.000	43.000	PCI/G	3.000	
SED15192	SD06009CH	7/22/92	RADIONUCLIDES	GROSS BETA	10/15/92	37.000	37.000	PCI/G	5.400	
SED15192	SD06009CH	7/22/92	RADIONUCLIDES	PLUTONIUM-239/240	1/07/93	.480	.480	PCI/G	.002	
SED15192	SD06009CH	7/22/92	RADIONUCLIDES	URANIUM-233/234	12/23/92	1.600	1.600	PCI/G	.022	B
SED15192	SD06009CH	7/22/92	RADIONUCLIDES	URANIUM-235	12/23/92	.076	.076	PCI/G	.037	J
SED15192	SD06009CH	7/22/92	RADIONUCLIDES	URANIUM-238	12/23/92	1.900	1.900	PCI/G	.022	B
SED15192	SD06009CH	7/22/92	VOAS	2-BUTANONE	7/27/92	4.000	4.000	UG/KG	10.000	J
SED15192	SD06009CH	7/22/92	VOAS	ACETONE	7/27/92	31.000	31.000	UG/KG	10.000	J
SED15192	SD06009CH	7/22/92	WATER-QUALITY	TOTAL ORGANIC CARBON	8/20/92	.660	.660	%	.050	X
SED15192	SD06033CH	8/13/92	WATER-QUALITY	TOTAL ORGANIC CARBON	8/20/92	.770	.770	%	.050	X
SED15192	SD06153CH	9/10/92	METALS	ALUMINUM	11/11/92	17700.000	17700.000	MG/KG	200.000	
SED15192	SD06153CH	9/10/92	METALS	ARSENIC	12/05/92	7.100	7.100	MG/KG	10.000	
SED15192	SD06153CH	9/10/92	METALS	BARIUM	11/11/92	230.000	230.000	MG/KG	200.000	
SED15192	SD06153CH	9/10/92	METALS	BERYLLIUM	11/11/92	1.300	1.300	MG/KG	5.000	
SED15192	SD06153CH	9/10/92	METALS	CALCIUM	11/11/92	18200.000	18200.000	MG/KG	5000.000	
SED15192	SD06153CH	9/10/92	METALS	CHROMIUM	11/11/92	18.800	18.800	MG/KG	10.000	
SED15192	SD06153CH	9/10/92	METALS	COBALT	11/11/92	9.500	9.500	MG/KG	50.000	
SED15192	SD06153CH	9/10/92	METALS	COPPER	11/11/92	25.400	25.400	MG/KG	25.000	
SED15192	SD06153CH	9/10/92	METALS	IRON	11/11/92	22700.000	22700.000	MG/KG	100.000	
SED15192	SD06153CH	9/10/92	METALS	LEAD	12/05/92	34.700	34.700	MG/KG	3.000	
SED15192	SD06153CH	9/10/92	METALS	LITHIUM	11/11/92	11.900	11.900	MG/KG	100.000	
SED15192	SD06153CH	9/10/92	METALS	MAGNESIUM	11/11/92	5040.000	5040.000	MG/KG	5000.000	
SED15192	SD06153CH	9/10/92	METALS	MANGANESE	11/92	328.000	328.000	MG/KG	15.000	

LOCATION CODE	SAMPLE NUMBER	SAMPLE DATE	TEST GROUP CODE	CHEMICAL NAME	ANALYSIS DATE	NEW RESULT	ADJ RESULT	UNITS	NEW DETECT LIMIT	QUALIFIER
SED15192	SD06153CH	9/10/92	METALS	NICKEL	11/11/92	18.700	18.700	MG/KG	40.000	
SED15192	SD06153CH	9/10/92	METALS	POTASSIUM	11/11/92	3440.000	3440.000	MG/KG	5000.000	
SED15192	SD06153CH	9/10/92	METALS	SELENIUM	12/07/92	5.500	5.500	MG/KG	5.000	
SED15192	SD06153CH	9/10/92	METALS	SODIUM	11/11/92	407.000	407.000	MG/KG	5000.000	
SED15192	SD06153CH	9/10/92	METALS	STRONTIUM	11/11/92	105.000	105.000	MG/KG	200.000	
SED15192	SD06153CH	9/10/92	METALS	TIN	11/11/92	32.900	32.900	MG/KG	200.000	
SED15192	SD06153CH	9/10/92	METALS	VANADIUM	11/11/92	45.900	45.900	MG/KG	50.000	
SED15192	SD06153CH	9/10/92	METALS	ZINC	11/11/92	89.800	89.800	MG/KG	20.000	
SED15192	SD06153CH	9/10/92	RADIONUCLIDES	AMERICIUM-241	11/25/92	.065	.065	PCI/G	0.000	
SED15192	SD06153CH	9/10/92	RADIONUCLIDES	GROSS ALPHA	10/28/92	19.850	19.850	PCI/G	2.300	
SED15192	SD06153CH	9/10/92	RADIONUCLIDES	GROSS BETA	10/27/92	28.140	28.140	PCI/G	2.600	
SED15192	SD06153CH	9/10/92	RADIONUCLIDES	PLUTONIUM-239/240	11/12/92	.387	.387	PCI/G	0.000	
SED15192	SD06153CH	9/10/92	RADIONUCLIDES	URANIUM-233/234	11/16/92	1.280	1.280	PCI/G	.048	
SED15192	SD06153CH	9/10/92	RADIONUCLIDES	URANIUM-235	11/16/92	.043	.043	PCI/G	.048	J
SED15192	SD06153CH	9/10/92	RADIONUCLIDES	URANIUM-238	11/16/92	1.494	1.494	PCI/G	.034	
SED15192	SD06153CH	9/10/92	WATER-QUALITY	TOTAL ORGANIC CARBON	10/07/92	.470	.470	%	.050	
SED15192	SD06208CH	10/06/92	METALS	ALUMINUM	12/07/92	15200.000	15200.000	MG/KG	200.000	
SED15192	SD06208CH	10/06/92	METALS	ARSENIC	12/19/92	5.600	5.600	MG/KG	10.000	
SED15192	SD06208CH	10/06/92	METALS	BARIUM	12/07/92	197.000	197.000	MG/KG	200.000	
SED15192	SD06208CH	10/06/92	METALS	BERYLLIUM	12/07/92	1.100	1.100	MG/KG	5.000	
SED15192	SD06208CH	10/06/92	METALS	CALCIUM	12/07/92	7310.000	7310.000	MG/KG	5000.000	
SED15192	SD06208CH	10/06/92	METALS	CHROMIUM	12/07/92	18.900	18.900	MG/KG	10.000	
SED15192	SD06208CH	10/06/92	METALS	COBALT	12/07/92	8.600	8.600	MG/KG	50.000	
SED15192	SD06208CH	10/06/92	METALS	COPPER	12/07/92	46.000	46.000	MG/KG	25.000	
SED15192	SD06208CH	10/06/92	METALS	IRON	12/07/92	17300.000	17300.000	MG/KG	100.000	
SED15192	SD06208CH	10/06/92	METALS	LEAD	12/18/92	35.100	35.100	MG/KG	3.000	
SED15192	SD06208CH	10/06/92	METALS	LITHIUM	12/07/92	13.400	13.400	MG/KG	100.000	
SED15192	SD06208CH	10/06/92	METALS	MAGNESIUM	12/07/92	4380.000	4380.000	MG/KG	5000.000	
SED15192	SD06208CH	10/06/92	METALS	MANGANESE	12/07/92	194.000	194.000	MG/KG	15.000	
SED15192	SD06208CH	10/06/92	METALS	NICKEL	12/07/92	18.400	18.400	MG/KG	40.000	
SED15192	SD06208CH	10/06/92	METALS	POTASSIUM	12/07/92	3200.000	3200.000	MG/KG	5000.000	
SED15192	SD06208CH	10/06/92	METALS	SODIUM	12/07/92	390.000	390.000	MG/KG	5000.000	
SED15192	SD06208CH	10/06/92	METALS	STRONTIUM	12/07/92	60.200	60.200	MG/KG	200.000	
SED15192	SD06208CH	10/06/92	METALS	VANADIUM	12/07/92	43.400	43.400	MG/KG	50.000	
SED15192	SD06208CH	10/06/92	METALS	ZINC	12/07/92	76.900	76.900	MG/KG	20.000	
SED15192	SD06208CH	10/06/92	RADIONUCLIDES	AMERICIUM-241	11/30/92	.091	.091	PCI/G	0.000	

LOCATION CODE	SAMPLE NUMBER	SAMPLE DATE	TEST GROUP CODE	CHEMICAL NAME	ANALYSIS DATE	NEW RESULT	ADJ RESULT	UNITS	NEW DETECT LIMIT	QUALIFIER
SED15192	SD06208CH	10/06/92	RADIONUCLIDES	GROSS ALPHA	10/28/92	24.280	24.280	PCI/G	2.600	
SED15192	SD06208CH	10/06/92	RADIONUCLIDES	GROSS BETA	10/24/92	29.440	29.440	PCI/G	2.500	
SED15192	SD06208CH	10/06/92	RADIONUCLIDES	PLUTONIUM-239/240	11/22/92	.488	.488	PCI/G	.011	
SED15192	SD06208CH	10/06/92	RADIONUCLIDES	URANIUM-233/234	11/19/92	1.279	1.279	PCI/G	.053	
SED15192	SD06208CH	10/06/92	RADIONUCLIDES	URANIUM-235	11/19/92	.012	.012	PCI/G	.053	J
SED15192	SD06208CH	10/06/92	RADIONUCLIDES	URANIUM-238	11/19/92	1.634	1.634	PCI/G	.053	
SED15292	SD06010CH	7/22/92	METALS	ALUMINUM	8/24/92	12200.000	12200.000	MG/KG	200.000	
SED15292	SD06010CH	7/22/92	METALS	ARSENIC	9/14/92	5.200	5.200	MG/KG	10.000	W
SED15292	SD06010CH	7/22/92	METALS	BARIUM	8/24/92	166.000	166.000	MG/KG	200.000	
SED15292	SD06010CH	7/22/92	METALS	BERYLLIUM	8/24/92	.700	.700	MG/KG	5.000	
SED15292	SD06010CH	7/22/92	METALS	CALCIUM	8/24/92	16600.000	16600.000	MG/KG	5000.000	
SED15292	SD06010CH	7/22/92	METALS	CHROMIUM	8/24/92	12.600	12.600	MG/KG	10.000	
SED15292	SD06010CH	7/22/92	METALS	COBALT	8/24/92	7.600	7.600	MG/KG	50.000	
SED15292	SD06010CH	7/22/92	METALS	COPPER	8/24/92	25.600	25.600	MG/KG	25.000	
SED15292	SD06010CH	7/22/92	METALS	IRON	8/24/92	17100.000	17100.000	MG/KG	100.000	
SED15292	SD06010CH	7/22/92	METALS	LEAD	9/14/92	29.100	29.100	MG/KG	3.000	
SED15292	SD06010CH	7/22/92	METALS	LITHIUM	8/24/92	11.100	11.100	MG/KG	100.000	
SED15292	SD06010CH	7/22/92	METALS	MAGNESIUM	8/24/92	3600.000	3600.000	MG/KG	5000.000	
SED15292	SD06010CH	7/22/92	METALS	MANGANESE	8/24/92	218.000	218.000	MG/KG	15.000	
SED15292	SD06010CH	7/22/92	METALS	MERCURY	8/11/92	.100	.100	MG/KG	.200	
SED15292	SD06010CH	7/22/92	METALS	NICKEL	8/24/92	13.800	13.800	MG/KG	40.000	
SED15292	SD06010CH	7/22/92	METALS	POTASSIUM	8/24/92	2610.000	2610.000	MG/KG	5000.000	
SED15292	SD06010CH	7/22/92	METALS	SILVER	8/24/92	1.500	1.500	MG/KG	10.000	
SED15292	SD06010CH	7/22/92	METALS	SODIUM	8/24/92	232.000	232.000	MG/KG	5000.000	
SED15292	SD06010CH	7/22/92	METALS	STRONTIUM	8/24/92	76.200	76.200	MG/KG	200.000	W
SED15292	SD06010CH	7/22/92	METALS	VANADIUM	8/24/92	33.100	33.100	MG/KG	50.000	
SED15292	SD06010CH	7/22/92	METALS	ZINC	8/24/92	63.600	63.600	MG/KG	20.000	
SED15292	SD06010CH	7/22/92	RADIONUCLIDES	AMERICIUM-241	1/08/93	.055	.055	PCI/G	.014	
SED15292	SD06010CH	7/22/92	RADIONUCLIDES	GROSS ALPHA	10/15/92	43.000	43.000	PCI/G	3.100	
SED15292	SD06010CH	7/22/92	RADIONUCLIDES	GROSS BETA	10/15/92	37.000	37.000	PCI/G	5.600	
SED15292	SD06010CH	7/22/92	RADIONUCLIDES	PLUTONIUM-239/240	1/07/93	.240	.240	PCI/G	.005	
SED15292	SD06010CH	7/22/92	RADIONUCLIDES	URANIUM-233/234	12/23/92	1.100	1.100	PCI/G	.027	B
SED15292	SD06010CH	7/22/92	RADIONUCLIDES	URANIUM-235	12/23/92	.090	.090	PCI/G	.072	J
SED15292	SD06010CH	7/22/92	RADIONUCLIDES	URANIUM-238	12/23/92	1.600	1.600	PCI/G	.027	B
SED15292	SD06010CH	7/22/92	VOAS	2-BUTANONE	7/27/92	9.000	9.000	UG/KG	10.000	J
SED15292	SD06010CH	7/22/92	VOAS	ACETONE	7/27/92	47.000	47.000	UG/KG	10.000	

:ATION CODE	SAMPLE NUMBER	SAMPLE DATE	TEST GROUP CODE	CHEMICAL NAME	ANALYSIS DATE	NEW RESULT	ADJ RESULT	UNITS	NEW DETECT LIMIT	QUALIFIER
:ED15292	SD06034CH	8/13/92	WATER-QUALITY	TOTAL ORGANIC CARBON	8/20/92	.930	.930	%	.050	X
:ED15292	SD06209CH	10/06/92	METALS	ALUMINUM	12/07/92	16100.000	16100.000	MG/KG	200.000	
:ED15292	SD06209CH	10/06/92	METALS	ARSENIC	12/19/92	5.500	5.500	MG/KG	10.000	
ED15292	SD06209CH	10/06/92	METALS	BARIUM	12/07/92	193.000	193.000	MG/KG	200.000	
:ED15292	SD06209CH	10/06/92	METALS	BERYLLIUM	12/07/92	1.100	1.100	MG/KG	5.000	
:ED15292	SD06209CH	10/06/92	METALS	CALCIUM	12/07/92	17600.000	17600.000	MG/KG	5000.000	
:ED15292	SD06209CH	10/06/92	METALS	CHROMIUM	12/07/92	19.100	19.100	MG/KG	10.000	
:ED15292	SD06209CH	10/06/92	METALS	COBALT	12/07/92	8.100	8.100	MG/KG	50.000	
ED15292	SD06209CH	10/06/92	METALS	COPPER	12/07/92	36.900	36.900	MG/KG	25.000	
ED15292	SD06209CH	10/06/92	METALS	IRON	12/07/92	20000.000	20000.000	MG/KG	100.000	
ED15292	SD06209CH	10/06/92	METALS	LEAD	12/18/92	29.400	29.400	MG/KG	3.000	
ED15292	SD06209CH	10/06/92	METALS	LITHIUM	12/07/92	13.400	13.400	MG/KG	100.000	
ED15292	SD06209CH	10/06/92	METALS	MAGNESIUM	12/07/92	4370.000	4370.000	MG/KG	5000.000	
ED15292	SD06209CH	10/06/92	METALS	MANGANESE	12/07/92	216.000	216.000	MG/KG	15.000	
ED15292	SD06209CH	10/06/92	METALS	NICKEL	12/07/92	18.000	18.000	MG/KG	40.000	
ED15292	SD06209CH	10/06/92	METALS	POTASSIUM	12/07/92	3100.000	3100.000	MG/KG	5000.000	
ED15292	SD06209CH	10/06/92	METALS	SODIUM	12/07/92	263.000	263.000	MG/KG	5000.000	
ED15292	SD06209CH	10/06/92	METALS	STRONTIUM	12/07/92	89.300	89.300	MG/KG	200.000	
ED15292	SD06209CH	10/06/92	METALS	VANADIUM	12/07/92	40.600	40.600	MG/KG	50.000	
ED15292	SD06209CH	10/06/92	METALS	ZINC	12/07/92	75.000	75.000	MG/KG	20.000	
:D15292	SD06209CH	10/06/92	RADIONUCLIDES	AMERICIUM-241	11/30/92	.045	.045	PCI/G	0.000	
:D15292	SD06209CH	10/06/92	RADIONUCLIDES	GROSS ALPHA	10/28/92	15.130	15.130	PCI/G	2.300	
'D15292	SD06209CH	10/06/92	RADIONUCLIDES	GROSS BETA	10/24/92	29.650	29.650	PCI/G	2.500	
D15292	SD06209CH	10/06/92	RADIONUCLIDES	PLUTONIUM-239/240	11/22/92	.337	.337	PCI/G	.006	
D15292	SD06209CH	10/06/92	RADIONUCLIDES	URANIUM-233/234	11/19/92	1.138	1.138	PCI/G	.044	
D15292	SD06209CH	10/06/92	RADIONUCLIDES	URANIUM-235	11/19/92	.043	.043	PCI/G	.031	J
D15292	SD06209CH	10/06/92	RADIONUCLIDES	URANIUM-238	11/19/92	1.217	1.217	PCI/G	.031	
D15292	SD06209CH	10/06/92	VOAS	2-BUTANONE	10/09/92	14.000	14.000	UG/KG	10.000	J
D15292	SD06209CH	10/06/92	WATER-QUALITY	TOTAL ORGANIC CARBON	11/10/92	.530	.530	%	.050	X

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FISH TISSUE ANALYSIS RESULTS

OU3 AQUATIC POTENTIAL COC EVALUATION

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TISSIA12.R1 from BIOSAMPS.DB and TISDATA2.DB

Table QC-31

8/23/94

OU 3 FISH SUMMARIES

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
GREAT WESTERN RESERVOIR										
CARP (WB)										
ARSENIC	MG/KG	1	1	1.00	.042	.042	.042			
BERYLLIUM	MG/KG	0	1				.004			
CADMIUM	MG/KG	1	1	1.00	.227	.227	.227			
CHROMIUM	MG/KG	0	1				.076			
COPPER	MG/KG	1	1	1.00	1.141	1.141	1.141			
GROSS BETA	PCI/G	1	1	1.00	10.000	10.000	10.000			
LEAD	MG/KG	1	1	1.00	.345	.345	.345			
MERCURY	MG/KG	1	1	1.00	.225	.225	.225			
NICKEL	MG/KG	1	1	1.00	.453	.453	.453			
SELENIUM	MG/KG	1	1	1.00	.803	.803	.803			
SILVER	MG/KG	0	1				.004			
URANIUM-233/234	PCI/G	1	1	1.00	.054	.054	.054			
URANIUM-235	PCI/G	1	1	1.00	.004	.004	.004			
URANIUM-238	PCI/G	1	1	1.00	.062	.062	.062			
ZINC	MG/KG	1	1	1.00	88.672	88.672	88.672			
CARP (WBX)										
AMERICIUM-241	PCI/G	1	1	1.00	.002	.002	.002			
ARSENIC	MG/KG	5	6	.83	.049	.084	.063	.025	.397	.084
BERYLLIUM	MG/KG	0	6				.004	.000	.078	.004
CADMIUM	MG/KG	6	6	1.00	.021	.252	.085	.086	1.014	.155
CHROMIUM	MG/KG	2	6	.33	.264	.314	.161	.101	.626	.244
COPPER	MG/KG	5	6	.83	.795	3.472	1.356	1.084	.799	2.248
GROSS ALPHA	PCI/G	3	3	1.00	-.018	.250	.124	.135	1.086	.351
GROSS BETA	PCI/G	6	6	1.00	5.200	12.000	8.050	2.640	.328	10.221
LEAD	MG/KG	6	6	1.00	.270	.636	.461	.127	.276	.565
MERCURY	MG/KG	6	6	1.00	.130	.280	.173	.056	.322	.219
NICKEL	MG/KG	5	6	.83	.173	.685	.406	.214	.528	.582

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
GREAT WESTERN RESERVOIR										
CARP (WBX)										
PLUTONIUM-238	PCI/G	1	1	1.00	.001	.001	.001			
PLUTONIUM-239/240	PCI/G	1	1	1.00	.001	.001	.001			
SELENIUM	MG/KG	6	6	1.00	.393	.831	.684	.160	.235	.816
SILVER	MG/KG	0	6				.004			.004
URANIUM-233/234	PCI/G	6	6	1.00	.068	.110	.095	.016	.170	.108
URANIUM-235	PCI/G	6	6	1.00	.002	.015	.009	.005	.540	.013
URANIUM-238	PCI/G	6	6	1.00	.050	.092	.074	.016	.217	.087
ZINC	MG/KG	6	6	1.00	47.472	111.060	70.149	24.068	.343	89.948
MINNOWS										
AMERICIUM-241	PCI/G	4	4	1.00	-.001	.003	.001	.002	1.366	.003
ARSENIC	MG/KG	5	5	1.00	.159	.262	.209	.039	.188	.246
BERYLLIUM	MG/KG	0	5				.007	.001	.143	.008
CADMIUM	MG/KG	5	5	1.00	.045	.116	.079	.029	.367	.107
CHROMIUM	MG/KG	4	5	.80	.223	.284	.230	.076	.330	.303
COPPER	MG/KG	5	5	1.00	1.180	7.015	3.226	2.304	.714	5.423
GROSS ALPHA	PCI/G	5	5	1.00	-.530	2.200	1.194	1.044	.875	2.190
GROSS BETA	PCI/G	5	5	1.00	11.000	22.000	13.600	4.722	.347	18.103
LEAD	MG/KG	5	5	1.00	.627	1.258	.903	.250	.277	1.142
MERCURY	MG/KG	0	5				.050	.000	.000	.050
NICKEL	MG/KG	5	5	1.00	.585	3.004	1.298	1.014	.781	2.265
PLUTONIUM-238	PCI/G	3	3	1.00	-.004	.003	0.000	.004	0.000	.006
PLUTONIUM-239/240	PCI/G	5	5	1.00	.001	.006	.004	.002	.541	.005
SELENIUM	MG/KG	5	5	1.00	.338	.625	.517	.112	.217	.623
SILVER	MG/KG	0	5				.004			.004
URANIUM-233/234	PCI/G	5	5	1.00	.120	.190	.142	.032	.225	.172
URANIUM-235	PCI/G	4	4	1.00	.006	.015	.011	.004	.343	.016
URANIUM-238	PCI/G	5	5	1.00	.081	.170	.120	.037	.310	.155

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
GREAT WESTERN RESERVOIR										
MINNOWS										
ZINC	MG/KG	5	5	1.00	37.778	44.294	41.444	2.698	.065	44.016
SUCKER SP. (WB)										
AMERICIUM-241	PCI/G	5	5	1.00	.001	.004	.002	.001	.593	.003
ARSENIC	MG/KG	7	7	1.00	.045	.333	.147	.100	.677	.221
BERYLLIUM	MG/KG	0	7				.007	.004	.576	.010
CADMIUM	MG/KG	7	7	1.00	.023	.085	.054	.027	.504	.074
CHROMIUM	MG/KG	4	7	.57	.341	.939	.320	.309	.964	.547
COPPER	MG/KG	7	7	1.00	1.538	9.385	3.977	3.196	.804	6.324
GROSS ALPHA	PCI/G	6	6	1.00	-.320	2.800	1.217	1.125	.925	2.142
GROSS BETA	PCI/G	7	7	1.00	5.500	15.000	11.014	2.921	.265	13.160
LEAD	MG/KG	5	7	.71	.255	1.273	.516	.430	.835	.832
MERCURY	MG/KG	0	7				.050	.000	.000	.050
NICKEL	MG/KG	6	7	.86	.183	1.984	.610	.642	1.052	1.081
PLUTONIUM-238	PCI/G	5	5	1.00	.001	.006	.002	.002	.864	.004
PLUTONIUM-239/240	PCI/G	7	7	1.00	.001	.006	.003	.002	.836	.004
SELENIUM	MG/KG	7	7	1.00	.423	.775	.539	.120	.222	.627
SILVER	MG/KG	0	7				.005	.002	.472	.006
URANIUM-233/234	PCI/G	7	7	1.00	.048	.210	.123	.063	.514	.169
URANIUM-235	PCI/G	7	7	1.00	-.002	.013	.006	.005	.772	.010
URANIUM-238	PCI/G	7	7	1.00	.040	.190	.101	.056	.557	.142
ZINC	MG/KG	7	7	1.00	13.721	32.679	19.563	6.795	.347	24.553

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
LINDSEY POND										
BASS SP. (M)										
AMERICIUM-241	PCI/G	1	1	1.00	.001	.001	.001			
ARSENIC	MG/KG	2	2	1.00	.081	.100	.090	.014	.155	.153
BERYLLIUM	MG/KG	0	2				.005	.001	.262	.012
CADMIUM	MG/KG	1	2	.50	.043	.043	.025	.025	.995	.138
CHROMIUM	MG/KG	0	2				.098	.003	.027	.110
COPPER	MG/KG	0	2				.552	.010	.018	.597
GROSS ALPHA	PCI/G	2	2	1.00	-.300	-.180	-.240	.085	-.354	.139
GROSS BETA	PCI/G	2	2	1.00	14.000	16.000	15.000	1.414	.094	21.314
LEAD	MG/KG	1	2	.50	.230	.230	.169	.087	.514	.556
MERCURY	MG/KG	1	2	.50	.145	.145	.098	.067	.689	.397
NICKEL	MG/KG	2	2	1.00	1.000	1.460	1.230	.325	.264	2.680
PLUTONIUM-238	PCI/G	2	2	1.00	-.001	.002	.001	.002	4.243	.010
PLUTONIUM-239/240	PCI/G	1	1	1.00	.001	.001	.001			
SELENIUM	MG/KG	2	2	1.00	.544	.571	.557	.019	.034	.642
SILVER	MG/KG	0	2				.004			.004
URANIUM-233/234	PCI/G	2	2	1.00	.010	.021	.016	.008	.502	.050
URANIUM-235	PCI/G	1	1	1.00	.012	.012	.012			
URANIUM-238	PCI/G	2	2	1.00	.005	.007	.006	.001	.236	.012
ZINC	MG/KG	2	2	1.00	6.638	7.507	7.073	.615	.087	9.817
BASS SP. (WB)										
ARSENIC	MG/KG	2	2	1.00	.044	.104	.074	.042	.572	.264
BERYLLIUM	MG/KG	0	2				.005	.001	.146	.008
CADMIUM	MG/KG	2	2	1.00	.018	.039	.029	.015	.517	.095
CHROMIUM	MG/KG	1	2	.50	.289	.289	.195	.132	.675	.784
COPPER	MG/KG	2	2	1.00	.943	1.500	1.221	.393	.322	2.978
GROSS ALPHA	PCI/G	1	1	1.00	-.140	-.140	-.140			
GROSS BETA	PCI/G	2	2	1.00	7.500	10.000	8.750	1.768	.202	16.643

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
LINDSEY POND										
BASS SP. (WB)										
LEAD	MG/KG	1	2	.50	.309	.309	.197	.158	.798	.901
MERCURY	MG/KG	0	2				.050			.050
NICKEL	MG/KG	2	2	1.00	.688	2.089	1.389	.991	.713	5.811
PLUTONIUM-238	PCI/G	1	1	1.00	.001	.001	.001			
SELENIUM	MG/KG	2	2	1.00	.569	.774	.672	.145	.215	1.317
SILVER	MG/KG	0	2				.004			.004
URANIUM-233/234	PCI/G	1	1	1.00	-.016	-.016	-.016			
URANIUM-235	PCI/G	2	2	1.00	-.004	.010	.003	.010	3.300	.047
URANIUM-238	PCI/G	2	2	1.00	.004	.004	.004			.004
ZINC	MG/KG	2	2	1.00	24.120	27.883	26.001	2.660	.102	37.879
MOWER RESERVOIR										
BASS SP. (M)										
AMERICIUM-241	PCI/G	1	1	1.00	.004	.004	.004			
ARSENIC	MG/KG	0	4				.019			.019
BERYLLIUM	MG/KG	0	4				.004	.000	.020	.004
CADMIUM	MG/KG	1	4	.25	.024	.024	.012	.008	.712	.021
CHROMIUM	MG/KG	0	4				.088	.005	.058	.094
COPPER	MG/KG	0	4				.177	.104	.588	.299
GROSS ALPHA	PCI/G	2	2	1.00	-.150	-.034	-.092	.082	-.892	.274
GROSS BETA	PCI/G	4	4	1.00	14.000	16.000	15.000	.816	.054	15.961
LEAD	MG/KG	0	4				.052	.030	.575	.086
MERCURY	MG/KG	4	4	1.00	.105	.260	.195	.066	.337	.272
NICKEL	MG/KG	2	4	.50	.265	.342	.218	.104	.478	.341
PLUTONIUM-238	PCI/G	2	2	1.00	-.001	.001	0.000	.001	0.000	.006
PLUTONIUM-239/240	PCI/G	2	2	1.00	-.001	.001	0.000	.001	0.000	.006

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
HOWER RESERVOIR										
BASS SP. (M)										
SELENIUM	MG/KG	4	4	1.00	.456	.527	.495	.031	.062	.531
SILVER	MG/KG	0	4				.004			.004
URANIUM-233/234	PCI/G	3	3	1.00	.011	.049	.028	.019	.690	.061
URANIUM-235	PCI/G	2	2	1.00	.005	.017	.011	.008	.771	.049
URANIUM-238	PCI/G	4	4	1.00	.003	.004	.004	.001	.165	.004
ZINC	MG/KG	4	4	1.00	5.753	6.322	6.094	.242	.040	6.379
AMERICIUM-241	PCI/G	1	1	1.00	.001	.001	.001			
ARSENIC	MG/KG	3	4	.75	.053	.093	.061	.033	.536	.099
BERYLLIUM	MG/KG	0	4				.004			.004
CADMIUM	MG/KG	2	4	.50	.024	.024	.016	.009	.600	.027
CHROMIUM	MG/KG	2	4	.50	.252	.359	.193	.137	.707	.354
COPPER	MG/KG	1	4	.25	1.888	1.888	.714	.797	1.117	1.651
GROSS ALPHA	PCI/G	4	4	1.00	-1.000	-.044	-.419	.410	-.979	.064
GROSS BETA	PCI/G	4	4	1.00	5.500	140.000	42.325	65.209	1.541	119.043
LEAD	MG/KG	0	4				.039	.019	.479	.061
MERCURY	MG/KG	4	4	1.00	.125	.210	.174	.037	.216	.218
NICKEL	MG/KG	0	4				.142	.116	.816	.279
PLUTONIUM-238	PCI/G	2	2	1.00	-.005	.001	-.002	.004	-2.121	.017
SELENIUM	MG/KG	4	4	1.00	.542	.715	.649	.076	.118	.739
SILVER	MG/KG	0	4				.004			.004
URANIUM-233/234	PCI/G	4	4	1.00	.003	.170	.050	.080	1.626	.144
URANIUM-235	PCI/G	3	3	1.00	.002	.017	.007	.008	1.144	.021
URANIUM-238	PCI/G	3	3	1.00	.003	.130	.047	.072	1.514	.168
ZINC	MG/KG	4	4	1.00	5.247	6.590	5.950	.569	.096	6.619
BASS SP. (WB)										
ARSENIC	MG/KG	5	5	1.00	.077	.120	.092	.017	.180	.108
BERYLLIUM	MG/KG	0	5				.004	.001	.135	.005

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
HOWER RESERVOIR										
BASS SP. (WB)										
CADMIUM	MG/KG	3	5	.60	.018	.038	.019	.013	.666	.031
CHROMIUM	MG/KG	2	5	.40	.218	.248	.157	.074	.469	.227
COPPER	MG/KG	3	5	.60	.520	1.646	.878	.611	.696	1.460
GROSS ALPHA	PCI/G	4	4	1.00	-.180	.130	-.033	.128	-3.891	.118
GROSS BETA	PCI/G	5	5	1.00	3.700	9.700	7.220	2.851	.395	9.938
LEAD	MG/KG	0	5				.056	.025	.442	.079
MERCURY	MG/KG	2	5	.40	.135	.345	.126	.128	1.015	.248
NICKEL	MG/KG	4	5	.80	.300	1.443	.642	.481	.748	1.100
PLUTONIUM-238	PCI/G	3	3	1.00	.001	.002	.002	.001	.346	.003
SELENIUM	MG/KG	5	5	1.00	.533	.937	.767	.147	.192	.908
SILVER	MG/KG	0	5				.004			.004
URANIUM-233/234	PCI/G	3	3	1.00	.002	.041	.016	.022	1.356	.053
URANIUM-235	PCI/G	2	2	1.00	-.002	.004	.001	.004	4.243	.020
URANIUM-238	PCI/G	3	3	1.00	.005	.007	.006	.001	.182	.008
ZINC	MG/KG	5	5	1.00	17.094	23.018	20.874	2.741	.131	23.487
SUCKER SP. (WB)										
ARSENIC	MG/KG	1	1	1.00	.059	.059	.059			
BERYLLIUM	MG/KG	0	1				.004			
CADMIUM	MG/KG	0	1				.008			
CHROMIUM	MG/KG	0	1				.064			
COPPER	MG/KG	1	1	1.00	.851	.851	.851			
GROSS ALPHA	PCI/G	1	1	1.00	.036	.036	.036			
GROSS BETA	PCI/G	1	1	1.00	13.000	13.000	13.000			
LEAD	MG/KG	0	1				.041			
MERCURY	MG/KG	0	1				.050			
NICKEL	MG/KG	0	1				.077			
PLUTONIUM-238	PCI/G	1	1	1.00	.001	.001	.001			

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
HOWER RESERVOIR										
SUCKER SP. (WB)										
PLUTONIUM-239/240	PCI/G	1	1	1.00	.004	.004	.004			
SELENIUM	MG/KG	1	1	1.00	.565	.565	.565			
SILVER	MG/KG	0	1				.004			
URANIUM-233/234	PCI/G	1	1	1.00	.006	.006	.006			
URANIUM-238	PCI/G	1	1	1.00	.017	.017	.017			
ZINC	MG/KG	1	1	1.00	11.699	11.699	11.699			
STANDLEY LAKE										
CARP (WB)										
AMERICIUM-241	PCI/G	1	1	1.00	-.001	-.001	-.001			
ARSENIC	MG/KG	5	7	.71	.041	.169	.095	.071	.743	.147
CADMIUM	MG/KG	7	7	1.00	.125	.803	.494	.204	.413	.644
CHROMIUM	MG/KG	4	7	.57	.264	.413	.228	.140	.614	.331
COPPER	MG/KG	7	7	1.00	1.103	6.790	2.404	2.011	.837	3.881
GROSS BETA	PCI/G	7	7	1.00	7.200	9.800	8.671	.978	.113	9.389
LEAD	MG/KG	7	7	1.00	.482	1.250	.746	.291	.390	.960
MERCURY	MG/KG	6	7	.86	.120	.250	.155	.061	.392	.200
NICKEL	MG/KG	7	7	1.00	.324	5.549	1.378	1.866	1.355	2.748
PLUTONIUM-238	PCI/G	2	2	1.00	-.001	.001	0.000	.001	0.000	.006
PLUTONIUM-239/240	PCI/G	2	2	1.00	-.001	.001	0.000	.001	0.000	.006
SELENIUM	MG/KG	7	7	1.00	.269	.643	.382	.124	.324	.473
SILVER	MG/KG	0	7				.004			.004
URANIUM-233/234	PCI/G	7	7	1.00	.046	.190	.102	.057	.562	.144
URANIUM-235	PCI/G	7	7	1.00	.004	.012	.008	.003	.365	.010
URANIUM-238	PCI/G	7	7	1.00	.032	.180	.106	.063	.594	.152
ZINC	MG/KG	7	7	1.00	71.819	150.492	94.413	26.299	.279	113.727

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
STANDLEY LAKE										
CARP (WB)										
CARP (WBX)										
ARSENIC	MG/KG	2	2	1.00	.060	.076	.068	.011	.168	.119
BERYLLIUM	MG/KG	0	1				.004			
CADMIUM	MG/KG	2	2	1.00	.036	.263	.149	.161	1.078	.869
CHROMIUM	MG/KG	1	2	.50	.262	.262	.184	.111	.605	.679
COPPER	MG/KG	2	2	1.00	.429	.663	.546	.165	.303	1.284
GROSS BETA	PCI/G	2	2	1.00	8.500	8.800	8.650	.212	.025	9.597
LEAD	MG/KG	2	2	1.00	.644	.730	.687	.061	.089	.960
MERCURY	MG/KG	2	2	1.00	.140	.185	.163	.032	.196	.305
NICKEL	MG/KG	2	2	1.00	.270	.310	.290	.028	.097	.416
PLUTONIUM-238	PCI/G	1	1	1.00	.001	.001	.001			
PLUTONIUM-239/240	PCI/G	2	2	1.00	.001	.034	.018	.023	1.333	.122
SELENIUM	MG/KG	2	2	1.00	.251	.581	.416	.233	.560	1.457
SILVER	MG/KG	0	2				.004			.004
URANIUM-233/234	PCI/G	2	2	1.00	.039	.390	.215	.248	1.157	1.323
URANIUM-235	PCI/G	2	2	1.00	.002	.017	.010	.011	1.116	.057
URANIUM-238	PCI/G	2	2	1.00	.046	.290	.168	.173	1.027	.938
ZINC	MG/KG	2	2	1.00	47.422	62.956	55.189	10.984	.199	104.230
CHANNEL CATFISH (WB)										
ARSENIC	MG/KG	1	2	.50	.078	.078	.048	.042	.865	.235
CADMIUM	MG/KG	1	2	.50	.036	.036	.022	.020	.931	.113
CHROMIUM	MG/KG	1	2	.50	.318	.318	.221	.137	.623	.834
COPPER	MG/KG	2	2	1.00	1.073	2.927	2.000	1.311	.656	7.853
GROSS ALPHA	PCI/G	1	1	1.00	.092	.092	.092			
GROSS BETA	PCI/G	2	2	1.00	1.400	6.100	3.750	3.323	.886	18.588

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
STANDLEY LAKE										
CHANNEL CATFISH (WB)										
LEAD	MG/KG	2	2	1.00	.345	.603	.474	.182	.384	1.287
MERCURY	MG/KG	1	2	.50	.275	.275	.163	.159	.979	.873
NICKEL	MG/KG	2	2	1.00	.180	2.072	1.126	1.337	1.188	7.097
PLUTONIUM-238	PCI/G	2	2	1.00	.001	.001	.001			.001
PLUTONIUM-239/240	PCI/G	1	1	1.00	.002	.002	.002			
SELENIUM	MG/KG	2	2	1.00	.219	.329	.274	.078	.283	.620
SILVER	MG/KG	0	2				.004			.004
URANIUM-233/234	PCI/G	2	2	1.00	.008	.062	.035	.038	1.091	.205
URANIUM-238	PCI/G	2	2	1.00	.016	.038	.027	.016	.576	.096
ZINC	MG/KG	2	2	1.00	13.368	25.401	19.384	8.509	.439	57.373
RAINBOW TROUT										
ARSENIC	MG/KG	6	6	1.00	.093	.313	.235	.078	.333	.300
BERYLLIUM	MG/KG	0	5				.004			.004
CADMIUM	MG/KG	1	6	.17	.042	.042	.013	.014	1.065	.025
CHROMIUM	MG/KG	0	6				.082	.011	.130	.091
COPPER	MG/KG	4	6	.67	1.129	2.421	1.405	.859	.611	2.112
GROSS ALPHA	PCI/G	5	5	1.00	-.300	.060	-.166	.140	-.841	
GROSS BETA	PCI/G	6	6	1.00	9.900	14.000	11.650	1.391	.119	12.794
LEAD	MG/KG	0	6				.049	.011	.218	.058
MERCURY	MG/KG	0	6				.050	.000	.000	.050
NICKEL	MG/KG	2	6	.33	.387	.450	.250	.152	.608	.375
PLUTONIUM-238	PCI/G	4	4	1.00	-.001	.002	.001	.001	1.678	.002
PLUTONIUM-239/240	PCI/G	1	1	1.00	.001	.001	.001			
SELENIUM	MG/KG	6	6	1.00	.262	.418	.352	.057	.163	.399
SILVER	MG/KG	0	6				.004			.004
URANIUM-233/234	PCI/G	5	5	1.00	.004	.027	.012	.009	.732	.021
URANIUM-235	PCI/G	3	3	1.00	.002	.007	.005	.003	.529	.009

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
STANDLEY LAKE										
RAINBOW TROUT										
URANIUM-238	PCI/G	5	5	1.00	.005	.010	.007	.002	.319	.009
ZINC	MG/KG	6	6	1.00	25.780	46.577	31.976	7.957	.249	38.522
ARSENIC	MG/KG	2	2	1.00	.145	.425	.285	.198	.694	1.169
BERYLLIUM	MG/KG	0	2				.004			.004
CADMIUM	MG/KG	1	2	.50	.035	.035	.021	.020	.919	.109
CHROMIUM	MG/KG	0	2				.101	.005	.045	.121
COPPER	MG/KG	0	2				.227	.134	.593	.827
GROSS ALPHA	PCI/G	1	1	1.00	.033	.033	.033			
GROSS BETA	PCI/G	2	2	1.00	8.900	13.000	10.950	2.899	.265	23.894
LEAD	MG/KG	1	2	.50	.259	.259	.149	.156	1.042	.844
MERCURY	MG/KG	0	2				.050			.050
NICKEL	MG/KG	1	2	.50	1.918	1.918	.987	1.317	1.334	6.867
PLUTONIUM-238	PCI/G	1	1	1.00	.001	.001	.001			
PLUTONIUM-239/240	PCI/G	1	1	1.00	.002	.002	.002			
SELENIUM	MG/KG	2	2	1.00	.269	.419	.344	.106	.310	.819
SILVER	MG/KG	0	2				.004			.004
URANIUM-233/234	PCI/G	2	2	1.00	.002	.008	.005	.004	.849	.024
URANIUM-238	PCI/G	2	2	1.00	.008	.010	.009	.001	.157	.015
ZINC	MG/KG	2	2	1.00	14.478	18.390	16.434	2.766	.168	28.784
SUCKER SP. (WB)										
AMERICIUM-241	PCI/G	2	2	1.00	-.001	.002	.001	.002	4.243	.010
ARSENIC	MG/KG	3	4	.75	.049	.122	.073	.048	.654	.130
BERYLLIUM	MG/KG	0	1				.004			
CADMIUM	MG/KG	4	4	1.00	.032	.068	.049	.017	.346	.069
CHROMIUM	MG/KG	2	4	.50	.240	.300	.176	.112	.635	.307
COPPER	MG/KG	3	4	.75	.876	1.073	.890	.230	.258	1.161
GROSS ALPHA	PCI/G	2	2	1.00	-.180	-.049	-.115	.093	-.809	.299

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
STANDLEY LAKE										
SUCKER SP. (WB)										
GROSS BETA	PCI/G	4	4	1.00	8.800	11.000	10.450	1.100	.105	11.744
LEAD	MG/KG	2	4	.50	.273	.286	.190	.104	.546	.312
MERCURY	MG/KG	0	4				.050			.050
NICKEL	MG/KG	4	4	1.00	.345	1.729	.746	.658	.883	1.520
PLUTONIUM-238	PCI/G	2	2	1.00	-.004	.002	-.001	.004	-4.243	.018
PLUTONIUM-239/240	PCI/G	2	2	1.00	-.001	.001	0.000	.001	0.000	.006
SELENIUM	MG/KG	4	4	1.00	.164	.412	.278	.103	.370	.400
SILVER	MG/KG	0	4				.004			.004
URANIUM-233/234	PCI/G	4	4	1.00	.013	.068	.043	.023	.532	.069
URANIUM-235	PCI/G	3	3	1.00	.002	.013	.009	.006	.676	.019
URANIUM-238	PCI/G	4	4	1.00	.025	.046	.034	.009	.261	.044
ZINC	MG/KG	4	4	1.00	14.731	22.066	18.522	3.220	.174	22.310
YELLOW PERCH/WALLEYE (M)										
ARSENIC	MG/KG	2	2	1.00	.074	.108	.091	.023	.258	.196
BERYLLIUM	MG/KG	0	2				.004			.004
CADMIUM	MG/KG	1	2	.50	.021	.021	.014	.009	.659	.055
CHROMIUM	MG/KG	0	2				.091	.003	.033	.104
COPPER	MG/KG	0	2				.326	.267	.817	1.517
GROSS ALPHA	PCI/G	2	2	1.00	-.520	-.520	-.520			
GROSS BETA	PCI/G	2	2	1.00	18.000	18.000	18.000			18.000
LEAD	MG/KG	0	2				.057	.003	.046	.069
MERCURY	MG/KG	0	2				.050			.050
NICKEL	MG/KG	1	2	.50	1.051	1.051	.676	.530	.783	3.042
PLUTONIUM-239/240	PCI/G	1	1	1.00	.001	.001	.001			
SELENIUM	MG/KG	2	2	1.00	.261	.460	.360	.141	.391	.988
SILVER	MG/KG	0	2				.008	.006	.747	.034
URANIUM-233/234	PCI/G	2	2	1.00	.007	.013	.010	.004	.424	.029

Chemical Name	Units	Number of Detects	Number of Samples	Frequency of Detection	Minimum Detected Value	Maximum Detected Value	Arithmetic Mean	Standard Deviation	Coeff. of Variation	Upper 95% UCL
ANDLEY LAKE										
LLOW PERCH/WALLEYE (H)										
URANIUM-235	PCI/G	1	1	1.00	.004	.004	.004			
URANIUM-238	PCI/G	2	2	1.00	.003	.004	.004	.001	.202	.007
ZINC	MG/KG	2	2	1.00	3.784	3.959	3.871	.124	.032	4.423
LLOW PERCH/WALLEYE (WB)										
AMERICIUM-241	PCI/G	2	2	1.00	-.001	.002	.001	.002	4.243	.010
ARSENIC	MG/KG	5	6	.83	.047	.178	.088	.054	.622	.132
BERYLLIUM	MG/KG	0	3				.004			.004
CADMIUM	MG/KG	5	6	.83	.015	.589	.118	.231	1.965	.308
CHROMIUM	MG/KG	1	6	.17	.220	.220	.127	.046	.359	.165
COPPER	MG/KG	4	6	.67	.479	1.044	.601	.287	.478	.838
GROSS ALPHA	PCI/G	4	4	1.00	-.280	-.012	-.096	.124	-1.298	.050
GROSS BETA	PCI/G	6	6	1.00	1.400	11.000	8.783	3.767	.429	11.883
LEAD	MG/KG	2	6	.33	.346	.509	.196	.187	.956	.350
MERCURY	MG/KG	1	6	.17	.195	.195	.074	.059	.798	.123
NICKEL	MG/KG	5	6	.83	.328	1.329	.566	.400	.706	.895
PLUTONIUM-238	PCI/G	3	3	1.00	-.002	-.001	-.001	.001	-.433	
PLUTONIUM-239/240	PCI/G	3	3	1.00	.001	.002	.001	.001	.433	.002
SELENIUM	MG/KG	6	6	1.00	.283	.706	.489	.154	.314	.616
SILVER	MG/KG	1	6	.17	.234	.234	.042	.094	2.231	.119
URANIUM-233/234	PCI/G	6	6	1.00	.005	.041	.017	.014	.840	.028
URANIUM-235	PCI/G	4	4	1.00	.002	.020	.010	.009	.891	.020
URANIUM-238	PCI/G	5	5	1.00	.002	.037	.014	.014	.966	.027
ZINC	MG/KG	6	6	1.00	17.795	311.132	68.248	118.997	1.744	166.137

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