NOTICE

All drawings located at the end of the document.

RMRS Rocky Mountain Remediation Services, L.L.C.
. . . protecting the environment

Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, Colorado 80402-0464
Phone: (303) 966-2677
Fax: (303) 966-8244

000062383

July 27, 1995

95-RM-KH-ER-RF-0019

Tim G. Hedahl
Director, ER/WM and Integration
Kaiser Hill
P. O. Box 464
Rocky Flats Environmental Technology Site
Golden, Colorado 80402-0464

Subject: LETTER OF TRANSMITTAL: OPERABLE UNIT (OU) 7 DRAFT INTERIM MEASURE/ INTERIM REMEDIAL ACTION (IM/IRA) DECISION DOCUMENT - JLM-028-95

This letter transmits 14 copies of the Operable Unit (0U) 7 Interim Measure/Interim Remedial Action (IM/IRA) Decision Document. Two copies are for Kaiser-Hill, and the remaining are to be transmitted to the Department of Energy (12).

The document has been prepared to incorporate the CERCLA/RCRA requirements of a Phase II RFI/RI report, Corrective Measures Study/Feasibility Study, and Proposed Plan.

The Department of Energy, Rocky Flats Field Office support staff reviewed a preliminary draft copy of the IM/IRA Decision Document in June. This document was revised to reflect comments received.

Transfer of this document by the Department of Energy to the Colorado Department of Public Health and Environment and the Environmental Protection Agency will fulfill the August 31, 1995 IAG milestone of "Submit Draft IM/IRA Decision Document." If revision of the document is required prior to transfer to the Colorado Department of Public Health and Environment and the Environmental Protection Agency, comments must be received by August 15, 1995, to ensure the milestone is achieved.

If you have questions concerning this transmittal, please contact Ed Mast, of my staff, at extension 8589.

Alan M Parker

James L. McAnally
President, RMRS, L. L.C.

LJPW:cb

Enclosures:
As Stated

1 of 1

cc:
cc:

S. J. Hahn	-	w/o attachments	A. M. Parker	-	w/o attachments
T. M. Lindsay	-	"	L. J. Peterson-Wright	-	"
P. J. Martin	-	"	N. B. Sandlin	-	"
E C. Mast	-	"	D. E. Steffen	-	"

ADMIN RECORD

1/371

BZ-A-000454

Phase I IM/IRA Decision Document for Operable Unit 7 Present Landfill

Draft Report

Text

July 27, 1995

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Golden, Colorado

2

Executive Summary

The Operable Unit (OU) 7 Draft Phase I Interim Measure/Interim Remedial Action (IM/IRA) Decision Document presents the proposed alternative for closure of OU 7. As agreed to by the U.S. Department of Energy, U.S. Environmental Protection Agency, and Colorado Department of Public Health and Environment, the alternative implemented as the interim action will also constitute the final action for OU 7. Also as agreed to by the agencies, this IM/IRA Decision Document, in conjunction with the OU 7 Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Report, constitutes the OU 7 Closure Plan.

OU 7 is located in the Rocky Flats buffer zone, north of the industrial area and consists of four Individual Hazardous Substance Sites (IHSSs) associated with historic operation of the landfill. The four IHSSs include IHSS 114, the Present Landfill; IHSS 203, Inactive Hazardous Waste Storage Area; and IHSSs 167.2 and 167.3, Spray Evaporation Areas. The Present Landfill has operated primarily as a municipal waste facility for Rocky Flats since 1968. The landfill is used for office trash, construction debris, scrap metal, dried sanitary sewage sludge, and other waste. Historically, the landfill has received incidental hazardous waste, including containers partially filled with paint or solvents, oil filters, and metal cuttings coated with hydraulic oil. The IHSSs associated with the landfill include an area southwest of the landfill (IHSS 203) used in 1986 and 1987 as a hazardous waste storage area for drums of liquid and solid waste. The other two IHSSs are spray evaporation areas southeast of the landfill, which received spray waters from the East Landfill Pond periodically between 1975 and 1994.

This Phase I IM/IRA Decision Document summarizes the results from two separate field investigations at OU 7 and provides the resultant interpretation of the nature and extent of contamination. This information is then used to quantify the risk to human health and the environment present at OU 7. Because OU 7 is being closed under a presumptive remedy approach, a comprehensive baseline risk assessment was not necessary. The presumptive remedy allows a comparison of all exposure pathways to the pathways that will be addressed by the presumptive remedy. This document concludes that the presumptive remedy, containment, will address all potential pathways with the exception of surface water and sediment in the East Landfill Pond and surface soils in spray evaporation areas. The pathways not addressed by the presumptive remedy were subjected to a focused risk assessment process. This risk assessment consisted of comparing the maximum site concentrations to preliminary remediation goals, quantification of exposure and toxicity values, and comparison to applicable or relevant and appropriate requirements (ARARs). No risks above the acceptable ranges were identified in the pathways not addressed by the proposed remedy.

3

The following Remedial Action Objectives (RAOs) were established for the Present Landfill closure, in accordance with EPA guidance:

1. Prevent direct contact with landfill contents
2. Minimize infiltration and resulting contaminant leaching to groundwater
3. Control surface-water run-off and erosion
4. Control landfill gas (treat as needed)
5. Remediate wetland areas (as needed)

These RAOs form the basis for identification of appropriate remedial action alternatives for the site. Section 5 of this report describes the nine alternatives initially identified as supportive of the RAOs. As per EPA guidance, the nine alternatives were evaluated against three criteria: effectiveness, implementability, and cost. This initial screening process eliminated five of the alternatives from further consideration. Four alternatives were carried through the detailed screening of alternatives.

The four alternatives evaluated in the detailed analysis of alternatives, presented in Section 6, include the following:

Alternative 1: No Action
Alternative 5: Single-Barrier Flexible Membrane Cover (FMC)
Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover
Alternative 9: Composite-Barrier FMC and Clay Cover

Alternative 1, the no-action alternative, is retained as a baseline for comparison in accordance with EPA guidance. The only difference between the other three alternatives is in the composition of the soil layer beneath the FMC. Alternative 5 includes common soil for bedding, Alternative 7 includes soils with a lower permeability, and Alternative 9 includes a thicker clay barrier layer rather than soil.

The detailed analysis of alternatives uses nine criteria to evaluate each alternative. The nine criteria are the following:

1. Overall protection of human health and the environment
2. Compliance with ARARs
3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, and volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. Regulatory agency acceptance
9. Community acceptance

4

After evaluating each of the alternatives against the nine criteria, a comparative analysis was performed to evaluate the alternatives relative to each other. This comparison is described and quantified via a weighted ranking system, which is presented in Section 6. Alternative 7 emerged from this multi-step evaluation process as the preferred alternative for the OU 7 remedial action. Alternative 7 achieves the site RAOs and ranks consistently well according to the nine criteria.

Alternative 7 consists of a single-barrier FMC underlain by a 12-inch soil layer with a permeability of 1E-05 cm/sec and a geocomposite gas-collection system. The FMC is covered with a lateral drainage layer and a 36-inch vegetative layer. Existing institutional controls are maintained, including limited site access, and new fencing around the cover is provided. This document also presents a post-closure monitoring plan for OU 7. Post-closure monitoring will be conducted for 30 years and will include semiannual upgradient and downgradient groundwater-monitoring wells, quarterly gas monitoring, and annual cover surveys and facility inspections.

Table of Contents

1. Introduction 1-1

1.1 Purpose of Report 1-2

1.2 Organization of Report 1-3

1.3 Other Maintenance and Remedial Actions 1-4

1.3.1 Leachate Accelerated Action 1-5

1.3.2 Slurry Wall Maintenance 1-5

1.3.3 Well Abandonment 1-5

1.4 Project Approach–the Presumptive Remedy 1-6

2. Site Characteristics 2-1

2.1 Description and Operational History of OU 7 2-1

2.1.1 Present Landfill (IHSS 114) 2-1

2.1.2 Inactive Hazardous Waste Storage Area (IHSS 203) 2-3

2.1.3 Asbestos-Disposal Areas 2-3

2.1.4 Historical Interim Response Actions 2-4

2.1.5 Spray Evaporation Areas (IHSSs 167.2 and 167.3) 2-5

2.1.6 OU 6 Trenches (IHSSs 166.1, 166.2, and 166.3) 2-6

2.2 Geology 2-6

2.2.1 General Geologic Framework 2-6

2.2.2 Description of Geologic Units 2-7

2.2.3 Distribution of Geologic Units 2-9

2.2.4 Geotechnical Properties of Geologic Units 2-10

2.2.5 Description of Pond Sediments 2-10

2.3 Hydrology 2-10

6

2.3.1 Conceptual Flow Model 2-11

2.3.2 Surface-Water Hydrology 2-12

2.3.2.1 Surface-Water Features 2-12

2.3.2.2 Components of the Conceptual Flow Model 2-12

2.3.3 Interactions Between Surface Water and Groundwater 2-13

2.3.4 Groundwater Hydrology 2-15

2.3.4.1 Groundwater Flow in the UHSU 2-15

2.3.4.2 Groundwater Flow in the LHSU 2-18

2.3.5 Water Balance for the Landfill 2-19

2.4 Ecology 2-19

2.4.1 Vegetation 2-19

2.4.2 Wildlife 2-21

2.4.3 Sensitive Habitats and Endangered Species 2-21

2.5 Nature and Extent of Contamination 2-22

2.5.1 Methodology for Background Comparisons and PCOC Identification 2-23

2.5.2 Landfill Gas 2-24

2.5.3 Landfill Leachate at the Seep 2-25

2.5.4 Surface Water in the East Landfill Pond 2-26

2.5.5 Sediments in the East Landfill Pond 2-27

2.5.6 Surface Soils in Spray Evaporation Areas 2-28

2.5.7 Subsurface Geologic Materials Downgradient of the Landfill 2-29

2.5.8 Groundwater Downgradient of the Landfill 2-30

3. Development of Remedial Action Objectives to Reduce Site Risks 3-1

3.1 Preliminary Remedial Action Objectives 3-1

3.2 Conceptual Site Model for Defining Risks 3-2

3.3 Evaluation of Risks 3-4

3.3.1 Methodology to Determine if a Response Action is Necessary 3-4

3.3.2 Present Landfill, IHSS 203, and Asbestos-Disposal Areas 3-6

3.3.3 Landfill Gas 3-6

3.3.4 Landfill Leachate at the Seep 3-6

3.3.5 Surface Water in the East Landfill Pond 3-7

3.3.6 Sediments in the East Landfill Pond 3-9

3.3.7 Surface Soils in Spray Evaporation Areas 3-10

3.3.8 Subsurface Geologic Materials Downgradient of the Landfill 3-12

3.3.9 Groundwater Downgradient of the Landfill 3-12

3.4 Compliance with ARARs 3-14

3.4.1 Potential Chemical-Specific ARARs 3-15

3.4.1.1 Landfill Leachate at the Seep 3-15

3.4.1.2 Surface Water in the East Landfill Pond 3-16

3.4.1.3 Groundwater Downgradient of the Landfill 3-16

3.4.2 Potential Location-Specific ARARs 3-19

3.4.2.1 Wetlands Requirements 3-19

3.4.2.2 Floodplain Requirements 3-19

3.4.2.3 Threatened or Endangered Species Requirements 3-20

3.4.2.4 Historic, Archaeological, and Cultural Resource Requirements 3-20

3.4.3 Potential Action-Specific ARARs 3-20

3.4.3.1 Closure Requirements 3-20

3.4.3.2 Air-Emission Requirements 3-21

3.4.3.3 Delisting Requirements 3-23

3.4.3.4 Discharge Requirements 3-24

3.5 Final Remedial Action Objectives or Response Actions 3-25

3.5.1 Elimination of Preliminary RAOs 3-25

3.5.1.1 Collect and Treat Leachate at the Source 3-26

3.5.1.2 Remediate Surface Water in the East Landfill Pond 3-26

3.5.1.3 Remediate Sediments in the East Landfill Pond 3-27

3.5.1.4 Remediate Surface Soils in Spray Evaporation Areas 3-27

3.5.1.5 Remediate Subsurface Geologic Materials Downgradient of the Landfill 3-27

3.5.1.6 Control Groundwater at the Source to Contain the Plume 3-27

3.5.1.7 Remediate Groundwater Downgradient of the Landfill 3-27

3.5.2 Development of Final RAOs 3-28

4. Identification and Screening of Technologies 4-1

4.1 General Response Actions 4-1

4.2 Identification and Screening of Technologies 4-1

4.2.1 Screening Process 4-2

4.2.2 No Action 4-2

4.2.3 Institutional Controls 4-2

4.2.4 Containment 4-3

4.2.5 Landfill Gas Collection 4-3

4.2.6 Landfill Gas Treatment 4-4

4.3 Results of Screening 4-4

5. Development of Alternatives 5-1

5.1 Cover Design 5-1

5.1.1 Extent of the Landfill Cover 5-1

5.1.2 Wetland and Sensitive-Habitat Mitigation 5-2

9

5.1.3 Grading Plan 5-2

5.1.4 Surface-Water Management 5-3

5.1.5 Cover Components 5-3

5.1.5.1 Vegetative-Cover Layer 5-3

5.1.5.2 Lateral-Drainage Layer 5-4

5.1.5.3 Barrier Layer 5-5

5.1.5.4 Gas-Collection Layer 5-6

5.1.5.5 General Grading Fill Layer 5-7

5.2 Description of Alternatives 5-7

5.2.1 Alternative 1: No Action 5-7

5.2.2 Alternative 2: Institutional Controls 5-7

5.2.2.1 Land Use and Access Restrictions 5-8

5.2.2.2 Groundwater Controls 5-8

5.2.2.3 Public Education 5-9

5.2.2.4 EPA Reviews 5-9

5.2.3 Alternative 3: Native Soil Cover 5-9

5.2.4 Alternative 4: Single-Barrier Clay Cover 5-9

5.2.5 Alternative 5: Single-Barrier FMC Cover 5-10

5.2.6 Alternative 6: Single-Barrier GCL Cover 5-10

5.2.7 Alternative 7: Single-Barrier FMC with a Low-Permeability Soil Cover 5-10

5.2.8 Alternative 8: Composite-Barrier FMC and GCL Cover 5-11

5.2.9 Alternative 9: Composite-Barrier FMC and Clay Cover 5-11

5.3 Screening of Alternatives 5-12

5.3.1 Screening Criteria 5-12

5.3.1.1 Effectiveness 5-12

5.3.1.2 Implementability 5-12

5.3.1.3 Cost 5-13

5.3.2 Alternative 1: No Action 5-13

5.3.2.1 Effectiveness 5-13

5.3.2.2 Implementability 5-13

5.3.2.3 Cost 5-14

5.3.3 Alternative 2: Institutional Controls 5-14

5.3.3.1 Effectiveness 5-14

5.3.3.2 Implementability 5-14

5.3.3.3 Cost 5-14

5.3.4 Alternative 3: Native Soil Cover 5-15

5.3.4.1 Effectiveness 5-15

5.3.4.2 Implementability 5-15

5.3.4.3 Cost 5-16

5.3.5 Alternative 4: Single-Barrier Clay Cover 5-16

5.3.5.1 Effectiveness 5-16

5.3.5.2 Implementability 5-16

5.3.5.3 Cost 5-18

5.3.6 Alternative 5: Single-Barrier FMC Cover 5-18

5.3.6.1 Effectiveness 5-18

5.3.6.2 Implementability 5-18

5.3.6.3 Cost 5-19

5.3.7 Alternative 6: Single-Barrier GCL Cover 5-20

5.3.7.1 Effectiveness 5-20

5.3.7.2 Implementability 5-20

5.3.7.3 Cost 5-21

5.3.8 Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover 5-21

5.3.8.1 Effectiveness 5-21

5.3.8.2 Implementability 5-22

5.3.8.3 Cost 5-22

5.3.9 Alternative 8: Composite-Barrier FMC and GCL 5-23

5.3.9.1 Effectiveness 5-23

5.3.9.2 Implementability 5-23

5.3.9.3 Cost 5-24

5.3.10 Alternative 9: Composite-Barrier FMC and Clay Cover 5-24

5.3.10.1 Effectiveness 5-24

5.3.10.2 Implementability 5-24

5.3.10.3 Cost 5-25

5.4 Summary of Screening 5-25

6. Detailed Analysis of Alternatives 6-1

6.1 Screening Process 6-1

6.2 Evaluation of Alternatives 6-3

6.2.1 Alternative 1: No Action 6-4

6.2.1.1 Description 6-4

6.2.1.2 Evaluation 6-4

6.2.2 Alternative 5: Single-Barrier FMC Cover 6-5

6.2.2.1 Description 6-5

6.2.2.2 Evaluation 6-9

6.2.3 Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover 6-13

6.2.3.1 Description 6-13

6.2.3.2 Evaluation 6-14

6.2.4 Alternative 9: Composite-Barrier FMC and Clay Cover 6-17

6.2.4.1 Description 6-17

6.2.4.2 Evaluation 6-17

6.3 Comparative Analysis 6-20

6.3.1 Long-Term Effectiveness and Permanence 6-20

6.3.2 Short-Term Effectiveness 6-21

6.3.3 Implementability 6-21

6.3.3.1 Technical Feasibility 6-21

6.3.3.2 Administrative Feasibility 6-22

6.3.3.3 Availability of Services and Materials 6-22

6.3.4 Cost 6-23

6.4 Summary of Comparative Analysis 6-23

7. Recommended Alternative 7-1

7.1 Description 7-1

7.2 Design Requirements 7-2

7.2.1 Compliance with RAOs 7-3

7.2.2 Compliance with ARARs 7-4

7.2.2.1 Chemical-Specific ARARs 7-4

7.2.2.2 Location-Specific ARARs 7-5

7.2.2.3 Action-Specific ARARs 7-6

7.3 Conceptual Design 7-9

7.3.1 Proposed Grading Plan 7-9

7.3.1.1 Settlement 7-10

7.3.1.2 Soil Erosion 7-10

13

7.3.1.3 Buttress East Side 7-10

7.3.1.4 General Fill 7-11

7.3.2 Surface-Water Control 7-11

7.3.3 Cover Section 7-12

7.3.4 Seepage Control 7-13

7.3.5 Gas Control 7-13

7.3.6 Surface-Water Controls 7-13

7.3.7 Institutional Controls 7-13

7.3.8 Cost Estimate 7-14

7.4 Title II Design 7-14

7.5 Justification for Recommended Alternative 7-15

8. Closure and Post-Closure Plans 8-1

8.1 Closure Plan 8-2

8.1.1 Facility Description 8-2

8.1.2 Extent of Operations and Management of Maximum Inventory 8-3

8.1.3 Notification of Closure 8-3

8.1.4 Final Cover 8-4

8.1.5 Decontamination Procedures 8-4

8.1.6 Groundwater Monitoring 8-4

8.1.7 Ancillary Closure Activities 8-5

8.1.8 Emergency Response 8-5

8.1.9 Closure Certification 8-6

8.1.10 Survey Plat 8-6

8.1.11 Record of Wastes 8-6

8.1.12 Deed Notation 8-6

14

8.1.13 Final Closure Schedule 8-7

8.2 Post-Closure Plan 8-7

8.2.1 Post-Closure Permit 8-7

8.2.2 Post-Closure Inspection and Maintenance 8-7

8.2.3 Post-Closure Monitoring 8-8

8.2.3.1 Gas Monitoring Program 8-9

8.2.3.2 Point of Compliance 8-9

8.2.3.3 Groundwater-Monitoring Program 8-10

8.2.4 5-Year Review 8-12

8.2.5 Post-Closure Certification 8-12

8.2.6 Financial Assurance and Cost Estimates 8-12

9. Environmental Assessment 9-1

9.1 Screening-Level Human Health Risk Assessment 9-1

9.1.1 Identification of Potential Contaminants of Concern or Activities of Concern 9-2

9.1.2 Characterization of Exposure 9-3

9.1.2.1 Potentially Exposed Populations and Exposure Pathways 9-3

9.1.2.2 Exposure Pathway Analysis 9-3

9.1.3 Potential Magnitude of Exposure and Risk 9-4

9.1.4 Identification of Uncertainty 9-5

9.2 Ecological Risk 9-5

9.2.1 Wildlife and Vegetation 9-6

9.2.1.1 Short-Term (Construction Period) Impacts 9-6

9.2.1.2 Long-Term Impacts 9-7

9.2.1.3 Sensitive Habitats and Endangered Species 9-7

15

9.2.2 Wetlands/Floodplains 9-8

9.2.2.1 Short-Term (Construction Period) Impacts 9-8

9.2.2.2 Long-Term Impacts 9-8

9.3 Impact to Air Quality 9-9

9.3.1 Estimation of Potential Fugitive-Dust Emissions 9-9

9.3.1.1 Haul Road Construction 9-11

9.3.1.2 Transport of Fill and Cover Material to the Landfill 9-11

9.3.1.3 Installation of Engineered Cover over the Landfill 9-12

9.3.2 Comparison to EPA Air Quality Standards 9-12

9.3.3 Estimation of Potential Methane Emissions 9-13

9.4 Impact to Surface-Water Quality 9-14

9.4.1 Short-Term (Construction Period) Impacts 9-14

9.4.2 Long-Term Impacts 9-15

9.5 Impact to Groundwater Quality 9-15

9.5.1 Short-Term (Construction Period) Impacts 9-16

9.5.2 Long-Term Impacts 9-16

9.6 Commitment of Irreversible and Irretrievable Resources 9-17

9.7 Impact to Transportation 9-18

9.8 Impact to Cultural, Historical, and Archaeological Resources 9-18

9.9 Cumulative Impacts 9-19

9.10 Comparison of the Preferred IM/IRA to the No-Action Alternative 9-19

10. References 10-1

List of Tables

Table 2-1 Geotechnical Classification Test Results for Soil Samples 2-33

Table 2-2 Analytes Detected in Leachate at the Seep (SW097) 2-34

Table 2-3 Analytes Detected in Surface Water in the East Landfill Pond (SW098) 2-39

Table 2-4 Analytes Detected in Sediment in the East Landfill Pond 2-43

Table 2-5 Analytes Detected in Surface Soils in the Vicinity of Spray Evaporation Areas 2-46

Table 2-6 Analytes Detected in Subsurface Geologic Materials Downgradient of the Landfill 2-48

Table 2-7 Analytes Detected in UHSU Groundwater in the Vicinity of the East Landfill Pond 2-53

Table 2-8 Analytes Detected in UHSU Groundwater Downgradient of the Dam 2-57

Table 2-9 Analytes Detected in LHSU Groundwater Downgradient of the Landfill 2-61

Table 3-1 Preliminary Remediation Goal (PRG) Screen for Leachate at the Seep 3-29

Table 3-2 Preliminary Remediation Goal (PRG) Screen for Surface Water in the East Landfill Pond 3-31

Table 3-3 Preliminary Remediation Goal Screen for Sediments in the East Landfill Pond 3-32

Table 3-4 Preliminary Remediation Goal (PRG) Screen for Surface Soils in the Vicinity of Spray Evaporation Areas 3-33

Table 3-5 Site-Specific Exposure Factors for Incidental Ingestion of Surface Soil[1] 3-34

Table 3-6 Site-Specific Exposure Factors for Particulate Inhalation of Surface Soil[1] 3-35

Table 3-7 Site-Specific Exposure Factors for External Irradiation from Surface Soil[1] 3-36

Table 3-8 Potential Risks Associated with Incidental Ingestion of Surface Soil[1] Open-Space Exposure Scenario 3-37

Table 3-9 Potential Risks Associated with Particulate Inhalation of Surface Soil[1] Open-Space Exposure Scenario 3-38

17

9.2.2.2 Long-Term Impacts 9-8

9.3 Impact to Air Quality 9-9

9.3.1 Estimation of Potential Fugitive-Dust Emissions 9-9

9.3.1.1 Haul Road Construction 9-11

9.3.1.2 Transport of Fill and Cover Material to the Landfill 9-11

9.3.1.3 Installation of Engineered Cover over the Landfill 9-12

9.3.2 Comparison to EPA Air Quality Standards 9-12

9.3.3 Estimation of Potential Methane Emissions 9-13

9.4 Impact to Surface-Water Quality 9-14

9.4.1 Short-Term (Construction Period) Impacts 9-14

9.4.2 Long-Term Impacts 9-15

9.5 Impact to Groundwater Quality 9-15

9.5.1 Short-Term (Construction Period) Impacts 9-16

9.5.2 Long-Term Impacts 9-16

9.6 Commitment of Irreversible and Irretrievable Resources 9-17

9.7 Impact to Transportation 9-18

9.8 Impact to Cultural, Historical, and Archaeological Resources 9-18

9.9 Cumulative Impacts 9-19

9.10 Comparison of the Preferred IM/IRA to the No-Action Alternative 9-19

10. References 10-1

List of Tables

Table 2-1 Geotechnical Classification Test Results for Soil Samples 2-33

Table 2-2 Analytes Detected in Leachate at the Seep (SW097) 2-34

Table 2-3 Analytes Detected in Surface Water in the East Landfill Pond (SW098) 2-39

Table 2-4 Analytes Detected in Sediment in the East Landfill Pond 2-43

Table 2-5 Analytes Detected in Surface Soils in the Vicinity of Spray Evaporation Areas 2-46

Table 2-6 Analytes Detected in Subsurface Geologic Materials Downgradient of the Landfill 2-48

Table 2-7 Analytes Detected in UHSU Groundwater in the Vicinity of the East Landfill Pond 2-53

Table 2-8 Analytes Detected in UHSU Groundwater Downgradient of the Dam 2-57

Table 2-9 Analytes Detected in LHSU Groundwater Downgradient of the Landfill 2-61

Table 3-1 Preliminary Remediation Goal (PRG) Screen for Leachate at the Seep 3-29

Table 3-2 Preliminary Remediation Goal (PRG) Screen for Surface Water in the East Landfill Pond 3-31

Table 3-3 Preliminary Remediation Goal Screen for Sediments in the East Landfill Pond 3-32

Table 3-4 Preliminary Remediation Goal (PRG) Screen for Surface Soils in the Vicinity of Spray Evaporation Areas 3-33

Table 3-5 Site-Specific Exposure Factors for Incidental Ingestion of Surface Soil[1] 3-34

Table 3-6 Site-Specific Exposure Factors for Particulate Inhalation of Surface Soil[1] 3-35

Table 3-7 Site-Specific Exposure Factors for External Irradiation from Surface Soil[1] 3-36

Table 3-8 Potential Risks Associated with Incidental Ingestion of Surface Soil[1] Open-Space Exposure Scenario 3-37

Table 3-9 Potential Risks Associated with Particulate Inhalation of Surface Soil[1] Open-Space Exposure Scenario 3-38

19

Table 3-10 Potential Risks Associated with External Irradiation from Surface Soil[1] Open-Space- Exposure Scenario 3-38

Table 3-11 Preliminary Remediation Goal (PRG) Screen for Subsurface Geologic Materials Downgradient of the Landfill 3-39

Table 3-12 Preliminary Remediation Goal (PRG) Screen for Groundwater Downgradient of the Landfill 3-40

Table 3-13 Site-Specific Exposure Factors for Groundwater Ingestion[1] 3-41

Table 3-14 Potential Risks Associated with Groundwater Ingestion[1] Future Onsite Office-Worker Exposure Scenario 3-42

Table 3-15 Potential Chemical-Specific ARARs for Surface Water 3-43

Table 3-16 Potential Chemical-Specific ARARs for Groundwater 3-46

Table 3-17 ARARs Comparison for Leachate at the Seep 3-50

Table 3-18 ARARs Comparison for Surface Water in the East Landfill Pond 3-54

Table 3-19 ARARs Comparison for Groundwater Downgradient of the Landfill 3-56

Table 3-20 Potential Location-Specific ARARs 3-61

Table 3-21 Potential Federal and State Action-Specific ARARs 3-62

Table 3-22 Regulatory and Technical Guidance to be Considered 3-64

Table 3-23 Comparison of PCOC Concentrations in Leachate at the Seep to MACs 3-66

Table 3-24 Evaluation of Remedial Action Objectives for Developing Response Actions 3-67

Table 4-1 Screening Criteria Summary 4-6

Table 4-2 Evaluation of Remedial Technologies Institutional Controls 4-7

Table 4-3 Evaluation of Remedial Technologies Containment 4-8

Table 4-4 Evaluation of Remedial Technologies Landfill Gas Collection 4-9

Table 4-5 Evaluation of Remedial Technologies Landfill Gas Treatment 4-10

Table 5-1 Summary of Landfill Cover Components 5-26

Table 5-2 Screening Criteria Summary 5-27

20

Table 5-3 Comparison of Effectiveness Factors 5-28

Table 5-4 Conceptual Cost Estimate Summary 5-29

Table 5-5 Summary of Comparative Analysis Alternatives Screening 5-30

Table 6-1 Evaluation Criteria for the Detailed Analysis of Alternatives 6-24

Table 6-2 Quantities of Material for Landfill Cover Construction 6-26

Table 6-3 Detailed Cost Estimate Summary 6-27

Table 6-4 Summary of Comparative Analysis 6-28

Table 7-1 Summary of EPA Guidance Criteria for Design of Cover Systems 7-16

Table 7-2 Design Components that Meet Closure ARARs 7-17

Table 7-3 Preliminary List of Drawings for the Title II Design 7-19

Table 7-4 Preliminary List of Technical Specifications for Landfill Closure 7-20

Table 8-1 Closure Timeline 8-13

Table 8-2 Post-Closure Inspection, Maintenance, and Monitoring Schedule 8-14

Table 8-3 Groundwater-Monitoring Parameters 8-15

Table 9-1 Uncertainties Associated with Assessing Risk 9-21

Table 9-2 Fugitive-Dust Emissions from IM/IRA Construction 9-22

Table 9-3 Modeled and Cumulative PM-10 Concentrations for IM/IRA Construction 9-22

Table 9-4 Summary of Potential Impacts: Preferred IM/IRA versus No Action 9-23

21

List of Figures

Figure 1-1 Location of the Rocky Flats Environmental Technology Site

Figure 1-2 Location of Operable Unit No. 7

Figure 1-3 Present Landfill and East Landfill Pond (June 1991)

Figure 1-4 Location of Other Maintenance and Remedial Actions

Figure 2-1 Locations of IHSSs and Historical Interim Response Actions

Figure 2-2 Typical Existing Groundwater-Intercept System Section

Figure 2-3 Generalized Stratigraphic Section

Figure 2-4 Geologic Map of Surficial Materials

Figure 2-5 Conceptual Flow Model for OU 7

Figure 2-6 Saturated Thickness of Unconsolidated Surficial Deposits (2nd Quarter 1995)

Figure 2-7 Groundwater Flowpaths from the Landfill

Figure 2-8 Hydraulic Conductivity Measurement for Each Geologic Unit

Figure 2-9 Potentiometric Map of Surficial Materials Groundwater (2nd Quarter 1995)

Figure 2-10 Potentiometric Map of Weathered Bedrock (2nd Quarter 1995)

Figure 2-11 Distribution of Habitat Types

Figure 2-12 Wetland Areas and Preble's Meadow Jumping Mouse Habitat

Figure 2-13 Surface-Water and Sediment Sampling Locations

Figure 2-14 Soil-Sampling Locations in the Vicinity of Spray Evaporation Areas

Figure 2-15 Downgradient Subsurface Geologic Materials and Groundwater Sampling Locations

Figure 3-1 Conceptual Site Model for Defining Risks at OU 7

Figure 3-2 F039 Determination for Environmental Media

Figure 3-3 Remediation Determination for Environmental Media

Figure 3-4 Conceptual Site Model for the Source Area

Figure 3-5 Conceptual Site Model for Landfill Gas

Figure 3-6 Conceptual Site Model for Landfill Leachate at the Seep

Figure 3-7 Conceptual Site Model for the East Landfill Pond

Figure 3-8 Conceptual Site Model for the Surface Soils in Spray Evaporation Areas

Figure 3-9 Conceptual Site Model for Subsurface Geologic Materials Downgradient of the Landfill

Figure 3-10 Conceptual Site Model for Groundwater Downgradient of the Landfill

Figure 5-1 Extent of the Landfill Cap

Figure 5-2 Proposed Conceptual Grading Plan, Extent of Cover, and Surface-Water Control Plan

Figure 5-2A Landfill Cover Cross-Section A-A′

Figure 5-2B Landfill Cover Cross-Sections B-B′ & C-C′

Figure 5-3 Cover Cross-Section Alternatives

Figure 5-4 Leakage Rates for Cover Alternatives

Figure 6-1 Alternative 1: No-Action

Figure 6-2 Alternative 5: Single-Barrier FMC Cover Cross Section

Figure 6-3 Alternative 7: Single-Barrier FMC & Low-Permeability Soil Cover Cross Section

Figure 6-4 Alternative 9: Composite-Barrier FMC and Clay Cover Cross Section

Figure 7-1 Recommended Alternative: Single-Barrier FMC & Low-Permeability Soil Cover Cross Section

Figure 7-2 Existing Topography and Surface Features

Figure 7-3 Proposed Conceptual Grading Plan, Extent of Cover, and Surface-Water Control Plan

Figure 7-4 Landfill Cover Cross-Section A-A′

Figure 7-5 Landfill Cover Cross-Sections B-B′ & C-C′

Figure 8-1 Groundwater-Monitoring Wells Remaining During Landfill Closure

Figure 8-2 Proposed Post-Closure Groundwater Monitoring Wells

List of Attachments

Draft Proposed Plan and Draft Modification of Colorado Hazardous Waste Permit for Rocky Flats Environmental Technology Site Operable Unit 7: Present Landfill

List of Appendices
(separate volume)

Appendix A Borehole Geologic Logs

Appendix B Drawdown Recovery Test Data and Analytical Solutions

Appendix C Groundwater Flow and Particle Tracking Modeling

Appendix D Screening-Level Ecological Risk Assessment for Surface Water and Sediment Associated with the East Landfill Pond

Appendix E Groundwater Contaminant Transport Simulations

Appendix F Waste Settlement Analysis

Appendix G HELP Modeling

Appendix H Cost Estimates

Appendix I Gas-Emission Estimates

Appendix J Annual Soil-Loss Calculations, Methodologies, and Assumptions

24

List of Acronyms and Abbreviations

%	percent
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per square meter
AC	acute
AG	agricultural
AOS	apparent opening size
APEN	Air Pollutant Emission Notice
AQ	aquatic
ARARs	applicable or relevant and appropriate requirements
ASTM	American Society for Testing and Materials
BDT	best demonstrated technology
bgs	below ground surface
CAD	Corrective Action Decision
CAQCC	Colorado Air Quality Control Commission
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CDNR	Colorado Department of Natural Resources
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CERFA	Community Environmental Response Facilitation Act
CFR	Code of Federal Regulations
CGI	combustible gas indicator
CH	chronic
CHWA	Colorado Hazardous Waste Act
cm/sec	centimeters per second
CMS/FS	corrective measures study/feasibility study
CN	curve numbers
CQA	construction quality assurance
CPT	cone penetration testing

25

CQA	construction quality assurance
CRDL	contract-required detection limit
CWA	Clean Water Act
CWQ	Colorado Water Quality
DCA	dichloroethane
DCE	dichloroethene
DD	Decision Document
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DW	drinking water
DW&F	drinking water and fish
EEC	ecological effects concentrations
ECOC	ecological contaminant of concern
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EqP	equilibrium partitioning
ERAM	ecological risk assessment methodology
FID	flame ionization detector
FFCA	Federal Facility Compliance Agreement
FMC	flexible membrane cover
FS	feasibility study
ft/min	feet per minute
ft^3/lb	cubic feet per pound
ft^3/yr	cubic feet per year
GC	gas chromatogram
GCL	geosynthetic clay liner
gpm	gallons per minute
GRA	general response actions
g/s	grams per second
HAP	hazardous air pollutant
HDPE	high-density polyethylene
HEAST	Health Effects Assessment Summary Tables

26

HELP	Hydrologic Evaluation of Landfill Performance
HH	human health
HI	hazard index
HQ	hazard quotient
IAG	Interagency Agreement
IDL	instrument detection limit
IHSS	individual hazardous substance site
IM/IRA	interim measure/interim remedial action
KaKl(w)	weathered undifferentiated Cretaceous Arapahoe and Laramie Formation
KaKlss(u)	unweathered undifferentiated Cretaceous Arapahoe and Laramie Formation
lbs/in^2	pounds per square inch
lb/yd^3	pounds per cubic yard
LDR	Land Disposal Restrictions
LHSU	lower hydrostratigraphic unit
LOAEL	lowest-observed-adverse-effects level
m	meters
m^2	square meters
MAC	maximum allowed concentration
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
Mg/yr	Megagrams per year
MOU	Memorandum of Understanding
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND-GC	no data - gas chromatogram
NMOC	non-methane organic compound
NOAEL	no-observed-adverse-effects level
NPDES	National Pollutant Discharge Elimination System
O&M	operation and maintenance
OU	operable unit

27

PAM	Proposed Action Memorandum
PCB	polychlorinated biphenyl
pCi/g	picocuries per gram
pCi/L	picocuries per liter
PCOC	potential contaminant of concern
PI	plasticity index
PID	photoionization detector
PM-10	respirable particualte matter
PPE	personal protective equipment
ppm	parts per million
PQL	practical quantitation limit
PRG	preliminary remediation goal
PSD	prevention of significant deterioration
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
Qc	Quaternary colluvium
Qvf	Quaternary valley-fill alluvium
RAO	remedial action objectives
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RFI	RCRA Facility Investigation
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SLRA	screening level risk assessment
SVOC	semivolatile organic compound
TBC	guidance or recommendation to be considered
TCA	trichloroethane
TCE	trichloroethene
TSDF	treatment, storage, and disposal facility

TOC	total organic compound
TOX	total organic halogen
TSP	total suspended particulates
TVS	table value standard
UCL_{95}	95 percent upper confidence limit
UHSU	upper hydrostratigraphic unit
USCS	Unified Soil Classification System
USLE	Universal Soil Loss Equation
UTL	upper tolerance limit
$UTL_{99/99}$	upper tolerance interval of the 99th percentile at the 99-percent confidence level
VOC	volatile organic compound
WIN	Well Installation Notification
WSIC	Waste Stream Identification and Characterization
WSRIC	Waste Stream Residue Identification and Characterization
yd^3	cubic yards

29

1. Introduction

The Rocky Flats Environmental Technology Site is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-1), and comprises approximately 6,550 acres of land in Sections 1 through 4 and 9 through 15 of Township 2 South, Range 70 West, 6th Principal Meridian. Major buildings are located within the industrial area, which encompasses approximately 400 acres (Figure 1-2). The industrial area is surrounded by a buffer zone of approximately 6,150 acres.

Rocky Flats is a government-owned, contractor-operated facility in the nationwide nuclear weapons production complex. The former mission at Rocky Flats was to produce components for nuclear weapons from plutonium, uranium, and non-radioactive materials. The current mission is to manage wastes and materials and to clean up and convert the Rocky Flats site to beneficial use in a manner that is safe, environmentally and socially responsible, physically secure, and cost effective.

This report addresses investigations at operable unit (OU) 7, which is located north of the industrial area on the western end of No Name Gulch and encompasses approximately 44 acres (Figure 1-2). OU 7 is one of 16 OUs at Rocky Flats. Each OU is made up of a number of individual hazardous substance sites (IHSSs). OU 7 comprises the Present Landfill (IHSS 114), Inactive Hazardous Waste Storage Area (IHSS 203), East Landfill Pond, Pond Area Spray Field (IHSS 167.2), and South Area Spray Field (IHSS 167.3). Figure 1-3 is a 1991 photograph that shows the landfill, pond, and adjacent spray evaporation areas.

The preliminary assessment performed under the U.S. Department of Energy (DOE) Environmental Restoration program identified some of the past onsite storage and disposal locations as potential sources of environmental contamination (DOE 1986). Additional information regarding historical plant operations, production activities, past waste disposal practices at Rocky Flats, and previous investigations not directly related to OU 7 are provided in the OU 7 Phase I Work Plan (DOE 1991a).

Hazardous constituents have been released (42 USC 9601 Section 101(22)) at Rocky Flats as a result of the production of nuclear weapons components, processing of radioactive substances, and fabrication of metals. A two-phase process was developed to remove these constituents. A Phase I Resource Conservation and Recovery Act (RCRA) facility investigation/remedial investigation (RFI/RI) was conducted at OU 7 from November 1992 through April 1993 to characterize the site physical features, describe contaminant sources, and determine the nature and extent of contamination in soils resulting from such releases. A Phase II RFI/RI was subsequently planned to

30

characterize the nature and extent of contamination in surface water, groundwater, and air and evaluate contaminant migration pathways.

These activities were initiated pursuant to an Interagency Agreement (IAG) among the DOE, the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE) dated January 22, 1991 (DOE 1991b), which is currently being revised. The IAG addresses RCRA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) issues that pertain to the site. CDPHE is the lead regulatory agency for the IAG program at OU 7.

The focus of investigations at OU 7 changed due to the adoption of a presumptive-remedy strategy for streamlined site characterization and site remediation by DOE, CDPHE, and EPA. As a result of this strategy, the Phase I RFI/RI Report and revised Phase I Work Plan were combined into a single document, the Final Work Plan Technical Memorandum for OU 7 (OU 7 Final Work Plan) (DOE 1994a), which was approved in September 1994. Supplemental fieldwork under the OU 7 Final Work Plan was conducted from October 1994 through January 1995. Findings of the supplemental Phase I field investigation are presented in this report.

In accordance with a resolution of the Senior Executive Committee of the IAG in April 1994 (DOE 1994b), two interim measure/interim remedial actions (IM/IRAs) were directed for OU 7. These include a separate IM/IRA for collection of leachate at the seep above the East Landfill Pond and an IM/IRA for closure of the Present Landfill. The seep collection IM/IRA is being implemented before closure as an accelerated action (Section 1.3.1). The landfill closure IM/IRA is addressed in this report.

1.1 Purpose of Report

This Phase I IM/IRA Decision Document (IM/IRA DD) presents the proposed alternative for landfill closure. The alternative addresses all source areas with risk levels greater than 1E-06 or a hazard index greater than 1. As agreed by DOE, CDPHE, and EPA, the interim action will be the final action for closure of OU 7. The Phase I IM/IRA DD and the Phase I RFI/RI Report constitute the OU 7 Closure Plan (CDPHE 1992). The IM/IRA DD was prepared in accordance with paragraphs 15 and 150 of the IAG (DOE 1991a). It is consistent with guidance in the preamble to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (55 Federal Register 8704) and is consistent with Colorado Hazardous Waste Act (CHWA) closure requirements (6 CCR 1007-3 Part 265). DOE has prepared a draft Proposed Plan in accordance with Section I.B.9 of the IAG (DOE 1991a), and it is included as an attachment to the IM/IRA DD. The IM/IRA DD and the Proposed Plan will undergo a single public involvement program.

31

1.2 Organization of Report

The IM/IRA DD is divided into 10 sections as follows:

Section 1, Introduction, discusses the purpose and organization of the report. Other maintenance or remedial actions at the Present Landfill are described, and the project approach is presented.

Section 2, Site Characteristics, describes the physical characteristics and operational history of OU 7; describes site-specific geology, hydrology, and ecology, including sensitive habitats and endangered species; and summarizes the nature and extent of contamination in all media. Information included in this section is from both the Phase I RFI/RI (DOE 1994a) and the additional Phase I field investigation.

Section 3, Development of Remedial Action Objectives to Reduce Site Risks, outlines the preliminary objectives of the remedial action, presents a conceptual site model for defining risks, summarizes the results of focused risk assessments for various environmental media, assesses compliance with applicable or relevant and appropriate requirements (ARARs), and presents final remedial action objectives (RAOs).

Section 4, Identification and Screening of Technologies, identifies and screens response actions and technologies that satisfy the RAOs. Screening is based on an evaluation of effectiveness, implementability, and cost. Favorable technologies are retained for consideration in the development of alternatives.

Section 5, Development of Alternatives, describes the general components of the alternatives developed; presents nine alternatives; summarizes the results of the alternatives screen using effectiveness, implementability, and cost; and presents the four alternatives retained for detailed analysis.

Section 6, Detailed Analysis of Alternatives, presents an evaluation of the four alternatives using the nine CERCLA criteria (overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume through treatment; short-term effectiveness; implementability; costs; regulatory agency acceptance; and community acceptance) and recommends the best alternative for final selection by CDPHE and EPA.

Section 7, Recommended Alternative, describes the proposed action, outlines design requirements, presents the conceptual design for the proposed action, and describes the process for developing the Title II design. The conceptual design includes the proposed grading plan, surface-water control, proposed cover section, seepage control, gas control, ancillary facilities, and estimated costs.

Section 8, Closure and Post-Closure Plans, details the plans that will be carried out during the closure and post-closure care periods to meet regulations stipulated in CHWA, 6 CCR 1007-3 Parts 265.11 and 265.117-120, respectively. The closure plan describes the facility, extent of operations, notification requirements, construction activities, decontamination procedures, groundwater monitoring, ancillary closure activities, emergency response, closure certification requirements, and a schedule for closure. The post-closure plan addresses permit requirements and describes routine inspection activities, gas monitoring, groundwater monitoring, the point-of-compliance, and the post-closure certification.

Section 9, Environmental Assessment, includes an evaluation of the impacts of the remedial action on human health, wildlife and vegetation, sensitive habitats and endangered species, wetlands and floodplains, air quality, surface-water quality, groundwater quality, irreversible and irretrievable resources, transportation, and cultural resources. Cumulative impacts are examined. Impacts of the preferred alternative are compared to the no-action alternative.

Section 10, References, presents references cited in the report.

The draft Proposed Plan for OU 7: Present Landfill Area is included as a separate attachment.

Supporting data are included in the appendices to the report. Appendix A presents borehole geologic logs in LOGGER format from the supplemental Phase I field investigation. Appendix B contains drawdown recovery test data and analytical solutions from the supplemental Phase I field investigation. Appendix C contains input parameters, results, and a summary of the groundwater modeling. Appendix D presents the screening-level ecological risk assessment for the leachate seep and surface water and sediment in the East Landfill Pond. Appendix E contains input parameters, results, contaminant distribution maps, and a summary of the contaminant-transport modeling. Appendix F presents settlement estimates. Appendix G presents input parameters, results, and a summary of the HELP modeling. Appendix H provides estimated costs and assumptions. Appendix I provides gas-emission estimates. Appendix J provides annual soil-loss calculations.

1.3 Other Maintenance and Remedial Actions

Several other actions are planned at OU 7, including implementing a leachate accelerated action, constructing a slurry wall on the north side of the landfill, and abandoning groundwater-monitoring wells within the landfill (Figure 1-4).

33

1.3.1 Leachate Accelerated Action

The Seep Collection IM/IRA is being implemented before closure as an accelerated action. A passive seep collection and treatment system is proposed as an accelerated action to eliminate discharge of F039 RCRA-listed waste from the leachate seep to the East Landfill Pond (Figure 1-4). The action was proposed in the Modified Passive Seep Collection and Treatment Proposed Action Memorandum (PAM) (DOE 1995a), which was submitted to CDPHE and EPA on June 15, 1995. The PAM includes a description of the interception and passive treatment components of the system and a conceptual design. Leachate will be intercepted with perforated pipe and directed to a tank containing carbon-based granular media that will separate the F039 waste from seep water. F039 waste will be absorbed by the carbon-based media. Treated water will be discharged directly to the East Landfill Pond. The modified PAM was approved by CDPHE and EPA on June 27, 1995. The system will be fully operational within six months.

1.3.2 Slurry Wall Maintenance

A slurry wall will be constructed on the north side of the landfill as a maintenance action to address the failure of the existing groundwater-intercept system and north slurry wall (Figure 1-4). Failure of the existing system is evidenced by (1) insignificant differences in heads in wells that straddle the existing groundwater-intercept system, (2) groundwater modeling, which shows that inflow occurs on the north side of the landfill, (3) as-built diagrams, which reveal that sections of the system were not keyed into bedrock, and (4) as-built diagrams, which show that minimum slopes could allow sediment buildup and blockage within the pipe drain.

The new slurry wall will reduce groundwater inflow, leachate generation, and outflow at the seep. The length of the slurry wall is estimated at 2,000 feet. The slurry wall will be keyed into weathered bedrock, consisting of siltstones and claystones of the undifferentiated Arapahoe and Laramie Formations. Depth of the slurry wall varies with the depth of weathered bedrock and ranges from 15 to 30 feet. Hydraulic conductivity of the weathered bedrock is 4E-07 centimeters per second (cm/sec). Construction of the slurry wall will occur in late 1995.

1.3.3 Well Abandonment

Twenty-six of the 54 existing monitoring wells in OU 7 that are sampled quarterly as RCRA-compliance wells or sitewide groundwater-protection wells will be abandoned (Figure 1-4). This action was proposed in a January 13, 1995, letter from DOE to CDPHE and EPA (DOE 1994c). CDPHE and EPA approved the well abandonment proposal on February 13, 1995 (CDPHE 1995). Well abandonment was proposed on the basis that the purpose of each well has been fulfilled, the wells fall under the

34

footprint of the landfill cap, the presence of the wells would compromise the integrity of the cap because holes would have to be cut in the synthetic liner, and unequal compaction of the fill material around the wells would potentially cause differential settlement of the cap. Well abandonment will be performed in early 1996.

1.4 Project Approach–the Presumptive Remedy

Presumptive remedies are preferred technologies for common categories of sites developed by EPA based on historical data from successful remedial actions at similar sites. The objective of the presumptive remedy approach is to streamline the site investigation and remedial action selection and reduce the cost and time required to implement the remedial action. The presumptive remedy approach was adopted by DOE, CDPHE, and EPA in May 1994 (EG&G 1993a, DOE 1994d). Letter approval was received from CDPHE in October 1994 (CDPHE 1994).

The approach was used to streamline the supplemental Phase I field investigation, which focused on gathering data for design of the presumptive remedies and assessment of contamination in groundwater downgradient of the landfill. As a result of this strategy, a comprehensive baseline risk assessment was no longer required. Use of the presumptive remedy also limited the need for initial identification and screening of alternatives for the corrective measures study/feasibility study (CMS/FS), or IM/IRA, and allowed the acceleration of the schedule for implementing remedial actions and achieving final closure.

The presumptive remedy for CERCLA municipal landfill sites is containment (EPA 1993a). Containment technologies are generally appropriate for municipal landfills because the waste poses a relatively low long-term threat and the volume and heterogeneity of the waste make treatment impracticable. Although the majority of the waste accepted at OU 7 is considered a municipal waste, some hazardous waste components have been detected in the leachate, indicating the presence of hazardous materials in the waste. Therefore, the specific criteria used for the landfill cover design are based on a RCRA Subtitle C facility. The containment presumptive remedy consists of the following:

- Institutional controls
- Landfill cap (RCRA Subtitle C equivalent)
- Landfill gas control (and treatment if needed)
- Leachate collection (and treatment if needed)
- Source area groundwater control

The presumptive remedy limits the alternatives that require detailed analysis to the components listed above. Characterization of the waste material within the landfill is not necessary for selecting a response action. Response actions selected for individual

36

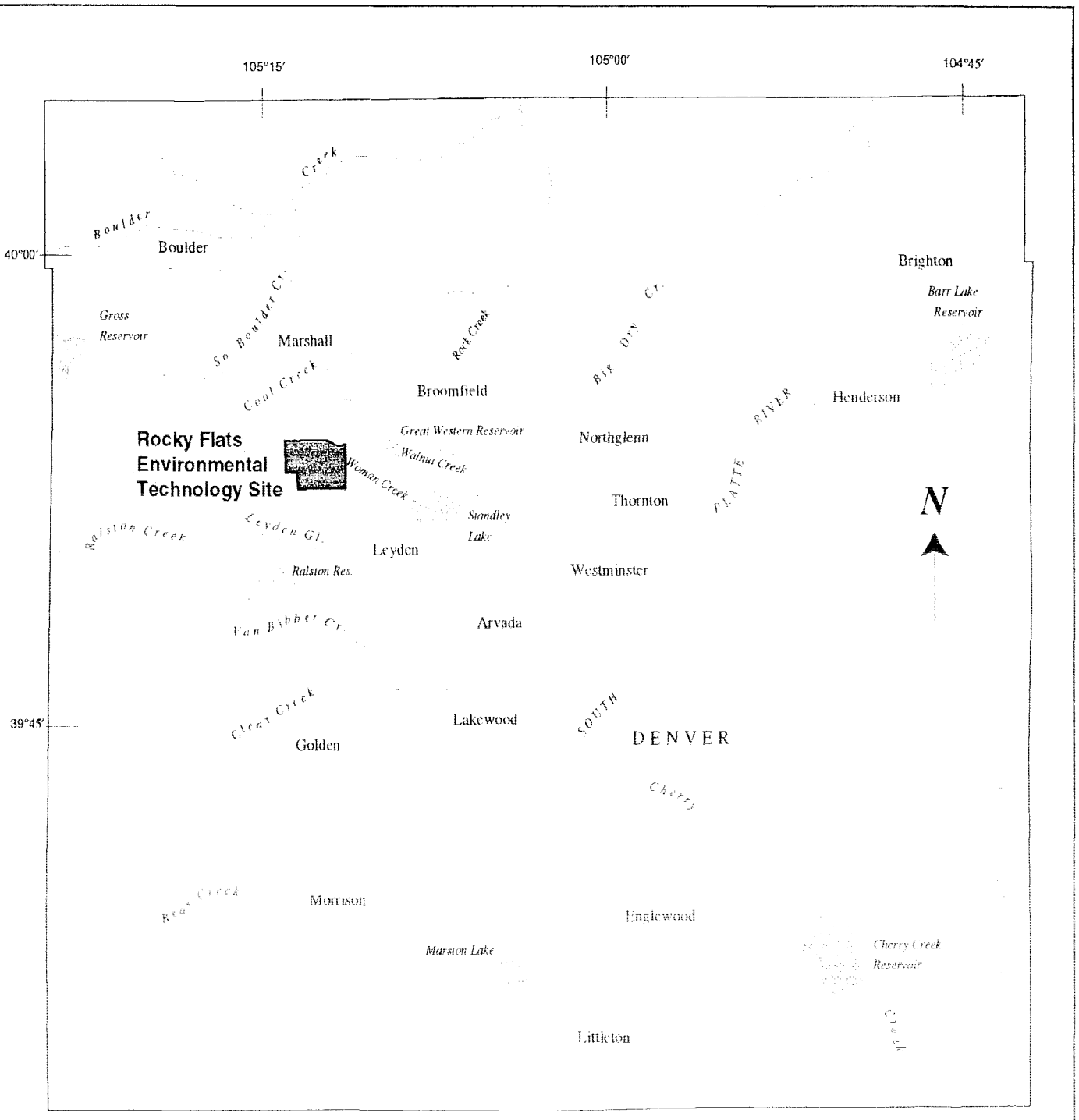
sites include only those components necessary based on site-specific conditions (EPA 1993a). The containment presumptive remedy addresses all pathways associated with the source.

Potentially affected media and exposure pathways outside the landfill are generally addressed separately. However, a response action for potentially affected media and exposure pathways outside the source area will be selected together with the presumptive remedy to develop a comprehensive response. For OU 7, potentially affected media include the following:

- Surface water in the East Landfill Pond
- Sediments in the East Landfill Pond
- Surface soils in spray evaporation areas
- Subsurface geologic materials downgradient of the landfill
- Groundwater downgradient of the landfill

The nature and extent of contamination in potentially affected media is addressed in Section 2. A focused risk evaluation and an ARARs comparison for these media are presented in Section 3.

Section 1
Figures



U.S. Department of Energy
Rocky Flats Environmental Technology Site,
Golden, Colorado

Location of the Rocky Flats Environmental Technology Site

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 1-1

G95ESIM/IRA DD OU 7/RFP & Vicinity-2510.ai

38

Figure 1-3

2. Site Characteristics

Sections 2.1 through 2.5 describe the physical characteristics and operational history of OU 7, geology, surface-water and groundwater hydrology, ecology, and nature and extent of contamination. Much of the information in these sections is taken from the OU 7 Final Work Plan (DOE 1994a).

2.1 Description and Operational History of OU 7

OU 7 lies north of the industrial area on the western end of No Name Gulch. IHSSs and historical interim response actions are shown in Figure 2-1. OU 7 includes the Present Landfill (IHSS 114), Inactive Hazardous Waste Storage Area (IHSS 203), and asbestos-disposal areas. In 1991, the boundary of OU 7 was modified to include the East Landfill Pond and adjacent spray evaporation areas (IHSSs 167.2 and 167.3) previously included in OU 6. The locations of these IHSSs were changed based on historical research, including a review of files and photographs from the Rocky Flats repository and employee interviews conducted for the historical release report (DOE 1992a). After the locations were changed, the IHSSs were transferred from OU 6 to OU 7.

Several other OU 6 IHSSs are also located within No Name Gulch, including trenches A, B, and C (IHSSs 166.1, 166.2, and 166.3, respectively) and a spray evaporation area (IHSS 167.1). In addition, a surface-water diversion system, groundwater-intercept system, and leachate-collection trench, which are historical interim actions, lie within OU 7. Historical data used to describe OU 7 were compiled from previous landfill investigations (Rockwell International 1988a, Rockwell International 1988b, Rockwell International 1988c, DOE 1991b); the historical release report (DOE 1992a); and data from the Phase I RFI/RI field investigation (DOE 1994a).

2.1.1 Present Landfill (IHSS 114)

Operation of the Present Landfill began on August 14, 1968, and is expected to continue until the new landfill opens in 1997. A portion of the natural drainage at the headwaters of No Name Gulch was filled with soils from an onsite borrow area to a thickness of approximately 5 feet to construct a surface on which to start landfilling. Waste delivered to the landfill was spread across the work area, compacted, and covered with soil (DOE 1994a).

In 1986 and 1987, studies were conducted to identify waste streams generated at the plant under the Waste Stream Identification and Characterization (WSIC) program. Of the 338 identified waste streams disposed in the landfill, 97 contained hazardous waste or hazardous constituents. As of November 1986, waste streams identified as

hazardous were no longer disposed in the landfill. In 1989, waste streams were further characterized under the Waste Stream Residue Identification and Characterization (WSRIC) program. Of the 183 identified waste streams disposed in the landfill since 1989, none are hazardous (DOE 1994a).

Nonhazardous waste streams disposed in the landfill include office trash, paper, rags, personal protective equipment, demolition materials, construction debris, scrap metal, empty flattened drums and containers, used filters, electrical components, dried sanitary-sewage sludge, and solid sump sludge. These sludges may have been radioactively contaminated (plutonium and depleted uranium). Hazardous waste streams disposed in the landfill include containers partially filled with paint, solvents, degreasing agents, and foam polymers; wipes and rags contaminated with these materials; paint and oil filters; and metal cuttings and shavings coated with hydraulic oil and carbon tetrachloride (DOE 1994a). The landfill was also the site of polychlorinated biphenyl (PCB) storage and asbestos disposal.

The landfill covers an area of approximately 20 acres. Waste material is generally thinnest along the boundaries and thickest along the east-west axis of the landfill. The thickness of waste material ranges from less than 1 foot to approximately 40 feet near the east face of the landfill, which coincides with the deepest portion of the original drainage. Waste material has not been placed beyond the clay barrier in the groundwater-intercept system or the slurry walls (DOE 1994a).

Five gas vents are present within the operating landfill (Figure 2-1). These vents are constructed of polyvinyl chloride (PVC) casing and project above the ground surface approximately 5 feet. The vents were installed in June 1992 to release landfill gases generated by microbial degradation of organic waste. The composition, quantity, and generation rates of the gases depend on factors such as waste quantity and composition, waste placement characteristics, landfill thickness, moisture content, and amount of oxygen present. Carbon dioxide is the principal gas generated during early stages of waste burial, as the waste undergoes aerobic microbial degradation. As oxygen is depleted, anaerobic microbial degradation produces methane and carbon dioxide.

Leachate from landfills is a product of natural biodegradation, infiltration of precipitation, and migration of groundwater through waste (EPA 1991a). Leachate has been forming since the landfill opened in 1968. Infiltration/percolation at the ground surface and inflow of groundwater are the primary sources of water to the landfill. The volume of leachate within the landfill is expected to vary as the potentiometric surface fluctuates in response to infiltration/percolation of precipitation through the interim soil cover. The volume is expected to decrease after the landfill cap and slurry wall are in place. The depth to leachate within the landfill is approximately 20 feet at the western

43

end, 16 feet in the middle, and 33 feet at the eastern end. Leachate presently seeps at the base of the east face of the landfill (SW097) (Figure 2-1).

2.1.2 Inactive Hazardous Waste Storage Area (IHSS 203)

The Inactive Hazardous Waste Storage Area is located at the southwest corner of the Present Landfill (Figure 2-1). The area was actively used between 1986 and 1987 as a hazardous-waste storage area for both drummed liquids and solids. Fifty-five-gallon drums containing liquids were stored in cargo containers; drums containing solids were stored outside cargo containers on the ground. RCRA-listed wastes were stored in some of the cargo containers and included solvents, coolants, machining wastes, cuttings, lubricating oils, organics, and acids. PCB-contaminated soil, debris, and transformer oil were stored in the other cargo containers. All drums and cargo containers were removed in May 1987. Hazardous materials are no longer stored at IHSS 203 (DOE 1994a).

Soil-gas and surface-soil sampling was conducted at IHSS 203 during the Phase I RFI/RI. Soil-gas samples were collected at 35 locations at approximately 5 feet below ground surface and analyzed for volatile organic compounds (VOCs) (Appendix C, DOE 1994a). Concentrations of VOCs in soil gas varied significantly within the sampling area, and distinct sources were not identified that could be confidently interpreted as contamination associated with spills or releases during waste storage activities. Because landfill wastes underlie IHSS 203, VOCs in soil gas in this area are probably associated with the landfill (DOE 1994a).

Surface-soil samples were collected at 49 locations from the 0- to 2-inch soil horizon and 18 locations from the 0- to 10-inch soil horizon. Samples were analyzed for PCBs, metals, and radionuclides. Two PCBs (Aroclor-1254 and Aroclor-1260) were detected at low concentrations in approximately 20 percent of the soil samples but are not present at depth. All but one of the results for the analysis of PCBs in soil from IHSS 203 were "J" qualified, denoting estimated PCB concentrations below the detection limit of 230 micrograms per kilogram (µg/kg). Metals and radionuclides were generally detected at concentrations or activities less than the maximum background concentration or activity (DOE 1994a).

2.1.3 Asbestos-Disposal Areas

Beginning in 1985, asbestos generated onsite was reportedly disposed in a designated 10-foot-deep pit located east of the landfill. The asbestos-containing material was placed in heavy plastic bags, disposed in the pit, and covered with soil when the pit became full. By December 1988, asbestos was disposed in several pits (Figure 2-1). Records indicate that disposal of asbestos continued until April 1990 (DOE 1994a).

Asbestos-disposal areas are presently delineated with warning signs. Bags of friable asbestos were disposed in the northern trench, and it is reported that some of the bags burst during disposal (Blaha 1994). Waste material is disposed in the southern trench; however, it is unclear whether asbestos was also disposed in the southern trench (Blaha 1994). Aerial photographs show that waste material was buried in the vicinity of the asbestos-disposal pits; this area is included in the waste-volume calculations.

During the Phase I RFI/RI, two soil samples were collected and analyzed for asbestos from the asbestos-disposal pits (DOE 1994a). A trace (less than 1 percent) of chrysotile asbestos was detected in the surface soil (DOE 1994a). No intrusive work was performed in these areas, and the ground surface appears to be undisturbed.

2.1.4 Historical Interim Response Actions

In 1973, tritium and strontium were detected in leachate draining from the landfill. Interim response actions were undertaken to control the generation and migration of landfill leachate (DOE 1994a). These actions included construction of a surface-water diversion ditch around the perimeter of the landfill, two detention ponds immediately east of the landfill, a subsurface groundwater-intercept system for diverting groundwater around the landfill, and a subsurface leachate-collection trench (Figure 2-1) depth from 10 to 20 feet. Construction began in October 1974 and was completed in January 1975.

A surface-water diversion ditch was constructed around the perimeter of the landfill in October 1974 to divert surface-water runoff around the landfill and reduce the infiltration of surface water into the landfill, thereby reducing the volume of leachate draining from the landfill (Figure 2-1). No waste disposal is known to have occurred outside of the surface-water diversion ditch.

As part of the original interim response action, two detention ponds were constructed in 1974 to control leachate generated by the landfill (DOE 1994a). These ponds were formed by constructing temporary berms across the drainage immediately downstream of the landfill. The West Landfill Pond impounded leachate generated by the landfill. The East Landfill Pond provided a backup system for overflow from the West Landfill Pond and was also used to collect intercepted groundwater as needed (DOE 1992a).

A more permanent embankment was eventually constructed for the East Landfill Pond. The new embankment was an engineered dam structure with a spillway. A low-permeability clay core keyed into bedrock was constructed within the embankment to reduce seepage from the pond (DOE 1994a).

A groundwater-intercept system was installed around the perimeter of the landfill in 1974 as an interim response action to divert groundwater around the landfill and thus

45

control generation and migration of leachate (Figure 2-1). The groundwater-intercept system is a clay barrier (not a slurry wall) on the outside wall of the leachate-collection trench with a perforated pipe outside the barrier to carry groundwater to the groundwater-intercept system discharge points (Figure 2-2).

Between 1977 and 1981, the leachate-collection trench and the West Landfill Pond were buried beneath waste during landfill expansion. In 1982, two soil-bentonite slurry walls were constructed near the eastern end of the landfill to prevent groundwater migration into the expanded landfill area. These slurry walls were tied into the north and south arms of the groundwater-intercept system and extend approximately 900 feet from the points of intersection (Figure 2-1). Based on as-built drawings, the slurry walls vary in depth from 10 to 20 feet. There is no known waste disposal outside of the clay barrier or the slurry walls (DOE 1994a).

Effectiveness of landfill structures was evaluated in 1994 for the Phase I RFI/RI using historical groundwater-elevation data along a number of transects. These data indicate that the groundwater-intercept system is functioning effectively except on the northwest side of the landfill (DOE 1994a).

As-built diagrams were reviewed for the IM/IRA DD. Approximately 275 feet of the leachate-collection system trench along the northwest side and 400 feet of the trench along the southwest side of the landfill are not keyed into bedrock. These diagrams establish a possible pathway that allows groundwater to flow into the landfill on the northwest side. Another possible pathway is desiccation cracking of the clay layer. Any blockage in the drain outside the clay barrier would further reduce the effectiveness of the intercept system. Because there is a groundwater divide just south of the landfill, the head on the south side of the landfill is fairly low and the groundwater-intercept system appears to be functioning, even though it is not keyed into bedrock.

2.1.5 Spray Evaporation Areas (IHSSs 167.2 and 167.3)

Spray evaporation of water from the East Landfill Pond to maintain the stored volume at 75-percent capacity (approximately 5,500,000 gallons) began in September 1975. Spray evaporation was discontinued in 1994. Two discrete spray areas have been identified (Figure 2-1): the Pond Area Spray Field (IHSS 167.2) on the north bank of the pond and the South Area Spray Field (IHSS 167.3) on the south bank of the pond. These IHSSs were originally in OU 6 but were transferred to OU 7 in 1994 (DOE 1994a). Dimensions of the spray fields are approximately 100 feet by 460 feet for IHSS 167.2 and 120 feet by 440 feet for IHSS 167.3. Surface soils in spray evaporation areas are potentially contaminated by pond water. Surface soils downgradient of the

46

East Landfill Pond dam are downwind and thus potentially affected by spray activities in these areas.

2.1.6 OU 6 Trenches (IHSSs 166.1, 166.2, and 166.3)

OU 6 trenches A, B, and C (IHSSs 166.1, 166.2, and 166.3) are located southeast of the landfill (Figure 2-1). Trenches A and B received uranium- and/or plutonium-contaminated sludge from the sewage treatment plant (Building 995) from approximately 1964 to 1974. The materials placed in Trench C are not known, but it is probable that sewage sludge was also placed in this trench (DOE 1992a). More information regarding the history of these IHSSs is presented in the Phase I RFI/RI Work Plan for Operable Unit 6 - Walnut Creek Priority Drainage (DOE 1992b).

2.2 Geology

The geology at OU 7 is a function of the regional tectonic setting and local depositional and erosional conditions. Geologic data used to characterize OU 7 were compiled from previous landfill investigations (Rockwell International 1988a, DOE 1991a); existing geologic characterization reports (EG&G 1992a, EG&G 1995a); U.S. Geological Survey publications (Spencer 1961, Van Horn 1972); Colorado School of Mines reports (Weimer 1976); data from the Phase I RFI/RI field investigation (DOE 1994a); and data from the supplemental Phase I field investigation. A summary of the general geologic framework, description and distribution of surficial and bedrock geologic units, description of geotechnical properties, and description of pond sediments are presented in the following sections. Geologic borehole logs from the additional Phase I field investigation are presented in Appendix A. Geologic borehole logs from the Phase I RFI/RI are presented in the OU 7 Final Work Plan (DOE 1994a).

2.2.1 General Geologic Framework

Rocky Flats is located on an eastward-sloping plain just east of the Colorado Front Range. The surface cover is composed of a series of coalescing alluvial fans developed during the Pleistocene. The Present Landfill is located near the eastern extent of the alluvial-fan deposits. The alluvial fans were deposited on a broad, gently sloping erosional surface, or pediment, which is underlain by more than 10,000 feet of gently dipping (less than 2 degrees) Pennsylvanian to Upper Cretaceous sedimentary rocks.

Dissection of the gravel-capped pediment has occurred by headward erosion and planation along eastward-flowing streams and their tributaries. Fluvial processes have formed moderately steep hillsides adjacent to the stream drainages, with the steepest slopes formed along the tops of the incised drainages. The landfill at OU 7 is located in No Name Gulch at the western limit of headward erosion and pediment dissection. Waste material has been placed on top of the bedrock and fills the valley to the top of

47

the pediment at approximately 6,000 feet. Some waste material is mounded above the top of the pediment in the center of the landfill. Waste material is confined laterally by the leachate-collection trench and slurry walls and by the bedrock slopes of the valley.

Figure 2-3 presents a generalized stratigraphic section that shows the vertical sequence of surficial deposits and bedrock. Surficial and bedrock geologic units that influence groundwater flow include the Rocky Flats Alluvium and the underlying Arapahoe and Laramie Formations. Also important is the artificial fill material of the landfill, which is not shown on the figure. The Fox Hills Sandstone occurs at a depth of approximately 700 to 800 feet, which is too deep to be affected by the landfill. As such, it is not described.

2.2.2 Description of Geologic Units

Surficial material consists of Quaternary alluvial-fan deposits of the Rocky Flats Alluvium, colluvial deposits, alluvial deposits of the valley-fill alluvium, and artificial fill (Figure 2-4). All surficial deposits are part of the upper hydrostratigraphic unit (UHSU) at Rocky Flats, which is discussed in more detail in Section 2.3.

The Rocky Flats Alluvium caps the divides north and south of No Name Gulch and was deposited as a series of coalescing alluvial fans on the pediment. Thickness of the Rocky Flats Alluvium is 25 to 30 feet on the northwest, west, and southwest sides of the landfill and 10 to 15 feet on the divides north and south of the East Landfill Pond. The Rocky Flats Alluvium is composed of reddish-brown to yellowish-brown, well graded, coarse gravel in a clayey-sand matrix. Pebbles and cobbles are composed of quartzite, granite, and gneiss. Maximum pebble size ranges from 1 to 3 inches in diameter. Caliche, which is a porous calcium carbonate cement, was described in drill cores from the divides north and south of the East Landfill Pond. These zones may be discharge points for alluvial groundwater along the hillsides above the pond.

Colluvium covers the hillsides between the pediment on which the Rocky Flats Alluvium is deposited and the No Name Gulch drainage and East Landfill Pond. Colluvial materials have been deposited by slope wash and downward creep of alluvial material and bedrock. The colluvium is 1 to 5 feet thick on the slopes around the East Landfill Pond and below the dam. The colluvium consists of brown, structureless clay with some sand and a trace of gravel. Soil development has occurred and roots are present down to depths of 3 feet.

Valley-fill alluvium is present in the No Name Gulch drainage below the East Landfill Pond and is derived from reworked alluvial material and bedrock. The alluvium is 3 to 8 feet thick in the OU 7 area and becomes thicker downstream to the east. The alluvium consists of brown, laminated to structureless clay with lenses of gravel. Gravels have a sandy-silt matrix that is often iron-stained.

Artificial fill and disturbed surficial material are present within the boundaries of the landfill, which includes IHSS 203 and the asbestos-disposal areas. Thickness of the artificial fill, which includes waste and interim-soil cover, ranges from approximately 5 to 45 feet. Artificial fill is thickest near the centerline of the valley and thinnest around the perimeter of the landfill, inside the surface-water diversion ditch. An actively slumping area occurs in the artificial-fill material on the northeast side of the landfill. Seeps were observed along the slope in this area.

Bedrock unconformably underlies the surficial deposits and consists of claystones, siltstones, and fine-grained sandstones of the undifferentiated Upper Cretaceous Arapahoe and Laramie Formations (Figure 2-3).

In general, the base of the Arapahoe Formation, which unconformably overlies the Laramie Formation, is marked by the presence of medium-grained to conglomeratic sandstones composed of well-rounded, frosted, quartz sand grains with pebbles of chert, rock fragments, and ironstone. The lowermost 20 feet of the Arapahoe Formation are shown underlying the Rocky Flats Alluvium on the divides north and south of No Name Gulch on geologic maps of Rocky Flats (EG&G 1992a, EG&G 1995a). However, sandstones exhibiting the distinctive characteristic of the basal Arapahoe Formation or No. 1 sandstone (Figure 2-3) are not exposed at the surface nor in any of the drill cores from OU 7. The contact between the Arapahoe and Laramie Formations is difficult to interpret in the absence of the marker or No. 1 sandstone bed. Therefore, in this report, the Arapahoe and Laramie Formations are undifferentiated. However, in the No Name Gulch drainage, the elevation of the bedrock is low enough that the bedrock is likely Laramie Formation.

The Laramie Formation is approximately 600 to 800 feet thick. The lower 300 feet is composed of laterally extensive sandstones, kaolinitic claystones, and coal beds. The upper 300 to 500 feet consist primarily of olive-gray and yellowish-orange claystones. Four sandstone units (designated as the No. 2, No. 3, No. 4, and No. 5 sandstones) have been identified in the bedrock beneath the No. 1 sandstone and are considered upper Laramie Formation (Figure 2-3) (EG&G 1992a, EG&G 1995a). Where present, the sandstones are olive-gray, very fine-grained, subangular, well-sorted, locally calcareous, silty, and clayey. Because they lie within claystones and are not in hydraulic connection with either the No. 1 sandstone or the surficial deposits, the No. 2 through No. 5 sandstones are not considered significant migration pathways for potential contaminants to groundwater (DOE 1994a).

The bedrock at OU 7 is composed of gray to brown, structureless claystones containing a trace of carbonaceous material and occasional thin interbeds of siltstone and, less frequently, fine-grained sandstone. Sandstones are composed of gray, very fine to fine-grained, subangular to subrounded, well-sorted, quartzose sand. Sandstones are

49

frequently interbedded with siltstones. These "coarser-grained" units vary from 10 to 30 feet thick.

2.2.3 Distribution of Geologic Units

Geologic units beneath the landfill waste consist of a thin covering of colluvium on hillsides and valley-fill alluvium in the No Name Gulch drainage, both underlain by the Laramie Formation. Lithologies of the colluvium are clays and silts. Lithology of the valley-fill alluvium is gravelly, clayey sand. Lithologies of the Laramie Formation are typically limited to claystones and siltstones. Laramie Formation sandstones (sometimes referred to as the No. 2 through No. 5 sandstones) were identified in well 0886 (at a depth of 59 feet), located near the East Landfill Pond; well 6487 (25 feet), located within the landfill; and wells 4187 (81 feet), B207089 (31 feet), B207189 (70 feet), and 53094 (60 feet), located in No Name Gulch downgradient of the dam.

Fine-grained sandstones subcrop beneath the alluvium only at well location B207089 (31 feet), which is downgradient of the dam. This sandstone pinches out approximately 500 feet downstream and is not present at well 4287. Shallow sandstones (present within 15 feet of the contact between alluvium and bedrock) were encountered in wells 6487 (25 feet), located within the landfill on the south side, and B206789 (8 feet), located on the southwest shore of the pond. Based on a 2-degree regional dip, these shallow sandstones will not subcrop in the OU 7 area and are not preferential pathways for migration of contaminants (DOE 1994a). Other Laramie Formation sandstones are present at depths where there is no hydraulic connection with surficial deposits.

Geologic units on the groundwater divides adjacent to the landfill consist of Rocky Flats Alluvium, underlain by the undifferentiated Arapahoe and Laramie Formations. Lithologies of the Rocky Flats Alluvium are clayey gravels and sands. Lithologies of the undifferentiated Arapahoe and Laramie Formations are typically limited to claystones and siltstones. Laramie Formation sandstones were identified in wells 0986, 70293, 70593, and 70893 at depths of 50 to 125 feet below ground surface. All of these wells are located upgradient of the landfill.

A possible fault was identified in the OU 7 area during the Sitewide Geoscience Characterization Study (EG&G 1995a). The inferred fault, which is more than 2 miles long, trends northeast-southwest and cuts across OU 7 east of the landfill face near the edge of the East Landfill Pond (Figure 2-4). The fault plane dips to the west. Displacement along the fault is reported to be 25 to 50 feet, based on structural offset of a marker bed (EG&G 1995a). A trench excavated across the northern end of the fault revealed a wide fracture zone in the bedrock; however, the fractures appeared to decrease with depth. The surficial deposits were not offset, suggesting that movement had not occurred since their deposition (EG&G 1995a).

2.2.4 Geotechnical Properties of Geologic Units

Selected samples from subsurface boreholes drilled near the alignment of the proposed slurry wall were tested to determine geotechnical properties of soils developed in alluvium and colluvium at these locations. Samples of soils developed in alluvium from boreholes 53494 and 53594 and soils developed in colluvium from boreholes 52794 and 53694 were submitted for testing (Figure 2-5). Tests performed included natural moisture content in accordance with the standard method designated by the American Society for Testing and Materials (ASTM) D2216, grain-size distribution using sieve and hydrometer testing in accordance with standard method ASTM D422, Atterberg limits in accordance with standard method ASTM D4318, and specific gravity in accordance with standard method ASTM D854.

A summary of the geotechnical classification is presented in Table 2-1. Test results from boreholes 53494 and 53594 indicate that the shallow soils at these locations are classified as clayey sand, based on the Unified Soil Classification System (USCS) in accordance with standard method ASTM D2487-83. Test results from boreholes 52794 and 53694 indicate that the shallow soils at these locations are classified as fat clay, based on the USCS. The clayey sand and fat clay determinations are generally consistent with soil descriptions of alluvium and colluvium, respectively.

2.2.5 Description of Pond Sediments

Sediments have been accumulating in the East Landfill Pond since its construction in 1974. The source of contaminant loading to pond sediments includes the leachate seep and surface-water run-off from surrounding slopes. Sediment in the East Landfill Pond was sampled and characterized during the Phase I RFI/RI (DOE 1994a). The sediment ranges from 0.5 to 0.8 feet thick and consists of clay, silt, and organic matter. The upper 0.2 to 0.5 feet consists of black silt and clay with very fine roots occurring in either thin mats or scattered throughout the core. No bedding or lamination was visible. The remaining 0.3 to 0.4 feet of core consists of very dark gray clay with some silt. Very fine roots were observed but they decreased with depth. Olive-gray claystone of the Laramie Formation underlies the pond sediment.

2.3 Hydrology

The hydrology at OU 7 is a function of the general geologic framework, recharge and discharge conditions, physical properties of the aquifer materials, hydrodynamic conditions, and landfill structures. Hydrogeologic data used to characterize OU 7 were compiled from previous landfill investigations (DOE 1991a); sitewide groundwater monitoring, assessment, and protection plans and reports (EG&G 1990, EG&G 1991, EG&G 1994a, EG&G 1995b, DOE 1992b, and DOE 1993a); and water-level measurement and hydraulic conductivity test activities of the Phase I RFI/RI (DOE

51

1994a) and supplemental field investigations. Drawdown-recovery test data and analytical solutions from the supplemental Phase I field investigation are presented in Appendix B. Additional information on the hydrogeology at OU 7 is presented in the OU 7 Final Work Plan (DOE 1994a).

2.3.1 Conceptual Flow Model

The conceptual flow model for OU 7 is illustrated in Figure 2-5 and encompasses surface-water hydrology, interactions between surface water and groundwater, and groundwater hydrology.

- Surface-water hydrology components of the conceptual model include precipitation, evapotranspiration, pond evaporation, surface-water run-off, and engineered water transfers.

- Interactions between surface-water flow and groundwater flow include infiltration/percolation, interflow, seep flow at SW097, groundwater baseflow into the pond, discharge from the existing groundwater-intercept system into the pond, and seepage flow downward out of the pond.

- Groundwater hydrology components include groundwater flow in surficial materials, seepage between surficial materials and weathered bedrock, groundwater flow in weathered bedrock, seepage between weathered bedrock and unweathered bedrock, and groundwater flow in unweathered bedrock.

Recharge, discharge, and interactions between the surface-water and groundwater components of the conceptual model are presented briefly here and discussed in more detail in the following sections.

Recharge or infiltration/percolation is a significant source of water to the landfill mass. Groundwater inflow under or through the existing groundwater-intercept system is another significant source of water to the landfill. These two sources of inflow are quantified in a water balance performed using numerical modeling, which is described in more detail in Section 2.3.5 and Appendix C. Outflow from the landfill mass is funneled to the vicinity of the seep at SW097 where it exits the landfill as either seep flow or groundwater baseflow. The East Landfill Pond collects surface-water run-off, seep flow, and groundwater baseflow. The dam acts as a barrier to the flow of groundwater in surficial materials. Flow in weathered bedrock is much less than flow in surficial materials. Some preferential flow paths, most likely fractures, exist in the weathered bedrock. These preferential flow paths are potential contributors to the migration of contaminants in weathered bedrock. Flow in unweathered bedrock is so small that any potential contaminant transport occurs by diffusion.

2.3.2 Surface-Water Hydrology

Surface-water features resulting from historical interim response actions control surface-water hydrology. Individual components of surface-water hydrology shown in the conceptual model (Figure 2-5) are described below.

2.3.2.1 Surface-Water Features

A surface-water diversion ditch was constructed around the perimeter of the landfill in 1974 to divert surface-water run-off around the landfill and reduce the infiltration of surface water into the landfill, thereby reducing the volume of leachate discharging as seep flow (Figure 2-1). On the north side of the landfill, the ditch runs under a perimeter road through a small culvert and east into a small, natural drainage that eventually joins No Name Gulch below the East Landfill Pond dam. On the south side of the landfill, the ditch runs east above the East Landfill Pond and drops into No Name Gulch below the dam. The diversion ditch is 2 to 3 feet deep, 5 feet wide at the bottom, and has a trapezoidal shape. The slopes and floor of the ditch are composed of sparsely vegetated native-soil material.

The East Landfill Pond covers approximately 2.5 acres (Figure 2-1). Pond water levels are controlled to prevent overflow into the spillway draining to No Name Gulch. Between 1975 and 1994, water volume was reduced to 75-percent capacity (approximately 5,500,000 gallons) by periodic spray evaporation. Spray evaporation operations ceased in 1994. Approximately 1,000,000 gallons of water were transferred (or pumped) from the East Landfill Pond to the A-series ponds in fall 1994. Water was also transferred from the East Landfill Pond to the A-series ponds in May 1995.

The pond water volume fluctuates seasonally but averages approximately 6,000,000 gallons (DOE 1994a). After water was transferred to the A-series ponds in fall 1994, the pond volume was reduced to approximately 5,000,000 gallons. Recharge to the pond occurs from groundwater baseflow in surficial materials, leachate from the seep, and surface-water run-off from the landfill and surrounding slopes. Discharge occurs by natural evaporation, seepage downward into weathered bedrock, seepage through the clay core of the dam, and engineered water transfers.

2.3.2.2 Components of the Conceptual Flow Model

Surface-water hydrology components include precipitation, evapotranspiration, pond evaporation, surface-water run-off, and water transfers from the East Landfill Pond to the A-series ponds.

Mean annual precipitation at Rocky Flats, including rainfall and snowmelt, is nearly 16 inches (DOE 1980). Approximately 40 percent of the annual precipitation falls during

53

April, May, and June. An additional 30 percent falls in July and August. Approximately 19 percent falls during September, October, and November. The remaining 11 percent falls in December, January, February, and March.

Pond evaporation is estimated at 70 percent of the pan evaporation, which ranges from 1 inch in December and January to 7 inches in September (DOE 1994a). Potential evapotranspiration, which includes both evaporation and transpiration by plants, varies in a pattern similar to that shown by pan evaporation. Site-specific potential evapotranspiration data are not available. At any given time, precipitation in excess of evapotranspiration will become surface-water run-off, infiltration, or interflow.

Surface-water run-off from the landfill and from the area surrounding the pond are major contributors to pond water (DOE 1994a). Some portion of the run-off is diverted by the surface-water diversion ditch, while a significant fraction flows to the East Landfill Pond.

As stated above, water is periodically transferred to the A-series ponds to control the water level in the East Landfill Pond.

2.3.3 Interactions Between Surface Water and Groundwater

Interactions between surface water and groundwater include infiltration/percolation, interflow, seep flow at SW097, groundwater baseflow into the pond, discharge from the existing groundwater-intercept system into the pond, and seepage flow downward out of the pond.

Infiltration is the process by which precipitation moves downward into the soil and includes the flow within the unsaturated zone (Freeze and Cherry 1979). For purposes of the conceptual model, water that infiltrates reaches the groundwater table and recharges the groundwater in surficial materials. Infiltration at OU 7 is assumed to be between 5 and 10 percent of the mean annual precipitation (or 0.8 to 1.6 inches).

Interflow is subsurface flow in the horizontal direction above the water table that is usually associated with storm events on hillsides. Interflow may be a significant contributor to the variability of the flow at the seep (SW097).

Leachate presently discharges from a seep located at the base of the east face of the landfill (Figure 2-1). Seep flow varies throughout the year and has been estimated at 1 to 7 gallons per minute (gpm). A significant fraction of the groundwater flow from the landfill is funneled toward the seep. The seep originates from the original stream channel in No Name Gulch that was filled in during construction and subsequent waste disposal in the landfill. The seep is also directly downgradient of the West Landfill Pond dam, which was breached before being covered with waste and interim soil cover.

54

This breached dam may serve to further direct groundwater flow toward the seep. As stated above, interflow is potentially a major source of the variability of the seep flow.

An intermittent seep has been observed north of SW097 on the hillside just below the north asbestos-disposal area. This intermittent seep is most likely caused by saturated materials related to storm events. Heavy surface-water run-off has been observed in this area following storm events. Recent slumps have also been observed.

Groundwater baseflow exists in surficial materials and weathered bedrock. In surficial materials, the baseflow that does not intersect the ground surface at the seep is a source of recharge to the pond. The saturated thickness of the surficial materials at the edge of the East Landfill Pond is much less than the saturated thickness directly to the west in the landfill (Figure 2-6). This reduction in saturated thickness contributes to the formation of the seep (DOE 1994a). Evidence of preferential flow also exists. The seep flows year-round while nearby alluvial well 0786 is often dry. The groundwater modeling for the site also indicates that preferential flow occurs in the vicinity of the seep (Appendix C). In weathered bedrock, the potentiometric surface is below the bottom of the pond and the baseflow in the weathered bedrock is not expected to be a source of recharge to the pond.

The existing groundwater-intercept system is configured to discharge either to the pond or to the discharge points east of the dam (Figure 2-1). Based on observations of no flow at the discharge points east of the dam, it is assumed that the system is currently discharging to the East Landfill Pond. Discharge points to the pond are not visible at the ground surface.

Water seeps from the pond into the weathered bedrock and through the weathered bedrock under the dam. Some water also seeps through the dam core. Flows are expected to be small based on the measured hydraulic conductivities in the weathered bedrock and the dam core (DOE 1994a, EG&G 1993b). This seepage is not effective in recharging the weathered bedrock downgradient of the pond. The weathered bedrock wells (B206889 and B206989) directly below the dam consistently exhibit water levels 12 to 15 feet below the top of bedrock, indicating only partial saturation of weathered bedrock and a "perched" water table condition for surficial materials.

The dam impedes groundwater flow in surficial materials. Particle tracking shows that contaminants from the landfill are intercepted by the pond (Figure 2-7) (Appendix C). The chemical composition of groundwater downgradient of the dam is statistically different than groundwater in the vicinity of the East Landfill Pond. (Section 2.5.8 contains a discussion of background comparisons and potential contaminants of concern [PCOCs].) The wells in surficial materials directly downgradient of the dam are often dry.

55

2.3.4 Groundwater Hydrology

Groundwater flow at OU 7 occurs in the UHSU, which consists of surficial materials and weathered bedrock and, to a lesser extent, in the lower hydrostratigraphic unit (LHSU), which consists of discontinuous sandstone lenses in unweathered bedrock.

2.3.4.1 Groundwater Flow in the UHSU

The UHSU, which corresponds to the uppermost "aquifer" at Rocky Flats (DOE 1993a), is unconfined and consists of saturated, unconsolidated surficial materials and weathered bedrock. As described in Section 2.2.2, surficial materials include the Rocky Flats Alluvium, colluvium, valley-fill alluvium, and artificial fill. Weathered bedrock is composed of undifferentiated Arapahoe and Laramie Formation claystones and siltstones. Claystones predominate at OU 7.

Groundwater flow in surficial materials is expected to be significantly greater than groundwater flow in either the weathered bedrock or the unweathered bedrock. Hydraulic conductivities were measured at OU 7 during the Phase I RFI/RI and supplemental Phase I field investigation using drawdown-recovery tests. Field procedures, data analysis, and results are presented in the OU 7 Final Work Plan (DOE 1994a). Drawdown-recovery test data and analytical solutions from the supplemental Phase I field investigation are included in Appendix B in this report. In addition, some slug tests were performed prior to the Phase I RFI/RI. The results from all of these tests were used in calculating the geometric mean of hydraulic conductivities for surficial materials, weathered bedrock, and unweathered bedrock. The location, type of test, result, and geometric mean of results are presented in Appendix B.

The geometric mean of the measured hydraulic conductivities for the different geologic units are as follows: (1) for surficial materials excluding artificial fill, the geometric mean is 1.6E-04 cm/sec or 0.47 feet/day, (2) for artificial fill, the geometric mean is 6.7E-05 cm/sec or 0.19 feet/day, and (3) for all surficial materials combined, the geometric mean is 1.3E-04 cm/sec or 0.36 feet/day. These hydraulic conductivity measurements are significantly greater than the measurements for weathered bedrock or unweathered bedrock. The geometric mean of measured hydraulic conductivities in the weathered bedrock of the Laramie Formation is 4.0E-07 cm/sec or 0.0011 feet/day. The geometric mean of measured hydraulic conductivities in unweathered bedrock is 6.4E-07 cm/sec or 0.0018 feet/day. The individual hydraulic conductivities for each geologic unit are presented graphically in Figure 2-8.

As described in the conceptual model above, sources of groundwater recharge to the UHSU include infiltration/percolation of precipitation, snowmelt, storm run-off, and downward seepage from the East Landfill Pond. Discharge occurs through evapotranspiration and surface seepage where the water table intersects the ground

56

surface. The level of groundwater rises annually in response to spring and summer recharge and declines during the remainder of the year.

Groundwater in the UHSU generally flows to the east; however, localized flow follows topographic slopes toward the pond or toward the drainage below the dam. Potentiometric surface maps for surficial materials and weathered bedrock for 2nd Quarter 1995 are presented in Figures 2-9 and 2-10, respectively. The depth to groundwater in the UHSU is approximately 5 feet in No Name Gulch. Groundwater flows to the east within the valley-fill alluvium; however, flow is intermittent. Certain UHSU groundwater-monitoring wells east of the East Landfill Pond dam are often dry.

The depth to groundwater within the landfill is approximately 20 feet at the western end, 16 feet in the middle, and 33 feet at the eastern end. Relatively high water levels in the middle of the landfill result from groundwater inflow under the groundwater-intercept system on the north side, as shown by the potentiometric surface map in Figure 2-9. The lower portion of the landfill waste in the original No Name Gulch drainage is saturated in this area. Maximum thickness of saturated waste material is nearly 20 feet.

Groundwater flow in surficial materials in the vicinity of the landfill is divided into two components: flow that is diverted by the existing groundwater-intercept system and slurry walls and flow that is not diverted by the existing groundwater-intercept system and slurry walls.

Some fraction of the flow is diverted by the existing groundwater-intercept system and slurry walls. Existing data indicate that the groundwater-intercept system and slurry walls are most effective in diverting groundwater on the west and south sides of the landfill (DOE 1994a). A groundwater divide between the No Name Gulch drainage and the North Walnut Creek drainage exists approximately 300 feet south of the south leachate-collection trench. The presence of this groundwater divide limits the amount of available groundwater flow on the south side of the landfill and contributes to the effectiveness of the groundwater-diversion structures. The saturated thickness of surficial materials is less on the south side of the landfill than on the north side.

Some fraction of the flow is not diverted by the existing groundwater-intercept system and slurry walls. This fraction is labeled "groundwater inflow under groundwater-intercept system" in Figure 2-5 but could also include flow through the groundwater-intercept system and flow through or under the existing slurry walls. Existing data indicate that the groundwater-intercept system and slurry walls are least effective on the north side of the landfill (DOE 1994a).

57

Groundwater flowing out of the east boundary of the landfill is funneled to the seep area. Some fraction discharges to the surface as seep water and the remainder enters the pond as groundwater baseflow. Because the bottom of the pond rests directly on weathered bedrock and the dam is keyed into weathered bedrock, the pond and dam interrupt the flow of contaminated groundwater from the landfill and impede its flow down No Name Gulch. Figure 2-7 shows the flow paths of particles in groundwater over a 30-year time period. Appendix C contains additional information and discussion of groundwater flow modeling and particle tracking.

Seepage occurs between surficial materials and weathered bedrock. Flow is expected to be mostly downward into the weathered bedrock based on measured water levels from well clusters. The surficial materials and weathered bedrock are combined as the UHSU because evidence points to a hydraulic connection between the two layers (EG&G 1995b). However, this connection is not evident in all well-cluster locations. For some well clusters (e.g., 70093/70193), the potentiometric surfaces for surficial materials and weathered bedrock are almost identical and move together seasonally. For other well clusters (e.g., 70393/70493 and 4087/B206989), head differences in excess of 20 feet are consistently observed. These head differences indicate that the weathered bedrock in this location is very tight and very little water flows through it. In these locations, flow in surficial materials exists as a "perched" water table over partially saturated weathered bedrock. The water-level elevations presented in figures 2-9 and 2-10 illustrate this phenomena. In all cases, the water level in the weathered-bedrock well is lower than the water level in the surficial-material well, which indicates a consistent downward gradient for groundwater flow.

Groundwater flow in weathered bedrock may be divided into two components: flow through the matrix and flow through fractures or zones of high hydraulic conductivity.

Based on the hydraulic conductivity measurements, flow through the weathered bedrock matrix is expected to be approximately three orders of magnitude less than flow in surficial materials. Weathered bedrock in the OU 7 vicinity consists almost exclusively of claystones. The weathered siltstones and sandstones that are present elsewhere at the site are absent at OU 7. The basal Arapahoe or No. 1 sandstone bed, which can be a significant water-bearing unit, is also absent.

Preferential flow through weathered bedrock fractures or zones of higher hydraulic conductivity is potentially greater than flow through the weathered bedrock matrix. These zones of higher hydraulic conductivity may be potential pathways for the migration of contaminants in weathered bedrock and are postulated to explain the apparent migration of certain contaminants in the weathered bedrock, such as nitrate/nitrite in wells B206889 and B206989. However, higher hydraulic conductivities were not observed at OU 7. Based on all available analytical and

hydraulic data, the extent of contamination and contaminant transport in the weathered bedrock is limited.

Groundwater flow may occur along an inferred bedrock fault that cuts across the southeastern edge of the landfill (Figure 2-4) (EG&G 1995a). However, the fault does not offset or fracture the overlying alluvium, and potential groundwater flow along the fault would likely be restricted to bedrock. Groundwater traveling along the fault zone would eventually discharge where the fault intersects the hillsides in No Name Gulch east of the landfill; therefore, it is likely that the fault does not serve as a source of inflow to the landfill.

Seepage occurs between the weathered bedrock and unweathered bedrock. This flow is expected to be in the downward direction. Water-elevation data from well clusters consistently show water elevations in unweathered bedrock to be lower than water elevations in weathered bedrock. The magnitude of this flow is expected to be very small. Because of their low hydraulic conductivities, the claystones and siltstones that compose the majority of the unweathered bedrock act as an effective hydraulic barrier to downward migration of groundwater from the UHSU (EG&G 1995b).

2.3.4.2 *Groundwater Flow in the LHSU*

The LHSU at OU 7 is composed of individual siltstones and sandstones separated by fairly thick confining layers (aquitards) of claystone. Flow rates are comparatively low in these lithologic units. Fracturing is much less extensive in unweathered bedrock than in weathered bedrock. LHSU wells at OU 7 are screened in clayey siltstones to silty fine-grained sandstones. Calcite occasionally occurs as a pore-filling cement. Sandstone lenses in the unweathered bedrock are thin and discontinuous and therefore, are not a major contributor to groundwater flow (EG&G 1992a, EG&G 1995a).

Hydraulic conductivities in these siltstones and sandstones are very low. A sitewide evaluation of hydraulic conductivities of LHSU claystones, siltstones, and sandstones shows the geometric means to be within one order of magnitude (2.48E-07 cm/sec, 1.59E-07 cm/sec, and 5.77E-07 cm/sec, respectively). These values indicate that flow rates in the LHSU are only marginally impacted by changes in lithology. Measured hydraulic conductivities at OU 7 are similar to these sitewide values with a geometric mean of 6.4E-07 cm/sec (Figure 2-8, Appendix B). Flow in unweathered bedrock is expected to be so small as to be negligible. Contaminant transport in unweathered bedrock is controlled primarily by diffusion because of the low linear groundwater velocities within the unit (EG&G 1995b). For these reasons, contaminant transport in the LHSU is expected to be negligible and is eliminated from further consideration.

59

2.3.5 Water Balance for the Landfill

As part of the surface-water hydrology investigations for the IM/IRA, a water balance was performed for the landfill mass using MODFLOW (McDonald and Harbaugh 1991) model outputs for the no-action alternative. Input parameters, modeling runs, results, and a discussion of the results are included in Appendix C. The model was calibrated using OU 7 data. Inflows that contribute to leachate generation include recharge by infiltration/percolation of precipitation after evapotranspiration, horizontal groundwater flow from the alluvium under or through the existing groundwater-intercept system (primarily on the north side) and under or through the north slurry wall, and vertical groundwater flow upward from the weathered bedrock beneath the landfill. Outflow is primarily horizontal flow at the seep.

Conclusions from water-balance calculations indicate that approximately 60 percent of the inflow is groundwater from the alluvium and 40 percent is recharge by infiltration of precipitation (the potential error in water balance calculations is approximately 5 percent). Most of the groundwater inflow (87 percent) occurs on the north side of the landfill. Contributions from the west side (6 percent) and the south side (7 percent) are relatively insignificant. The water balance shows that both a cap and a slurry wall on the north side of the landfill would significantly reduce additional leachate generation. The water balance for the landfill mass is presented in Appendix C.

2.4 Ecology

The buffer zone surrounding the industrial area at Rocky Flats generally supports a wide variety of native plant communities and wildlife. However, the areas in and around OU 7 have been subject to extensive physical disturbances associated with heavy equipment used for landfill operations and construction of the East Landfill Pond and groundwater-intercept system. Ecological data used to characterize OU 7 were compiled from threatened and endangered species evaluations (ASI 1991), the Phase I RFI/RI field investigation (DOE 1994a), and the sitewide conceptual model (DOE 1995b). Additional ecological information is presented in the screening-level ecological risk assessment in Appendix D.

2.4.1 Vegetation

Specific plant communities present within OU 7 include mesic and xeric mixed grassland, disturbed area (developed or barren land), short marsh, wet meadow, and wetlands (Figure 2-11).

Mesic and xeric mixed grasslands are the most prevalent native habitat types at OU 7. These diverse plant community occurs on broad flat uplands, valley floors, and hillsides (Figure 2-11). Differences in slope, aspect, soil type, disturbance, and land-

use history are reflected in differences in dominance of the various grasses and forbs characterizing these grasslands.

Species richness was sampled along 2-meter by 50-meter belt transects within the mesic mixed grassland (DOE 1994a). Of the 106 species identified, 34 were graminoids, 63 forbs, 5 shrubs, and 4 cacti. Of these, 68 percent were native perennial species, suggesting a possible trend toward a native grassland climax community. Dominant grasses were western wheatgrass, Canada bluegrass, prairie junegrass, and big bluestem. Kentucky bluegrass, little bluestem, crested wheatgrass, sand dropseed, blue grama, and needle-and-thread were also present. Dominant forbs were diffuse knapweed, Louisiana sage, and Canada thistle. Secondary forbs included prairie aster, slimflower scurfpea, and klamath weed. Wild rose was the most commonly encountered shrub, and prickly pear the most common cactus encountered along transects within this habitat type.

A belt transect sampled within the disturbed community contained 27 plant species: 7 grasses, 1 sedge, and 19 forbs (DOE 1994a). Native species constituted 70 percent of the community, including all of the dominant grasses such as big bluestem, blue grama, Canada bluegrass, and mountain muhly. Narrowleaf sedge was also common. The dominant forb was diffuse knapweed, an introduced and aggressive weed that infests disturbed sites such as roadsides and waste areas. Other forbs included Louisiana sage, hairy golden-aster, blazing star, western ragweed, and klamath weed. Fringed sagebrush was the only shrub encountered in the disturbed community belt transect.

A large section of OU 7 is developed land or barren land due to continuous earth moving at the landfill (Figure 2-11). Plants have little opportunity to germinate, grow, or establish in bare areas. Most of the original topsoil has either been lost through wind and water erosion or buried in the landfill.

Tall and short marsh occur in the area around the East Landfill Pond (Figure 2-11). Tall marsh occurs at the pond margins and is comprised of a near monoculture of broad-leaved cattail, which probably impacts establishment and growth of other hydrophytic plants. The static water level, before the pond was subject to water transfers, probably promoted the persistence of the cattails. The short marsh type occurs in the sprayed areas north and south of the pond where intermittent spray operations caused more variable hydrologic conditions. The short marsh area is dominated by Baltic rush, which prefers mesic to hydric conditions but will tolerate drier conditions. Disturbed areas around the pond contain weedy species such as Canada thistle and western ragweed (DOE 1994a).

Riparian areas downgradient of the East Landfill Pond are poorly developed and lack extensive woody vegetation. Relatively well-developed riparian areas of North Walnut Creek lie approximately one-half mile to the south (DOE 1995b).

2.4.2 Wildlife

Wildlife within OU 7 includes large and small mammals, birds, reptiles, amphibians, and aquatic macroinvertebrates.

The most abundant large mammal is the mule deer. White-tailed deer have also been infrequently observed. Large carnivores present at Rocky Flats are the coyote, red fox, gray fox, striped skunk, long-tailed weasel, badger, bobcat, and raccoon. Eastern cottontails and white-tailed jackrabbits are also present. Small mammals (rodents) present are the thirteen-lined ground squirrel, northern pocket gopher, hispid pocket mouse, silky pocket mouse, plains harvest mouse, western harvest mouse, deer mouse, Mexican woodrat, house mouse, prairie vole, meadow vole, meadow jumping mouse, and western jumping mouse (DOE 1980, DOE 1993b).

Common grassland birds at Rocky Flats include the western meadowlark, horned lark, vesper sparrow, grasshopper sparrow, western kingbird, and eastern kingbird. Marshland areas support the sora rail, common snipe, song sparrow, red-winged blackbird, yellow-headed blackbird, common yellowthroat, and song sparrow. In addition, open water areas attract water birds such as the pie-billed grebe, double-crested cormorant, great blue heron, black-crowned night-heron, green-winged teal, mallard, gadwall, killdeer, and spotted sandpiper. Common birds of prey include the northern harrier, Swainson's hawk, red-tailed hawk, American kestrel, great horned owl, and long-eared owl. Occasionally, the bald eagle, rough-legged hawk, golden eagle, prairie falcon, and short-eared owl are observed (DOE 1994a).

The Rocky Flats site supports several species of reptiles and amphibians. Snake species include the bullsnake, yellow-bellied racer, western terrestrial gartersnake, and prairie rattlesnake. Western painted turtles are also present. Amphibian species include the plains leopard frog, Woodhouse's toad, northern chorus frog, and tiger salamander.

The East Landfill Pond apparently does not support fish and supports only a limited benthic macroinvertebrate community (DOE 1994a).

2.4.3 Sensitive Habitats and Endangered Species

Wetlands have been designated along the shoreline of the East Landfill Pond and in the pond itself by the U.S. Army Corps of Engineers (Figure 2-12) (COE 1994). Historically constant water levels in the pond have resulted in a well-established,

vegetated littoral zone at the north, south, and west pond margins. Cattails are the dominant emergent vegetation in these areas, and the area is used by common wetland wildlife species.

The East Landfill Pond includes approximately 3 percent of the open water habitat and 6 percent of the available shoreline habitat at Rocky Flats; the adjacent wetland represents approximately 1.6 percent of the total (COE 1994). Since the pond was constructed only about 20 years ago, it is probably not a historically important component of the local ecosystem. The pond apparently does not contain fish or crayfish populations. Without a complex aquatic food web that includes upper-level aquatic consumers, the pond is a limited resource for aquatic-feeding wildlife. Because the pond lacks predaceous fish such as bass, it may be a resource for breeding amphibians such as tiger salamanders, chorus frogs, and bullfrogs (Appendix D).

Slopes around the East Landfill Pond have been identified as potential habitat for the Preble's meadow jumping mouse (Figure 2-12) (DOE 1995b). The Preble's meadow jumping mouse has been petitioned for listing as a threatened or endangered species pursuant to the Endangered Species Act. The meadow jumping mouse currently receives protection as a non-game species under the Colorado Non-game, Endangered, or Threatened Species Conservation Act. The Preble's meadow jumping mouse is a subspecies of the meadow jumping mouse and, therefore, receives protection under state law.

Three federally listed endangered wildlife species potentially occur at Rocky Flats: the black-footed ferret, peregrine falcon, and bald eagle (ASI 1991). Potential habitat for several Colorado "Category 2" wildlife species occurs at Rocky Flats. These are the ferruginous hawk, Preble's meadow jumping mouse, white-faced ibis, mountain plover, long-billed curfew, and swift fox (ASI 1991). Small size and lack of an appropriate prey base precludes OU 7 as an important habitat for these federally listed or Category 2 species (DOE 1994a). Four plant species potentially present at Rocky Flats include one federally listed threatened species, Ute lady's tresses; one Category 2 species, Colorado butterfly plant; and two species of concern in Colorado, forktip three-awn and toothcup. None have been found at Rocky Flats (ASI 1991).

2.5 Nature and Extent of Contamination

The RI/FS RFI/CMS process for OU 7 was streamlined under the presumptive remedy framework. Characterization of the contents of the landfill (waste material) is not necessary or appropriate for selecting a response action (EPA 1993a). Historical information and results from limited characterization efforts are presented in Section 2.1 for the Present Landfill, Inactive Hazardous Waste Storage Area, and asbestos-disposal areas. Limited characterization of landfill gas and leachate was

63

performed during the Phase I RFI/RI and results are presented below. Sampling efforts for the Phase I RFI/RI and supplemental Phase I field investigation were focused on characterizing areas where contaminant migration was suspected such as surface water and sediment in the East Landfill Pond, surface soils in spray evaporation areas, and subsurface geologic materials and groundwater downgradient of the landfill. The nature and extent of contamination in these media are presented below.

2.5.1 Methodology for Background Comparisons and PCOC Identification

Site-to-background comparisons were performed for metals, radionuclides, and indicator parameters using statistical tests recommended by Gilbert (EG&G 1994b). Statistical tests include the Gehan test, slippage test, quantile test, t-test, and hot-measurement test. The hot-measurement test is a comparison of the maximum detection to the upper tolerance limit of the 99th percentile at the 99-percent confidence level ($UTL_{99/99}$) for background samples. Results were presented for all media in the OU 7 Final Work Plan (DOE 1994a). Data from the sitewide Background Geochemical Characterization Report (EG&G 1993c) were used for background samples of sediment, groundwater, seep water, and surface water. Data from soil samples collected in the Rock Creek drainage (DOE 1993b) were used for background samples of surface soils. Metals, radionuclides, and indicator parameters having elevated concentrations relative to background, as indicated by any one of the inferential statistical tests or the hot-measurement test, were identified as PCOCs. Organic compounds were considered PCOCs if detected in samples from OU 7.

For this report, OU 7 data were aggregated in populations that reflect potential collection or treatment alternatives. The following populations of data were evaluated: landfill gas, leachate at the seep, surface water in the East Landfill Pond, sediment in the pond, surface soils in the vicinity of spray evaporation areas, subsurface geologic materials (colluvium) downgradient of the landfill, subsurface geologic materials (weathered bedrock) downgradient of the landfill, groundwater in the vicinity of the East Landfill Pond upgradient of the dam, and groundwater downgradient of the dam.

Specific data sets used for each medium include the following:

- Landfill gas - 163 chemical-concentration measurements at 33 locations using field instruments that provide screening-level data (i.e., EPA Level II); one sampling event from Phase I RFI/RI

- Landfill gas - *in situ* soil-gas sampling; 67 samples collected at 33 locations; one sampling event from Phase I RFI/RI (EPA Level IV and V)

- Leachate at the seep (SW097) - monthly data (1990-1991); four months from Phase I RFI/RI (1992-1993) (EPA Level IV and V)

64

- Surface water in the East Landfill Pond (SW098) - monthly data (1990-1991); four months from Phase I RFI/RI (1992-1993) (EPA Level IV and V)

- Sediments in the East Landfill Pond - three samples; one sampling event from Phase I RFI/RI (1993) (EPA Level IV and V)

- Surface soils in the vicinity of spray evaporation areas - 133 samples from 0 to 2 inches, 67 samples from 0 to 10 inches, one event from Phase I RFI/RI (1993); 12 samples from 0 to 2 inches, 4 samples from 0 to 10 inches, one event from supplemental Phase I field investigation (1994) (EPA Level IV and V)

- Subsurface geologic materials downgradient of the landfill - 21 samples from 2 boreholes (70993 and 71093), 7 from colluvium and 14 from weathered bedrock, one event from Phase I RFI/RI (1993) (EPA Level IV and V)

- Groundwater downgradient of the landfill in the vicinity of the pond and downgradient of the dam - quarterly data (1990-1994), four months from Phase I RFI/RI wells (1992-1993), one month from 1994 wells (EPA Level IV and V)

The nature and extent of contamination for these media is detailed below. Landfill gas data were not evaluated statistically. Environmental media characterized by other data sets were not investigated for this report because these media are upgradient or within the source. Data sets not included are surface soils in IHSS 114 and IHSS 203, subsurface geologic materials upgradient of the landfill, surface-water discharge from the north and south groundwater intercepts, groundwater upgradient of the landfill, and groundwater within the landfill. Information on contaminant distribution in these media can be found in the OU 7 Final Work Plan (DOE 1994a).

2.5.2 Landfill Gas

Gas flow through landfill waste and soils occurs in response to pressure gradients (i.e., advective flow), concentration gradients (i.e., diffusive flow), compaction and settling of wastes, barometric pressure changes, and displacement due to potentiometric surface fluctuations. Advection of landfill gas is typically the predominant transport mechanism (EPA 1991a). Off-gassing pressures up to 0.44 pounds per square inch (lbs/in^2) were measured during the Phase I RFI/RI (DOE 1994a). Gas pressures exceeding approximately 0.05 lbs/in^2 indicate an advective, pressure-driven system (Emcon Associates 1982).

The composition of landfill-generated gases was evaluated on the basis of screening-level data on total combustible gases, methane, and carbon dioxide. The composition of landfill gas at OU 7 is 45 to 70 percent methane and 20 to 40 percent carbon dioxide, indicating anaerobic conditions (DOE 1994a). Concentrations of methane and carbon dioxide are highest in the eastern portion of the landfill where wastes are thickest and

most recently disposed. In general, landfill gases appear to be contained within the existing intercept system. Concentrations of methane and carbon dioxide are relatively low, as expected, in the vicinity of the gas-venting wells. Gas concentration maps and cross sections are included in the OU 7 Final Work Plan (DOE 1994a).

Concentrations of non-methane organic compounds (NMOCs) were determined by subtracting methane concentrations from the concentrations of total combustible gases. As a result, the reported concentrations of NMOCs may include minor amounts of inorganic gases such as hydrogen sulfide. Concentrations of NMOCs range from 0 to 152,000 milligrams per liter (mg/L) and average 30,000 mg/L (DOE 1994a).

In situ soil-gas sampling was performed to characterize hazardous air pollutants (HAPs) in the unsaturated zone of the landfill. Concentrations were reported as mg/L but no corresponding emission rates for generated gases were reported. HAPs detected at the landfill include 1,2-dichloroethene, 1,1,1-trichloroethane, trichloroethene, methylene chloride, acetone, 2-butanone, toluene, xylene, and hydrogen sulfide.

2.5.3 Landfill Leachate at the Seep

The composition of landfill-generated leachate was evaluated on the basis of screening-level data collected during the Phase I RFI/RI and seep samples collected monthly during the Phase I RFI/RI and the 1990-1991 surface-water monitoring program. Screening-level data were collected from 16 locations; 26 samples were collected. Methane concentrations from screening-level data ranged from 0.0003 to 31.4 mg/L and typically approached the solubility limit of 35 mg/L at 17 degrees Celsius (Merck Index 1989). Methane concentrations at OU 7 are consistent with methane concentrations of 25 mg/L observed at other landfills (Beadecker and Back 1979).

Surface-water samples were collected from the seep at the base of the east face of the landfill (SW097, Figure 2-13). Background comparisons were performed to identify PCOCs using the Gilbert methodology (EG&G 1994b). Analytes detected in leachate at concentrations that exceeded background concentrations include metals, radionuclides, and indicator parameters. VOCs and semivolatile organic compounds (SVOCs) were detected. Concentration ranges, detection limits, detection frequencies, and PCOCs identified are presented in Table 2-2. Additional information is presented in the OU 7 Final Work Plan (DOE 1994a).

According to the Gilbert methodology (EG&G 1994b), professional judgment was used to eliminate certain analytes from the PCOC list (Table 2-2). Two rationales were used for the elimination of analytes: (1) the analytes calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients (EPA 1989a) and (2) other analytes were eliminated from consideration as PCOCs because of infrequent detection, detection in method blanks, or detection in background samples.

Alpha-BHC was eliminated as a PCOC because it was detected only once, the result was reported as zero, and the result was "I" qualified, which indicates that there was interference and the result is an estimated value. Carbon disulfide, tetrachloroethene, and vinyl acetate were eliminated as PCOCs because they were infrequently detected, suggesting that the results are outliers and are not representative of the true population.

Methylene chloride was eliminated as a PCOC for two reasons: (1) many of the detections, including the maximum detection are 1990 data that were never validated and are "B" qualified (detected in laboratory blanks) and (2) methylene chloride is a common laboratory contaminant that was often detected in background groundwater samples. Methylene chloride was detected in 26 of 100 samples, or 26 percent, in the background data set. The maximum detection in background was 31 µg/L. The $UTL_{99/99}$ for the background data set is 21 µg/L. By contrast, methylene chloride was detected in 9 of 20 samples, or 45 percent, in the leachate data set. The maximum detection in leachate was 190 µg/L.

The following analytes are identified as PCOCs for leachate at a the seep:

- Metals - antimony (20 µg/L), barium (645 µg/L), iron (81,005 µg/L), lithium (48 µg/L), manganese (1,623 µg/L), strontium (920 µg/L), and zinc (2,974 µg/L)
- Radionuclides - strontium-89,90 (1.35 picocuries per liter [pCi/L]), and tritium (393 pCi/L)
- SVOCs - 2,4-dimethylphenol (5 µg/L), 2-methylnaphthalene (16 µg/L), 4-methyphenol (4µg/L), acenaphthene (3 µg/L), bis(2-ethylhexyl)phthalate (5 µg/L), dibenzofuran (1 µg/L), diethyl phthalate (3 µg/L), fluorene (2 µg/L), naphthalene (18 µg/L), and phenanthrene (4 µg/L)
- VOCs - 1,1-dichloroethane (6 µg/L), 1,2-dichloroethene (4 µg/L), 2-butanone (12 µg/L), 2-hexanone (5 µg/L), 4-methyl-2-pentanone (11 µg/L), acetone (34 µg/L), benzene (2 µg/L), chloroethane (22 µg/L), chloromethane (5 µg/L), ethylbenzene (13 µg/L), o-xylene (6 µg/L), toluene (3 µg/L), total xylene (14 µg/L), trichloroethene (2 µg/L), and vinyl chloride (5 µg/L)
- Indicator parameters - nitrite (30 µg/L)

2.5.4 Surface Water in the East Landfill Pond

The composition of pond water was evaluated on the basis of surface-water monitoring samples collected monthly during the Phase I RFI/RI and the 1990-1991 surface-water monitoring program. Surface-water samples were collected from station SW098, located in the central east section of the pond adjacent to the dam (Figure 2-13). Background comparisons were performed to identify PCOCs using the Gilbert

methodology (EG&G 1994b). Analytes that were detected at concentrations or activities above background include metals and radionuclides, VOCs and SVOCs were detected; however, none of the VOCs or SVOCs were detected frequently. Concentration ranges, detection limits, detection frequencies, and PCOCs identified are presented in Table 2-3. Only analytes that were detected are included in the table. Additional information is presented in the OU 7 Final Work Plan (DOE 1994a).

Professional judgment was used to eliminate certain analytes from the PCOC list (Table 2-3). Again, two rationales were used for the elimination of analytes: (1) the analytes calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients (EPA 1989a) and (2) other analytes were eliminated from consideration as PCOCs because of infrequent detection, detection in method blanks, or detection in background samples. Acetone, methylene chloride, and vinyl acetate were eliminated because they were infrequently detected, suggesting that the results are outliers and are not representative of the true population. Acetone and methylene chloride were also detected in laboratory blanks ("B" qualified) and are common laboratory contaminants.

The following analytes are identified as PCOCs for surface water in the East Landfill Pond:

- Metals - arsenic (1 µg/L), lithium (79 µg/L), manganese (105 µg/L), molybdenum (20 µg/L), nickel (10 µg/L), strontium (476 µg/L), thallium (2 µg/L), and tin (41 µg/L)
- Radionuclides - americium-241 (0.007 pCi/L), strontium-89,90 (1.4 pCi/L), tritium (139 pCi/L), uranium-235 (0.1 pCi/L), and uranium-238 (1.1 pCi/L)
- SVOCs - bis(2-ethylhexyl)phthalate (5 µg/L) and di-n-butyl phthalate (5 µg/L)

2.5.5 Sediments in the East Landfill Pond

Sediment samples were collected at three locations in the pond to assess the impact of a potential point source of contamination from the seep and nonpoint run-off from the landfill. Samples were analyzed for VOCs, SVOCs, radionuclides, metals, and inorganics (Figure 2-13). None of the radionuclides exceeded background $UTL_{99/99}$ values. Three VOCs and several SVOCs were detected in pond sediments. All SVOC results are estimated values below the quantitation limit ("J" qualified); however, they were not eliminated from the PCOC list. Concentration ranges, detection limits, detection frequencies, qualifiers, and PCOCs identified are presented in Table 2-4. Only analytes that were detected are included in the table. Additional information is presented in the OU 7 Final Work Plan (DOE 1994a).

68

Professional judgment was used to eliminate certain analytes from the PCOC list (Table 2-4). The analytes calcium, magnesium, potassium, and sodium were eliminated as PCOCs because they are essential nutrients (EPA 1989a). Acetone was detected in the laboratory blank ("B" qualified) for the maximum detection; however, because it was detected in more than 50 percent of the samples, acetone was not eliminated from the PCOC list.

The following analytes are identified as PCOCs for sediments in the pond:

- Metals - zinc (106 mg/kg)
- SVOCs - acenaphthene (220 µg/kg), anthracene (240 µg/kg), benzo(a)anthracene (300 µg/kg), benzo(a)pyrene (293 µg/kg), benzo(b)fluoranthene (343 µg/kg), benzo(ghi)perylene (253 µg/kg), benzo(k)fluoranthene (230 µg/kg), benzoic acid (537 µg/kg), bis(2-chloroisopropyl)ethene (259 µg/kg), bis(2-ethylhexyl)phthalate (213 µg/kg), chrysene (29 µg/kg), fluoranthene (415 µg/kg), fluorene (251 µg/kg), indeno(1,2,3-cd)pyrene (247 µg/kg), phenanthrene (346 µg/kg), and pyrene (386 µg/kg)
- VOCs - 2-butanone (17 µg/kg), acetone (65 µg/kg), and toluene (307 µg/kg)

2.5.6 Surface Soils in Spray Evaporation Areas

Surface-soil samples were collected on a grid from the landfill eastward across the spray evaporation areas and surrounding slopes and downwind below the dam (Figure 2-14). Soil samples were collected at 133 locations from the 0- to 2-inch soil horizon and 67 locations from the 0- to 10-inch soil horizon during the Phase I RFI/RI (DOE 1994a). Soil samples were collected at 12 locations from the 0- to 2-inch soil horizon and 4 locations from the 0- to 10-inch soil horizon during the supplemental Phase I field investigation. All samples were analyzed for metals and radionuclides.

Background comparisons were performed to identify PCOCs using the Gilbert methodology (EG&G 1994b). Analytes that were detected at concentrations or activities above background concentrations or activities include metals, radionuclides, and indicator parameters. Concentration ranges, detection limits, detection frequencies, qualifiers, and PCOCs identified are presented in Table 2-5. Only analytes that were detected are included in the table. Additional information is presented in the OU 7 Final Work Plan (DOE 1994a).

Arsenic was detected in all samples and was frequently detected above background. The maximum concentration of arsenic is 16 milligrams per kilogram (mg/kg) at a location southwest of the South Area Spray Field (SS702293, Figure 2-14). The maximum activity of americium-241 is 1 picocurie per gram (pCi/g) at a location on the hillslope south of the pond (SS703793, Figure 2-14). This area was regraded

69

during routine maintenance at the landfill in September 1993 and falls under the proposed footprint of the landfill cap. The maximum activity of radium-226 is 2 pCi/g at a location downwind of the spray evaporation areas below the dam (SS711193, Figure 2-14). Radium-226 was not detected in confirmation samples collected during the supplemental Phase I fieldwork.

Professional judgment was used to eliminate calcium, magnesium, potassium, and sodium as PCOCs because they are essential nutrients (EPA 1989a).

The following analytes are identified as PCOCs for surface soils in the vicinity of the East Landfill Pond:

- Metals - antimony (4 mg/kg), barium (194 mg/kg), beryllium (1 mg/kg), cobalt (7 mg/kg), copper (17 mg/kg), lead (26 mg/kg), mercury (0.1 mg/kg), selenium (1 mg/kg), silver (1 mg/kg), strontium (48 mg/kg), thallium (0.2 mg/kg), vanadium (32 mg/kg), and zinc (56 mg/kg)

- Radionuclides - americium-241 (0.02 pCi/g); plutonium-239,240 (0.05 pCi/g); and radium-226 (1 pCi/g)

- Indicator parameters - nitrate/nitrite (4 mg/kg)

2.5.7 Subsurface Geologic Materials Downgradient of the Landfill

Subsurface geologic materials were sampled in two boreholes to characterize potential leachate-contaminated materials downgradient of the landfill (70993 and 71093) (Figure 2-15). Samples were collected at 2-foot increments in colluvium and 4-foot increments in weathered bedrock. A total of 21 samples were collected; 7 from colluvium and 14 from bedrock. All samples were analyzed for VOCs, SVOCs, PCBs, metals, radionuclides, and indicator parameters (total organic carbon [TOC], nitrate, and sulfide).

Background comparisons were performed to identify PCOCs using the Gilbert methodology (EG&G 1994b). Analytes that were detected at concentrations or activities above background include metals, radionuclides, and indicator parameters in colluvium, and metals in weathered bedrock. SVOCs and VOCs were detected. Concentration ranges, detection limits, detection frequencies, and PCOCs identified are presented in Table 2-6. Only analytes that were detected are included in the table. Additional information is presented in the OU 7 Final Work Plan (DOE 1994a).

Professional judgment was used to eliminate calcium, magnesium, potassium, and sodium as PCOCs in colluvium and weathered bedrock because they are essential nutrients (EPA 1989a). All SVOC results are estimated values below the quantitation limit ("J" qualified); however, they were not eliminated from the PCOC list.

1,1,1-trichloroethane was eliminated as a PCOC in weathered bedrock because it was detected only once, which suggests that the detection is an outlier and is not representative of the true population. The result was also "J" qualified, indicating that it is an estimated value.

The following analytes are identified as PCOCs for subsurface geologic material in colluvium downgradient of the landfill:

- Metals - barium (230 mg/kg)
- Radionuclides - cesium-137 (0.584 pCi/g)
- SVOCs - chrysene (150 µg/kg), fluoranthene (189 µg/kg), phenanthrene (188 µg/kg), and pyrene (189 µg/kg)
- VOCs - 4-methyl-2-pentanone (17 µg/kg), toluene (850 µg/kg), and total xylenes (3 µg/kg)
- Indicator parameters - nitrate/nitrite (400 mg/kg)

The following analytes are identified as PCOCs for subsurface geologic material in weathered bedrock downgradient of the landfill:

- Metals - arsenic (3.4 mg/kg), barium (97 mg/kg), cobalt (9 mg/kg), lead (22 mg/kg), manganese (275 mg/kg), strontium (97 mg/kg), and zinc (70 mg/kg)
- VOCs - toluene (309 µg/kg)

2.5.8 Groundwater Downgradient of the Landfill

Groundwater downgradient of the landfill is separated into two populations for data evaluation to assist in delineating areas where groundwater has been impacted by migration of landfill leachate (Figure 2-15). These populations are groundwater in the vicinity of the East Landfill Pond upgradient of the dam and groundwater downgradient of the dam. Nine existing wells are screened across surficial material or weathered bedrock: three near the East Landfill Pond and six downgradient of the dam. Four wells are screened across unweathered bedrock sandstones or siltstones: one near the pond and three downgradient of the dam. Groundwater samples have been collected from the older wells since 1986 or 1989 and from the new wells since December 1994. Data from 1990 to 1995 were used in this report. Appendix B lists the well locations, geologic formation the well is screened across, hydrostratigraphic unit, date the well was installed, and population for data aggregation (wells in the vicinity of the East Landfill Pond versus wells downgradient of the dam). Figure 2-15 shows the well locations and outlines the populations used for data aggregation.

71

Background comparisons for inorganic analytes and radionuclides were performed on the two populations of UHSU groundwater to identify PCOCs using the Gilbert methodology (EG&G 1994b). Analytes that fail any of the tests are identified as PCOCs. The results of the statistical tests for wells in the vicinity of the East Landfill Pond and downgradient of the dam are presented in Tables 2-7 and 2-8, respectively. In addition to the inorganic analytes and radionuclides that fail the statistical tests, all VOCs and SVOCs detected in groundwater are considered PCOCs unless eliminated by professional judgment.

Professional judgment was used to eliminate certain analytes from the PCOC list. Two major rationales were used for the elimination of analytes: (1) the analytes calcium, magnesium, potassium, and sodium were eliminated because they are essential nutrients (EPA 1989a) and (2) other analytes were eliminated from consideration as PCOCs because of infrequent detection, detection in method blanks, or detection in background samples.

For the groundwater in vicinity of the East Landfill Pond (Table 2-7), 1,1-dichloroethane, acetone, benzene, chloroethane, ethylbenzene, toluene, and total xylenes were eliminated because infrequent detection suggests that the detection(s) are outliers. Methylene chloride was eliminated for two reasons: (1) many of the detections are 1990 data that were never validated and are "B" qualified (detected in laboratory blanks) and (2) methylene chloride is a common laboratory contaminant that was often detected in background groundwater samples. For the data set used for background comparisons, methylene chloride was detected in 43 of 298 samples, or 14 percent of samples. The maximum detection in background was 42 µg/L. The $UTL_{99/99}$ for the background data set is 16 µg/L. For the groundwater in vicinity of the East Landfill Pond, methylene chloride was detected in 7 of 51 samples, or 14 percent of samples. The maximum detection in this data set was 8 µg/L. The $UTL_{99/99}$ is 6.0 µg/L.

For the groundwater downgradient of the dam (Table 2-8), antimony, benzene, and toluene were eliminated because infrequent detection suggests that the detection(s) are outliers. Methylene chloride was eliminated for the same reasons stated above. For the groundwater downgradient of the dam, methylene chloride was detected in 10 of 52 samples, or 19 percent of samples. The maximum detection of the methylene chloride in this data set was 12 µg/L. The $UTL_{99/99}$ is 9 µg/L.

The following are identified as PCOCs for the UHSU groundwater in the vicinity of the East Landfill Pond:

- Metals - antimony (18 µg/L), lithium (207 µg/L), selenium (665 µg/L), silver (3 µg/L), and strontium (1,446 µg/L)

72

- Radionuclides - uranium-238 (32.63 pCi/L)
- SVOCs - bis(2-ethylhexyl)phthalate (4 µg/L)
- VOCs - carbon tetrachloride (2 µg/L), tetrachloroethene (2 µg/L), and trichloroethene (2 µg/L)
- Indicator parameters - chloride (155,699 µg/L), nitrate/nitrite (48,704 µg/L), orthophosphate (20.71 µg/L), and sulfate (621,840 µg/L)

The following are identified as PCOCs for the UHSU groundwater downgradient of the East Landfill Pond dam:

- Metals - lithium (100 µg/L) and strontium (1,355 µg/L)
- Radionuclides - strontium-89,90 (0.17 pCi/L)
- Indicator parameters - chloride (311,351 µg/L), fluoride (692 µg/L), nitrate/nitrite (7.7 µg/L), orthophosphate (30.14 µg/L), and sulfate (1,081,886 µg/L)

Background comparisons for inorganic analytes and radionuclides were performed on one population of LHSU groundwater to determine PCOCs. The results of the statistical tests for LHSU wells downgradient of the landfill are presented in Table 2-9. Again, some analytes were eliminated by professional judgment. Calcium, magnesium, potassium, and sodium were eliminated as PCOCs because they are essential nutrients (EPA 1989a). Acetone, chlorobenzene, toluene, and total xylenes were eliminated as PCOCs because infrequent detection suggests that the detection(s) are outliers. Methylene chloride was eliminated for the reasons stated above. The PCOCs remaining for LHSU downgradient of the landfill are carbonate (6,000 µg/L) and orthophosphate (13.6 µg/L). Given the hydrology of the unweathered bedrock (Section 2.3.4.2) and the nature of these analytes, groundwater in the LHSU downgradient of the landfill will not receive further consideration.

Section 2
Tables

Table 2-1
Geotechnical Classification Test Results for Soil Samples

Borehole Number	Sample Number	Sample Depth (feet)	Description and USCS Soil Classification	Natural Moisture Content (ASTM D2216)	Grain-Size Distribution (ASTM D422)	Atterberg Limits (ASTM D4318)	Specific Gravity (ASTM D854)
53494	BH70405ST	0 to 12.6	Alluvium, Clayey Sand (SC)	5.7%	Gravel 35% Sand 39% Silt 10% Clay 16%	PI = 14%	2.67
53594	BH70403ST	0 to 1.8	Alluvium, Clayey Sand (SC)	8.0%	Gravel 25% Sand 40% Silt 17% Clay 18%	PI = 17%	2.64
53694	BH70401ST	0 to 2	Colluvium, Fat Clay (CH)	13.9%	Gravel 0% Sand 8% Silt 30% Clay 62%	PI = 41%	2.52
52794	BH70407ST	0 to 2	Colluvium, Fat Clay (CH)	21.2%	Gravel 22% Sand 10% Silt 23% Clay 45%	PI = 44%	2.65

Definitions

ASTM American Society for Testing and Materials
USCS Unified Soil Classification System
PI plasticity index
% percent

Table 2-2
Analytes Detected in Leachate at the Seep (SW097)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Metals										
Aluminum	10 - 30,000	16/19	29	26,900	–	–	2,629	39,136	pCi/L	
Antimony	0.05 - 60	4/18	14	60.4	–	A	20	20,054	pCi/L	1
Arsenic	0.7 - 10	8/16	1.4	3	B	–	3	3,485	pCi/L	
Barium	0.02 - 50,000	19/19	297	1,550	–	–	645	63,510	pCi/L	2
Beryllium	0.2 - 5	2/18	0.2	1.4	–	JA	1	1,702	pCi/L	
Cadmium	0.1 - 16.5	4/18	1	7.6	–	–	3	1,760	pCi/L	
Calcium	14.5 - 100,000	19/19	126,000	212,000	–	–	151,737	56,909	pCi/L	1,2,3
Chromium	2.4 - 27.5	7/18	2	29.6	–	–	9	3,328	pCi/L	
Cobalt	0.02 - 50	10/18	2.7	19.1	B	–	11	16,938	pCi/L	
Copper	2.4 - 25	8/18	2	94.9	–	–	12	8,281	pCi/L	
Iron	4.7 - 30,000	19/19	61,300	155,000	–	–	81,005	16,477	pCi/L	2
Lead	0.8 - 2,000	14/18	1.5	11	–	V	5	1,482	pCi/L	
Lithium	2 - 2,000	15/19	34	107	–	V	48	35,577	pCi/L	2
Magnesium	0.1 - 200,000	19/19	29,300	49,000	–	–	34,868	1,156,026	pCi/L	2,3
Manganese	1 - 10,000	19/19	1320	2,490	–	–	1,623	3,024	pCi/L	2
Mercury	0.02 - 0.2	1/18	0.1	0.28	–	–	0.1	58.9	pCi/L	
Molybdenum	5.7 - 200	6/18	4	28.5	B	–	21	32,559	pCi/L	
Nickel	0.02 - 40	5/18	5	31	–	V	12	13,308	pCi/L	
Potassium	10 - 200,000	18/19	5,000	11,700	–	–	6,511	1,607,524	pCi/L	2,3
Selenium	1.1 - 5	2/18	1.1	7	W	–	2	1,710	pCi/L	
Silver	2.6 - 25	8/18	2.7	16.7	–	–	5	3,388	pCi/L	
Sodium	10 - 50,000	19/19	57,700	110,000	–	V	71,468	39,331	pCi/L	1,2,3
Strontium	3.5 - 10,000	17/19	814	1,370	–	–	920	241,118	pCi/L	2
Tin	10 - 200	8/18	11	243	–	–	48	33,576	µg/L	

Table 2-2
Analytes Detected in Leachate at the Seep (SW097)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Vanadium	3.2 - 10,000	12/19	3.1	211	–	–	25	16,634	µg/L	
Zinc	1.8 - 10,000	19/19	857	16,000	–	–	2,974	3,708	µg/L	1,2
Pesticides										
alpha-BHC	0.05 - 0.28	1/3	0	0	I	–	0.06	–	µg/L	4,5
Radionuclides										
Americium-241	0 - 0.013	16/16	-0.000404	0.02121	–	V	0.007	0.03	pCi/L	
Cesium-137	0.47 - 1	14/14	-0.21	0.6057	J	–	0.15	2.1	pCi/L	
Gross alpha	1.5 - 7.4	8/8	0.8918	6.639	–	V	2.9	29	pCi/L	
Gross beta	1.69 - 11.5	8/8	3.753	17	–	V	10	31	pCi/L	1,2,6
Plutonium-238	0.01 - 0.01	2/2	-0.000465	0.00222	J	A	0.00088	0.025	pCi/L	
Plutonium-239	0.003 - 0.003	1/1	0.009	0.009	–	–	0.009	–	pCi/L	
Plutonium-239/240	0 - 0.013	16/16	0.001	0.01606	–	A	0.007	–	pCi/L	
Radium-226	0.03 - 0.03	1/1	0.58	0.58	–	A	0.58	17	pCi/L	
Strontium-89,90	0.21 - 1	9/9	0.66	4.06	–	V	1.35	4.9	pCi/L	1,2
Strontium-90	0.2 - 0.59	3/3	0.5442	1.1	–	–	0.7	–	pCi/L	
Tritium	155 - 450	19/19	185.4	1,500	–	A	393	732	pCi/L	2
Uranium-233,-234	0.1 - 0.6	12/12	-0.0238	4.2	B	A	0.8	–	pCi/L	
Uranium-235	0 - 0.6	12/12	-0.012	0.084	J	A	0.03	0.3	pCi/L	
Uranium-238	0.086 - 0.6	12/12	0.03914	3.76	–	A	1	1.8	pCi/L	
Semivolatile Organic Compounds										
2,4-Dimethylphenol	10	1/5	3	3	J	A	5	–	µg/L	4
2-Methylnaphthalene	10	5/5	12	23	–	V	16	–	µg/L	4

Table 2-2
Analytes Detected in Leachate at the Seep (SW097)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
4-Methylphenol	10	3/5	2	4	J	–	4	–	µg/L	4
Acenaphthene	10	5/5	2	3	J	A	3	–	µg/L	4
Bis(2-ethylhexyl)phthalate	10 - 12	1/5	2	2	J	A	5	8	µg/L	4
Dibenzofuran	10	5/5	1	2	J	A	1	–	µg/L	4
Diethyl phthalate	10	4/5	1	3	J	A	3	8	µg/L	4
Fluorene	10	5/5	2	3	J	A	2	–	µg/L	4
Naphthalene	10	5/5	14	22	–	V	18	–	µg/L	4
Phenanthrene	10	5/5	4	5	J	A	4	–	µg/L	4
Volatile Organic Compounds										
1,1-Dichloroethane	5	17/20	2	10	–	V	6	–	µg/L	4
1,2-Dichloroethene	5	10/20	2	14	–	V	4	3	µg/L	4
2-Butanone	10	6/19	6	76	–	V	12	19	µg/L	4
2-Hexanone	10	1/20	1	10	–	V	5	–	µg/L	4
4-Methyl-2-Pentanone	10	5/20	10	87	J	A	11	–	µg/L	4
Acetone	10	10/20	10	220	–	A	34	29	µg/L	4
Benzene	5	11/20	1	2	J	–	2	3	µg/L	4
Carbon disulfide	5	1/20	5	6	–	–	3	4	µg/L	4,5
Chloroethane	10	15/20	10	57	–	V	22	–	µg/L	4
Chloromethane	10	2/20	4	7	J	A	5	–	µg/L	4
Ethylbenzene	5	19/20	1	18	–	–	13	–	µg/L	4
Methylene chloride	5	9/20	3	190	B	–	14	21	µg/L	4,5
o-Xylene	5	3/4	5	8	–	–	6	–	µg/L	4
Tetrachloroethene	5	2/20	1	1	J	–	2	3	µg/L	4,5

Table 2-2
Analytes Detected in Leachate at the Seep (SW097)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Toluene	5	19/20	5	88	–	–	38	3	µg/L	4
Total xylenes	5	19/20	1	25	J	A	14	3	µg/L	4
Trichloroethene	5	11/20	1	4	J	–	2	3	µg/L	4
Vinyl acetate	10	1/19	10	49	–	–	7	–	µg/L	4,5
Vinyl chloride	10	5/20	3	11	–	V	5	–	µg/L	4
Indicator Parameters										
Bicarbonate as $CaCO_3$	1000 - 10,000	15/15	554,000	705,000	–	V	595,800	–	µg/L	
Carbonate as $CaCO_3$	1000 - 10,000	2/9	0	0	–	–	3,889	–	µg/L	
Chloride	100 - 50,000	14/14	1800	66,300	–	V	53,650	64,366	µg/L	
Cyanide	10 - 20	1/14	1.5	36.8	–	–	9	252	µg/L	
Dissolved organic carbon	1,000 - 1,000	4/4	14,000	27,000	–	JA	18,750	16,997	µg/L	
Fluoride	100- 200	12/12	390	540	–	V	469.2	643	µg/L	
Nitrate/nitrite	20 - 200	6/10	20	870	–	V	263	3,130	µg/L	
Nitrite	20- 20	6/9	20	63	–	V	30.33	1,576	µg/L	2
Oil and grease	200- 11,100	4/12	800	42,100	–	V	7,013	14,681	µg/L	
Orthophosphate	10- 200	3/10	50	150	–	–	60.9	210	µg/L	
pH	–	5/5	6.8	7.3	–	–	7	–	pH	
Phosphorus	50- 1,000	9/9	95	1,380	–	–	387	272	µg/L	
Silica	400 - 2,000	3/3	7,400	43,000	–	–	19,567	36,561	µg/L	
Silicon	7.3 - 2,000	13/13	7,060	44,000	–	–	13,547	16,293	µg/L	
Solids, nonvolatile suspended	5,000 - 5,000	6/6	10,000	199,000	–	–	83,167	–	µg/L	
Sulfate	200 - 25,000	5/14	200	29,600	–	V	5,084	41,114	µg/L	
Total dissolved solids	10,000	15/15	470,000	870,000	–	–	729,333	372,696	µg/L	
Total organic carbon	1,000 - 1,000	3/3	19,000	24,500	–	V	20,833	21,993	µg/L	

Table 2-2
Analytes Detected in Leachate at the Seep (SW097)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background $UTL_{99/99}$ Concentration	Units	PCOC
Total suspended solids	4,000 - 5,000	12/12	10,000	250,000	–	–	144,667	157,368	µg/L	

Notes

All analytes are total analytes unless otherwise noted.
For non-detects, one-half the detection limit is used in calculating the mean result.

1 Analyte determined to be PCOC by hot measurement test.
2 Analyte determined to be PCOC by inferential statistics test(s).
3 Analyte not considered a PCOC because it is a nutrient.
4 All detected organic analytes are considered PCOCs unless eliminated by professional judgment.
5 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples.
6 Analyte not considered a PCOC because it is not a measure of a single contaminant.
Analyte removed from consideration as PCOC.

Data Qualifiers

— data qualifier or validation field in database is blank.
B for inorganics, reported value is < CRDL but > IDL (estimated value).
B for organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit.
B for radionuclides, constituent also detected in blank whose concentration was > minimum detectable activity.
I for organics, interference with target peak (estimated value).
J for organics, data indicate presence of compound but below detection limit (estimated value).
U for inorganics and organics, analyte analyzed but not detected at the quantitation limit.

Data Validation Codes

— *data qualifier field in database is blank.*
A acceptable result.
JA acceptable result (for estimated value).
V valid result.

Definitions

PCOC potential contaminant of concern
$UTL_{99/99}$ upper tolerance limit of the 99th percentile at the 99-percent confidence level
CRDL contract-required detection limit
IDL instrument detection limit
µg/L micrograms per liter

Table 2-3
Analytes Detected in Surface Water in the East Landfill Pond (SW098)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL 95/95 Concentration	Units	PCOC
Metals										
Aluminum	10 - 200	16/22	30.4	271	–	–	75	39,136	µg/L	
Antimony	0.05 - 500	2/22	8	16.9	B	–	22	20,054	µg/L	
Arsenic	0.7 - 10	9/21	0.9	2.2	–	V	1	3,485	µg/L	2
Barium	0.02 - 200	22/22	16	250	–	V	172	63,510	µg/L	
Beryllium	0.2 - 5	1/22	0.5	0.7	–	JA	1	1,702	µg/L	
Cadmium	0.1 - 5	1/22	1	2.1	–	JA	1	1,760	µg/L	
Calcium	14.3 - 5,000	22/22	3,180	55,000	–	V	39,972	56,909	µg/L	2,3
Cesium	5 - 2,500	2/23	33	50	B	–	211	475,272	µg/L	
Chromium	2.4 - 20	2/22	2	10.9	–	–	3	3,328	µg/L	
Copper	2.1 - 25	8/22	2	16	–	JA	5	8,281	µg/L	
Iron	4.3 - 100	22/22	16.3	1,150	–	V	507	16,477	µg/L	
Lead	0.8 - 20	7/21	0.9	5.3	–	JA	2	1,482	µg/L	
Lithium	2 - 100	20/21	7.7	109	–	–	79	35,577	µg/L	2
Magnesium	0.1 - 5,000	22/22	4,270	48,300	–	–	39,349	1,156,026	µg/L	2,3
Manganese	1 - 15	21/22	2.5	430	–	V	105	3,024	µg/L	2
Mercury	0.2 - 0.2	3/22	0.1	0.54	–	V	0.1	58.9	µg/L	
Molybdenum	5.7 - 500	3/21	3	13.1	B	–	20	32,559	µg/L	2
Nickel	0.02 - 40	14/22	6.3	22	–	V	10	13,308	µg/L	2
Potassium	10 - 5,000	22/22	1,360	10,900	–	V	8,754	1,607,524	µg/L	2,3
Silicon	7.3 - 100	14/14	298	3670	–	V	2,302	16,293	µg/L	
Silver	2.5 - 30	3/22	2	4	–	JA	3	3,388	µg/L	
Sodium	10 - 5,000	22/22	19,900	196,000	–	–	161,177	39,331	µg/L	1,2,3

Table 2-3
Analytes Detected in Surface Water in the East Landfill Pond (SW098)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL 95/95 Concentration	Units	PCOC
Strontium	2.3 - 200	21/21	44.9	598	–	–	476	241,118	µg/L	2
Thallium	0.1 - 10	2/21	1	7.4	–	JA	2	6,503	µg/L	2
Tin	10-1,000	6/21	10	44.3	B	–	41	33,576	µg/L	2
Vanadium	2 - 50	5/22	2	9	B	–	4	16,634	µg/L	
Zinc	1.8 - 20	19/22	4	105	–	–	17	3,708	µg/L	
Radionuclides										
Americium-241	0 - 0.19	15/15	0.0005655	0.031	U	A	0.007	0.03	pCi/L	1,2
Cesium-137	0.23 - 1.16	11/11	-0.2323	0.1344	–	V	-0.06	2.1	pCi/L	
Gross alpha	2 - 8.68	11/11	-0.67	5	U	V	2	29	pCi/L	2,6
Gross beta	2.6 - 7.6	11/11	7.9	16	–	V	11	31	pCi/L	2,6
Plutonium-239	0 - 0.03	6/6	0	0.022	–	–	0.007		pCi/L	
Plutonium-239/240	0 - 0.01	11/11	-0.000364	0.023	–	A	0.004		pCi/L	
Radium-226	0.211 - 0.211	1/1	0.23	0.23	–	V	0.23	17	pCi/L	
Strontium-89,90	0.23 - 1	5/5	0.6635	1.924	–	A	1.4	4.9	pCi/L	2
Strontium-90	0.36 - 0.58	5/5	0.7084	1.208	–	V	1.02		pCi/L	
Tritium	160 - 460	20/20	-10	257.8	J	V	139	732	pCi/L	2
Uranium-233,-234	0 - 0.232	9/9	0.7626	1.594	–	V	1.1		pCi/L	
Uranium-235	0 - 0.281	9/9	-0.01	0.3	–	A	0.1	0.3	pCi/L	1,2
Uranium-238	0.08 - 0.263	9/9	0.6996	1.964	–	A	1.1	1.8	pCi/L	1,2
Semivolatile Organic Compounds										
Bis(2-ethylhexyl)phthalate	9 - 11	1/8	1	1	J	A	5	8	µg/L	4
Di-n-butyl phthalate	9 - 11	1/8	1	1	J	A	5		µg/L	4

Table 2-3
Analytes Detected in Surface Water in the East Landfill Pond (SW098)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background UTL 95/95 Concentration	Units	PCOC
Volatile Organic Compounds										
Acetone	10	1/21	6	12	B	–	6	29	µg/L	4,5
Methylene chloride	5	3/21	4	8	B	–	3	21	µg/L	4,5
Vinyl acetate	10	1/20	10	80	–	–	9		µg/L	4,5
Indicator Parameters										
Bicarbonate as $CaCO_3$	1,000 - 10,000	16/16	213,000	489,000	–	V	391,063		µg/L	
Carbonate	10,000 - 10,000	1/4	10,000	15,300	–	V	7,575	10,987	µg/L	
Carbonate as $CaCO_3$	1,000 - 10,000	9/12	0	76,500	–	V	28,167		µg/L	
Chloride	200- 25,000	16/16	137,000	190,000	–	–	164,875	64,366	µg/L	
Dissolved organic carbon	1,000 - 2,000	6/6	21,900	32,400	–	V	27,250	16,997	µg/L	
Fluoride	100 - 200	15/15	590	890	–	–	770	643	µg/L	
Nitrate	100	1/3	100	200	–	JA	100	–	µg/L	
Nitrate/nitrite	20 - 100	6/13	20	320	–	JA	80	3,130	µg/L	
Oil and grease	200 - 7,100	3/14	400	800	–	–	2,289	14,681	µg/L	
Orthophosphate	10 - 50	2/11	40	40	–	–	27.73	210	µg/L	
pH	—	4/4	8.2	8.3	–	–	8.2	–	pH	
Phosphorus	50 - 1,000	3/10	50	638	B	–	96	272	µg/L	
Silica	400 - 2,000	5/5	2,300	12,000	–	–	6,360	36,561	µg/L	
Solids, nonvolatile suspended	50,00 - 5,000	2/6	5,000	12,000	–	V	4,667	–	µg/L	
Sulfate	500 - 10,000	16/16	7,000	25,600	–	V	16,031	41,114	µg/L	
Total dissolved solids	10,000	16/16	230,000	814,000	–	V	705,125	372,696	µg/L	

Table 2-3
Analytes Detected in Surface Water in the East Landfill Pond (SW098)

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	Background $UTL_{99/99}$ Concentration	Units	PCOC
Total organic carbon	1,000 - 2,000	6/6	26,000	51,000	—	—	33,633	21,993	µg/L	
Total suspended solids	4,000 - 5,000	3/11	4,000	4,900,000	—	—	448,864	157,368	µg/L	

Notes

All analytes are total analytes unless otherwise noted.
For non-detects, one-half the detection limit is used in calculating the mean result.

1 Analyte determined to be PCOC by hot measurement test.
2 Analyte determined to be PCOC by inferential statistics test(s).
3 Analyte not considered a PCOC because it is a nutrient.
4 All detected organic analytes are considered PCOCs unless eliminated by professional judgment.
5 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples.
6 Analyte not considered a PCOC because it is not a measure of a single contaminant.
Analyte removed from consideration as PCOC.

Data Qualifiers

— data qualifier or validation field in database is blank.
B for inorganics, reported value is < CRDL but > IDL (estimated value).
B for organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit.
J for inorganics, value > IDL but control sample analysis not within control limits (estimated value).
J for organics, data indicate presence of compound but below detection limit (estimated value).
U for inorganics and organics, analyte analyzed but not detected at the quantitation limit.

Data Validation Codes

— data qualifier field in database is blank.
A acceptable result.
JA acceptable result (for estimated value).
V valid result.

Definitions

CRDL contract-required detection limit
IDL instrument detection limit
PCOC potential contaminant of concern
$UTL_{99/99}$ upper tolerance limit of the 99th percentile at the 99-percent confidence level

Table 2-4
Analytes Detected in Sediment in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{90/95}$ Concentration*	Units	PCOC
Metals											
Aluminum	7.7 - 12	2/2	12,300	16,600	–	V	SED70193	14,450	29,600	mg/kg	
Arsenic	0.32 - 0.42	3/3	2.7	5	–	V	SED70193	4	67	mg/kg	
Barium	1.6 - 2.5	3/3	174	215	–	V	SED70093	198	795	mg/kg	
Beryllium	0.22 - 0.34	3/3	0.81	1.5	–	JA	SED70193	1.2	2.6	mg/kg	
Calcium	7.5 - 11.7	2/2	6,290	7,850	–	V	SED70193	7,070	80,900	mg/kg	3
Chromium	0.64 - 0.99	3/3	12.3	17.5	–	V	SED70193	14.7	29.5	mg/kg	
Cobalt	0.64 - 0.99	3/3	5.7	7.6	–	V	SED70093	6.8	–	mg/kg	
Copper	0.71 - 1.1	3/3	11.2	18.6	–	V	SED70193	16	175.4	mg/kg	
Iron	1.8 - 2.8	2/2	11,600	15,400	–	V	SED70193	13,500	143,900	mg/kg	
Lead	2.5 - 3.8	3/3	21.6	33.7	–	V	SED70193	29.7	261.1	mg/kg	
Lithium	0.83 - 1.3	2/2	6.1	9.9	–	V	SED70193	8	–	mg/kg	
Magnesium	9.5 - 14.8	2/2	2,170	3,250	–	V	SED70193	2,710	6,470	mg/kg	3
Manganese	0.59 - 0.91	2/2	147	186	–	V	SED70193	167	–	mg/kg	
Nickel	2.7 - 4.2	3/3	9.3	15.3	–	V	SED70093	12.7	35.2	mg/kg	
Potassium	190 - 295	2/2	1,350	2,640	–	V	SED70193	1,995	3,227	mg/kg	3
Selenium	0.3 - 0.5	3/3	0.41	1.1	–	JA	SED70193	0.8	5.2	mg/kg	
Silicon	1.8 - 2.8	2/2	226	344	–	V	SED70193	285	–	mg/kg	
Silver	0.88 - 1.4	1/3	0.88	0.88	–	JA	SED70293	0.7	–	mg/kg	
Sodium	15 - 23.4	2/2	286	447	–	V	SED70193	367	2,127	mg/kg	3
Strontium	1.3 - 2.1	2/2	43.5	61.5	–	V	SED70193	52.5	356	mg/kg	
Tin	4.1 - 6.3	1/3	5.3	5.3	–	V	SED70293	3.8	–	mg/kg	
Vanadium	0.78 - 1.2	3/3	28.8	41	–	V	SED70193	34	86	mg/kg	
Zinc	0.59 - 0.91	3/3	49.2	187	–	V	SED70093	106	148	mg/kg	1

Table 2-4
Analytes Detected in Sediment in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration*	Units	PCOC
Radionuclides											
Americium-241	0.0021 - 0.0041	3/3	0.00452	0.01789	–	A	SED70093	0.01151	–	pCi/g	
Cesium-137	0	3/3	0.2863	0.732	X	–	SED70093	0.458	3.51	pCi/g	
Gross alpha	2.5 - 3.1	3/3	11.4	16.42	–	V	SED70193	14.6	–	pCi/g	
Gross beta	1.90 - 2.1	3/3	27.76	28.94	–	V	SED70093	28.3	–	pCi/g	
Plutonium-239/240	0.0087 - 0.015	3/3	0.007202	0.09828	–	A	SED70093	0.04480	–	pCi/g	
Strontium-89,90	0.042 - 0.074	3/3	0.1148	0.2366	–	V	SED70093	0.171	–	pCi/g	
Uranium-233,-234	0.042 - 0.098	3/3	0.9126	1.136	–	A	SED70093	1.022	–	pCi/g	
Uranium-235	0.05 - 0.062	3/3	0.05464	0.07382	–	A	SED70193	0.06158	–	pCi/g	
Uranium-238	0.056 - 0.076	3/3	0.8104	1.396	–	A	SED70093	1.16	–	pCi/g	
Semivolatile Organic Compounds											
Acenaphthene	450 - 790	1/3	100	100	J	A	SED70093	220	–	µg/kg	2
Anthracene	450 - 790	1/3	160	160	J	A	SED70093	240	–	µg/kg	2
Benzo(a)anthracene	450 - 790	1/3	340	340	J	A	SED70093	300	–	µg/kg	2
Benzo(a)pyrene	450 - 790	1/3	320	320	J	A	SED70093	293	–	µg/kg	2
Benzo(b)fluoranthene	450 - 790	1/3	450	470	J	A	SED70093	343	–	µg/kg	2
Benzo(ghi)perylene	450 - 790	1/3	200	200	J	A	SED70093	253	–	µg/kg	2
Benzo(k)fluoranthene	450 - 790	1/3	130	130	J	A	SED70093	230	–	µg/kg	2
Benzoic acid	2,200 - 3,900	3/3	260	870	J	A	SED70093	537	–	µg/kg	2
Bis(2-chloroisopropyl)ether	450 - 790	1/3	47	47	J	A	SED70293	259	–	µg/kg	2
Bis(2-ethylhexyl)phthalate	450 - 790	1/3	80	80	J	A	SED70093	213	–	µg/kg	2
Chrysene	450 - 790	1/3	310	310	J	A	SED70093	290	–	µg/kg	2
Fluoranthene	450 - 790	2/3	79	830	–	V	SED70093	415	–	µg/kg	2
Fluorene	450 - 790	1/3	92	92	J	A	SED70093	217	–	µg/kg	2

Table 2-4
Analytes Detected in Sediment in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{99/99}$ Concentration*	Units	PCOC
Indeno(1,2,3-cd)pyrene	450 - 790	1/3	180	180	J	A	SED70093	247	–	µg/kg	2
Phenanthrene	450 - 790	2/3	73	630	J	A	SED70093	346	–	µg/kg	2
Pyrene	450 - 790	2/3	74	750	J	A	SED70093	386	–	µg/kg	2
Volatile Organic Compounds											
2-Butanone	13 - 24	1/3	13	35	–	V	SED70093	17	–	µg/kg	2
Acetone	13 - 24	2/3	63	130	B	V	SED70193	68	–	µg/kg	2
Toluene	10 - 33	3/3	180	440	–	V	SED70293	307	–	µg/kg	2
Indicator Parameters											
% solids	0.1	4/4	42.1	75.8	–	V	SED70293	54.4	–	%	
pH	0.2	3/3	6.7	7.2	–	V	SED70193	7	–	pH	
Total organic carbon	500	3/3	7,800	9,400	X	V	SED70293	8,367	–	mg/kg	

Notes

* Background $UTL_{99/99}$ concentrations for seep sediment data. There are no background data for pond sediments.
1 Analyte determined to be PCOC by hot measurement test.
2 All detected organic analytes are PCOCs unless eliminated through professional judgment.
3 Analyte not considered a PCOC because it is a nutrient.

Data Qualifiers

– data qualifier field in database is blank.
B for organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit.
J for organics, data indicate presence of compound but below detection limit (estimated value).
X for inorganics (pre-1992), detection limit greater than normal, sample matrix interference.

Data Validation Codes

– data qualifier field in database is blank.
A acceptable result.
JA acceptable result (for estimated value).
V valid result.

Definitions

PCOC potential contaminant of concern
$UTL_{99/99}$ upper tolerance limit of the 99th percentile at the 99-percent confidence level

Table 2-5
Analytes Detected in Surface Soils in the Vicinity of Spray Evaporation Areas

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Metals											
Aluminum	3.7 - 40	216/216	5,100	24,400	–	V	SS700493	12,006	25,879	mg/kg	
Antimony	3.7 - 14.5	6/215	3.7	9.1	–	V	SS719693	4	–	mg/kg	1
Arsenic	0.14 - 2.6	216/216	1.2	15.7	–	V	SS702293	5	13	mg/kg	1
Barium	0.34 - 40	216/216	30	1120	–	V*	SS705193	194	532	mg/kg	1
Beryllium	0.06 - 1	161/216	0.36	1.5	–	V	SS120894	1	5.0	mg/kg	2
Cadmium	0.5 - 1.7	13/215	0.5	1.5	–	V	SS710493	0	5	mg/kg	
Calcium	2.1 - 1,000	215/215	1,890	54,800	–	V	SS705093	8,672	16,659	mg/kg	1,2,3
Chromium	0.47 - 3.3	216/216	4.3	24.7	–	V	SS700493	13	28	mg/kg	
Cobalt	0.49 - 10	201/216	2.8	16.2	–	V	SS712093	7	24	mg/kg	2
Copper	0.47 - 5	216/216	7.1	640	–	V	SS121394	17	30	mg/kg	1,2
Iron	0.89 - 20	216/216	4,390	59,600	–	V	SS121594	13,515	29,052	mg/kg	1,3
Lead	0.16 - 17.2	216/216	6.4	167	–	V	SS708893	26	62	mg/kg	1
Lithium	0.58 - 20	84/91	1.9	16.4	–	V	SS121094	8	22	mg/kg	
Magnesium	5.9 - 1,000	215/215	921	7,910	–	V	SS700293	2,666	7,718	mg/kg	1,3
Manganese	0.16 - 3	215/215	20.9	1,370	–	V	SS700593	215	2,100	mg/kg	
Mercury	0.076 - 0.17	21/213	0.05	0.14	–	V	SS708693	0.1	–	mg/kg	1
Molybdenum	1.2 - 40	16/92	1.4	4.1	–	V	SS702993	1	37	mg/kg	
Nickel	1.2 - 8	215/216	4.6	23.8	–	V	SS121394	12	27	mg/kg	
Potassium	96.8 - 1,000	216/216	407	3,620	–	V	SS711093	1,925	6,190	mg/kg	3
Selenium	0.23 - 1	115/204	0.23	2.9	–	V	SS121594	1	1.4	mg/kg	1,2
Silicon	1.3 - 2.1	76/76	93.7	628	–	V	SS705393	267	3,542	mg/kg	
Silver	0.51 - 2	66/215	0.53	3	–	V	SS709593	1	–	mg/kg	1
Sodium	5.6 - 1,000	194/216	22.6	1,280	–	V	SS708293	123	1,052	mg/kg	1,3
Strontium	0.33 - 40	92/92	22.2	80.6	–	V	SS720193	48	113	mg/kg	2
Thallium	0.31 - 2	4/212	0.31	2.1	–	V	SS121594	0.2	2.0	mg/kg	1

Table 2-5
Analytes Detected in Surface Soils in the Vicinity of Spray Evaporation Areas

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{99/99}$ Concentration	Units	PCOC
Tin	3.1 - 40	5/92	3.1	10	–	V	SS708993	3	70	mg/kg	
Vanadium	0.6 - 10	216/216	9.7	86.2	–	V	SS705293	32	60	mg/kg	1
Zinc	0.42 - 4	216/216	21.5	113	–	V	SS120894	56	99	mg/kg	1,2
Radionuclides											
Americium-241	0 - 0.033	200/200	0	1.076	–	V	SS703793	0.02	0.058	pCi/g	1,2
Cesium-134	0 - 0.12	66/66	-0.381	0.12	–	V	SS120594	-0.02	–	pCi/g	
Cesium-137	0 - 0.26	210/210	-0.0722	2.27	–	V	SS700893	0	3.5	pCi/g	
Gross alpha	1.1 - 9	214/214	7.2	29	–	V	SS120794	15	43	pCi/g	
Gross beta	1.8 - 5.3	202/202	17.71	42	–	V	SS120794	26	53	pCi/g	
Plutonium-239/240	0 - 0.06	196/196	-0.00101	0.4692	–	V	SS704293	0.05	0.13	pCi/g	1,2
Radium-226	0 - 0.51	106/106	0.4355	1.787	–	V	SS711193	1	1.5	pCi/g	1,2
Radium-228	0 - 0.98	132/132	0.7629	2.597	–	V	SS704493	1.6	4.8	pCi/g	
Strontium-89,90	0.02 - 0.5	214/214	-0.004	1.017	–	V	SS708993	0.2	2.1	pCi/g	
Uranium-233,-234	0 - 0.3	213/213	0.5558	1.5	–	V	SS702593	0.9	1.8	pCi/g	
Uranium-235	0 - 0.3	213/213	-0.0305	0.12	–	V	SS701993	0	0.187	pCi/g	
Uranium-238	0 - 0.3	213/213	0.5589	1.626	–	V	SS708293	0.9	2	pCi/g	
Indicator Parameters											
% solids	0.1 - 0.1	200/200	29.5	91.4	–	V	SS720093	75	129.3	%	
Nitrate/nitrite	0.5 - 1	164/216	0.68	45	–	V	SS710893	4	9.6	mg/kg	1,2
Total organic carbon	0.05 - 500	187/216	0.05	54,000	–	V	SS701193	10,700	–	mg/kg	

Notes

1 Analyte determined to be PCOC by hot measurement test.
2 Analyte determined to be PCOC by inferential statistics test(s).
3 Analyte not considered a PCOC because it is a nutrient.

Data Validation Codes

V valid result

Data Qualifiers

– data qualifier or validation field in database is blank.

Definitions

PCOC potential contaminant of concern
$UTL_{99/99}$ upper tolerance limit of the 99th percentile at the 99-percent confidence level

Table 2-6
Analytes Detected in Subsurface Geologic Materials Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Colluvial Material (Qc)											
Metals											
Aluminum	6.9 - 7.8	7/7	10,400	16,100	–	V	71093	12,657	27,862	mg/kg	
Arsenic	0.24 - 0.36	7/7	3.3	7.9	–	V	70993	5	9	mg/kg	
Barium	1.4 - 1.6	7/7	91.4	624	–	JA	71093	230	465	mg/kg	1
Beryllium	0.2 - 0.22	7/7	0.74	1.2	–	JA	70993	1	25	mg/kg	
Calcium	6.7 - 7.6	7/7	5,620	7,350	–	V	71093	6,404	31,386	mg/kg	2
Chromium	0.56 - 0.64	7/7	11.2	16.9	–	V	71093	13.2	37	mg/kg	
Cobalt	0.56 - 0.64	7/7	5.6	10.9	–	V	71093	9	17	mg/kg	
Copper	0.63 - 0.72	7/7	12.6	17.7	–	V	71093	15	33	mg/kg	
Iron	1.6 - 1.9	7/7	12,300	18,400	–	V	71093	14,486	38,544	mg/kg	
Lead	2 - 2.6	7/7	16.5	27.9	–	JA	71093	23	32	mg/kg	
Lithium	0.74 - 0.84	7/7	6.1	9.9	–	V	71093	8	23	mg/kg	
Magnesium	8.4 - 9.6	7/7	2,500	3,550	–	V	71093	2,923	7,873	mg/kg	2
Manganese	0.52 - 0.59	7/7	106	262	–	V	70993	198	753	mg/kg	
Nickel	2.4 - 2.7	7/7	13.1	18.4	–	V	71093	15.2	42	mg/kg	
Potassium	169 - 193	7/7	970	1,780	–	V	71093	1,294	3,175	mg/kg	2
Selenium	0.26 - 0.34	7/7	0.34	0.74	–	JA	70993	0.52	7	mg/kg	
Silicon	1.6 - 1.8	7/7	315	659	–	JA	71093	410	–	mg/kg	
Sodium	13.3 - 15.3	7/7	84.5	912	–	V	70993	378	3,004	mg/kg	2
Strontium	1.2 - 1.4	7/7	49.9	107	–	V	71093	67	142	mg/kg	
Tin	3.6 - 4.1	5/7	3.7	8.9	–	JA	71093	5.6	626	mg/kg	
Vanadium	0.69 - 0.79	7/7	20.6	43.6	–	V	71093	28.4	73	mg/kg	
Zinc	0.52 - 0.59	7/7	55	72.2	–	V	71093	61	133	mg/kg	

Table 2-6
Analytes Detected in Subsurface Geologic Materials Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Radionuclides											
Americium-241	0	6/6	0.001197	0.0143	J	A	71093	0.0061	–	pCi/g	
Cesium-137	0.1 - 0.1	6/6	-0.0142	0.2386	–	–	71093	0.0584	0.1	pCi/g	1
Gross alpha	0.8 - 3.4	6/6	8.03	16.8	–	V	70993	13.6	65	pCi/g	
Gross beta	2.3 - 2.5	6/6	21.88	26.18	–	V	70993	24.0	40	pCi/g	
Plutonium-239/240	0 - 0.016	4/4	0.002438	0.01842	J	A	70993	0.01076	–	pCi/g	
Radium-226	0.5	6/6	0.8443	1.083	–	–	70993	0.974	2	pCi/g	
Radium-228	0.5	6/6	1.322	1.859	–	–	70993	1.623	3	pCi/g	
Strontium-89,90	0.04 - 0.06	6/6	0.1022	0.4153	J	A	71093	0.1852	1.2	pCi/g	
Tritium	450 - 450	6/6	97.59	301.5	J	V	70993	170.1	456	pCi/g	
Uranium-233,-234	0.029 - 0.081	6/6	0.7916	1.166	–	A	71093	0.97	–	pCi/g	
Uranium-235	0 - 0.042	6/6	0.02566	0.05357	J	A	70993	0.03664	0.2	pCi/g	
Uranium-238	0 - 0.057	6/6	0.961	1.233	–	A	71093	1.06	2	pCi/g	
Semivolatile Organic Compounds											
Chrysene	380 - 440	1/7	43	43	J	A	70993	180	–	µg/kg	3
Fluoranthene	380 - 440	1/7	110	110	J	A	70993	189	–	µg/kg	3
Phenanthrene	380 - 440	1/7	100	100	J	A	70993	188	–	µg/kg	3
Pyrene	380 - 440	1/7	110	110	J	A	70993	189	–	µg/kg	3
Volatile Organic Compounds											
4-Methyl-2-pentanone	12 - 14	1/5	12	58	–	V	70993	17	–	µg/kg	3
Toluene	12 - 64	5/5	160	2,000	–	V	70993	850	–	µg/kg	3
Total xylenes	6 - 7	1/5	2	2	J	A	70993	3	–	µg/kg	3

Table 2-6
Analytes Detected in Subsurface Geologic Materials Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Indicator Parameters											
% solids	0.1	7/7	73.9	85.6	–	V	71093	81	–	%	
Nitrate	1	2/5	1	2	–	JA	70993	1	–	mg/kg	
Nitrate/nitrite	1	3/5	1	20,000	–	V	71093	4,001	66	mg/kg	1
Total organic carbon	0.05	5/5	500	21,000	–	V	71093	8,540	–	mg/kg	
pH	0.2	7/7	7.8	8.4	–	V	70993	8.1	–	pH	
Weathered Bedrock Material (KaKI-w)											
Metals											
Aluminum	5.8 - 7.5	11/11	5,320	7,880	–	V	70993	7,035	43,375	mg/kg	
Arsenic	0.19 - 1.4	11/11	1.3	11.4	–	V	70993	3.4	10	mg/kg	1
Barium	1.2 - 1.5	11/11	24.5	254	–	JA	71093	97	205	mg/kg	1
Beryllium	0.16 - 0.21	11/11	0.53	1.1	–	JA	71093	1	9	mg/kg	
Cadmium	0.49 - 0.64	4/11	0.49	1.5	–	V	71093	0.5	–	mg/kg	
Calcium	5.6 - 7.3	11/11	2,770	15,900	–	V	71093	6,036	8,274	mg/kg	1,2
Chromium	0.48 - 0.61	11/11	6.4	10.6	–	V	71093	8	52.7	mg/kg	
Cobalt	0.48 - 0.61	11/11	2.2	21	–	V	71093	9	17	mg/kg	1
Copper	0.53 - 0.68	11/11	13.2	24.3	–	V	71093	19	44	mg/kg	
Iron	1.4 - 1.8	11/11	4,880	24,600	–	V	71093	13,893	36,178	mg/kg	
Lead	1 - 2.3	11/11	12.6	31.2	–	JA	70993	22	26	mg/kg	1
Lithium	0.62 - 0.8	11/11	3.4	10	–	V	70993	7	24	mg/kg	
Magnesium	7.1 - 9.2	11/11	1,840	3,130	–	V	71093	2,470	7,221	mg/kg	2
Manganese	0.44 - 0.57	11/11	20.2	896	–	JA	71093	275	706	mg/kg	1
Mercury	0.08 - 0.11	2/11	0.08	0.18	–	JA	70993	0.1	–	mg/kg	
Nickel	2 - 2.6	11/11	3.1	38.2	–	V	71093	17	52	mg/kg	
Potassium	143 - 184	11/11	830	1,330	–	V	71093	993	3,362	mg/kg	2
Selenium	0.23 - 0.3	7/11	0.27	1.9	–	JA	71093	0.8	–	mg/kg	

92

Table 2-6
Analytes Detected in Subsurface Geologic Materials Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{99/95}$ Concentration	Units	PCOC
Silicon	1.3 - 1.7	11/11	224	1200	–	JA	71093	589	–	mg/kg	
Silver	0.66 - 0.85	2/11	0.66	0.89	–	V	71093	0.5	62	mg/kg	
Sodium	11.3 - 14.5	11/11	256	939	–	V	70993	495	2,804	mg/kg	2
Strontium	1 - 1.3	11/11	46.6	197	–	V	71093	97	32.2	mg/kg	1
Thallium	0.26 - 0.34	2/11	0.28	0.66	–	JA	71093	0.2	–	mg/kg	
Tin	3.1 - 3.9	4/11	3.1	9.4	–	JA	70993	3.5	629	mg/kg	
Vanadium	0.59 - 0.75	11/11	10.3	29.2	–	V	71093	19	91	mg/kg	
Zinc	0.44 - 0.57	11/11	41.9	84.4	–	JA	71093	70	68	mg/kg	1
Radionuclides											
Americium-241	0	11/11	-0.000329	0.009491	J	A	70993	0.00289	–	pCi/g	
Cesium-137	0.1	11/11	-0.0344	0.01489	J	–	70993	-0.0039	–	pCi/g	
Gross alpha	1.9 - 3.4	11/11	5.615	14.18	–	V	70993	10.8	–	pCi/g	
Gross beta	2.3 - 2.6	11/11	21.21	25.64	–	V	71093	23.7	–	pCi/g	
Plutonium-239/240	0 - 0.016	8/8	0	0.007367	J	A	71093	0.003372	–	pCi/g	
Radium-226	0.5	11/11	0.9136	1.312	–	–	70993	1.13	2.5	pCi/g	
Radium-228	0.5	11/11	1.048	1.584	–	–	70993	1.360	–	pCi/g	
Strontium-89,90	0.04 - 0.05	11/11	0.02282	0.8017	J	A	71093	0.1849	2.6	pCi/g	
Tritium	440 - 450	11/11	-37.7	309.2	J	V	70993	80.2		pCi/L	
Uranium-233,-234	0.021 - 0.055	11/11	0.7383	1.408	–	A	70993	1.016	–	pCi/g	
Uranium-235	0 - 0.046	11/11	-0.00387	0.1053	J	A	70993	0.0527	–	pCi/g	
Uranium-238	0 - 0.033	11/11	0.8527	1.309	–	A	70993	1.12	–	pCi/g	
Volatile Organic Compounds											
1,1,1-Trichloroethane	6	1/11	2	2	J	A	70993	3	–	µg/kg	3, 4
Toluene	6 - 110	11/11	120	580	–	JA	70993	309	–	µg/kg	3

Table 2-6
Analytes Detected in Subsurface Geologic Materials Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{99/99}$ Concentration	Units	PCOC
Indicator Parameters											
% solids	0.1 - 0.1	11/11	82.7	89.4	–	V	71093	87	–	%	
Total organic carbon	0.05	3/11	500	2,600	–	V	71093	700	–	mg/kg	
pH	0.2	11/11	7.6	8.6	–	V	71093	8	–	pH	

Notes

Sample locations are 70993 and 71093.

1 *Analyte determined to be PCOC by hot measurement test.*
2 Analyte not considered a PCOC because it is a nutrient.
3 All detected organic analytes are considered PCOCs unless eliminated by professional judgment.
4 Analyte not considered a PCOC because of infrequent detection and/or detection is in blanks or background samples.

Data Qualifiers

_ data qualifier or validation field in database is blank.
J for inorganics, value > IDL but control sample analysis not within control limits (estimated value).
J for organics, data indicate presence of compound but below detection limit (estimated value).
V valid result.

Data Validation Codes

_ data qualifier field in database is blank.
A acceptable result.
JA acceptable result (for estimated value).

Definitions

Qc Quaternary colluvium
KaKl(w) weathered undifferentiated Cretaceous Arapahoe and Laramie formations
PCOC potential contaminant of concern
$UTL_{99/99}$ upper tolerance limit of the 99th percentile at the 99-percent confidence level

Table 2-7
Analytes Detected in UHSU Groundwater in the Vicinity of the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Metals											
Aluminum	16 - 200	7/7	217	635	–	V	B206789	385	26,324	µg/L	
Antimony	17 - 60	1/7	14	58	B	Y	B206789	18	52	µg/L	1
Arsenic	2 - 10	1/7	1	2.7	–	V	B206789	1	8	µg/L	
Barium	9 - 200	4/7	16.1	22	B	Y	B206789	16	311	µg/L	
Calcium	17 - 5,000	7/7	151,000	167,000	–	V	B206789	158,000	148,662	µg/L	1,2,3
Cesium	20 - 1,000	1/6	23	45	B	Y	B206789	122	866	µg/L	
Chromium	3 - 10	2/7	2	17	–	JA	B206789	4	192	µg/L	
Copper	2 - 25	1/7	2	8	B	Y	B206789	4	42	µg/L	
Iron	5 - 100	7/7	238	527	–	V	B206789	383	32,398	µg/L	
Lead	1 - 5	2/7	1	1.2	B	V	B206789	1	20	µg/L	
Lithium	2 - 100	7/7	186	225	–	Y	B206789	207	177	µg/L	1,2
Magnesium	36 - 5,000	7/7	40,700	44,900	–	V	B206789	42,500	33,725	µg/L	1,2,3
Manganese	1 - 15	5/7	2.8	9.7	–	V	B206789	6.3	643	µg/L	
Nickel	10 - 40	1/7	3	11.1	B	Y	B206789	5	101	µg/L	
Potassium	620 - 5,000	6/7	3,640	3,760	B	V	B206789	3,489	5,243	µg/L	2,3
Selenium	0 - 5	7/7	488	815	+	JA	B206789	665	131	µg/L	1,2
Silicon	13 - 100	6/6	5,950	7,170	–	V	B206789	6,447	62,830	µg/L	
Silver	4 - 10	1/7	2	10.9	N	JA	B206789	3	7	µg/L	1,2
Sodium	21 - 5,000	7/7	139,000	148,000	–	V	B206789	144,429	147,829	µg/L	1,2,3
Strontium	1 - 200	7/7	1,360	1,560	–	V	B206789	1,446	1,110	µg/L	1,2
Thallium	2 - 10	1/7	1	1	B	V	B206789	1	9	µg/L	
Tin	18 - 200	1/7	10	19.2	B	V	B206789	12	170	µg/L	
Vanadium	3 - 50	3/7	2.9	8.9	BE	JA	B206789	5	71	µg/L	

Table 2-7
Analytes Detected in UHSU Groundwater in the Vicinity of the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Zinc	3 - 20	4/7	9.1	52.7	–	JA	B206789	19.3	184	µg/L	
Radionuclides											
Americium-241	0.01	1/1	-0.433	-0.433	J	–	B206789	-0.433	0.04	pCi/L	
Gross alpha	9.2	1/1	53.9	53.9	–	V	0786	53.9	391	pCi/L	
Gross beta	8.6	1/1	29.4	29.4	–	V	0786	29.4	221	pCi/L	
Plutonium-239/240	0.01	2/2	0.001103	0.004	–	A	B206789	0.003	–	pCi/L	
Radium-226	0.06 - 0.5	2/2	0.35	0.52	–	A	B206789	0.44	1.29	pCi/L	
Tritium	210 - 840	28/28	-164.49541	368	J	V	0786	82	13,413	pCi/L	
Uranium-233,-234	0	1/1	49.32	49.32	–	A	B206889	49.32	–	pCi/L	
Uranium-235	0.07	1/1	2.62	2.62	–	A	B206889	2.62	5.2	pCi/L	
Uranium-238	0.07 - 0.18	2/2	29.81	35.45	–	A	B206889	32.63	114	pCi/L	2
Semivolatile Organic Compounds											
Bis(2-ethylhexyl)phthalate	10	1/2	3	3	J	A	B206789	4	–	µg/L	4
Volatile Organic Compounds											
1,1-Dichloroethane	0.1 - 10	1/51	0.1	0.3	–	V	0786	2	3	µg/L	4,5
Acetone	10 - 100	2/41	9	24	B	–	B206889	8	16	µg/L	4,5
Benzene	0.1 - 10	2/51	0.1	0.5	J	A	B206889	2	3	µg/L	4,5
Carbon tetrachloride	0.2 - 10	2/51	0.2	7.11	–	Y	B206889	2	516	µg/L	4
Chloroethane	0.4 - 10	2/51	0.4	3	J	A	0786	4	–	µg/L	4,5
Ethylbenzene	0.2 - 10	1/51	0.2	0.3	J	A	B206889	2	–	µg/L	4,5
Methylene chloride	0.1 - 10	7/51	0.1	8	B	–	B206889	2	16	µg/L	4,5
Tetrachloroethene	0.1 - 10	1/51	0.1	0.769	–	Y	B206889	2	44	µg/L	4
Toluene	0.1 - 10	1/51	0.1	3	J	A	B206889	2	4	µg/L	4,5

Table 2-7
Analytes Detected in UHSU Groundwater in the Vicinity of the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Total xylenes	0.5 - 10	1/46	0.5	3	J	A	B206889	3	3	µg/L	4,5
Trichloroethene	0.1 - 10	1/51	0.1	1.43	–	Y	B206889	2	38	µg/L	4
Indicator Parameters											
Bicarbonate as $CaCO_3$	1,000 - 10,000	21/21	135,000	860,000	–	V	0786	316,225	–	µg/L	
Carbonate as $CaCO_3$	1,000 - 10,000	4/13	0	1,430	B	V	B206789	1,264	–	µg/L	
Chemical oxygen demand	5,000 - 10,000	9/10	10,000	55,000	–	Y	0786	24,456	–	µg/L	
Chloride	200 - 25,000	21/21	59,000	460,000	–	V	B206889	155,697	63,635	µg/L	1,2
Fluoride	100 - 200	20/20	300	1,900	–	V	0786	692	2,024	µg/L	
Nitrate/nitrite	20 - 200,000	34/38	20	290,000	–	JA	B206889	4,8704	55,685	µg/L	1,2
Orthophosphate	10 - 50	4/7	10	30	–	–	B206789	20.71	53	µg/L	2
pH	–	2/2	7.1	7.7	–	–	B206789	7.4	–	pH	
Silica	400 - 2,000	8/8	5,500	25,000	–	JA	B206789	9,000	35,735	µg/L	
Sodium fluoride	100	1/1	520	520	–	V	B206789	520	–	µg/L	
Sodium sulfate	20,000	1/1	524,000	524,000	–	V	B206789	524,000	–	µg/L	
Solids, nonvolatile suspended	5,000	1/1	29,000	29,000	–	JA	B206889	29,000	–	µg/L	
Sulfate	2,000 - 250,000	20/20	170,000	1,600,000	–	V	B206889	621,840	613,607	µg/L	1,2
Total dissolved solids	5,000 - 14,000	21/21	1,140,000	3,700,000	–	V	B206889	1,521,476	–	µg/L	
Total organic carbon	1,000 - 5,000	14/14	3,000	22,000	–	V	0786	8,975	–	µg/L	
Total suspended solids	4,000 - 5,000	19/20	5,000	590,000	–	–	B206789	63,675	1,402,588	µg/L	

Table 2-7
Analytes Detected in UHSU Groundwater in the Vicinity of the East Landfill Pond

Notes

All analytes are total analytes unless otherwise noted.
Organic analytes with zero hits are not reported.
Metal analytes with zero hits are reported.
All radionuclide results are considered hits.
The minimum result may be a hit or not a hit.
The maximum detection may only be a hit.
In calculating the mean, one-half of the detection limit is used for those results that are not hits.

1 Analyte determined to be PCOC by hot measurement test.
2 Analyte determined to be PCOC by inferential statistics test(s).
3 Analyte not considered a PCOC because it is a nutrient.
4 All detected organic analytes are considered PCOCs unless eliminated by professional judgment.
5 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples.

Data Qualifiers

— data qualifier field in database is blank.
+ correlation coefficient for matrix spike analysis is less than 0.995 (estimated value).
B for inorganics, reported value is < CRDL but > IDL (estimated value).
B for organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit.
E for inorganics, value is an estimate due to interference (estimated value).
J for inorganics, value > IDL but control sample analysis not within control limits (estimated value).
J for organics, data indicate presence of compound but below detection limit (estimated value).
N for inorganics, spiked sample recovery is not within control limits (estimated value).

Data Validation Codes

— data qualifier or validation field in database is blank.
A acceptable result.
JA acceptable result (for estimated value).
V valid result.
Y analytical results in validation process.

Definitions

CRDL *contract-required detection limit*
IDL instrument detection limit
PCOC potential contaminant of concern
$UTL_{99/99}$ upper tolerance limit of the 99th percentile at the 99-percent confidence level

98

Table 2-8
Analytes Detected in UHSU Groundwater Downgradient of the Dam

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Metals											
Aluminum	200	7/8	141	3,080	–	–	4287	938	26,324	µg/L	
Antimony	60	1/8	8	66.8	–	JA	B207089	17	52	µg/L	1,5
Arsenic	10	1/8	1	1.9	B	–	4287	1	8	µg/L	
Barium	200	7/8	27.5	94.5	B	–	4287	45	311	µg/L	
Cadmium	5	2/8	1	2.4	B	V	B207089	1	4	µg/L	
Calcium	5,000	8/8	77,800	149,000	–	V	B207089	127,400	148,662	µg/L	1,2,3
Chromium	10	5/8	2.5	18	–	V	B207089	7	192	µg/L	
Copper	25	2/8	3.5	9.4	B	–	4287	4	42	µg/L	
Iron	100	8/8	124	2,890	–	–	4287	888	32,398	µg/L	
Lead	3 - 5	2/8	1	2.6	B	–	4287	1	20	µg/L	
Lithium	100	8/8	13.5	138	–	V	B207089	100	177	µg/L	2
Magnesium	5,000	8/8	11,300	44,100	–	V	B207089	34,313	33,725	µg/L	1,2,3
Manganese	15	8/8	14.1	109	–	V	B207089	47	643	µg/L	
Molybdenum	200	2/8	2	7.3	B	V	B207089	4	204	µg/L	
Nickel	40	4/8	4	8.4	B	–	4287	6	101	µg/L	
Potassium	5,000	8/8	1,290	6,730	–	V	B207089	5,194	5,243	µg/L	1,2,3
Selenium	5	1/8	1	1	B	JA	B207089	1	131	µg/L	
Silicon	100	4/4	2,720	13,300	N	JA	4287	5,615	62,830	µg/L	
Silver	10	2/7	2	3.2	B	–	4287	2	7	µg/L	
Sodium	5,000	7/7	23,200	465,000	–	V	B207089	330,300	147,829	µg/L	1,2,3
Strontium	200	7/7	412	1,870	–	V	B207089	1,355	1,110	µg/L	1,2
Tin	200	2/7	10	20.2	B	V	B207089	12	170	µg/L	
Vanadium	50	5/7	5	32.1	B	–	4287	13	71	µg/L	

Table 2-8
Analytes Detected in UHSU Groundwater Downgradient of the Dam

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Zinc	20	5/7	11.3	33.4	–	V	B207089	22.1	184	µg/L	
Radionuclides											
Americium-241	0 - 0.03	23/23	0	0.012	–	A	B207089	0.005	0.04	pCi/L	
Cesium-134	2.21	1/1	0.64	0.64	–	–	B207089	0.64		pCi/L	
Cesium-137	0.6 - 2.37	10/10	-0.498	0.4298	J	A	B207089	0	1.1	pCi/L	
Gross alpha	4.8 - 74.07	2/2	0	19	–	Y	B207089	10	391	pCi/L	
Gross beta	10 - 21.82	2/2	3.46	13	–	Y	B207089	8	221	pCi/L	
Plutonium-238	0.00314 - 0.01	2/2	0.002318	0.01164	–	–	B207089	0.00698	0.04715	pCi/L	
Plutonium-239/240	0 - 0.087	25/25	-0.000272	0.009	J	V	B207089	0.002	–	pCi/L	
Radium-226	0.096	1/1	0.64	0.64	B	Y	B207089	0.64	1.29	pCi/L	
Strontium-89,90	0.25 - 1.6	4/4	-0.14	0.49	–	A	4287	0.17	1.2	pCi/L	2
Strontium-90	0	1/1	1.31	1.31	–	–	B207089	1.31	–	pCi/L	
Tritium	0 - 820	37/37	-141	400	U	–	B207089	97	13,413	pCi/L	
Uranium-233,-234	0 - 0.61	4/4	2.8	20.09	–	A	4087	7.8	–	pCi/L	
Uranium-235	0 - 0.74	4/4	0.082	0.7962	–	A	4287	0.456	5.2	pCi/L	
Uranium-238	0 - 0.61	4/4	1.5	13.23	–	A	4087	5	114	pCi/L	
Volatile Organic Compounds											
Benzene	0.1 - 5	1/53	0.1	0.1	J	–	B207089	2	3	µg/L	4,5
Methylene chloride	0.1 - 5	10/52	0.1	12	B	–	B207089	2	16	µg/L	4,5
Toluene	0.1 - 5	2/54	0.1	1	J	–	B206989	2	4	µg/L	4,5

106

Table 2-8
Analytes Detected in UHSU Groundwater Downgradient of the Dam

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Indicator Parameters											
Ammonia	30 - 100	5/14	80	214	–	Y	B207089	75	–	µg/L	
Bicarbonate as $CaCO_3$	1,000 - 10,000	32/32	38,000	670,000	–	V	B207089	311,825	–	µg/L	
Carbonate as $CaCO_3$	1,000 - 10,000	8/24	0	12,000	–	V	4087	1,764	–	µg/L	
Chemical oxygen demand	0 - 10,000	13/16	4,800	21,000	–	V	4287	10,048	–	µg/L	
Chloride	200 - 100,000	29/29	12,000	530,000	–	V	B207089	311,351	63,635	µg/L	1,2
Cyanide	5 - 100	2/22	1	5.6	B	V	B207089	8	12	µg/L	
Fluoride	0 - 100	32/32	230	3,400	–	–	4087	692	2,024	µg/L	1
Nitrate/nitrite	20 - 2,800	32/35	20	72,000	–	V	B206989	7,714	55,685	µg/L	1,2
Orthophosphate	10 - 50	12/21	6	150	–	JA	4287	30.14	53	µg/L	1,2
pH	0.1	3/3	7.6	7.73	–	Y	B207089	7.7	–	pH	
Silica	400	10/10	2,600	9,000	–	–	4087	4,460	35,735	µg/L	
Specific conductivity	1	2/2	3,105.2	3,110	–	Y	B207089	3108	–	µmhos/cm	
Sulfate	1,000 - 100,000	32/32	33,000	19,000,000	–	–	B207089	1,081,886	613,607	µg/L	1,2
Total dissolved solids	5,000 - 14,000	32/32	280,000	5,100,000	–	V	B206989	1,529,688	–	µg/L	
Total organic carbon	1,000 - 5,000	15/17	190	10,500	–	Y	4087	4,190	–	µg/L	
Total suspended solids	4,000 - 5,000	30/32	4,000	442,000	–	V	4287	74,484	1,402,588	µg/L	

Notes

All analytes are total analytes unless otherwise noted.
Organic analytes with zero hits are not reported.
Metal analytes with zero hits are reported.
All radionuclide results are considered hits.
The minimum result may be a hit or not a hit.
The maximum detection may only be a hit.
In calculating the mean, one-half of the detection limit is used for those results that are not hits.

1 Analyte determined to be PCOC by hot measurement test.
2 Analyte determined to be PCOC by inferential statistics test(s).
3 Analyte not considered a PCOC because it is a nutrient.
4 All detected organic analytes are considered PCOCs unless eliminated by professional judgment.
5 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples.

Table 2-8
Analytes Detected in UHSU Groundwater Downgradient of the Dam

Data Qualifiers

—	data qualifier or validation field in database is blank.
B	for inorganics, reported value is < CRDL but > IDL (estimated value).
B	for organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit.
J	for inorganics, value > IDL but control sample analysis not within control limits (estimated value).
J	for organics, MS data indicate presence of compound but below detection limit (estimated value).
N	for inorganics, spiked sample recovery is not within control limits (estimated value).
U	for inorganics and organics, analyte analyzed but not detected at the quantitation limit.

Data Validation Codes

—	data qualifier field in database is blank.
A	acceptable result.
JA	acceptable result (for estimated value).
V	valid result.
Y	analytical results in validation process.

Definitions

CRDL	contract-required detection limit
IDL	instrument detection limit
PCOC	potential contaminant of concern
$UTL_{99/99}$	upper tolerance interval of the 99th percentile at the 99-percent confidence level

102

Table 2-9
Analytes Detected in LHSU Groundwater Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Metals											
Aluminum	200	1/1	2,490	2,490	N*	JA	4187	2,490	13,788	µg/L	
Antimony	60	1/1	28.1	28.1	B	JA	4187	28.1	1,269	µg/L	
Barium	200	1/1	387	387	–	V	4187	387	1,424	µg/L	
Calcium	5,000	1/1	108,000	108,000	–	V	4187	108,000	127,687	µg/L	2
Chromium	10	1/1	60.7	60.7	–	V	4187	60.7	1,210	µg/L	
Cobalt	50	1/1	3.1	3.1	B	V	4187	3.1	1,237	µg/L	
Copper	25	1/1	16.9	16.9	B	V	4187	16.9	1,338	µg/L	
Iron	100	1/1	2,400	2,400	*	JA	4187	2,400	18,339	µg/L	
Lead	3	1/1	4.4	4.4	–	V	4187	4.4	22	µg/L	
Lithium	100	1/1	91.9	91.9	B	V	4187	91.9	150	µg/L	
Magnesium	5,000	1/1	26,200	26,200	–	V	4187	26,200	28,140	µg/L	2
Manganese	15	1/1	121	121	–	V	4187	121	615	µg/L	
Molybdenum	200	1/1	24	24	B	V	4187	24	1,241	µg/L	
Nickel	40	1/1	48.4	48.4	–	V	4187	48.4	1,266	µg/L	
Potassium	5,000	1/1	6,220	6,220	–	V	4187	6,220	8,801	µg/L	2
Selenium	5	1/1	3	3	B	V	4187	3	5	µg/L	
Sodium	5,000	1/1	437,000	437,000	–	V	4187	437,000	659,404	µg/L	2
Strontium	200	1/1	1,470	1,470	–	V	4187	1,470	1,725	µg/L	
Vanadium	50	1/1	11.6	11.6	B	V	4187	11.6	1,274	µg/L	
Zinc	20	1/1	52.6	52.6	E	JA	4187	52.6	1,401	µg/L	

103

Table 2-9
Analytes Detected in LHSU Groundwater Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Radionuclides											
Americium-241	0.00377 - 0.01	4/4	0	0.00696	–	Y	53094	0.004	0.072	pCi/L	
Cesium-137	1	1/1	0.3585	0.3585	J	–	B207189	0.3585	1.05	pCi/L	
Gross alpha	1	1/1	8.4	8.4	–	V	0886	8.4	133	pCi/L	
Gross beta	2.9	1/1	5.4	5.4	–	V	0886	5.4	110.7	pCi/L	
Plutonium-238	0.01 - 0.0119	3/3	-0.00257	0.002145	J	–	B207189	0.00007	–	pCi/L	
Plutonium-239/240	0 - 0.01	4/4	0.0006231	0.01192	–	A	B207189	0.006	–	pCi/L	
Radium-226	0.5	1/1	1.5	1.5	–	–	4187	1.5	–	pCi/L	
Tritium	200 - 910	26/26	-173	300	U	V	B207189	31	1,779	pCi/L	
Uranium-233,-234	0.14	1/1	3.24	3.24	–	A	4187	3.24	–	pCi/L	
Uranium-235	0.06	1/1	0.08	0.08	–	A	4187	0.08	0.27	pCi/L	
Uranium-238	0.13	1/1	1.2	1.2	–	A	4187	1.2	–	pCi/L	
Volatile Organic Compounds											
Acetone	10 - 100	3/39	4	10	B	–	B207189	8	12	µg/L	3,4
Chlorobenzene	0.2 - 5	1/46	0.2	1	J	–	4187	2	–	µg/L	3,4
Methylene chloride	0.1 - 5	13/46	0.1	16	–	V	0886	3	12	µg/L	1,3,4
Toluene	0.1 - 5	3/46	0.1	2	J	A	0886	2	–	µg/L	3,4
Total xylenes	5	1/40	1	1	J	A	4187	2	4	µg/L	3,4
Indicator Parameters											
Ammonia	30.0 - 100	2/4	100	513	–	Y	4187	170	–	µg/L	
Bicarbonate as $CaCO_3$	1,000 - 10,000	36/38	1,000	180,000	–	V	0886	116,371	–	µg/L	
Carbonate	1,000 - 10,000	2/8	1,000	23,000	–	V	0886	6,000	17,826	µg/L	1
Carbonate as $CaCO_3$	1,000 - 10,000	19/30	0	220,000	–	V	B207189	30,122	–	µg/L	

Table 2-9
Analytes Detected in LHSU Groundwater Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Location of Maximum Detection	Mean	Background $UTL_{95/95}$ Concentration	Units	PCOC
Chemical Oxygen Demand	5,000 - 10,000	10/10	5,000	37,000	–	V	4187	14,470	–	µg/L	
Chloride	200 - 50,000	36/36	12,000	1,100,000	–	–	4187	572,823	532,358	µg/L	
Fluoride	100	37/37	300	1,500	–	V	0886	792.4	2,303	µg/L	
Nitrate/nitrite	20 - 5,000	35/38	20	2,400	–	V	0886	1,287	4,180	µg/L	
Nitrite	20 - 5,000	1/3	20	250	–	–	4187	920	4,859	µg/L	
Orthophosphate	10 - 50	2/13	10	80	–	–	4187	13.46	51	µg/L	1
pH		2/2	8.8	12	–	–	B207189	10	–	pH	
Silica	400	15/15	2,300	6,200	–	–	0886	3,460	12,145	µg/L	
Sodium fluoride	100	1/1	650	650	–	V	4187	650	–	µg/L	
Sodium sulfate	10,000	1/1	53,000	53,000	–	V	4187	53,000	–	µg/L	
Solids, nonvolatile suspended	5,000	1/1	138,000	138,000	–	JA	B207189	138,000	–	µg/L	
Specific conductivity	10	2/2	490	3,300	–	Y	4187	1,895	–	µmhos/cm	
Sulfate	2,000 - 10,000	37/37	6,000	79,000	–	JA	B207189	27,908	992,074	µg/L	
Total dissolved solids	10,000 - 14,000	38/38	230,000	2,000,000	–	V	4187	1,241,658	2,059,573	µg/L	
Total organic carbon	1,000 - 5,000	11/13	1,000	4,120	–	Y	0886	2,105	–	µg/L	
Total suspended solids	4,000 - 5,000	36/37	5,000	450,000	–	V	0886	137,122	2,956,564	µg/L	

Notes

All analytes are total analytes unless otherwise noted.
Organic analytes with zero hits are not reported.
Metal analytes with zero hits are reported.
All radionuclide results are considered hits.
The minimum result may be a hit or not a hit.
The maximum detection may only be a hit.
In calculating the mean, one-half of the detection limit is used for those results that are not hits.
Because of the small number of site samples, inferential statistics were not performed. Only the hot measurement test was used to compare site data to background data.

105

Table 2-9
Analytes Detected in LHSU Groundwater Downgradient of the Landfill

1 Analyte determined to be PCOC by hot measurement test.
2 Analyte not considered a PCOC because it is a nutrient.
3 All detected organic analytes are considered PCOCs unless eliminated by professional judgment.
4 Analyte not considered a PCOC because of infrequent detection and/or detection in blanks or background samples.

Data Qualifiers

— data qualifier or field validation field in database is blank.
* for inorganics, duplicate analysis is not within control limits (estimated value).
B for inorganics, reported value is < CRDL but > IDL (estimated value).
B for organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit.
E for inorganics, value is an estimate due to interference (estimated value).
J for inorganics, value > IDL but control sample analysis not within control limits (estimated value).
J for organics, data indicate presence of compound but below detection limit (estimated value).
N for inorganics, spiked sample recovery is not within control limits (estimated value).

Data Validation Codes

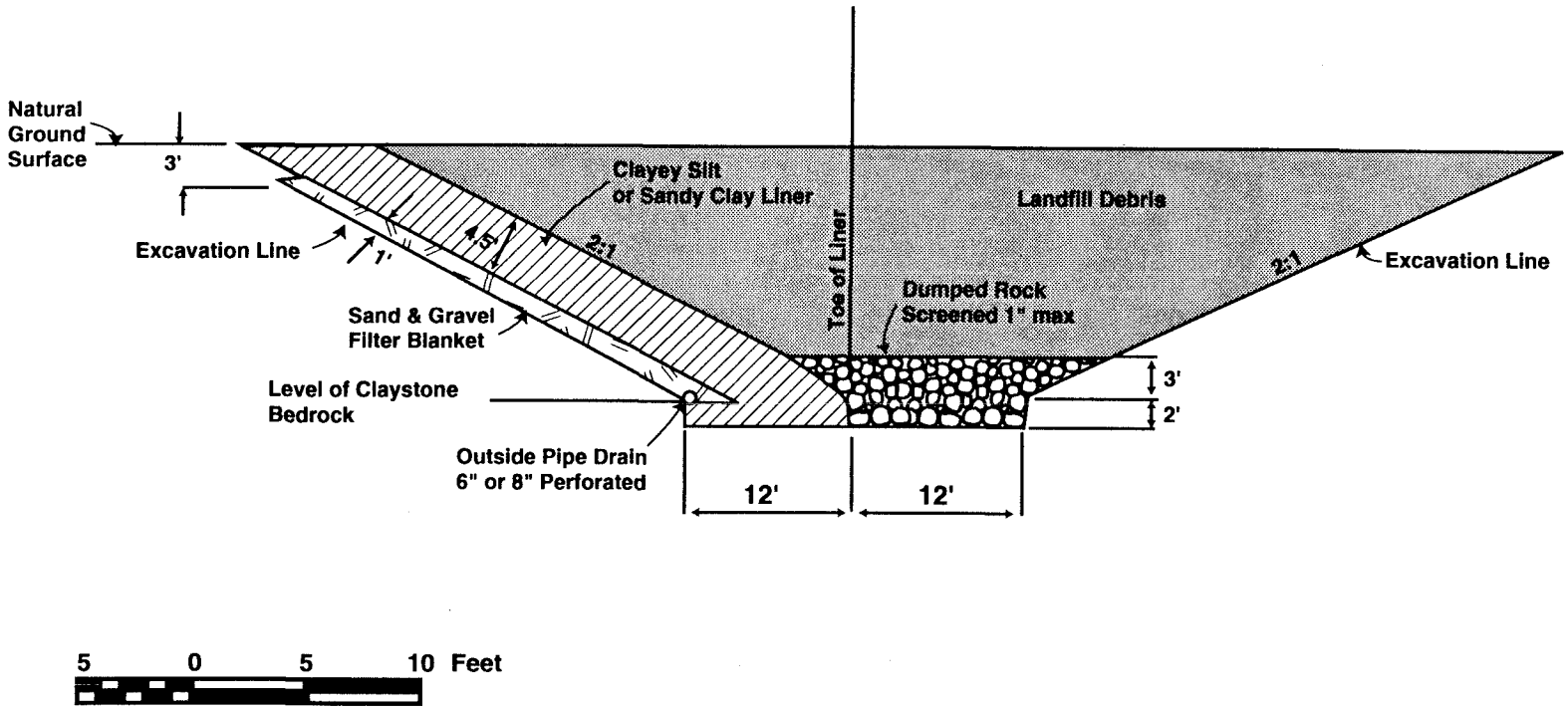
— data qualifier field in database is blank.
A acceptable result.
JA acceptable result (for estimated value).
V valid result.
Y analytical results in validation process.

Definitions

CRDL contract-required detection limit
IDL instrument detection limit
PCOC potential contaminant of concern
$UTL_{99/99}$ upper tolerance limit of the 99th percent confidence level

106

Section 2
Figures



Adapted from Rockwell International 1982

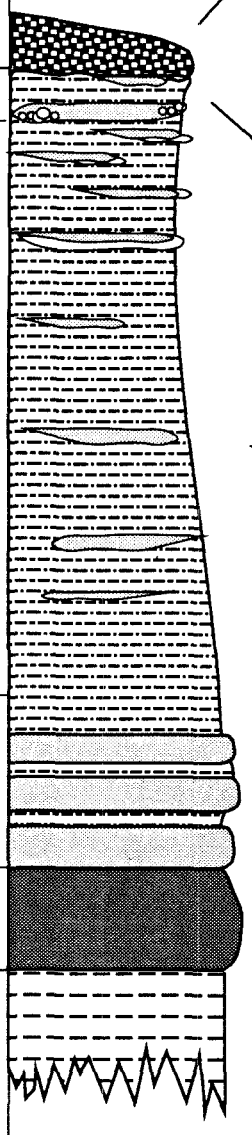
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Typical Existing Groundwater-Intercept System Section

Phase I IM/IRA DD	Operable Unit No. 7
July 1995	Figure 2-2

G95ESUM/IRA DD OU 7\Leachate Section-2510.ill

Age	Formation	Thickness (feet)
Quaternary	Rocky Flats Alluvium/ Colluvium	0-30
Cretaceous	Arapahoe Formation	0-20
	Laramie Formation	600-800
		upper interval: 300-500
		lower interval: 300
	Fox Hills Sandstone	90-140
	Pierre Shale and older units	



Clayey Sandy Gravels – reddish brown to yellowish brown matrix, grayish-orange to dark gray, poorly sorted, angular to subrounded, cobbles, coarse gravels, coarse sands and gravelly clays: varying amounts of caliche

Claystones, Silty Claystones, and Sandstones – light to medium olive-gray with some dark olive-black claystone, silty claystone, and fine-grained sandstone, weathers yellowish orange to yellowish brown; a mappable, light to *olive gray, medium- to coarse-grained, frosted sandstone* to conglomeratic sandstone occurs locally at the base (Arapahoe marker bed or No. 1 sandstone)

Claystones, Silty Claystones, Clayey Sandstones, and Sandstones – *kaolinitic, light to medium* gray claystone and silty claystone and some dark gray to black carbonaceous claystone, thin (2') coal beds and thin discontinuous, very fine to medium-grained, moderately sorted sandstone interval (No. 2 through No. 5 sandstones)

Sandstones, Claystones, and Coals – light to medium gray, fine- to coarse-grained, moderately to well sorted, silty, immature quartzose sandstone with numerous claystones, and subbituminous coal beds and seams that range from 2' to 8' thick)

Sandstones – grayish orange to light gray, calcareous, fine-grained, subrounded glauconitic, friable sandstone

Source: EG&G 1992a

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Generalized Stratigraphic Section

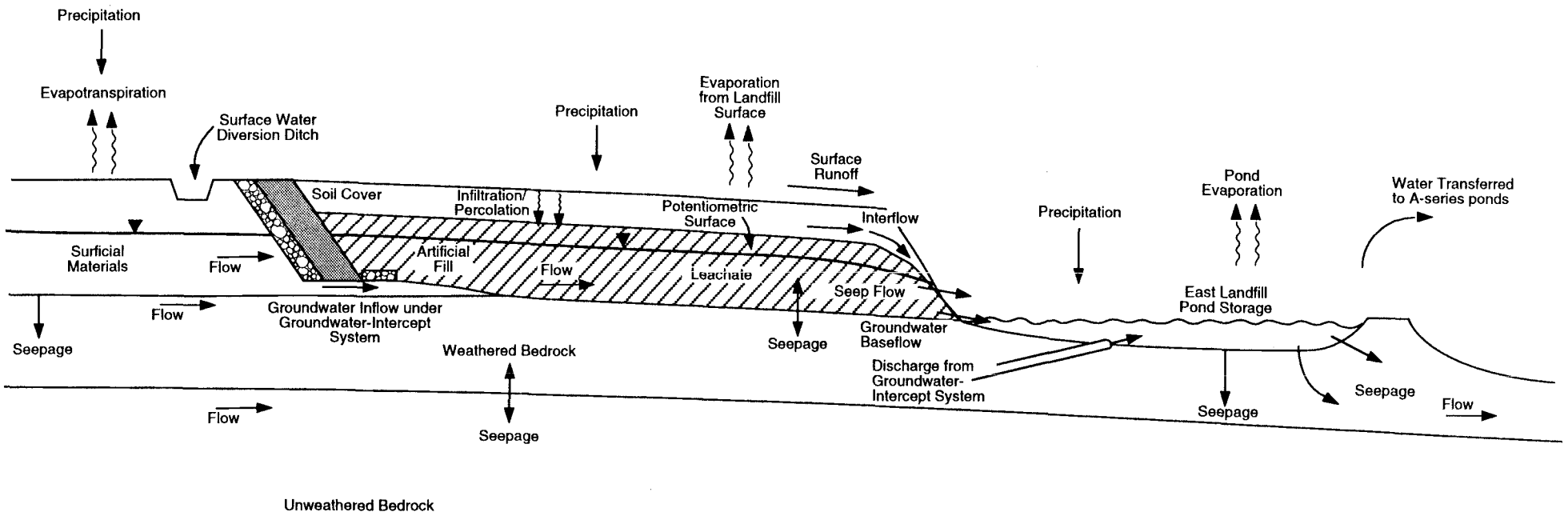
Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 2-3

G95\ESV\IRA DD OU 7\Gen. Strat.-2501.mdw

110

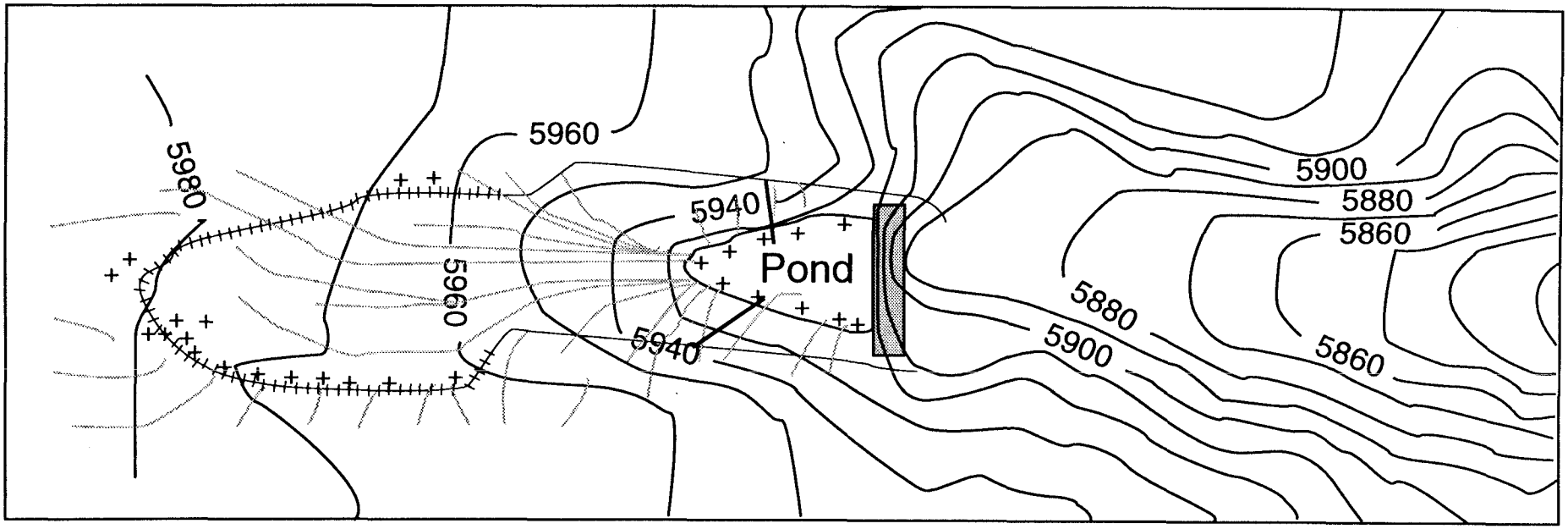
Present Landfill Area Cross Section



Not to scale

U.S. DEPARTMENT OF ENERGY Rocky Flats Environmental Technology Site, Golden, Colorado	
Conceptual Flow Model for OU 7	
Phase I IM/IRA DD	Operable Unit No. 7
July 1995	Figure 2.5

G95\ES\IM\IRA DD OU 7\Conceptual flow model 2510



Existing groundwater intercept system, perforated

Existing groundwater intercept system, nonperforated

Dam (low hydraulic conductivity)

Particle entering boundary

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Groundwater Flowpaths from the Landfill

Phase I IM/IRA DD

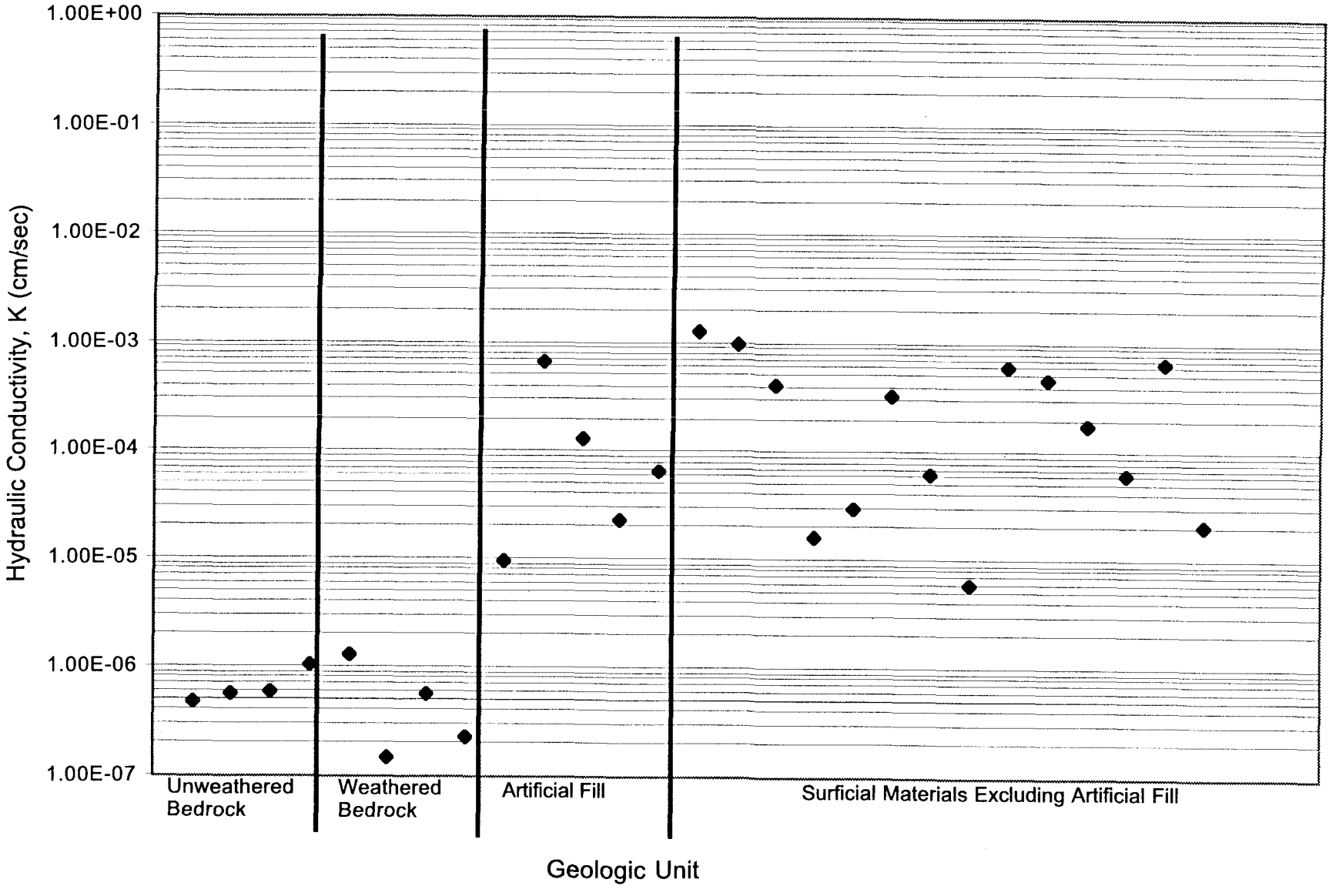
Operable Unit No. 7

July 1995

Figure 2-7

G95ESIM/IRA DD OU 7GW Flowpaths-2510.ill

Figure 2-8
Hydraulic Conductivity Measurements for Each Geologic Unit



G95ES\IM\RA DD OU 7\Geologic Unit-2510.CD

115

3. Development of Remedial Action Objectives to Reduce Site Risks

This section presents the process used to develop RAOs or response actions. Preliminary RAOs are identified for each medium, risks are defined using a conceptual site model, potential exposure pathways associated with each medium are identified, and risks to human health and the environment are evaluated using a focused or streamlined risk assessment approach, as recommended in EPA guidance for presumptive remedies (EPA 1993a). Compliance with ARARs is assessed by comparing chemical-specific ARARs for surface water and groundwater to mean concentrations detected at OU 7 and by identifying location-specific and action-specific ARARs. Final RAOs are developed by eliminating preliminary RAOs for which there is no risk to the potential receptor, analytes do not exceed ARARs, or the exposure pathway is incomplete. Final RAOs are used for the identification and screening of technologies presented in Section 4.

3.1 Preliminary Remedial Action Objectives

In order to meet the overall objective of protecting human health and the environment under CERCLA (EPA 1991a), preliminary RAOs were developed for each medium. RAOs are medium-specific or operable unit-specific goals for protecting human health and the environment (EPA 1988).

RAOs for presumptive remedy components of OU 7 (the landfill), which will remain a long-term waste management area, are specified in EPA guidance and include the following (EPA 1993a):

- Prevent direct contact with landfill contents
- Minimize infiltration and resulting contaminant leaching to groundwater
- Control surface-water run-off and erosion
- Control landfill gas (treat as needed)
- Collect and treat leachate at the source (as needed)
- Control groundwater at the source to contain the plume

RAOs for the other components at OU 7 may include the following as needed:

- Remediate surface water in the East Landfill Pond (as needed)
- Remediate sediments in the East Landfill Pond (as needed)
- Remediate wetland areas (as needed)
- Remediate surface soils in spray evaporation areas (as needed)
- Remediate subsurface geologic materials downgradient of the landfill (as needed)
- Remediate groundwater downgradient of the landfill (as needed)

To evaluate alternatives in terms of overall protection of human health and the environment, the manner in which site risks identified in the conceptual site model are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls was considered (EPA 1991a). Containment will accomplish RAOs for the presumptive remedy components at OU 7 by addressing all pathways associated with the source. RAOs for the other components will be evaluated in terms of exposure pathways, risk, and compliance with ARARs in the following sections. The anticipated future land use for the area surrounding the landfill is open space (EPA 1995a). There are no plans for future development of groundwater for any use at OU 7. Also, existing information shows that there is only limited availability of groundwater downgradient of the landfill (Section 2.3).

3.2 Conceptual Site Model for Defining Risks

Data collected during the Phase I RFI/RI, presented in the OU 7 Final Work Plan (DOE 1994a) and summarized in Section 2, were used to develop a conceptual site model. The model identifies the suspected sources, contaminant release and transport mechanisms, exposure points or affected media, and exposure routes (Figure 3-1).

Contaminant sources include solid and liquid hazardous and nonhazardous wastes in the Present Landfill, soils in IHSS 203 where hazardous wastes were stored, and asbestos in the asbestos-disposal areas. Mechanisms for contaminant releases include the following:

- Erosion of interim cover material exposing landfill contents directly, or release of landfill contents by erosion and run-off
- Volatilization of landfill gas
- Leachate seep discharge to the East Landfill Pond
- Spray evaporation of pond water
- Leaching of contaminants into the groundwater

Primary transport mechanisms are movement of landfill gas, movement with surface-water run-off, movement with the leachate seep, and movement with groundwater. Spray evaporation activities ceased in 1994; therefore, continued releases are no longer occurring by this mechanism.

Contaminants in landfill gas may migrate into the atmosphere. After contaminants from the leachate seep or from run-off have entered the East Landfill Pond, they may remain suspended or dissolved in surface water, be deposited in sediment at the bottom of the pond, be discharged to groundwater, or be taken up by plants or aquatic life in

wetland areas. After contaminants in water from the pond have been sprayed onto the surrounding slopes and have infiltrated the soil, they may subsequently be leached out of the soil by run-off or infiltration/percolation or be dispersed by the wind.

After contaminants have entered the groundwater, several migration pathways are possible. Groundwater in the UHSU could discharge to surface water in the East Landfill Pond. Groundwater in the UHSU could also migrate downgradient, discharge to surface water in No Name Gulch, migrate with surface water to the confluence of No Name Gulch and North Walnut Creek, and eventually migrate offsite. This migration pathway is not likely because groundwater modeling has shown that migration is slowed considerably or possibly even stopped by the dam. Discharge from groundwater to surface water below the dam is not expected because the intermittent stream in No Name Gulch is a losing stream that discharges to groundwater. Groundwater in the UHSU could migrate slowly downgradient, remaining as groundwater. This migration pathway is the most likely, as shown by groundwater modeling. Groundwater in the UHSU could also seep into the confining layers of the unweathered bedrock and eventually reach the sandstones of the LHSU. However, hydraulic conductivity values for the confining layer are low and downward seepage is minimal (Section 2.3). Contaminants in groundwater may also be deposited in subsurface geologic materials downgradient of the landfill.

VOCs detected in landfill leachate could be transported by seeps, surface-water run-off, or groundwater. During transport, VOCs in groundwater may be subject to adsorption, hydrolysis, and biological degradation under aerobic or anaerobic conditions. As stated above, discharge from groundwater to surface water below the dam is not expected and contaminants are most likely absorbed or migrate within groundwater.

Potential exposure pathways associated with OU 7 (Figure 3-1) include ingestion and dermal contact with waste materials, inhalation of dust, and physical hazards from the source; inhalation and explosion of landfill gas; inhalation and ingestion of and dermal contact with leachate from the seep and surface water and sediment from the East Landfill Pond; inhalation and ingestion of dermal contact with and external irradiation from soils in spray evaporation areas and subsurface geologic materials downgradient of the landfill; and inhalation and ingestion of, and dermal contact with groundwater from wells downgradient of the landfill.

Because the contents of the landfill, IHSS 203, and the asbestos-disposal areas will be contained, the conceptual site model is most useful for identifying areas beyond the landfill that may pose a threat to human health or the environment. Risks posed by these media are evaluated below.

3.3 Evaluation of Risks

Baseline risk assessments evaluate the potential threat to human health and the environment in the absence of any remedial action and often provide both the basis for determining if remedial action is necessary and the justification for performing remedial actions. Under the presumptive remedy approach, a quantitative baseline risk assessment is not necessary to evaluate if the containment remedy addresses pathways and contaminants of concern associated with the source. Rather, all potential exposure pathways can be identified using the conceptual site model and compared to the pathways addressed by the containment presumptive remedy (EPA 1993a). For pathways not addressed by the containment presumptive remedy, a focused or streamlined risk assessment was performed. The methodology for the focused risk assessment is described below.

3.3.1 Methodology to Determine if a Response Action is Necessary

Leachate resulting from land-disposed hazardous wastes classified by more than one waste code under RCRA Subpart D or from a mixture of wastes classified under RCRA Subparts C and D is designated F039 RCRA-listed waste contained in groundwater (6 CCR 1007-3 Part 261). The method used to determine the hazardous waste classification and resultant treatment standards for various environmental media at OU 7 is shown in Figure 3-2 (DOE 1995c). The first step is to determine if land disposal of hazardous waste has occurred. The second step is to ascertain if leachate exists by application of the "derived from" rule. The third step is to determine if multisource leachate (F039) exists. And, the final step is to determine if the "contained in" policy applies to these environmental media. If it does, the waste must meet standards or be remediated or treated to meet standards. When standards are met, the media no longer "contains" listed waste.

Only leachate within the landfill is considered F039 RCRA-listed waste. Leachate that discharges at the seep, surface water in the East Landfill Pond, pond sediments, surface soils in spray evaporation areas, and subsurface geologic materials and groundwater downgradient of the landfill constitute leachate "contained in" environmental media. Therefore, risk-based analyses were performed to determine if these media pose a threat to human health or the environment.

Methods used to evaluate chemical data for samples collected from these environmental media are shown in Figure 3-3. The methodology uses PCOCs previously identified following the Gilbert methodology (EG&G 1994b) and encompasses a focused risk assessment that includes a preliminary remediation goal (PRG) screen and risk calculations. All organics detected were considered PCOCs.

126

The risk evaluation is used to determine if remediation of other (non-presumptive remedy) media is required.

Land-use scenarios used for the PRG screen and the risk calculations were based on recommendations from the Future Land-Use Working Group (DOE 1995d) and include an open-space scenario for landfill leachate, surface water, sediment, and soil; a construction-worker scenario for subsurface geologic materials; and a future onsite office-worker scenario for groundwater. Residential uses have been eliminated from the future land-use plan (DOE 1995d).

Sitewide PRGs were developed for use in Rocky Flats environmental remediation activities for analytes that have toxicity criteria and are based on a target cancer risk of 1E-06 or a hazard index (HI) of 1. PRGs used in this report are from the Final Programmatic Risk-Based Preliminary Remediation Goals (DOE 1995e), Draft Programmatic PRGs for Rocky Flats Plant—Open Space (DOE 1995e), and Programmatic Preliminary Risk-Based Remediation Goals for RFETS (DOE 1995g). The maximum detected concentration of each PCOC, as identified in Section 2.5, was compared to the PRG for that analyte. If the maximum concentration of an analyte was less than the PRG, the analyte was dropped from further consideration. If the maximum detected concentration of an analyte was greater than the PRG, the analyte was evaluated in the focused risk assessment. Maximum concentrations are used for the PRG screen to provide a conservative approach that is consistent with the CDPHE risk-based conservative screen (CDPHE/EPA/DOE 1994), performed prior to baseline risk assessments at Rocky Flats.

None of the PCOCs in landfill leachate, surface water, sediment, or subsurface geologic materials failed the PRG screen; therefore, PCOCs in these media were dropped from further consideration. Risks were estimated for PCOCs in surface soil and groundwater that failed the PRG screen using the 95 percent upper confidence limit of the mean concentration (UCL_{95}). Risks were calculated for incidental ingestion and particulate inhalation of, and external irradiation from surface soil by an open-space receptor and for groundwater ingestion by a future onsite office worker. Risks were not calculated for dermal exposure to surface soils because the OU 7 surface-soil PCOCs included only metals and radionuclides and, in accordance with EPA guidance, dermal exposure to metals and radionuclides cannot be quantified (EPA 1989a). Site-specific exposure factors and open-space exposure parameters were used to calculate risks (DOE 1995h, DOE 1995i). Environmental media with carcinogenic risks that fall below or within the EPA acceptable risk range of 1E-04 to 1E-06 and noncarcinogenic risks that are below the HI of 1 do not require a response action (EPA 1993a).

A screening-level ecological risk assessment was performed to determine if PCOCs in leachate, surface water, and sediment present an unacceptable toxicological risk to

127

aquatic life and wildlife. Exposure and toxicity of PCOCs in sediment and pond water to aquatic life are used to determine if conditions in the pond are adequate to support a functional aquatic habitat. Potential toxicity of leachate, pond water, and sediment to aquatic-feeding avian and mammalian wildlife species (mallards and raccoons) and to non-aquatic wildlife species (mule deer, coyotes, and Preble's meadow jumping mouse) was evaluated.

Ecological exposures and risk estimations are based on the same data used to characterize the nature and extent of contamination (Section 2.5) and the potential human health risks presented below. Risks were characterized by comparing chemical concentrations in abiotic media to literature-based benchmarks to determine if PCOCs are present in concentrations that could be toxic to aquatic life or wildlife (DOE 1995b, DOE 1995j). Conservative assumptions were adopted in developing benchmarks and estimating exposures to minimize the chance of underestimating risk. Results are summarized below and presented in detail in Appendix D.

3.3.2 Present Landfill, IHSS 203, and Asbestos-Disposal Areas

A quantitative risk assessment is not necessary for the source area. Potential exposure to soils and waste material in the Present Landfill, IHSS 203, and asbestos-disposal areas from direct contact, volatilization, and/or wind will be addressed by the presumptive remedy for source containment (Figure 3-4). The proposed landfill cover will prevent exposure to source materials. In accordance with EPA guidance, it is not necessary or appropriate to estimate the risk associated with future residential land use because such use would be incompatible with the need to maintain the integrity of the containment system (EPA 1993a).

3.3.3 Landfill Gas

A quantitative risk assessment is not necessary for landfill gas. Potential exposure to landfill gas will be addressed by the presumptive remedy for gas control (Figure 3-5). The proposed landfill cover will include a gas-venting layer. Gas emissions will be contingent upon air-emission ARARs.

3.3.4 Landfill Leachate at the Seep

A quantitative risk assessment is not necessary for leachate in the source area. However, a focused risk assessment was performed as a conservative measure to evaluate the potential risk from ingestion of leachate. Potential exposure to landfill leachate will be addressed by the presumptive remedy for source containment (Figure 3-6). The proposed landfill cap will cover the seep area and prevent exposure to leachate, reduce contaminant leaching to groundwater, and ultimately reduce leachate

128

generation and migration. In addition, leachate will be intercepted and treated at the seep before closure as an accelerated action for OU 7.

Potential human receptors are open-space recreational users. A PRG screen was performed for landfill leachate (SW097) using an open-space exposure scenario (DOE 1995f). Results of the PRG screen are presented in Table 3-1. None of the 35 PCOCs from Section 2.5.3, Nature and Extent of Contamination in Landfill Leachate at the Seep, exceeded the PRGs for an open-space recreational user. Therefore, there is no risk to human health from inhalation or incidental ingestion of, or dermal exposure to leachate at the seep.

Potential ecological receptors include terrestrial and avian wildlife. A screening-level ecological risk assessment was performed to determine if PCOCs in leachate from the seep present an unacceptable toxicological risk to aquatic life and wildlife (Appendix D). Baseline risk estimates were based on the conservative assumption that receptors spend all of their time at the East Landfill Pond.

Under these conditions, the HI was greater than 1 for mallards, raccoons, and coyotes (mallard HI = 50; raccoon HI = 3; mule deer HI = 0.08; coyote HI = 3; Preble's meadow jumping mouse HI = 0.02). Risk to mallards is from potential exposure to naphthalene, 2-methylnaphthalene, bis(2-ethylhexyl)phthalate, and phenanthrene. Risk to raccoons is from potential exposure to naphthalene, 2-methylnaphthalene, bis(2-ethylhexyl)phthalate, and total xylenes. Risk to coyotes is from potential exposure to naphthalene, 2-methylnaphthalene, phenanthrene, and barium.

Hazard quotients for individual PCOCs and hazard indices are estimated for risks associated with no-observed-adverse-effects levels (NOAELs); risk is lower for exceeding lowest-observed-adverse-effects levels (LOAELs). Sources of uncertainty for ecological risk are the actual bioavailability of PCOCs, assumptions about frequency and duration of exposures, and importance of the East Landfill Pond as a habitat resource (Appendix D). Because it was assumed that mallards, raccoons, and coyotes spend all of their time at the pond and drink exclusively from the seep, risks were conservatively overestimated.

3.3.5 Surface Water in the East Landfill Pond

A focused or streamlined risk assessment is necessary for surface water in the East Landfill Pond because surface water is not a component of the presumptive remedy. Potential exposure pathways identified in the conceptual site model can be used to determine affected media, exposure routes, and potential receptors (Figure 3-7). After contaminants from the leachate seep or from run-off have entered the East Landfill Pond, they may remain suspended or dissolved in surface water, be discharged to groundwater, or be taken up by plants or aquatic life in wetland areas. Potential

exposure pathways evaluated include inhalation and incidental ingestion of, and dermal contact with surface water in the East Landfill Pond.

Potential human receptors include open-space recreational users. A PRG screen was performed for pond water (SW098) using an open-space exposure scenario (DOE 1995f). Results of the PRG screen are presented in Table 3-2. None of the 15 PCOCs from Section 2.5.4, Nature and Extent of Contamination in Surface Water in the East Landfill Pond, exceeded the PRGs for an open-space receptor, and, therefore, no risk assessment was performed. There is no risk to human health from inhalation, incidental ingestion, or dermal exposure of surface water from the East Landfill Pond.

Potential ecological receptors include aquatic life and terrestrial and avian wildlife. A screening-level ecological risk assessment was performed to determine if PCOCs in pond water present an unacceptable toxicological risk to aquatic life and wildlife (Appendix D). Only one of the surface water PCOCs (manganese) exceeded state water quality standards or risk-based benchmarks. The cumulative risk, expressed as the HI, also did not exceed 1. These data are consistent with whole effluent toxicity tests performed on water samples from the pond. Results of the literature-based toxicity screen, laboratory toxicity testing, and preliminary risk calculation indicate that pond water represents negligible risk to aquatic life. Baseline risk estimates were based on the conservative assumption that receptors spend all of their time at the pond.

Using these assumptions, the HI was greater than 1 only for mallards (mallard HI = 10; raccoon HI = 0.3; mule deer HI = 0.01; coyote HI = 0.03; Preble's meadow jumping mouse HI = 0.03). Risk to mallards is from potential exposure to bis(2-ethylhexyl)phthalate and di-n-butyl phthalate. Sources of uncertainty for ecological risk are the actual bioavailability of PCOCs, assumptions about frequency and duration of exposures, and importance of the East Landfill Pond as a habitat resource. Because it was assumed that mallards spend all of their time at the East Landfill Pond, risk to mallards was conservatively overestimated.

The East Landfill Pond includes approximately 3 percent of the open-water habitat and 6 percent of the available shoreline habitat at Rocky Flats; the adjacent wetland represents approximately 1.6 percent of the total wetland areas at Rocky Flats (COE 1994). Risks to vegetation were evaluated as part of the screening-level ecological risk assessment. Risks to vegetation are minimal (Appendix D).

Since the East Landfill Pond was constructed only 20 years ago, it is probably not a historically important component of the local ecosystem (Appendix D). The pond apparently does not contain fish or crayfish populations. Without a complex aquatic food web that includes upper-level aquatic consumers, the pond is a limited resource for aquatic-feeding wildlife. The pond area has been identified as potential habitat for

130

one federal candidate species, Preble's meadow jumping mouse (DOE 1995b), but its occurrence there has not been confirmed. It is possible that other state or federally protected species may use the pond area occasionally, but the resources at the East Landfill Pond are not critical to any of them (DOE 1995j, Appendix D).

3.3.6 Sediments in the East Landfill Pond

A focused or streamlined risk assessment for sediment in the East Landfill Pond is necessary because pond sediment is not a component of the presumptive remedy. Potential exposure pathways identified in the conceptual site model can be used to determine affected media, exposure routes, and potential receptors (Figure 3-7). After contaminants from the leachate seep or from run-off have entered the East Landfill Pond, they may be deposited in sediment at the bottom of the pond, or be taken up by plants or aquatic life in wetland areas. Potential exposure pathways evaluated include inhalation and incidental ingestion of, and dermal contact with sediment from the East Landfill Pond. Potential human receptors include open-space recreational users.

A PRG screen was performed for pond sediment using an open-space exposure scenario (DOE 1995g). Results of the PRG screen are presented in Table 3-3. None of the 20 PCOCs from Section 2.5.5, Nature and Extent of Contamination in Sediments from the East Landfill Pond, exceeded the PRGs for an open-space user, and, therefore, no risk assessment was performed. There is no risk to human health from inhalation or incidental ingestion of, or dermal contact with sediment from the East Landfill Pond.

Potential ecological receptors include aquatic life and terrestrial and avian wildlife. A screening-level ecological risk assessment was performed to determine if PCOCs in sediment present an unacceptable toxicological risk to aquatic life and wildlife (Appendix D). Baseline risk estimates were based on the conservative assumption that receptors spend all of their time at the East Landfill Pond. The HI for exposure of aquatic life to sediments was greater than 1,100. PCOCs contributing most to risk estimates were fluorene, anthracene, chrysene, benzo(b)fluoranthene, and barium. Results of toxicity tests performed on pond sediments are not consistent with these results and indicate no toxicity to aquatic life (Appendix D).

Preliminary risk calculations based on exposure estimations appear to overestimate risks to aquatic life. Based on these calculations, risk of toxicity to sediment-associated organisms appears to be high, but results of site-specific surface-water and sediment toxicity tests indicate no toxicity (Appendix D). In addition, many of the species present in sediment samples are moderately tolerant of polluted sediments suggesting that conditions in the pond are not as toxic as indicated by the hazard quotients. Risk to aquatic life appears to be minimal (Appendix D).

131

Using these assumptions, the HI was greater than 1 for raccoons, mule deer, coyotes, and Preble's meadow jumping mice (mallard HI = 0.8; raccoon HI = 6; mule deer HI = 3; coyote HI = 4; Preble's meadow jumping mouse HI = 3). Risk to raccoons is from potential exposure to aluminum, vanadium, and arsenic. Risk to mule deer, coyotes, and Preble's meadow jumping mice is from potential exposure to aluminum (Appendix D). Again, sources of uncertainty are bioavailability of PCOCs, assumptions about exposures, and importance of the pond as a habitat resource. Although there is risk to terrestrial wildlife, it is unlikely that receptors spend all of their time at the East Landfill Pond, and therefore, the risk is conservatively overestimated.

3.3.7 Surface Soils in Spray Evaporation Areas

A focused risk assessment for surface soils in spray evaporation areas is necessary because surface soils are not a component of the presumptive remedy. Potential exposure pathways identified in the conceptual site model can be used to determine affected media, exposure routes, and potential receptors (Figure 3-8). After contaminants in water from the pond have been sprayed onto the surrounding slopes and have infiltrated the soil, they subsequently may be leached out of the soil by run-off or infiltration/percolation or dispersed by the wind. Potential exposure pathways include particulate inhalation, ingestion, dermal contact, and external irradiation.

Potential human receptors are open-space recreational users. Risks were calculated for PCOCs identified in the combined 0- to 2-inch and 0- to 10-inch soil horizons in the vicinity of the East Landfill Pond. Samples were collected from the landfill eastward across the spray evaporation areas and surrounding slopes and downwind below the dam. A PRG screen was performed for surface soil using an open-space scenario (DOE 1995f). Results of the PRG screen are presented in Table 3-4. The UCL_{95} for each PCOC that failed the PRG screen was used to estimate the risks of incidental ingestion and particulate inhalation of, and external irradiation from surface soil for an open-space recreational user. Risks were not calculated for dermal exposure to surface soils because the surface-soil PCOCs included only metals and radionuclides and, in accordance with EPA guidance, dermal exposure to metals and radionuclides cannot be quantified (EPA 1989a).

The methodology used to evaluate the risks of exposure to surface soil was taken from Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A (EPA 1989a) and Part B (EPA 1991b). The open-space scenario assumes that a recreational user visits the open-space area 25 times per year. Exposure parameters for each pathway are presented in Tables 3-5, 3-6, and 3-7 (DOE 1995h). Intake factors were calculated using the equations listed below.

132

Incidental Ingestion

$$\text{Chemical Intake Factor (mg/kg-day)} = \frac{IR \times ME \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake Factor (mg)} = IR \times ME \times EF \times ED$$

where:
- IR = ingestion rate
- ME = matrix effect in the GI tract (absorption factor)
- EF = exposure frequency
- ED = exposure duration
- BW = body weight
- AT = averaging time

Particulate Inhalation

$$\text{Chemical Intake Factor (m}^3\text{/day)} = \frac{IR \times 1/PEF \times RF \times DF \times ET \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake Factor (kg)} = IR \times 1/PEF \times RF \times DF \times ET \times EF \times ED$$

where:
- IR = inhalation rate
- PEF = particulate emission factor (standard default [EPA 1991b])
- RF = respirable fraction (PM-10)
- DF = respiratory deposition factor
- ET = exposure time
- EF = exposure frequency
- ED = exposure duration
- BW = body weight
- AT = averaging time

External Irradiation

$$\text{Intake Factor (years)} = ET \times SF \times EF \times ED$$

where:
- ET = gamma exposure time factor
- SF = gamma shielding factor
- EF = exposure frequency ratio
- ED = exposure duration

Cancer slope factors and reference doses were taken from Health Effects Assessment Summary Tables (HEAST) (EPA 1994a) and Final Programmatic Risk-Based Preliminary Remediation Goals (DOE 1995e), which includes a compilation of current toxicity factor information. Risks were calculated for ingestion, particulate inhalation,

133

and external irradiation. Results of the risk calculations are presented in Tables 3-8, 3-9, and 3-10. Carcinogenic risk is within the acceptable risk range for incidental ingestion by a child (4E-06), incidental ingestion by an adult (2E-06), particulate inhalation (2E-11), and external irradiation (6E-09). Noncarcinogenic risk (hazard index) is below 1 for incidental ingestion by a child (HI = 0.008) and incidental ingestion by an adult (HI = 0.0009). These results indicate that there is no risk to human health from incidental ingestion, particulate inhalation, or external irradiation from surface soils in spray evaporation areas.

3.3.8 Subsurface Geologic Materials Downgradient of the Landfill

A focused or streamlined risk assessment for subsurface geologic materials downgradient of the landfill is necessary because subsurface soils are not a component of the presumptive remedy. Potential exposure pathways identified in the conceptual site model can be used to determine affected media, exposure routes, and potential receptors (Figure 3-9). After contaminants from the leachate seep into the groundwater, they may migrate downgradient and be deposited in subsurface geologic materials. Potential exposure pathways evaluated include particulate inhalation, ingestion, dermal contact, and external irradiation.

A PRG screen was performed for subsurface geologic materials using an onsite construction-worker exposure scenario (DOE 1995g). Results of the PRG screen are presented in Table 3-11. None of the 10 PCOCs in colluvium or 8 PCOCs in weathered bedrock from Section 2.5.7, Nature and Extent of Contamination in Subsurface Geologic Materials Downgradient of the Landfill, exceeded the PRGs for construction workers, and, therefore, no risk assessment was performed. There is no risk to human health from particulate inhalation and ingestion of, dermal contact with, and external irradiation from subsurface soils downgradient of the landfill.

3.3.9 Groundwater Downgradient of the Landfill

A focused risk assessment for groundwater downgradient of the landfill is necessary because groundwater that has migrated away from the source area is not a component of the presumptive remedy. After contaminants have entered the groundwater, they most likely migrate downgradient through the UHSU to the confluence of No Name Gulch and North Walnut Creek and potentially migrate offsite. Groundwater modeling has shown that migration is slowed considerably or possibly even stopped by the dam. Discharge from groundwater to surface water downgradient of the dam is not expected. The intermittent stream in No Name Gulch is a losing stream that discharges to groundwater. Discharge does occur to the pond. During transport, contaminants in groundwater may be subject to adsorption, hydrolysis, and biological degradation under aerobic or anaerobic conditions.

134

Potential exposure pathways associated with groundwater downgradient of the landfill include inhalation and ingestion of, and dermal contact with groundwater from downgradient wells (Figure 3-10). As recommended by the Future Land-Use Working Group, potential human receptors for groundwater are future onsite office workers. Risks were calculated for PCOCs identified in UHSU groundwater from two populations: wells in the vicinity of the East Landfill Pond upgradient of the dam and wells downgradient of the dam. These populations were evaluated separately to determine the downgradient limit of contamination. In the event that groundwater collection and treatment were needed, the system could be designed to collect only contaminated groundwater instead of all groundwater downgradient of the landfill.

A PRG screen was performed for groundwater using a future onsite office-worker scenario. The maximum detected concentration of each PCOC was compared to the PRG for that analyte (DOE 1995e). Results of the PRG screen are presented in Table 3-12. If the maximum detected concentration or activity of an analyte was less than the PRG, the analyte was dropped from further consideration. If the maximum detected concentration of an analyte was greater than the PRG, the analyte was evaluated in the risk assessment. A focused human health risk assessment was performed for groundwater in both populations using a future onsite office-worker groundwater-ingestion scenario. The UCL_{95} for each PCOC that failed the PRG screen was used to calculate the risks of groundwater ingestion.

The methodology used to assess risks at OU 7 was taken from Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part A (EPA 1989a). The future onsite office-worker scenario assumes that a worker ingests 1 liter of water per day for 250 days per year. Exposure parameters are presented in Table 3-13 (DOE 1995h). Intake factors were calculated using the equations listed below.

Groundwater Ingestion

$$\text{Chemical Intake Factor (L/kg-day)} = \frac{IR \times FI \times EF \times ED}{BW \times AT}$$

$$\text{Radionuclide Intake Factor (liters)} = IR \times FI \times EF \times ED$$

where:
- IR = ingestion rate
- FI = fraction ingested from the contaminated source
- EF = exposure frequency
- ED = exposure duration
- BW = body weight
- AT = averaging time

Oral cancer slope factors and oral reference doses were taken from HEAST (EPA 1994a) and Final Programmatic Risk-Based Preliminary Remediation Goals (DOE 1995e), which includes a compilation of current toxicity factor information. Results of the risk calculations are presented in Table 3-14.

The carcinogenic risk from ingestion of UHSU groundwater in the vicinity of the pond upgradient of the dam is within the acceptable risk range of 1E-04 to 1E-06 (1E-05); however, the noncarcinogenic risk is above the acceptable risk or HI of 1 (HI = 3). The primary contributor to noncarcinogenic risk is selenium (HI = 1.5).

The risks from ingestion of UHSU groundwater downgradient of the dam are within the acceptable risk range (carcinogenic risk less than 1E-06; noncarcinogenic risk, HI = 0.2). Therefore, there is no risk to future onsite office workers from ingestion of UHSU groundwater downgradient of the dam. There is some potential risk associated with ingestion of UHSU groundwater in the vicinity of the East Landfill Pond upgradient of the dam. However, the potential exposure pathway associated with groundwater downgradient of the landfill is incomplete. There are no plans to develop groundwater in the future, therefore, no one will be ingesting groundwater from wells.

3.4 Compliance with ARARs

Pursuant to the IAG, onsite remedial actions at OU 7 must comply with all applicable RCRA and CHWA requirements and must also address CERCLA requirements (DOE 1991b). CERCLA Section 121(d), as amended by SARA, requires that, at a minimum, any remedial action achieve overall protection of human health and the environment and comply with ARARs. Laws included under this ARARs umbrella include all federal environmental laws and state standards more stringent than their federal counterpart. State regulations promulgated under federally authorized programs are considered federal requirements (EPA 1990a). Because Rocky Flats is a DOE facility, DOE orders apply with the same force as applicable federal regulations (EPA 1989b).

Laws and regulations identified as ARARs are either applicable or relevant and appropriate. Applicable requirements are those "cleanup standards, standards of control, or other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental laws; or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site" (40 CFR Part 300.5). Relevant and appropriate requirements are defined as "those standards that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site" (40 CFR Part 300.5).

136

ARARs are used to create a framework for determining the health and risk-based limits for remedial action and to develop remedial alternatives. Ultimately, it is necessary to demonstrate that the final remedy addresses all pathways and contaminants of concern, not just those that trigger the need for remedial action (EPA 1991a). Onsite actions must comply only with the substantive aspects of ARARs; offsite activities must adhere to both substantive and administrative requirements. Substantive requirements include cleanup standards or levels of control; administrative requirements prescribe methods and procedures such as fees, permitting, inspection, and reporting requirements.

There are three types of ARARs: chemical-specific, location-specific, and action-specific. This division is a convenient way to categorize regulations in a way that ties them to the remedial process. The following sections identify potential ARARs for OU 7 by type of requirement. In addition, guidance to be considered (TBC) is identified where appropriate. TBCs are advisories, criteria, or guidance that may be useful in developing CERCLA remedies (40 CFR Part 300.400[g][3]). TBCs may be used to supplement promulgated standards when the meaning of those standards is ambiguous or when they do not address a particular situation.

3.4.1 Potential Chemical-Specific ARARs

Chemical-specific ARARs identify acceptable limits for an amount or concentration of a chemical that may be present in the environment. These standards usually take the form of health-based or risk-based numerical limitations that restrict ambient concentrations of various chemical substances above a threshold level. All applicable or relevant and appropriate federal chemical-specific standards (e.g., maximum contaminant levels [MCLs] and land disposal restrictions [LDRs] universal treatment standards) must be complied with when determining appropriate cleanup levels for landfill leachate, surface water in the East Landfill Pond, and groundwater downgradient of the landfill. State ARARs must also be complied with if they are promulgated and are more stringent than federal standards. For chemicals that do not have associated federal or state potential ARARs, the practical quantitation limit (PQL), cited in the regulations, or 10 times the EPA Contract Laboratory Program detection limit when no PQL is cited, is proposed. Table 3-15 presents potential chemical-specific ARARs for surface water. Table 3-16 presents potential chemical-specific ARARs for groundwater. There are no chemical-specific ARARs for sediments or surface soils.

3.4.1.1 Landfill Leachate at the Seep

Mean concentrations of all analytes detected in landfill leachate at the seep were compared to the potential chemical-specific ARARs for surface water. Mean concentrations of three metals (aluminum, manganese, and zinc), two SVOCs

(2-methylnaphthalene, naphthalene), and five VOCs (benzene, methylene chloride, tetrachloroethane, vinyl acetate, and vinyl chloride) exceed potential ARARs (Table 3-17). Of these, the maximum detection of tetrachloroethane is less than the ARAR; however, the mean exceeds the ARAR because one-half the detection limit was used for non-detects in calculating the mean result, and the detection limits vary and can be quite high. Vinyl acetate was detected in only one of 19 samples, and although this detection exceeds the ARAR, the single detection suggests that this detection is an outlier and is not representative of landfill leachate. The maximum detection of methylene chloride is from 1990. These data were never validated and are "B" qualified, indicating that they were detected in the laboratory blank. These data are not appropriate for an ARARs comparison, and therefore tetrachloroethane, vinyl acetate, and methylene chloride are not considered further.

Seven analytes exceed ARARs in landfill leachate: aluminum, benzene, manganese, 2-methylnaphthalene, naphthalene, vinyl chloride, and zinc.

3.4.1.2 Surface Water in the East Landfill Pond

Mean concentrations of all analytes detected in surface water in the East Landfill Pond were compared to the potential chemical-specific ARARs for surface water. Mean concentrations of one metal (manganese) and one VOC (vinyl acetate) exceed potential ARARs (Table 3-18). Vinyl acetate was detected in only one of 19 samples, and although this detection exceeds the ARAR, the low detection frequency suggests that this detection is an outlier and is not representative of surface water in the pond. Sixty percent of the manganese detections exceed the ARAR for manganese.

3.4.1.3 Groundwater Downgradient of the Landfill

Mean concentrations of all analytes detected in UHSU groundwater in individual wells downgradient of the landfill (in the vicinity of the pond and downgradient of the dam) were compared to the potential chemical-specific ARARs for groundwater. Mean concentrations of one metal (selenium), four VOCs (1,1-dichloroethane, benzene, carbon tetrachloride, and tetrachloroethene), and three indicator parameters (fluoride, nitrate/nitrite, and sulfate) exceed potential ARARs (Table 3-19).

Of these, the maximum detections of 1,1-dichloroethane, benzene, and tetrachloroethene are less than their respective ARARs; however, the mean exceeds the ARAR because one-half the detection limit was used for non-detects in calculating the mean result. Carbon tetrachloride was detected in two of 18 samples, and only one of these detections exceeds the ARAR; the low detection frequency suggests that this detection is an outlier and is not representative of contaminants from the landfill source. Fluoride was detected in five samples in one well; one of the detections exceeds ARARs. The low detection frequency and the limited spatial extent of fluoride

suggests that this detection is an outlier and is not representative of contaminants from the landfill. These data are not appropriate for an ARARs comparison, and therefore, 1,1-dichloroethane, benzene, tetrachloroethene, carbon tetrachloride, and fluoride are not considered further.

Three analytes exceed ARARs in UHSU groundwater downgradient of the landfill: nitrate/nitrite, selenium, and sulfate. Selenium exceeds ARARs only in UHSU groundwater in the vicinity of the pond. Nitrate/nitrite and sulfate exceed ARARs in UHSU groundwater in the vicinity of the pond and downgradient of the dam.

Contaminant-transport modeling was performed to simulate the movement of contaminants in groundwater to evaluate the effect of potential releases and determine how far contaminants that currently exceed ARARs will travel downgradient after landfill closure. Two-dimensional contaminant-transport modeling was performed using an analytical solution developed by Domenico and Robbins (1985) and coded into the TPLUME model (Golder Associates 1989). The input parameters and Surfer plots of outputs are presented in Appendix E. Model simulations were performed for chloride, selenium, and sulfate in surficial materials and for chloride, nitrate/nitrite, selenium, and sulfate in weathered bedrock. Chloride was modeled because it is an indicator parameter for VOCs.

For weathered bedrock, a sensitivity analysis on hydraulic conductivity was performed. Using the geometric mean hydraulic conductivity for weathered bedrock measured at OU 7 (4E-07 cm/sec), all of the modeled contaminants exhibited minimal movement (Appendix E, Figures E8 through E11). At this hydraulic conductivity, transport is controlled by diffusion. The UCL_{95} of sitewide hydraulic conductivity values for weathered bedrock (5.6E-05 cm/sec) was used in another set of simulations. These simulations exhibited more contaminant movement than the initial simulations, but none of the simulated contaminant plumes reached downgradient well 53194 (Appendix E, Figures E12 through E15). Based on these simulations and the flow regime in the weathered bedrock (Section 2.3), the weathered bedrock pathway is not considered to be complete with respect to human or environmental receptors.

For surficial materials, the contaminant modeling showed that ARARs would be exceeded for selenium and sulfate at downgradient well 53194 in 30 years if the dam were removed. However, there are several reasons why these modeling results are overly conservative:

- Constant source versus declining source assumption. The TPLUME model assumes a constant source of contamination over the entire period of the simulation. Actual conditions at OU 7 indicate a declining source(s). If the landfill mass is the source of contaminants, the proposed cap and slurry wall (to be performed as a maintenance action) will reduce groundwater flow through the landfill and

139

contaminant transport out of the landfill. For selenium, the source is suspected to be naturally occurring selenium dissolved from the soil matrix by groundwater unsaturated with respect to selenium. This groundwater may be related to the spray evaporation of pond water. Since the spray evaporation ended in 1994, this source should be reduced over time. For sulfate and nitrate/nitrite, the source is suspected to be either the buried sludges in IHSSs 166.1 and 166.3 or naturally occurring sulfate and nitrate released from the soil matrix. Although the existing nitrate/nitrite data do not show any temporal trends, the sulfate data show a slight but distinct decrease in concentrations over time.

- Use of weathered-bedrock concentrations as source terms for surficial-materials modeling. The TPLUME simulations for selenium and sulfate used weathered-bedrock concentrations as source terms for surficial-materials modeling because of data gaps for surficial materials. This assumption is excessively conservative. The measured potentiometric surfaces show a strong downward hydraulic gradient between the surficial materials and weathered bedrock in the vicinity of the dam with head differences of more than 20 feet. The measured concentrations of selenium and sulfate in surficial materials are much lower than the measured concentrations in the weathered bedrock.

- Effect of the East Landfill Pond dam as a barrier to contaminant migration. The TPLUME model assumes homogeneous, isotropic conditions and cannot account for hydraulic barriers. As a result, the model does not take into account the effect of the dam as a barrier to contaminant migration. As described in Sections 2.3 and 2.5, and Appendix C, the dam has proven to be a significant barrier to groundwater flow and contaminant migration in surficial materials.

Based on the flow modeling and particle tracking in Appendix C and the contaminant-transport modeling in Appendix E, contaminant migration down No Name Gulch is expected to be minimal. Although the landfill has been operational for almost 30 years, leachate migration has been insignificant. Wells 4287, 52894, and 53194 will be adequate to monitor groundwater quality downgradient of the landfill. Exceedance of ARARs at these wells is not expected during the 30-year post-closure period. The carcinogenic risk levels associated with the ingestion of groundwater by onsite office workers is less than 1E-06. The noncarcinogenic risk is above the acceptable risk or HI of 1 (HI = 3). However, the exposure pathway associated with the UHSU groundwater downgradient of the landfill is incomplete. This risk should stay in the acceptable range over the 30-year post-closure monitoring period. As the landfill cap and slurry wall reduce leachate generation, migration, and contaminant loading, the water quality in the monitoring wells will improve.

Wells downgradient of the dam that meet potential ARARs for UHSU groundwater include 4287, 52894, and 53194.

3.4.2 Potential Location-Specific ARARs

Location-specific ARARs identify requirements that apply because the site has a special quality related to geography or the presence of a protected resource. These requirements may limit the remedial action that may be implemented or create the need for more stringent remedial efforts. Potential location-specific ARARs for OU 7 are presented in Table 3-20. Location-specific ARARs most pertinent to OU 7 concern wetlands, floodplains, and endangered species. Also of concern are historic, natural, cultural, or archaeological resources.

3.4.2.1 Wetlands Requirements

Remedial actions at OU 7 will have to be implemented to minimize the destruction, loss, or degradation of wetlands (40 CFR 6.302[a]). As described in Section 2.4.3, wetlands have been designated along the shoreline and within the East Landfill Pond by the U.S. Army Corps of Engineers (Figure 2-12) (COE 1994). The wetland composes about 1.6 percent of the total wetlands at Rocky Flats. The loss of wetland areas that fall under the proposed footprint of the landfill cover and injury to remaining wetland areas will be mitigated as needed.

A wetlands assessment will be required under 40 CFR Part 6. The Clean Water Act (CWA) Section 404 (40 CFR Part 6) requires a permit for actions to dispose of dredge and fill material in waters of the United States. Because the East Landfill Pond and pond margins have been designated as wetlands, they are considered waters of the United States under the CWA. Remedial actions will likely impact the pond; consequently, the CWA Section 404 permitting requirements and Executive Order 11990 have been identified as potential ARARs and substantive provisions must be met (Table 3-20).

3.4.2.2 Floodplain Requirements

The remedial action is not required to comply with the Floodplain Environmental Review Requirements in 10 CFR 1022, because the floodplains at Rocky Flats do not meet the definition in the regulation (DOE 1994e). Floodplains are defined in 10 CFR 1022 as "the lowlands adjoining inland and coastal waters and relatively flat areas and flood prone areas of offshore islands including, at a minimum, that area inundated by a one percent or greater chance of flood in any given year." The floodplains at Rocky Flats do not adjoin inland bodies of water, nor are they relatively flat, flood prone areas. Although the streams that flow through the site have a mappable 100-year floodplain, these are not floodplains as defined in 10 CFR 1022, and therefore, floodplain requirements of 10 CFR 1022 do not apply.

3.4.2.3 Threatened or Endangered Species Requirements

Riparian areas along No Name Gulch and the areas adjacent to the East Landfill Pond have been identified as potential habitat for Preble's meadow jumping mouse (Figure 2-12), which is protected under the Colorado Nongame, Endangered, or Threatened Species Conservation Act (CRS 33-2-101 to 107). This act is a potential ARAR for OU 7. Given the current protection of the Preble's meadow jumping mouse under state law, DOE's commitment to protect natural resources under the Natural Resource Trustee Memorandum of Understanding (DOE 1994f), and the potential for listing Preble's meadow jumping mouse under the Endangered Species Act, habitat mitigation will be performed as needed.

3.4.2.4 Historic, Archaeological, and Cultural Resource Requirements

Compliance with federal and state laws designed to preserve areas with historical, natural, cultural, or archaeological value requires the identification of cultural resources and prehistoric or historic artifacts located at OU 7. An archaeological and historical study of the Rocky Flats area was conducted in 1989 (Burney *et al.* 1989). Cultural resource site density appears to be fairly low. The study found some evidence of short-term prehistoric use such as camping, hunting, and scattered historic settlement; however, the rocky terrain and thin soils prevented more intense, long-term use of the area. The historic preservation officer for the state of Colorado reviewed these findings and concluded that "there will be no effect on significant cultural resources by undertakings proposed" at Rocky Flats (CHS 1992).

3.4.3 Potential Action-Specific ARARs

Action-specific ARARs are management, performance, or treatment standards that are triggered by the particular activities selected to accomplish a remedy. Action-specific requirements do not, in themselves, determine the remedial alternative; rather, they indicate how a selected alternative must be achieved. Table 3-21 lists the potential federal and state action-specific ARARs that have been identified for OU 7. Table 3-22 lists standards and other guidance that have been identified as TBC. Action-specific ARARs most pertinent to OU 7 are RCRA and CHWA closure requirements, air-emission requirements, delisting requirements, discharge requirements under the National Pollutant Discharge Elimination System (NPDES), and post-closure groundwater-monitoring requirements.

3.4.3.1 Closure Requirements

Because records indicate that some hazardous waste was disposed at the landfill, it was designated as an interim status RCRA-regulated unit and was included in the Part B permit application for Rocky Flats (Rockwell International 1986). The Present Landfill

142

is being closed under interim status regulations in accordance with Section I.B.11.b of the IAG (DOE 1991a). CHWA and RCRA Subtitle C closure requirements are applicable because hazardous wastes were disposed in the Present Landfill after November 19, 1980, which is the effective date of RCRA (EPA 1993a).

Two types of closure are allowed under RCRA Subtitle C: clean closure and landfill closure. The Present Landfill at OU 7 will be closed under landfill closure standards, which require post-closure care and maintenance of the unit for at least 30 years after closure (EPA 1989c). Closure ARARs require that the landfill must be capped with a final cover designed and constructed to provide long-term minimization of migration of liquids, function with minimum maintenance, promote drainage and minimize erosion, accommodate settling and subsidence, and have a permeability less than or equal to the natural subsoils present (6 CCR 1007-3 Part 265.310[a]). Post-closure care includes maintenance of the final cover and maintenance of a groundwater-monitoring system (6 CCR 1007-3 Parts 265.117 and 265.228[b]).

3.4.3.2 Air-Emission Requirements

Closure of the Present Landfill could potentially trigger some air pollution control and permitting requirements. Placement of the cap will require standard construction project dust-control measures. The final capped facility could potentially release regulated quantities of VOCs and other regulated air pollutants. An evaluation of applicable federal and Colorado regulations governing these types of facilities relative to air permitting is described below.

Colorado Air Regulation No. 1 requires new construction projects on sites over 1 acre in a non-attainment area to implement standard dust-control measures defined in the regulations. The placement of the cap as part of a CERCLA action would meet the definition of new construction under Regulation No. 1. Thus, the requirements for dust control would be considered an ARAR under CERCLA. Additionally, unpaved roadways with vehicle traffic of 150 vehicles per day (in a non-attainment area) and haul roads exceeding 40 haul loads or 200 vehicles per day are required to submit a control and abatement plan describing the control measures that will be taken to minimize such fugitive-dust generation. Some standard dust-control measures are provided in Regulation No. 1 and include basic activities such as application of dust suppressant, covering hauled loads, and daily compaction of the construction site, which should not greatly impact the planned activities.

Air pollution control permits for sources in Colorado are issued by the Air Pollution Control Division of CDPHE. Requirements are outlined in Colorado Air Quality Control Commission (CAQCC) Regulation No. 3 and include requirements for operating permits and for prevention of significant deterioration (PSD). Facilities

subject to these requirements must file an air pollutant emission notice (APEN) for each source or group of sources of uncontrolled emissions. Facilities that file an APEN must then determine whether they will require a construction permit under Part B of Regulation No. 3. Applicability can be triggered in three ways.

- For each potential emission point, a determination is made whether actual uncontrolled emissions of criteria pollutants (CO, NO_x, SO_2, particulates [PM-10], total suspended particulates [TSP], ozone [O_3], VOCs, lead, fluorides, H_2SO_4 mist, H_2S, total reduced sulfur, reduced sulfur compounds, and municipal waste combustion products) are above established *de minimis* levels. Determinations are based on either actual measured data or on estimates developed by approved methods.

- Colorado has developed its own system for estimating the actual uncontrolled emissions of a designated set of HAPs based on the location of the emission point, distance from the property line, height of the release point, and reporting "bin", or category, of the pollutant being evaluated. If any HAPs are emitted above *de minimis* levels, the facility must file an APEN.

- Specific categories of sources are required to file for permits based on standards developed for their operations. No specific requirements for municipal solid-waste landfills currently exist in Colorado regulations, and there are no plans to include specific requirements for landfills until federal regulations are finalized.

Thresholds for triggering required reporting and permitting activities are based on whether the source is located in an attainment or non-attainment area, as defined in the regulations. Rocky Flats is located in a non-attainment area. The threshold limit requiring an APEN for uncontrolled emissions of criteria pollutants is 1 ton per year. If it can be demonstrated that emissions of criteria pollutants from the entire facility are less than 1 ton per year, then no APEN is required. As outlined in the NCP, only the substantive requirements must be met for onsite CERCLA responses (55 Federal Register 8756, March 8, 1990).

Requirements for air pollution control and permitting for landfills are contingent on the type of landfill operation. At the federal level, landfills considered municipal solid-waste landfills have been the subject of a rulemaking process that resulted in a proposed rule (56 Federal Register 24468, May 30, 1991), a revision to the proposed rule (58 Federal Register 33790, June 21, 1993), and significant internal and external review and comment. No final rule has been published at this time. Hazardous waste landfills permitted under RCRA are not covered under the proposed rules but are subject to specific requirements at the time of closure in terms of cap design and other monitoring. However, there are no specific provisions in the RCRA treatment, storage, and disposal facility regulations for air pollution controls.

144

Based on this regulatory status, no specific landfill air pollution control standards apply to OU 7.

Closure of the landfill will require an APEN, a construction permit, development of a fugitive emission control plan, and implementation of standard dust control procedures during construction. Specific controls for gas emissions from the landfill after closure are not expected to be required based on estimated emission rates of NMOCs.

3.4.3.3 Delisting Requirements

DOE proposes to delist landfill leachate, which is considered F039 RCRA-listed waste contained in groundwater (EPA 1990a). Under the presumptive remedy, it is proposed that the leachate be delisted (i.e., shown to be nonhazardous) and thus no longer subject to CHWA and RCRA Subtitle C hazardous waste regulations. Instead, the leachate will be managed in accordance with CHWA and RCRA Subtitle D requirements, which are ARARs for leachate. If leachate or groundwater sampling during the post-closure period shows that the maximum allowed concentrations (MACs) are not being attained for delisting, the leachate will be managed as Subtitle C hazardous waste and ARARs under Subtitle C will be met.

The basis for delisting is that the leachate is not hazardous, does not exhibit hazardous-waste characteristics, and does not pose a threat to human health or the environment (Section 3.3.4). In addition, the proposed remedy (landfill cap) will cover the seep area, prevent exposure to leachate, reduce contaminant leaching to groundwater, and ultimately reduce leachate generation and migration (Section 2.3.5). A slurry wall will be constructed as a maintenance action to reduce groundwater inflow, leachate generation, and outflow at the seep. In addition, leachate will be collected and treated at the seep as an accelerated action before closure. As the landfill dewaters, leachate generation is reduced, and a decrease in contaminant concentrations in leachate is expected. As outlined in the NCP (55 Federal Register 8756, March 8, 1990), only the substantive requirements of delisting must be met for onsite CERCLA responses.

The substantive requirements of 40 CFR 260.20 and 260.22 are documented here and include a general discussion of why delisting is warranted, concentrations of each constituent remaining, comparison of actual concentrations to the MACs for specific constituents, results of fate and transport modeling to show calculated concentrations at a receptor well, and a contingency plan to address leachate that does not achieve delistable levels. These requirements are outlined in A Guide to Delisting of RCRA Wastes for Superfund Remedial Responses (EPA 1990b) and clarified in Petitions to Delist Hazardous Wastes - A Guidance Manual (EPA 1993b). EPA guidance requires upgradient and downgradient groundwater-monitoring data for delisting decisions (EPA 1993b). Upgradient data are summarized in the OU 7 Final Work Plan (DOE

145

1994a). Downgradient data are presented in this report. Statistical comparisons of upgradient data to downgradient data are presented in the Annual RCRA Groundwater Monitoring Report (EG&G 1994a).

Concentrations of contaminants in the leachate are presented in Tables 2-4, 3-1, and 3-16. Concentrations of contaminants in groundwater downgradient of the leachate seep are presented in Tables 2-10, 2-11, 3-11, 3-13, and 3-18. The text corresponding to these tables describes the nature and extent of contamination (Sections 2.5.3 and 2.5.8), risk evaluations (Sections 3.3.4 and 3.3.9), and compliance with potential chemical-specific ARARs (Section 3.4.1). Table 3-23 provides a comparison of maximum detected concentrations in leachate at the seep to MACs from the delisting guidance (EPA 1990b). The maximum detected concentration of only one analyte exceeds the MAC. The maximum detection of 1,1-dichloroethane in leachate is 10 µg/L; the MAC is 2.524 µg/L. However, the detection limit (5 µg/L) is also greater than the MAC. The potential ARAR for 1,1-dichloroethane is 59 µg/L.

Two-dimensional contaminant-transport modeling was performed using the methodology described previously. The input parameters and Surfer plots of outputs are presented in Appendix E. Model simulations were performed for 1,1-dichloroethane in surficial materials. Well 53194 was used as the receptor well. The contaminant modeling showed that the MAC for 1,1-dichloroethane would not be exceeded at downgradient well 53194 in 30 years. As the landfill cap and slurry wall reduce leachate generation, migration, and contaminant loading, the water quality in downgradient monitoring wells will improve. As described in Sections 2.3 and 2.5 and Appendix C, the dam has proven to be a significant barrier to groundwater flow and contaminant migration in surficial materials.

In accordance with the requirements for delisting (EPA 1990b, EPA 1993b), groundwater monitoring will be performed during the post-closure period to determine whether MACs for delisting have been attained. A contingency plan will be developed to address leachate and groundwater that do not meet delistable levels.

3.4.3.4 Discharge Requirements

Criteria and standards for NPDES (40 CFR Part 125) under the Clean Water Act and Colorado Water Quality Control Act are applicable under the IAG (DOE 1991b). Because OU 7 is an onsite CERCLA action, an NPDES permit is not required for discharges from the East Landfill Pond to No Name Gulch. However, DOE will have to comply with the substantive provisions of these acts. In the short term, effluent limitations will be achieved through the accelerated action or leachate treatment system. In the long term, effluent limitations will be achieved with the final remedy or

landfill cap. After closure, excess water in the East Landfill Pond will be discharged to No Name Gulch. Discharge requirements will be negotiated with CDPHE and EPA.

3.5 Final Remedial Action Objectives or Response Actions

Final RAOs were developed based on preliminary RAOs (Section 3.1), the conceptual site model for defining risks, exposure pathways, site risks, potential ARARs, and the presumptive remedy approach. A quantitative risk assessment is not necessary to evaluate whether the containment remedy addresses all pathways and contaminants of concern associated with the source. Rather, all potential exposure pathways identified using the conceptual site model were compared to the pathways addressed by the containment presumptive remedy (EPA 1993a). Exposure pathways addressed by the presumptive remedy include direct contact with the source and exposure to leachate and landfill gas (Table 3-24).

For media not addressed by the presumptive remedy, EPA guidance (EPA 1993a) states that an active response is not required if contaminant concentrations exceed chemical-specific standards but the site risk is within the acceptable risk range for carcinogens (1E-04 to 1E-06). Risks were evaluated and an ARARs comparison was performed for these media. A reasonably anticipated future land use, the open-space scenario, was used for evaluating risks from exposure to leachate, surface water, sediment, and surface soils. Onsite construction-worker and onsite office-worker scenarios were used for evaluating risks from exposure to subsurface geologic materials and groundwater downgradient of the landfill, respectively. Ultimately, it is necessary to demonstrate that the final remedy addresses all pathways and contaminants of concern.

3.5.1 Elimination of Preliminary RAOs

Preliminary RAOs were eliminated from the final response action because (1) there is no risk to the potential receptor, (2) analytes do not exceed ARARs, or (3) the exposure pathway is incomplete. RAOs eliminated include the following:

- Collect and treat leachate at the source
- Remediate surface water in the East Landfill Pond
- Remediate sediments in the East Landfill Pond
- Remediate surface soils in spray evaporation areas
- Remediate subsurface geologic materials downgradient of the landfill
- Control groundwater at the source to contain the plume
- Remediate groundwater downgradient of the landfill

The rationale for eliminating each of these RAOs is summarized in Table 3-24 and presented below.

147

3.5.1.1 Collect and Treat Leachate at the Source

Potential exposure to landfill leachate will be addressed by the presumptive remedy for source containment (Table 3-24). The proposed landfill cap will cover the seep area and prevent exposure to leachate, reduce leachate generation and migration, and reduce contaminant loading to groundwater. A slurry wall will be constructed as a separate action to reduce groundwater inflow, leachate generation, and outflow at the seep. In addition, leachate will be collected and treated at the seep as an accelerated action for OU 7 before closure, even though leachate collection and removal activities are not required for closure of interim-status units (6 CCR 1007-3 Part 265.310).

Based on results of the PRG screen and ecological risk assessment, there is no associated risk to human health from landfill leachate. The cumulative risk for avian and terrestrial wildlife, expressed as the HI, was greater than 1 for mallards, raccoons, and coyotes. Because it was assumed that these species spend all of their time at the East Landfill Pond, risk was overestimated. Based on results of an ARARs comparison, seven analytes exceed ARARs in landfill leachate: aluminum, benzene, manganese, 2-methylnaphthalene, naphthalene, vinyl chloride, and zinc. Only one analyte (1,1-dichloroethane) is above MACs for delisting, and the detection limit for 1,1-dichloroethane is greater than the MAC.

DOE proposes to monitor discharge from the passive leachate-treatment system until the landfill cover is constructed. After the containment presumptive remedy is in place, the seep discharge point will be covered, approximately 94 percent of the source water will be eliminated (Section 2.3), and the pathway for exposure of human and ecological receptors to leachate will be incomplete.

3.5.1.2 Remediate Surface Water in the East Landfill Pond

Based on results of the PRG screen, there is no associated risk to human health or terrestrial or aquatic organisms from surface water in the pond (Table 3-24). One of the surface water PCOCs exceeded state water quality standards or risk-based benchmarks (manganese). For ecological receptors the cumulative risk, expressed as the HI, was greater than 1 only for mallards. Because it was assumed that mallards spend all of their time at the East Landfill Pond, risk to mallards was overestimated. The pond exceeds only one potential ARARs for surface water (manganese).

DOE proposes to leave the portion of the pond and wetlands not covered by the cap in place. The East Landfill Pond represents approximately 1.6 percent of the total wetland area at Rocky Flats (COE 1994) and has been identified as potential habitat for the Preble's meadow jumping mouse (DOE 1995b). The dam acts as a barrier to groundwater migration and is effective in preventing contaminants in groundwater from migrating down No Name Gulch.

3.5.1.3 *Remediate Sediments in the East Landfill Pond*

Based on results of the PRG screen and the ecological risk assessment, no response action is required for sediments in the East Landfill Pond because the sediments pose no risk to human health and minimal risk to aquatic life and wildlife (Table 3-24). DOE proposes to leave the pond sediments in place.

3.5.1.4 *Remediate Surface Soils in Spray Evaporation Areas*

Because carcinogenic risks fall below or within the EPA acceptable risk range of 1E-04 to 1E-06 and noncarcinogenic risks are below the HI of 1, surface soils do not require a response action (Table 3-24). DOE proposes to leave the surface soils in the vicinity of spray evaporation areas undisturbed.

3.5.1.5 *Remediate Subsurface Geologic Materials Downgradient of the Landfill*

Based on the PRG screen, no response action is required for subsurface geologic materials downgradient of the landfill because the subsurface soils pose no risk to human health (Table 3-24). DOE proposes to leave the subsurface soils undisturbed.

3.5.1.6 *Control Groundwater at the Source to Contain the Plume*

Source-area groundwater control to contain the plume will be addressed in several ways. As described in Section 2.3.5, the presumptive remedy (landfill cap) and maintenance actions (slurry wall) will reduce inflow to the landfill by approximately 94 percent, which will reduce the flow rate of the leachate seep. The proposed landfill cap will cover the seep area, reducing contaminant leaching to groundwater. Groundwater modeling has shown that migration is likely slowed considerably or possibly even stopped by the dam. Discharge from groundwater to surface water is not expected downgradient of the dam because the intermittent stream in No Name Gulch is a losing stream that discharges to groundwater. Discharge does occur to the pond. Groundwater in the UHSU may also seep down into the confining layers of the unweathered bedrock; however, hydraulic conductivity values for the confining layer are low and downward seepage is minimal.

3.5.1.7 *Remediate Groundwater Downgradient of the Landfill*

The carcinogenic risk from ingestion of UHSU groundwater in the vicinity of the pond upgradient of the dam is within the acceptable risk range of 1E-04 to 1E-06 (1E-05); however, the noncarcinogenic risk is above the acceptable risk or HI of 1 (HI = 3). The primary contributor to noncarcinogenic risk is selenium (HI = 1.5). The risks from ingestion of UHSU groundwater downgradient of the dam are within the acceptable risk range (carcinogenic risk less than 1E-06; noncarcinogenic risk, HI = 0.2). Therefore, there is minimal risk to future onsite office workers from ingestion of

149

UHSU groundwater. The potential exposure pathway associated with UHSU groundwater downgradient of the landfill is incomplete because the containment presumptive remedy will eliminate approximately 94 percent of the source water and the seep discharge point will be covered, which eliminates the contaminant release/transport mechanism. No plans are anticipated for the future development of groundwater for any use at OU 7, which eliminates the exposure route (Table 3-24).

Three analytes exceed ARARs in UHSU groundwater downgradient of the landfill: nitrate/nitrite, selenium, and sulfate. Selenium exceeds ARARs only in groundwater in the vicinity of the pond. (Selenium was not detected in groundwater downgradient of the dam.) Contaminant-transport modeling indicates that concentrations of selenium in groundwater will exceed ARARs at well 53194 in 30 years (Appendix E); however, the modeling neglected the effects of the dam, which would likely impede the migration of contaminants, and uses concentrations in weathered bedrock for surficial materials (Section 2.5.7). In addition, the pond area will be covered by the landfill cap, reducing the amount of recharge to groundwater in this area. Nitrate/nitrite and sulfate exceed ARARs in groundwater in the vicinity of the pond and downgradient of the dam. Contaminant-transport modeling indicates that concentrations of sulfate in groundwater will exceed ARARs at well 53194 in 30 years because the sulfate source appears to be downgradient of the dam (Appendix E). The groundwater modeling is excessively conservative because it assumes a constant source; uses concentrations in weathered bedrock for surficial materials; assumes homogeneous, isotropic conditions; and does not take into account the effect of the dam (Section 3.4.1.3).

Wells downgradient of the dam that meet potential ARARs for UHSU groundwater include 4287, 52894, and 53194. These wells are proposed as downgradient wells for the post-closure groundwater-monitoring system (6 CCR 1007-3 Part 265.90[a]). Samples collected from these wells are representative of groundwater quality downgradient of the landfill, and the wells are capable of detecting potential future releases from the landfill.

3.5.2 Development of Final RAOs

Final RAOs that will be used for the identification and screening of technologies (Section 4) and the development of alternatives (Section 5) include the following:

- Prevent direct contact with landfill contents
- Minimize infiltration and resulting contaminant leaching to groundwater
- Control surface-water run-off and erosion
- Control landfill gas (treat as needed)
- Remediate wetland areas (as needed)

Section 3
Tables

151

Table 3-1
Preliminary Remediation Goal (PRG) Screen for Leachate at the Seep

PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Surface Water PRG[1]	Units	Maximum > PRG[2]
Metals					
Antimony	60.4	SW097	13,600	µg/L	no
Barium	1,550	SW097	2,380,000	µg/L	no
Iron	155,000	SW097	—	µg/L	no
Lithium	107	SW097	681,000	µg/L	no
Manganese	2,490	SW097	170,000	µg/L	no
Strontium	1,370	SW097	20,400,000	µg/L	no
Zinc	16,000	SW097	10,200,000	µg/L	no
Radionuclides					
Strontium-89,90[3]	4.06	SW097	795	pCi/L	no
Tritium	1,500	SW097	823,000	pCi/L	no
Indicator Parameters					
Nitrite	63	SW097	3,410,000	µg/L	no
Semivolatile Organic Compounds					
2,4-Dimethylphenol	3	SW097	681,000	µg/L	no
2-Methylnaphthalene	23	SW097	—	µg/L	no
4-Methylphenol	4	SW097	—	µg/L	no
Acenaphthene	3	SW097	2,040,000	µg/L	no
Bis(2-ethylhexyl)phthalate	2	SW097	5,680	µg/L	no
Dibenzofuran	2	SW097	—	µg/L	no
Diethyl phthalate	3	SW097	27,300,000	µg/L	no
Fluorene	3	SW097	1,360,000	µg/L	no
Naphthalene	22	SW097	1,360,000	µg/L	no
Phenanthrene	5	SW097	—	µg/L	no
Volatile Organic Compounds					
1,1-Dichloroethane	10	SW097	3,410,000	µg/L	no
1,2-Dichloroethene	14	SW097	307,000	µg/L	no
2-Butanone	76	SW097	20,400,000	µg/L	no
2-Hexanone	10	SW097	—	µg/L	no
4-Methyl-2-pentanone	87	SW097	2,730,000	µg/L	no
Acetone	220	SW097	3,410,000	µg/L	no
Benzene	2	SW097	2,740	µg/L	no

Table 3-1
Preliminary Remediation Goal (PRG) Screen for Leachate at the Seep

PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Surface Water PRG[1]	Units	Maximum > PRG[2]
Chloroethane	57	SW097	—	µg/L	no
Chloromethane	7	SW097	6,110	µg/L	no
Ethylbenzene	18	SW097	3,410,000	µg/L	no
Toluene	88	SW097	6,810,000	µg/L	no
Total xylenes	25	SW097	68,100,000	µg/L	no
Trichloroethene	4	SW097	7,230	µg/L	no
Vinyl chloride	11	SW097	41.8	µg/L	no
o-Xylene[4]	8	SW097	68,100,000	µg/L	no

Notes

— no PRG is available

1 PRGs are presented in Draft Programmatic PRGs for Rocky Flats Plant - Open Space (DOE 1995e).

2 If the maximum detected concentration is greater than the PRG, the analyte is evaluated in a risk assessment. PRGs are developed for those analytes with toxicity criteria. Only analytes with PRGs are evaluated in a risk assessment. If no maximum detected concentrations exceed the PRG, a risk assessment is not performed.

3 The PRG is for strontium-90 and daughter products because it is more conservative than the PRG for strontium-89.

4 The PRG is for total xylenes.

Table 3-2
Preliminary Remediation Goal (PRG) Screen for Surface Water in the East Landfill Pond

PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Surface Water PRG[1]	Units	Maximum > PRG[2]
Metals					
Arsenic	2.2	SW098	45.4	µg/L	no
Lithium	109	SW098	681,000	µg/L	no
Manganese	430	SW098	170,000	µg/L	no
Molybdenum	13.1	SW098	170,000	µg/L	no
Nickel	22	SW098	681,000	µg/L	no
Strontium	598	SW098	20,400,000	µg/L	no
Thallium	7.4	SW098	—	µg/L	no
Tin	44.3	SW098	20,400,000	µg/L	no
Radionuclides					
Americium-241	0.031	SW098	136	pCi/L	no
Strontium-89,90[3]	1.924	SW098	795	pCi/L	no
Tritium	257.8	SW098	823,000	pCi/L	no
Uranium-235[4]	0.3	SW098	946	pCi/L	no
Uranium-238[5]	1.964	SW098	717	pCi/L	no
Semivolatile Organic Compounds					
Bis(2-ethylhexyl)phthalate	1	SW098	5,680	µg/L	no
Di-n-butyl phthalate	1	SW098	3,410,000	µg/L	no

Notes

— no PRG is available

1 PRGs are presented in Draft Programmatic PRGs for Rocky Flats Plant - Open Space (DOE 1995e).
2 If the maximum detected concentration is greater than the PRG, the analyte is evaluated in a risk assessment. PRGs are developed for those analytes with toxicity criteria. Only analytes with PRGs are evaluated in a risk assessment. If no maximum detected concentrations exceed the PRG, a risk assessment is not performed.
3 The PRG is for strontium-90 and daughter products because it is more conservative than the PRG for strontium-89.
4 The PRG is for uranium-235 and daughter products.
5 The PRG is for uranium-238 and daughter products.

154

Table 3-3
Preliminary Remediation Goal Screen for Sediments in the East Landfill Pond

PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Soil/Sediment PRGs[1]	Units	Maximum > PRG[2]
Metals					
Zinc	187	SED70093	7.68E+05	mg/kg	no
Semivolatile Organic Compounds					
Acenaphthene	100	SED70093	4.61E+08	µg/kg	no
Anthracene	160	SED70093	2.30E+09	µg/kg	no
Benzo(a)anthracene	340	SED70093	2.45E+04	µg/kg	no
Benzo(a)pyrene	320	SED70093	2.45E+03	µg/kg	no
Benzo(b)fluoranthene	470	SED70093	2.45E+04	µg/kg	no
Benzo(ghi)perylene	200	SED70093	—	µg/kg	no
Benzo(k)fluoranthene	130	SED70093	2.45E+05	µg/kg	no
Benzoic acid	870	SED70093	3.07E+10	µg/kg	no
Bis(2-chloroisopropyl)ether	47	SED70293	2.56E+05	µg/kg	no
Bis(2-ethylhexyl)phthalate	80	SED70093	1.28E+05	µg/kg	no
Chrysene	310	SED70093	2.45E+06	µg/kg	no
Fluoranthene	830	SED70093	3.07E+08	µg/kg	no
Fluorene	92	SED70093	3.07E+08	µg/kg	no
Indeno(1,2,3-cd)pyrene	180	SED70093	2.45E+04	µg/kg	no
Phenanthrene	630	SED70093	—	µg/kg	no
Pyrene	750	SED70093	2.30E+08	µg/kg	no
Volatile Organic Compounds					
2-Butanone	35	SED70093	4.61E+09	µg/kg	no
Acetone	130	SED70193	7.68E+08	µg/kg	no
Toluene	440	SED70293	1.54E+09	µg/kg	no

Notes

— no PRG is available

1 PRGs are presented in Programmatic Preliminary Risk-based Remediation Goals for RFETS-Open Space (DOE 1995f).

2 If the maximum detected concentration is greater than the PRG, the analyte is evaluated in a risk assessment. PRGs are developed for those analytes with toxicity criteria. Only analytes with PRGs are evaluated in a risk assessment. If no maximum detected concentrations exceed the PRG, a risk assessment is not performed.

Definitions

PCOC potential contaminant of concern

Table 3-4
Preliminary Remediation Goal (PRG) Screen for Surface Soils in the Vicinity of Spray Evaporation Areas

PCOC	Maximum Detected Concentration	Location of Maximum	Open Space Soil PRG[1]	Units	Maximum > PRG[2]
Metals					
Antimony	9.1	SS719693	3,070	mg/kg	no
Arsenic	15.7	SS702293	10	mg/kg	yes
Barium	1,120	SS705193	535,000	mg/kg	no
Beryllium	1.5	SS120894	4.08	mg/kg	no
Cobalt	16.2	SS712093	461,000	mg/kg	no
Copper	640	SS121394	307,000	mg/kg	no
Lead	167	SS708893	—	mg/kg	no
Mercury	0.14	SS708693	2,310	mg/kg	no
Selenium	2.9	SS121594	38,400	mg/kg	no
Silver	3	SS709593	38,400	mg/kg	no
Strontium	80.6	SS720193	>1,000,000	mg/kg	no
Thallium	2.1	SS121594	—	mg/kg	no
Vanadium	86.2	SS705293	53,800	mg/kg	no
Zinc	113	SS120894	>1,000,000	mg/kg	no
Radionuclides					
Americium-241	1.076	SS703793	23.6	pCi/g	no
Plutonium-239/240	0.4692	SS704293	69.8	pCi/g	no
Radium-226[3]	1.787	SS711193	0.0247	pCi/g	yes
Indicator Parameters					
Nitrate/nitrite	45	SS710893	>1,000,000	mg/kg	no

Notes

— no PRG is available

1 PRGs are presented in Draft Programmatic PRGs for Rocky Flats Plant - Open Space (DOE 1995e).

2 If the maximum detected concentration is greater than the PRG, the analyte is evaluated in the risk assessment (Tables 3-8, 3-9, and 3-10). PRGs are developed for those analytes with toxicity criteria. Only analytes with PRGs are evaluated in the risk assessment.

3 The PRG is for radium-226 and daughter products.

Table 3-5
Site-Specific Exposure Factors for Incidental Ingestion of Surface Soil[1]

Exposure Factor	Abbreviation	Reasonable Maximum Exposure (RME) Value		Units
		Child	Adult	
Ingestion Rate	IR	100	50	mg/visit
Matrix Effect in GI Tract (Absorption Factor)	ME	chemical specific[2]	chemical specific[2]	unitless
Exposure Frequency	EF	25	25	visits/year
Exposure Duration	ED	6	24	years
Body Weight	BW	15	70	kg
Averaging Time - Noncarcinogen	ATN	2,190	8,760	days
Averaging Time - Carcinogen	ATC	25,550	25,550	days

Notes

1 Exposure parameters are presented in Final Open-Space Exposure Parameters (DOE 1995h).
2 All absorption factors are 1, conservatively assuming 100 percent absorption.

157

Table 3-6
Site-Specific Exposure Factors for Particulate Inhalation of Surface Soil[1]

Exposure Factor	Abbreviation	Reasonable Maximum Exposure (RME) Value Adult	Units
Inhalation Rate	IR	1.4	m^3/hour
Particulate Emission Factor	PEF	4.63E+10	m^3/kg
Respirable Fraction (PM-10)	RF	0.46	unitless
Respiratory Deposition Factor	DF	0.85	unitless
Exposure Time	ET	5.0	hours/visit
Exposure Frequency	EF	25	visits/year
Exposure Duration	ED	30	years
Body Weight	BW	70	kg
Averaging Time - Carcinogen	ATC	25,550	days

Note

[1] Exposure parameters are presented in Final Open-Space Exposure Parameters (DOE 1995h) and Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual, Part B (EPA 1991b).

Table 3-7
Site-Specific Exposure Factors for External Irradiation from Surface Soil[1]

Exposure Factor	Abbreviation	Reasonable Maximum Exposure (RME) Value Adult	Units
Gamma Exposure Time Factor	ET	0.2	unitless
Gamma Shielding Factor	SF	1.0	unitless
Exposure Frequency Ratio	EF	0.07	unitless
Exposure Duration	ED	30	years

Note

[1] Exposure parameters are presented in Final Open-Space Exposure Parameters (DOE 1995h).

Table 3-8
Potential Risks Associated with Incidental Ingestion of Surface Soil[1]
Open-Space Exposure Scenario

Child Exposure									
Carcinogens[2]	**UCL_{95}**		**Intake[3]**				**Oral Cancer Slope Factor[4]**		**Carcinogenic Risk**
Arsenic	5.5	mg/kg	0.039	mg/kg-day	0.00000022	mg/kg-day	1.75E+01	$(mg/kg/day)^{-1}$	4E-06
Radium-226	1.0	pCi/g	15,000	mg	16	pCi	2.95E-09	risk/pCi	5E-08
Total Carcinogenic Risk									**4E-06**
Noncarcinogens[2]	**UCL_{95}**		**Intake[3]**				**Chronic Reference Dose[4]**		**Hazard Quotient**
Arsenic	5.5	mg/kg	0.457	mg/kg-day	0.0000025	mg/kg-day	3E-03	mg/kg-day	0.008
Hazard Index									**0.008**
Adult Exposure									
Carcinogens[2]	**UCL_{95}**		**Intake[3]**				**Oral Cancer Slope Factor[4]**		**Carcinogenic Risk**
Arsenic	5.5	mg/kg	0.017	mg/kg-day	0.000000092	mg/kg-day	1.75E+01	$(mg/kg-day)^{-1}$	2E-06
Radium-226	1.0	pCi/g	30,000	mg	31	pCi	2.95E-09	risk/pCi	9E-08
Total Carcinogenic Risk									**2E-06**
Noncarcinogens[2]	**UCL_{95}**		**Intake[3]**				**Oral Chronic Reference Dose[4]**		**Hazard Quotient**
Arsenic	5.5	mg/kg	0.049	mg/kg-day	0.00000027	mg/kg-day	3E-03	mg/kg-day	0.0009
Hazard Index									**0.0009**

Notes

1 Risks were calculated for those chemicals with oral toxicity criteria. Slight rounding may occur.
2 PCOCs identified from the PRG screen (Table 3-4)
3 Exposure factors used to calculate intake for incidental ingestion of surface soil in an open-space exposure scenario are presented in Table 3-5.
4 Oral toxicity values are from DOE (1995c) and HEAST (EPA 1994a).

Table 3-9
Potential Risks Associated with Particulate Inhalation of Surface Soil[1]
Open-Space Exposure Scenario

Carcinogens[2]	UCL_{95}		Intake[3]		Inhalation Cancer Slope Factor[4]		Carcinogenic Risk
Arsenic	5.5	mg/kg	1.4E-12	mg/kg-day	1.51E+01	$(mg/kg\text{-}day)^{-1}$	2E-11
Radium-226	1.04	pCi/g	4.6E-04	pCi	2.72E-09	risk/pCi	1E-12
Total Carcinogenic Risk							**2E-11**

Notes

1 Risks were calculated for those chemicals with inhalation toxicity criteria. Slight rounding may occur.
2 PCOCs identified from the PRG screen (Table 3-4).
3 Exposure factors used to calculate intake for particulate inhalation of surface soil in an open-space exposure scenario are presented in Table 3-6.
4 Inhalation toxicity values are from DOE (1995c) and HEAST (EPA 1994a).

Table 3-10
Potential Risks Associated with External Irradiation from Surface Soil[1]
Open-Space Exposure Scenario

Carcinogens[2]	UCL_{95}		External Exposure[3]		External Exposure Cancer Slope Factor[4]		Carcinogenic Risk
Radium-226	1.04	pCi/g	0.44	pCi-yr/g	1.31E-08	risk/yr per pCi/g soil	6E-09
Total Risk							**6E-09**

Notes

1 Risks were calculated for those chemicals with external exposure toxicity criteria. Slight rounding may occur.
2 PCOCs identified from the PRG screen (Table 3-4).
3 Exposure factors used to calculate intake for external irradiation from surface soil in an open-space exposure scenario are presented in Table 3-7.
4 External exposure values are from HEAST (EPA 1994a).

Table 3-11
Preliminary Remediation Goal (PRG)
Screen for Subsurface Geologic Materials Downgradient of the Landfill

PCOC	Maximum Detected Concentration	Location of Maximum	Construction Worker Subsurface Soil PRGs[1]	Units	Maximum > PRG[2]
Colluvial Material (Qc)					
Metals					
Barium	624	71093	1.24E+05	mg/kg	no
Radionuclides					
Cesium-137	0.2386	71093	—	pCi/g	no
Semivolatile Organic Compounds					
Chrysene	43	70993	1.70E+07	µg/kg	no
Fluoranthene	110	70993	7.10E+07	µg/kg	no
Phenanthrene	100	70993	—	µg/kg	no
Pyrene	110	70993	5.32E+07	µg/kg	no
Volatile Organic Compounds					
4-Methyl-2-pentanone	58	70993	1.42E+08	µg/kg	no
Toluene	2,000	70993	3.29E+05	µg/kg	no
Total xylenes	2	70993	9.81E+04	µg/kg	no
Indicator Parameters					
Nitrate/nitrite[3]	20,000	71093	2.84E+06	mg/kg	no
Weathered Bedrock Material (KaKl-w)					
Metals					
Arsenic	11.4	70993	7.09E+01	mg/kg	no
Barium	254	71093	1.24E+05	mg/kg	no
Cobalt	21	71093	1.06E+05	mg/kg	no
Lead	31.2	70993	-	mg/kg	no
Manganese	3130	71093	8.86E+03	mg/kg	no
Strontium	939	70993	1.06E+06	mg/kg	no
Zinc	84.4	71093	5.32E+05	mg/kg	no
Volatile Organic Compounds					
Toluene	580	70993	3.29E+05	µg/kg	no

Notes

— no PRG is available.

1 PRGs are presented in Programmatic Preliminary Risk-based Remediation Goals for RFETS-Construction Worker (DOE 1995f).

2 If the maximum detected concentration is greater than the PRG, the analyte is evaluated in a risk assessment. PRGs are developed for those analytes with toxicity criteria. Only analytes with PRGs are evaluated in a risk assessment. If no maximum detected concentrations exceed the PRG, a risk assessment is not performed.

3 PRG for nitrate, because it is the dominant species.

Definitions

PCOC potential contaminant of concern
Qc Quaternary colluvium
KaKl(w) weathered undifferentiated Cretaceous Arapahoe and Laramie Formations

Table 3-12
Preliminary Remediation Goal (PRG) Screen for Groundwater Downgradient of the Landfill

PCOC	Maximum Detected Concentration	Location of Maximum	Residential Groundwater PRG[1]	Units	Maximum > PRG[2]
UHSU Groundwater in the Vicinity of the East Landfill Pond					
Metals					
Antimony	58	B206789	14.6	µg/L	yes
Lithium	225	B206789	730	µg/L	no
Selenium	815	B206789	182	µg/L	yes
Silver	10.9	B206789	182	µg/L	no
Strontium	1,560	B206789	21,900	µg/L	no
Radionuclides					
Uranium-238[3]	35.45	B206889	2.38	pCi/L	yes
Indicator Parameters					
Chloride	460,000	B206889		µg/L	no
Nitrate/nitrite[4]	290,000	B206889	58,400	µg/L	yes
Orthophosphate	30	B206789	—	µg/L	no
Sulfate	1,600,000	B206889	—	µg/L	no
Semivolatile Organic Compounds					
Bis(2-ethylhexyl)phthalate	3	B206789	6.07	µg/L	no
Volatile Organic Compounds					
Carbon tetrachloride	7.11	B206889	0.26	µg/L	yes
Tetrachloroethene	0.769	B206889	1.43	µg/L	no
Trichloroethene	1.43	B206889	2.55	µg/L	no
UHSU Groundwater Downgradient of the Dam					
Metals					
Lithium	138	B207089	730	µg/L	no
Strontium	1,870	B207089	21,900	µg/L	no
Radionuclides					
Strontium-89,90[5]	0.49	4287	1.32	pCi/L	no
Carbonate as $CaCO_3$	12,000	4087	—	µg/L	no
Indicator Parameters					
Chloride	530,000	B207089	—	µg/L	no
Fluoride	3,400	4087	2,190	µg/L	yes
Nitrate/nitrite[4]	72,000	B206989	58,400	µg/L	yes
Orthophosphate	150	4287	—	µg/L	no
Sulfate	19,000,000	B207089	—	µg/L	no

Notes

— no PRG is available

1 PRGs are presented in Final Programmatic Risk-Based Preliminary Remediation Goals, Revision 2 (DOE 1995d).
2 If the maximum detected concentration is greater than the PRG, the analyte is evaluated in the risk assessment (Table 3-13). PRGs are developed for those analytes with toxicity criteria. Only analytes with PRGs are evaluated in the risk assessment.
3 The PRG is for uranium-238 and daughter products.
4 The PRG is for nitrate because it is the dominant species present.
5 The PRG is for strontium-90 and daughter products because it is more conservative than the PRG for strontium-89.

163

Table 3-13
Site-Specific Exposure Factors for Groundwater Ingestion[1]

Exposure Factor	Abbreviation	Reasonable Maximum Exposure (RME) Value	Units
		Adult	
Ingestion Rate	IR	1.0	L/day
Fraction Ingested from Contaminated Source	FI	1.0	unitless
Exposure Frequency	EF	250	days/year
Exposure Duration	ED	25	years
Body Weight	BW	70	kg
Averaging Time - Noncarcinogen	ATN	9,125	days
Averaging Time - Carcinogen	ATC	25,550	days

Note

[1] Exposure parameters are presented in Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment (DOE 1995g).

164

Table 3-14
Potential Risks Associated with Groundwater Ingestion[1]
Future Onsite Office-Worker Exposure Scenario

UHSU Groundwater in the Vicinity of the East Landfill Pond							
Carcinogens[2]	**UCL_{95}**		**Intake[3]**		**Oral Cancer Slope Factor[4]**		**Carcinogenic Risk**
Carbon tetrachloride	2.7	µg/L	0.0000094	mg/kg-day	1.3E-01	$(mg/kg\text{-}day)^{-1}$	1E-06
Uranium-238[4]	35	pCi/L	221,563	pCi	4.27E-11	risk/pCi	9E-06
Total Carcinogenic Risk							**1E-05**
Noncarcinogens[2]	**UCL_{95}**		**Intake[3]**		**Oral Chronic Reference Dose[4]**		**Hazard Quotient**
Antimony	32	µg/L	0.00031	mg/kg-day	4E-04	mg/kg-day	0.8
Carbon tetrachloride	2.7	µg/L	0.000026	mg/kg-day	7E-04	mg/kg-day	0.04
Nitrate/nitrite[5]	69,339	µg/L	0.68	mg/kg-day	1.6E+00	mg/kg-day	0.4
Selenium	749	µg/L	0.0073	mg/kg-day	5E-03	mg/kg-day	1.5
Hazard Index							**3**
UHSU Groundwater Downgradient of the Dam							
Noncarcinogens[2]	**UCL_{95}**		**Intake[3]**		**Oral Chronic Reference Dose[4]**		**Hazard Quotient**
Fluoride	894	µg/L	0.0088	mg/kg-day	6E-02	mg/kg-day	0.1
Nitrate/nitrite[6]	12,849	µg/L	0.13	mg/kg-day	1.6E+00	mg/kg-day	0.08
Hazard Index							**0.2**

Notes

1. Risks were calculated for those chemicals with oral toxicity criteria. Slight rounding may occur.
2. PCOCs identified from the PRG screen (Table 3-11).
3. Exposure factors used to calculate intake for groundwater ingestion in a future onsite office-worker exposure scenario are presented in Table 3-12.
4. Oral toxicity values are from (DOE 1995d) and HEAST (EPA 1994a).
5. The maximum detected concentration was used to calculate risk because the UCL_{95} is greater than the maximum detected concentration.
6. The oral chronic reference dose is for nitrate because it is the dominant species present.

165

Table 3-15
Potential Chemical-Specific ARARs for Surface Water

Analyte	ARAR/ TBC	Unit	Law/Regulation	Citation
Metals				
Aluminum	87	µg/L	Colorado Water Quality Standard, AQ	5 CCR 1002-8, 3.1.11
Antimony	300	µg/L	Practical Quantitation Limit (PQL)	
Arsenic	50	µg/L	SDWA MCL	40 CFR 141
Barium	1,000	µg/L	RCRA MCL	40 CFR 264.94
Beryllium	4	µg/L	Segment 4 & 5 Standard	Standard is 1-day average
Cadmium	TVS		Segment 4 & 5 Standard	
Chromium	50	µg/L	RCRA MCL	40 CFR 264.94
Cobalt	50	µg/L	Colorado Water Quality Standard, AG	5 CCR 1002-8, 3.1.11
Copper	TVS		Segment 4 & 5 Standard	
Lead	TVS		Segment 4 & 5 Standard	
Lithium	2,500	µg/L	Colorado Water Quality Standard, AG	5 CCR 1002-8, 3.1.11
Manganese	50	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Mercury	10	µg/L	Segment 4 & 5 Standard	
Nickel	125	µg/L	Segment 4 & 5 Standard	
Selenium	17	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Silver	50	µg/L	RCRA MCL	40 CFR 264.94
Tin	8,000	µg/L	PQL	
Vanadium	100	µg/L	Colorado Water Quality Standard, AG	5 CCR 1002-8, 3.1.11
Zinc	2,000	µg/L	Colorado Water Quality Standard, AG	5 CCR 1002-8, 3.1.11
Radionuclides				
Americium-241	30	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Cesium-137	3,000	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Plutonium-239/240	30	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Plutonium-238	30	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5

Table 3-15
Potential Chemical-Specific ARARs for Surface Water

Analyte	ARAR/ TBC	Unit	Law/Regulation	Citation
Plutonium-239	30	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Radium 226	100	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Strontium-89,90	8	pCi/L	SDWA MCL	40 CFR 141
Tritium	1,000	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Uranium-233,-234	500	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Uranium-235	600	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Uranium-238	600	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Indicator Parameters				
Cyanide	200	µg/L	SDWA MCL	40 CFR 141
Fluoride	2,000	µg/L	Colorado Water Quality Standard, DW	5 CCR 1002-8, 3.1.11
Nitrate/nitrite	10,000	µg/L	SDWA MCL	40 CFR 141
Nitrite	500	µg/L	Segment 4 & 5 Standard	Standard is 1-day average
Sulfate	250,000	µg/L	Colorado Water Quality Standard, DW	5 CCR 1002-8, 3.1.11
Volatile Organic Compounds				
1,1-Dichloroethane	59	µg/L	6 CCR 1007-3	Sec 268.43
1,2-Dichloroethene	70	µg/L	SDWA MCL	40 CFR 141
2-Butanone	280	µg/L	6 CCR 1007-3	Sec 268.43
2-Hexanone	50	µg/L	Practical Quantitation Limit (PQL)	6 CCR 1007-3, 264, App. IX
4-Methyl-2-pentanone	140	µg/L	6 CCR 1007-3	Sec 268.43
Acetone	280	µg/L	6 CCR 1007-3	Sec 268.43
Benzene	1	µg/L	Colorado Water Quality Standard, HH, DW, DW&F	5 CCR 1002-8, 3.1.11
Chloromethane	5.7	µg/L	Colorado Water Quality Standard, DW&F	5 CCR 1002-8, 3.1.11
Ethylbenzene	57	µg/L	RCRA LDR	40 CFR 268.40
Methylene chloride	4.7	µg/L	Colorado Water Quality Standard, HH, DW&F	5 CCR 1002-8, 3.1.11
Tetrachloroethene	1	µg/L	PQL	5 CCR 1002-8, 3.1.11

Table 3-15
Potential Chemical-Specific ARARs for Surface Water

Analyte	ARAR/ TBC	Unit	Law/Regulation	Citation
Toluene	1,000	µg/L	SDWA MCL	40 CFR 141
Total xylenes	10,000	µg/L	SDWA MCL	40 CFR 141
Trichloroethene	2.7	µg/L	Colorado Water Quality Standard, HH, DW&F	5 CCR 1002-8, 3.1.11
Vinyl acetate	5	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Vinyl chloride	2	µg/L	SDWA MCL	40 CFR 141
Semivolatile Organic Compounds				
2-Methylnaphthalene	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
2,4-Dimethylphenol	36	µg/L	RCRA LDR	40 CFR 268.40
Acenaphthene	520	µg/L	Colorado Water Quality Standard, AQ, CH	5 CCR 1002-8, 3.1.11
Bis(2-ethylhexyl)phthalate	10	µg/L	PQL	5 CCR 1002-8, 3.1.11
Dibenzofuran	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Diethyl phthalate	200	µg/L	RCRA LDR	40 CFR 268.40
Fluorene	10	µg/L	PQL	5 CCR 1002-8, 3.1.11
Naphthalene	10	µg/L	PQL	5 CCR 1002-8, 3.1.11
Phenanthrene	10	µg/L	PQL	5-CCR 1002-8, 3.1.11

Abbreviations

AG	agricultural
AQ	aquatic
CCR	Colorado Code of Regulations
CFR	Code of Federal Regulations
CH	chronic
DW	drinking water
DW&F	drinking water and fish
HH	human health
LDR	Land Disposal Restrictions
MCL	maximum contaminant level
PQL	practical quantitation limit
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
TVS	table value standard

Table 3-16
Potential Chemical-Specific ARARs for Groundwater

Analyte	Potential ARAR	Unit	Law/Regulation	Citation
Metals				
Antimony	300	µg/L	Practical Quantitation Limit (PQL)	6 CCR 1007-3, 264, App. IX
Arsenic	50	µg/L	SDWA MCL	40 CFR 141
Barium	1,000	µg/L	RCRA MCL	40 CFR 264.94
Beryllium	2	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Cadmium	5	µg/L	SDWA MCL	40 CFR 141
Chromium	50	µg/L	RCRA MCL	40 CFR 264.94
Cobalt	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Copper	1,300	µg/L	MCLG	40 CFR 141.50-52
Lead	50	µg/L	RCRA MCL	40 CFR 264.94
Manganese	200 (AG)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Mercury	2	µg/L	SDWA MCL	40 CFR 141
Nickel	100	µg/L	SDWA MCL	40 CFR 141
Selenium	20	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Silver	70	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Thallium	400	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Tin	8,000	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Vanadium	40	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Zinc	2,000 (AG)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Radionuclides				
Americium-241	1.2 (DW)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Cesium-137	120 (DW)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Plutonium-239/240	1.2 (DW,a)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Radium-226	4 (DW)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Strontium-89,90	8	pCi/L	SDWA MCL	40 CFR 141

169

Table 3-16
Potential Chemical-Specific ARARs for Groundwater

Analyte	Potential ARAR	Unit	Law/Regulation	Citation
Tritium	20,000	pCi/L	SDWA MCL	40 CFR 141
Uranium-233,-234	20 (DW,b)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Uranium-235	24 (DW,b)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Uranium-238	24 (DW,b)	pCi/L	Radiation Protection of the Public and the Environment	DOE Order 5400.5
Total uranium	40	pCi/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Indicator Parameters				
Cyanide	200	µg/L	SDWA MCL	40 CFR 141
Fluoride	2,000 (DW)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Nitrate/nitrite	10,000	µg/L	SDWA MCL	40 CFR 141
Sulfate	250,000 (DW)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Volatile Organic Compounds				
1,1-Dichloroethane	1	µg/L	PQL	6 CCR 1007-3, 264, App. IX
1,1-Dichloroethene	7	µg/L	SDWA MCL	40 CFR 141
1,1,1-Trichloroethane	200	µg/L	SDWA MCL	40 CFR 141
1,1,2-Trichloroethane	1	µg/L	PQL	6 CCR 1007-3, 264, App. IX
1,2-Dichloroethene	0 (cis) 100 (trans)	µg/L	SDWA MCL	40 CFR 141
1,2-Dichloropropane	1	µg/L	PQL	
1,4-Dichlorobenzene	75	µg/L	SDWA MCL	40 CFR 141
2-Butanone	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
2-Hexanone	50	µg/L	PQL	6 CCR 1007-3, 264, App. IX
4-Methyl-2-pentanone	50	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Acetone	100	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Benzene	1 (HH, DW, DW&F)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Bromodichloromethane	1	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Bromoform	4	µg/L	Colorado Basic Standard for Groundwater	5 CCR 1002-8, 3.11

Table 3-16
Potential Chemical-Specific ARARs for Groundwater

Analyte	Potential ARAR	Unit	Law/Regulation	Citation
Carbon tetrachloride	1	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Chlorobenzene	100 (HH, DW, DW&F)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Chloroethane	5	µg/L	PQL	6 CCR 1007-3, Part 264, App. IX
Chloromethane	5.7 (DW&F)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Chloroform	6	µg/L	Colorado Basic Standard for Groundwater	5 CCR 1002-8, 3.11
Ethylbenzene	680	µg/L	Colorado Basic Standard for Groundwater	5 CCR 1002-8, 3.11
Methylene chloride	4.7 (HH, DW&F)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Tetrachloroethene	1	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Toluene	1,000	µg/L	SDWA MCL	40 CFR 141
Total xylenes	10,000	µg/L	SDWA MCL	40 CFR 141
Trichloroethene	2.7 (HH, DW&F)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Trichlorofluoromethane	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Vinyl acetate	5	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Vinyl chloride	2	µg/L	SDWA MCL	40 CFR 141
Semivolatile Organic Compounds				
1,4-Dichlorobenzene	75	µg/L	SDWA MCL	40 CFR 141
2-Chloronapthalene	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
2-Methylnaphthalene	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
2,4-Dimethylphenol	2,120 (AQ, AC)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
2,4,5-Trichlorophenol	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
4-Nitrophenol	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Acenaphthene	520 (AQ, CH)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Bis(2-ethylhexyl)phthalate	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Dibenzofuran	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Di-n-butyl phthalate	2,700 (HH, DW&F)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11

171

Table 3-16
Potential Chemical-Specific ARARs for Groundwater

Analyte	Potential ARAR	Unit	Law/Regulation	Citation
Di-n-octyl phthalate	30	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Diethyl phthalate	23,000 (HH, DW&F)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Dimethylphthalate	313 (DW&F)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Fluorene	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Naphthalene	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Pentachlorophenol	50	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Phenanthrene	10	µg/L	PQL	6 CCR 1007-3, 264, App. IX
Phenol	2,500 (AQ, CH)	µg/L	Colorado Water Quality Standard	5 CCR 1002-8, 3.1.11
Pesticides				
Aroclor-1232	50	µg/L	PQL	
Aroclor-1242	50	µg/L	PQL	

Abbreviations

a	f1 value of 1 E-03
AC	acute
AG	agricultural
AQ	aquatic
b	f1 value of 5 E-02
CCR	Colorado Code of Regulations
CFR	Code of Federal Regulations
CH	chronic (30-day)
DW	drinking water
DW&F	drinking water and fish
HH	human health
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
PQL	practical quantitation limit
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
TVS	table value standard

Table 3-17
ARARs Comparison for Leachate at the Seep

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
Metals										
Aluminum	10 - 30,000	16/19	13	29	26,900	—	—	2,629	87	µg/L
Antimony	0.05 - 60	4/18	0	14	60.4	—	A	20	300	µg/L
Arsenic	0.7 - 10	8/16	0	1.4	3	B	—	3	50	µg/L
Barium	0.02 - 50,000	19/19	1	297	1,550	—	—	645	1,000	µg/L
Beryllium	0.2 - 5	2/18	0	0.2	1.4	—	JA	1	4	µg/L
Calcium	14.5 - 100,000	19/19	0	126,000	212,000	—	—	151,737	TVS	µg/L
Chromium	2.4 - 27.5	7/18	0	2	29.6	—	—	9	50	µg/L
Cobalt	0.02 - 50	10/18	0	2.7	19.1	B	—	11	50	µg/L
Copper	2.4 - 25	8/18	0	2	94.9	—	—	12	TVS	µg/L
Lead	0.8 - 2,000	14/18	0	1.5	11	—	V	5	TVS	µg/L
Lithium	2 - 2,000	15/19	0	34	107	—	V	48	2,500	µg/L
Manganese	1 - 10,000	19/19	19	1,320	2,490	—	—	1,623	50	µg/L
Mercury	0.02 - 0.2	1/18	0	0.1	0.28	—	—	0.1	10	µg/L
Nickel	0.02 - 40	5/18	0	5	31	—	V	12	125	µg/L
Selenium	1.1 - 5	2/18	0	1.1	7	W	—	2	17	µg/L
Silver	2.6 - 25	8/18	0	2.7	16.7	—	—	5	50	µg/L
Tin	10 - 200	8/18	0	11	243	—	—	48	8,000	µg/L
Vanadium	3.2 - 10,000	12/19	1	3.1	211	—	—	25	100	µg/L
Zinc	1.8 - 10,000	19/19	16	857	16,000	—	—	2,974	2,000	µg/L
Radionuclides										
Americium-241	0 - 0.013	16/16	0	-0.000404	0.02121	—	V	0.007	30	pCi/L
Cesium-137	0.47 - 1	14/14	0	-0.21	0.6057	J	—	0.15	3,000	pCi/L
Plutonium-238	0.01	2/2	0	-0.000465	0.00222	J	A	0.00088	30	pCi/L

173

Table 3-17
ARARs Comparison for Leachate at the Seep

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
Plutonium-239	0.003	1/1	0	0.009	0.009	—	—	0.009	30	pCi/L
Plutonium-239/240	0 - 0.013	16/16	0	0.001	0.01606	—	A	0.007	30	pCi/L
Radium-226	0.03	1/1	0	0.58	0.58	—	A	0.58	100	pCi/L
Strontium-89,90	0.21 - 1	9/9	0	0.66	4.06	—	V	1.35	8	pCi/L
Tritium	155 - 450	19/19	1	185.4	1,500	—	A	393	1,000	pCi/L
Uranium-233,-234	0.1 - 0.6	12/12	0	-0.0238	4.2	B	A	0.8	500	pCi/L
Uranium-235	0 - 0.6	12/12	0	-0.012	0.084	J	A	0.03	600	pCi/L
Uranium-238	0.086 - 0.6	12/12	0	0.03914	3.76	—	A	1	600	pCi/L
Semivolatile Organics										
2,4-Dimethylphenol	10	1/5	0	3	3	J	A	5	36	µg/L
2-Methylnaphthalene	10	5/5	5	12	23	—	V	16	10	µg/L
Acenaphthene	10	5/5	0	2	3	J	A	3	520	µg/L
Bis(2-ethylhexyl)phthalate	10 - 12	1/5	0	2	2	J	A	5	10	µg/L
Dibenzofuran	10	5/5	0	1	2	J	A	1	10	µg/L
Diethyl phthalate	10	4/5	0	1	3	J	A	3	200	µg/L
Fluorene	10	5/5	0	2	3	J	A	2	10	µg/L
Naphthalene	10	5/5	5	14	22	—	V	18	10	µg/L
Phenanthrene	10	5/5	0	4	5	J	A	4	10	
Volatile Organics										
1,1-Dichloroethane	5	17/20	0	2	10	—	V	6	59	µg/L
1,2-Dichloroethene	5	10/20	0	2	14	—	V	4	70	µg/L
2-Butanone	10	6/19	0	6	76	—	V	12	280	µg/L
2-Hexanone	10	1/20	0	1	10	—	V	5	50	µg/L
4-Methyl-2-pentanone	10	5/20	0	10	87	J	A	11	140	µg/L

Table 3-17
ARARs Comparison for Leachate at the Seep

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
Acetone	10	10/20	0	10	220	—	A	34	280	µg/L
Benzene	5	11/20	4	1	2	J	—	2	1	µg/L
Chloromethane	10	2/20	1	4	7	J	A	5	5.7	µg/L
Ethylbenzene	5	19/20	0	1	18	—	—	13	57	µg/L
Methylene chloride	5	9/20	5	3	190	B	—	14	4.7	µg/L
Tetrachloroethene	5	2/20	0	1	1	J	—	2[1]	1	µg/L
Toluene	5	19/20	0	5	88	—	—	38	1,000	µg/L
Total xylenes	5	19/20	1	1	25	J	A	14	10,000	µg/L
Trichloroethene	5	11/20	1	1	4	J	—	2	2.7	µg/L
Vinyl acetate	10	1/19	5	10	49	—	—	7[2]	5	µg/L
Vinyl chloride	10	5/20	0	3	11	—	V	5	2	µg/L
Indicator Parameters										
Cyanide	10 - 20	1/14	0	1.5	36.8	—	—	9	200	µg/L
Fluoride	100 - 200	12/12	0	390	540	—	V	469.2	2,000	µg/L
Nitrate/nitrite	20 - 200	6/10	0	20	870	—	V	263	10,000	µg/L
Nitrite	20	6/9	0	20	63	—	V	30.33	500	µg/L
Sulfate	200 - 25,000	5/14	0	200	29,600	—	V	5,084	250,000	µg/L

Notes

Shaded analytes indicate mean result exceeds ARAR.
All analytes are total analytes unless otherwise noted.
Analytes with zero detections are not reported.
For non-detects, one-half the detection limit is used in calculating the mean result.

[1] For tetrachloroethene, the maximum detection equals the ARAR; the mean exceeds the ARAR because one-half detection limit for non-detects exceeds the ARAR.
[2] For vinyl acetate, one detection out of nineteen causes mean to exceed ARAR; suggests that one detection is outlier and should be discarded.

115

Table 3-17
ARARs Comparison for Landfill Leachate

Data Qualifiers

–	Data qualifier field in database is blank.
B	For inorganics, reported value is < crdl but > idl (estimated value).
B	For organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit.
B	For radionuclides, constituent also detected in blank whose concentration was > minimum detectable activity.
I	Organics, interference with target peak (estimated value).
J	For organics, ms data indicate presence of compound but below detection limit (estimated value).
U	For inorganics and organics, analyte analyzed but not detected at the quantitation limit.
W	Inorganics: post-digestion spike for gfaa analysis is out of control limits while sample absorbance is less than 50 percent of spike absorbance.

Data Validation Codes

–	data validation field in database is blank
A	acceptable result
JA	acceptable result (for estimated value)
V	valid result

Table 3-18
ARARs Comparison for Surface Water in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
Metals										
Aluminum	10 - 200	16/22	5	30.4	271	—	—	75	87	µg/L
Antimony	0.05 - 500	2/22	0	8	16.9	B	—	22	300	µg/L
Arsenic	0.7 - 10	9/21	0	0.9	2.2	—	V	1	50	µg/L
Barium	0.02 - 200	22/22	0	16	250	—	V	172	1,000	µg/L
Beryllium	0.2 - 5	1/22	0	0.5	0.7	—	JA	1	4	µg/L
Chromium	2.4 - 20	2/22	0	2	10.9	—	—	3	50	µg/L
Lithium	2 - 100	20/21	0	7.7	109	—	—	79	2,500	µg/L
Manganese	1 - 15	21/22	14	2.5	430	—	V	105	50	µg/L
Mercury	0.2	3/22	0	0.1	0.54	—	V	0.1	10	µg/L
Nickel	0.02 - 40	14/22	0	6.3	22	—	V	10	125	µg/L
Silver	2.5 - 30	3/22	0	2	4	—	JA	3	50	µg/L
Tin	10 - 1,000	6/21	0	10	44.3	B	—	41	8,000	µg/L
Vanadium	2 - 50	5/22	0	2	9	B	—	4	100	µg/L
Zinc	1.8 - 20	19/22	0	4	105	—	—	17	2,000	µg/L
Radionuclides										
Americium-241	0 - 0.19	15/15	0	0.0005655	0.031	U	A	0.007	30	pCi/L
Cesium-137	0.23 - 1.16	11/11	0	-0.2323	0.1344	—	V	-0.06	3,000	pCi/L
Plutonium-239	0 - 0.03	6/6	0	0	0.022	—	—	0.007	30	pCi/L
Plutonium-239/240	0 - 0.01	11/11	0	-0.000364	0.023	—	A	0.004	30	pCi/L
Radium-226	0.211	1/1	0	0.23	0.23	—	V	0.23	100	pCi/L
Strontium-89,90	0.23 - 1	5/5	0	0.6635	1.924	—	A	1.4	8	pCi/L
Tritium	160 - 460	20/20	0	-10	257.8	J	V	139	1,000	pCi/L
Uranium-233,-234	0 - 0.232	9/9	0	0.7626	1.594	—	V	1.1	500	pCi/L

177

Table 3-18
ARARs Comparison for Surface Water in the East Landfill Pond

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean Result	ARAR	Units
Uranium-235	0 - 0.281	9/9	0	-0.01	0.3	—	A	0.1	600	pCi/L
Uranium-238	0.08 - 0.263	9/9	0	0.6996	1.964	—	A	1.1	600	pCi/L
Semivolatile Organics										
Bis(2-ethylhexyl)phthalate	9 - 11	1/8	0	1	1	J	A	5	10	µg/L
Di-n-butyl phthalate	9 - 11	1/8	0	1	1	J	A	5		µg/L
Volatile Organics										
Acetone	10	1/21	0	6	12	B	—	6	280	µg/L
Methylene chloride	5	3/21	2	4	8	B	—	3	4.7	µg/L
Vinyl acetate	10	1/20	1	10	80	—	—	9[1]	5	µg/L
Indicator Parameters										
Fluoride	100 - 200	15/15	0	590	890	—	—	770	2,000	µg/L
Nitrate/nitrite	20 - 100	6/13	0	20	320	—	JA	80	10,000	µg/L
Sulfate	500 - 10,000	16/16	0	7,000	25,600	—	V	16,031	250,000	µg/L

Notes

Shaded analytes indicate mean result exceeds ARAR.
All analytes are total analytes unless otherwise noted.
Analytes with zero detections are not reported.
For non-detects, one-half the detection limit is used in calculating the mean result.
[1] For vinyl acetate, one detection out of nineteen causes mean to exceed ARAR; suggests that one detection is outlier and should be discarded.

Data Qualifiers

— data qualifier field in database is blank
B for inorganics, reported value is < CRDL but > IDL (estimated value)
B for organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit
J for organics, MS data indicate presence of compound but below detection limit (estimated value)
U for inorganics and organics, analyte analyzed but not detected at the quantitation limit

Data Validation Codes

— data validation field in database is blank
A acceptable result
JA acceptable result (for estimated value)
V valid result

Table 3-19
ARARs Comparison for Groundwater Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Number of Samples	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	ARAR	Units
0786 Summary Statistics											
Radionuclides											
Tritium	210 - 470	9/9	0	9	134.2	368	J	V	215	20,000	pCi/L
Volatile Organics											
1,1-Dichloroethane	0.1 - 5	1/14	0	14	0.1	0.3	–	V	2	1	µg/L
Chloroethane	0.4 - 10	2/14	0	14	0.4	3	J	A	4	5	µg/L
Methylene chloride	0.1 - 5	4/14	0	14	0.1	3	J	A	2	4.7	µg/L
Indicator Parameters											
Fluoride	100	5/5	0	5	1,200	1,900	–	V	1,540	2,000	µg/L
Nitrate/nitrite	20 - 100	5/9	0	9	20	1,800	–	V	248.3	10,000	µg/L
Sulfate	2,000 - 5,000	5/5	0	5	170,000	250,000	–	V	210,000	250,000	µg/L
4087 Summary Statistics											
Radionuclides											
Americium-241	0.01	1/1	0	1	0.002	0.002	–	A	0.002	1.2	pCi/L
Plutonium-239/240	0	1/1	0	1	0.006	0.006	–	A	0.006	1.2	pCi/L
Tritium	253 - 650	5/5	0	5	0	260.8	J	V	169.4	20,000	pCi/L
Uranium-233,-234	0.36	1/1	0	1	20.09	20.09	–	A	20.09	20	pCi/L
Uranium-235	0.31	1/1	0	1	0.5933	0.5933	–	A	0.5933	24	pCi/L
Uranium-238	0.25	1/1	0	1	13.23	13.23	–	A	13.23	24	pCi/L
Volatile Organics											
Methylene chloride	0.2 - 5	2/8	0	8	0.2	2	J	–	2	4.7	µg/L
Indicator Parameters											
Fluoride	100	5/5	1	5	1,500	3,400	–	–	2,060	2,000	µg/L
Nitrate/nitrite	20 - 100	4/5	0	5	20	644	–	Y	305	10,000	µg/L
Sulfate	2,000 - 5,000	5/5	5	5	280,000	770,000	–	–	522,000	250,000	µg/L
4287 Summary Statistics											
Metals											
Arsenic	10	1/2	0	2	1.9	1.9	B	–	1	50	µg/L
Barium	200	2/2	0	2	79.6	94.5	B	–	87.1	1,000	µg/L
Chromium	10	2/2	0	2	6.9	9.5	B	–	8.2	50	µg/L
Copper	25	1/2	0	2	6.7	9.4	B	–	6.4	1,300	µg/L
Lead	3	2/2	0	2	1.1	2.6	B	–	1.9	50	µg/L
Manganese	15	2/2	0	2	58.7	59.8	E	–	59.3	200	µg/L
Nickel	40	2/2	0	2	7.1	8.4	B	–	7.8	100	µg/L
Silver	10	1/2	0	2	2	3.2	B	–	2	70	µg/L
Tin	200	1/2	0	2	11.5	11.5	B	–	12	8,000	µg/L
Vanadium	50	2/2	0	2	24.3	32.1	B	–	28.2	40	µg/L
Zinc	20	2/2	0	2	21.9	28.9	E	–	25.4	2,000	µg/L

Table 3-19
ARARs Comparison for Groundwater Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Number of Samples	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	ARAR	Units
Radionuclides											
Americium-241	0 - 0.01	4/4	0	4	0.00107	0.011	–	JA	0.005	1.2	pCi/L
Cesium-137	0.6 - 0.82	2/2	0	2	-0.0334	0.38	–	A	0.17	120	pCi/L
Plutonium-239/240	0 - 0.01	4/4	0	4	0.0002529	0.004	–	A	0.002	1.2	pCi/L
Strontium-89,90	0.25	1/1	0	1	0.49	0.49	–	A	0.49	8	pCi/L
Tritium	216.7 - 520	6/6	0	6	-84.9	390	–	–	128	20,000	pCi/L
Uranium-233,-234	0.61	1/1	0	1	4.078	4.078	–	A	4.078	20	pCi/L
Uranium-235	0.74	1/1	0	1	0.7962	0.7962	–	A	0.7962	24	pCi/L
Uranium-238	0.61	1/1	0	1	3.683	3.683	–	A	3.683	24	pCi/L
Volatile Organic Compounds											
Methylene chloride	0.1 - 5	1/9	0	9	0.1	1	J	V	2	4.7	µg/L
Indicator Parameters											
Fluoride	100	8/8	0	8	400	800	–	V	618.8	2,000	µg/L
Nitrate/nitrite	20 - 100	6/7	0	7	40	200	–	V	94.3	10,000	µg/L
Sulfate	2,000 - 5,000	8/8	0	8	33,000	79,221	–	V	48,253	250,000	µg/L
53194 Summary Statistics											
Radionuclides											
Americium-241	0.00436	1/1	0	1	0.006443	0.006443	–	Y	0.006443	1.2	pCi/L
Plutonium-239/240	0.0125	1/1	0	1	0.004633	0.004633	J	Y	0.004633	1.2	pCi/L
Tritium	384	1/1	0	1	14.34	14.34	J	Y	14.34	20,000	pCi/L
B206789 Summary Statistics											
Metals											
Antimony	17 - 60	1/7	0	7	14	58	B	Y	18	300	µg/L
Arsenic	2 - 10	1/7	0	7	1	2.7	–	V	1	50	µg/L
Barium	9 - 200	4/7	0	7	16.1	22	B	Y	16	1,000	µg/L
Chromium	3 - 10	2/7	0	7	2	17	–	JA	4	50	µg/L
Copper	2 - 25	1/7	0	7	2	8	B	Y	4	1,300	µg/L
Lead	1 - 5	2/7	0	7	1	1.2	B	V	1	50	µg/L
Manganese	1 - 15	5/7	0	7	2.8	9.7	–	V	6.3	200	µg/L
Nickel	10 - 40	1/7	0	7	3	11.1	B	Y	5	100	µg/L
Selenium	0 - 5	7/7	7	7	488	815	+	JA	665	20	µg/L
Silver	4 - 10	1/7	0	7	2	10.9	N	JA	3	70	µg/L
Thallium	2 - 10	1/7	0	7	1	1	B	V	1	400	µg/L
Tin	18 - 200	1/7	0	7	10	19.2	B	V	12	8,000	µg/L
Vanadium	3 - 50	3/7	0	7	2.9	8.9	BE	JA	5	40	µg/L
Zinc	3 - 20	4/7	0	7	9.1	52.7	–	JA	19.3	2,000	µg/L
Radionuclides											
Americium-241	0.01	1/1	0	1	-0.433	-0.433	J	–	-0.433	1.2	pCi/L
Plutonium-239/240	0.01	2/2	0	2	0.001103	0.004	–	A	0.003	1.2	pCi/L
Radium-226	0.06 - 0.5	2/2	0	2	0.35	0.52	–	A	0.44	4	pCi/L
Tritium	211.7 - 840	10/10	0	10	-138	230	U	V	21	20,000	pCi/L

Table 3-19
ARARs Comparison for Groundwater Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Number of Samples	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	ARAR	Units
Semivolatile Organic Compounds											
Bis(2-ethylhexyl)phthalate	10	1/2	0	2	3	3	J	A	4	10	µg/L
Volatile Organic Compounds											
Acetone	10	1/17	0	17	9	11	B	–	5	100	µg/L
Benzene	0.1 - 10	1/19	0	19	0.1	0.1	J	–	2	1	µg/L
Methylene chloride	0.1 - 10	1/19	0	19	0.1	3	J	–	2	4.7	µg/L
Indicator Parameters											
Fluoride	100 - 200	13/13	0	13	300	500	–	–	399.2	2,000	µg/L
Nitrate/nitrite	20 - 2,800	18/18	0	18	3,000	9,700	–	–	6,583	10,000	µg/L
Sulfate	2,000 - 100,000	13/13	13	13	560,000	900,000	–	V	643,600	250,000	µg/L
B206889 Summary Statistics											
Radionuclides											
Tritium	268 - 660	9/9	0	9	-164.49541	130.4	J	–	16	20,000	pCi/L
Uranium-233,-234	0	1/1	0	1	49.32	49.32	–	A	49.32	20	pCi/L
Uranium-235	0.07	1/1	0	1	2.62	2.62	–	A	2.62	24	pCi/L
Uranium-238	0.07 - 0.18	2/2	0	2	29.81	35.45	–	A	32.63	24	pCi/L
Volatile Organic Compounds											
Acetone	10 - 100	1/13	0	13	10	24	B	–	10	100	µg/L
Benzene	0.1 - 5	1/18	0	18	0.1	0.5	J	A	2	1	µg/L
Carbon tetrachloride	0.2 - 5	2/18	0	18	0.2	7.11	–	Y	3	1	µg/L
Ethylbenzene	0.2 - 5	1/18	0	18	0.2	0.3	J	A	2	680	µg/L
Methylene chloride	0.1 - 5	2/18	1	18	0.1	8	B	–	3	4.7	µg/L
Tetrachloroethene	0.1 - 5	1/18	0	18	0.1	0.769	–	Y	2	1	µg/L
Toluene	0.1 - 5	1/18	0	18	0.1	3	J	A	2	1,000	µg/L
Total xylenes	0.5 - 5	1/16	0	16	0.5	3	J	A	2	10,000	µg/L
Trichloroethene	0.1 - 5	1/18	0	18	0.1	1.43	–	Y	2	2.7	µg/L
Indicator Parameters											
Fluoride	100	2/2	0	2	450	500	–	V	475	2,000	µg/L
Nitrate/nitrite	20 - 200,000	11/11	11	11	82,000	290,000	–	JA	157,275	10,000	µg/L
Sulfate	2,000 - 250,000	2/2	2	2	1,420,000	1,600,000	–	V	1,510,000	250,000	µg/L
B206989 Summary Statistics											
Radionuclides											
Tritium	236.92 - 420	5/5	0	5	-141	107.12	–	V	-17	20,000	pCi/L
Volatile Organic Compounds											
Methylene chloride	0.1 - 5	3/15	2	15	0.1	8	B	–	2	4.7	µg/L
Toluene	0.1 - 5	1/16	0	16	0.1	1	J	–	2	1,000	µg/L
Indicator Parameters											
Fluoride	100	1/1	0	1	230	230	–	V	230	2,000	µg/L
Nitrate/nitrite	20	5/5	5	5	36,000	72,000	–	V	49,600	10,000	µg/L
Sulfate	5,000	1/1	1	1	2,600,000	2,600,000	–	V	2,600,000	250,000	µg/L

181

Table 3-19
ARARs Comparison for Groundwater Downgradient of the Landfill

Analyte	Detection Limit Range	Detection Frequency	Detections Exceeding ARARs	Number of Samples	Minimum Result	Maximum Detection	Qualifier for Maximum Detection	Validation for Maximum Detection	Mean	ARAR	Units
B207089 Summary Statistics											
Metals											
Antimony	60	1/6	0	6	8	66.8	–	JA	21	300	µg/L
Barium	200	5/6	0	6	27.5	42.9	B	V	32	1,000	µg/L
Cadmium	5	2/6	0	6	1	2.4	B	V	1	5	µg/L
Chromium	10	3/6	0	6	2.5	18	–	V	7	50	µg/L
Copper	25	1/6	0	6	3.5	6.2	B	JA	4	1,300	µg/L
Manganese	15	6/6	0	6	14.1	109	–	V	43	200	µg/L
Nickel	40	2/6	0	6	4	7.5	B	JA	6	100	µg/L
Selenium	5	1/6	0	6	1	1	B	JA	1	20	µg/L
Silver	10	1/5	0	5	2	2.2	B	V	2	70	µg/L
Tin	200	1/5	0	5	10	20.2	B	V	12	8,000	µg/L
Vanadium	50	3/5	0	5	5	11.5	B	JA	7	40	µg/L
Zinc	20	3/5	0	5	11.3	33.4	–	V	20.8	2,000	µg/L
Radionuclides											
Americium-241	0 - 0.03	17/17	0	17	0	0.012	–	A	0.005	1.2	pCi/L
Cesium-137	0.74 - 2.37	8/8	0	8	-0.498	0.4298	J	A	0	120	pCi/L
Plutonium-239/240	0 - 0.087	19/19	0	19	-0.000272	0.009	J	V	0.002	1.2	pCi/L
Radium-226	0.096	1/1	0	1	0.64	0.64	B	Y	0.64	4	pCi/L
Strontium-89,90	0.38 - 1.6	3/3	0	3	-0.14	0.31	–	A	0.06	8	pCi/L
Tritium	0 - 820	20/20	0	20	-78.34	400	U	–	103	20,000	pCi/L
Uranium-233,-234	0 - 0.36	2/2	0	2	2.8	4.25	–	–	3.5	20	pCi/L
Uranium-235	0 - 0.25	2/2	0	2	0.082	0.351	–	–	0.217	24	pCi/L
Uranium-238	0 - 0.37	2/2	0	2	1.5	1.58	–	–	1.5	24	pCi/L
Volatile Organic Compounds											
Benzene	0.1 - 5	1/18	0	18	0.1	0.1	J	–	2	1	µg/L
Methylene chloride	0.1 - 5	4/19	2	19	0.1	12	B	–	3	4.7	µg/L
Toluene	0.1 - 5	1/19	0	19	0.1	0.2	J	–	2	1,000	µg/L
Indicator Parameters											
Cyanide	5 - 100	2/17	0	17	1	56,000	B	V	9	200	µg/L
Fluoride	0 - 100	18/18	0	18	300	750	–	Y	369.6	2,000	µg/L
Nitrate/nitrite	20 - 2,800	17/18	0	18	665	2,400	–	JA	1,101	10,000	µg/L
Sulfate	1,000 - 100,000	18/18	18	18	440,000	19,000,000	–	–	1,612,462	250,000	µg/L

Table 3-19
ARARs Comparison for Groundwater Downgradient of the Landfill

Data Qualifiers

—	Data qualifier field in database is blank
+	Correlation coefficient for matrix spike analysis is less than 0.995 (estimated value)
B	For inorganics, reported value is < CRDL but > IDL (estimated value)
B	For organics, analyte is also detected in blank; for common lab contaminants include as detection if blank result > 10 times detection limit; for all other organics include if blank result > 5 times detection limit
B	For radionuclides, constituent also detected in associated blank whose concentration was greater than CRDL
E	For inorganics, value is an estimate due to interference (estimated value)
J	For inorganics, value > IDL but control sample analysis not within control limits (estimated value)
J	For organics, MS data indicate presence of compound but below detection limit (estimated value)
N	For inorganics, spiked sample recovery is not within control limits (estimated value)
U	Organics and inorganics, analyte analyzed but not detected at the quantitation limit

Data Validation Codes

—	Data qualifier field in database is blank
A	acceptable result
JA	acceptable result (For Estimated Value)
V	valid result
Y	analytical results in validation process

183

Table 3-20
Potential Location-Specific ARARs

Law/Regulation	Citation	Description	ARAR Designation	Comments
Federal Laws				
Endangered Species Act	16 USC § 1538, 50 CFR Part 17	Ensures that remedial/removal actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify their critical habitats.	Applicable	Listed endangered species found around Rocky Flats include the bald eagle. Category 2 species found at Rocky Flats include the ferruginous hawk and Preble's meadow jumping mouse. The Rocky Flats area supports habitat for many other endangered and category 2 species, but none have been found.
Bald and Golden Eagle Protection Act	16 USC § 668a, 50 CFR Part 22	Contains permitting requirements to take (kill or destroy habitat), possess, or transport bald (American) and golden eagles, their nests, or their eggs anywhere in the United States.	Applicable	General applicability. Bald and golden eagles have been identified migrating through Rocky Flats. Some habitat at Rocky Flats is suitable for nesting.
Fish and Wildlife Coordination Act	16 USC § 661, *et seq.*	Requires consultation by the federal department or agency proposing or authorizing any modification of any stream or other water body and adequate provision for protection of fish and wildlife resources.	Applicable	Applicable because possible remedial action (e.g., reducing the size of the pond as a result of the extent of the landfill cap) may affect wildlife that depend on the pond.
Wetlands Assessment	Executive Order 11990, 40 CFR Part 6, Appendix A	Federal agencies must prevent, to the extent possible, the adverse impacts of destroying or modifying wetlands and must prevent direct or indirect support of new construction in wetlands if there is a practicable alternative.	Applicable	Applicable because riparian areas around the East Landfill Pond have been identified as wetland areas.
Clean Water Act	33 CFR §§ 320 - 330, 40 CFR Part 230	Action to dispose of dredge and fill material in waters of the United States is prohibited without a permit. Under CERCLA § 121(e), no permitting is required for onsite actions; however, consultation with the U.S. Army Corps of Engineers remains important.	Applicable	Action to drain the East Landfill Pond is a dredging operation within the parameters of the Clean Water Act.
State Laws				
Colorado Nongame, Endangered, or Threatened Species Conservation Act	CRS Part 33-2-101 to -107	Establishes requirements for protection of wildlife.	Applicable	Parallels the federal Endangered Species Act. In addition to the species identified above, Rocky Flats contains two species of concern in Colorado: forktip three-awn and toothcup.

Definitions

ARAR applicable or relevant and appropriate requirement
CERCLA Comprehensive Environmental Response, Compensation and Liability Act
CFR Code of Federal Regulation
CRS Colorado Revised Statutes
USC United States Code

Table 3-21
Potential Federal and State Action-Specific ARARs

Law/Regulation	Citation	Description	ARAR Designation	Comments
Federal Laws				
Hazardous Waste Management Regulations Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes that are subject to regulation as hazardous wastes.	Applicable	Characterization of waste at the landfill may determine the selection of a remedy.
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes the methodology for determining if a solid waste is a hazardous waste.	Applicable	Characterization of waste at the landfill may determine the selection of a remedy.
Resource Conservation and Recovery Act	42 USC § 9621, *et seq.*			
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable possibility of adverse effect on health or the environment.	Relevant and appropriate	Not applicable because it applies to ongoing operations at solid waste disposal facilities (OU 7 is now regulated as an interim status facility under 40 CFR 265). Relevant and appropriate to identifying criteria that may pose a reasonable probability of adverse effect on human health or the environment.
Criteria for Municipal Solid Waste Landfills	40 CFR Part 258	Establishes minimum criteria for municipal solid waste landfills to ensure protection to human health and the environment. Subpart E, Ground Water Monitoring and Corrective Action; Subpart F, Closure and Post-Closure Care; and Appendix 1 and 2 are all identified as potential ARARs.	Relevant and appropriate	Not applicable because OU 7 is not a municipal site. Relevant and appropriate because OU 7 contains wastes typical for a municipal landfill. Identified sections relate to post-closure environmental issues.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards that define the acceptable management of hazardous waste for owners and operators of facilities that treat, store, and dispose of hazardous waste.	Relevant and appropriate	CDH directs that monitoring and post-closure care requirements are relevant and appropriate for detecting contaminant levels near the East Landfill Pond.
Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 265	Establishes minimum national standards that define the acceptable management of hazardous waste during the period of interim status and until certification of final closure, or if the facility is subject to post-closure until responsibilities are fulfilled.	Applicable	Applicable because OU 7 is undergoing closure as an interim status RCRA facility pending closure.
Land Disposal Restrictions	40 CFR Part 268	Establishes restrictions for the land disposal of hazardous wastes.	Relevant and appropriate	Not applicable because OU 7 remediation does not "place" hazardous wastes outside the area of contamination. It is relevant and appropriate because the type of place regulated is sufficiently similar.
Clean Water Act	33 USC §§ 1251-1376			
Discharge of Stormwater	40 CFR § 122.21 and § 122.26	Controls point source discharges of stormwater associated with industrial activity, including requirements for pollution prevention plans.	Relevant and appropriate	Relevant and appropriate because industrial activity includes landfills.

185

Table 3-21
Potential Federal and State Action-Specific ARARs

Law/Regulation	Citation	Description	ARAR Designation	Comments
Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR Part 125, Subpart K	Requires that best management practices be maintained by the operator of a system that discharges pollutants directly into the environment and requires that point source discharges be monitored to ensure compliance with effluent discharge limits.	Applicable	Applicable through the NPDES Federal Facility Compliance Agreement (FFCA-CWA 90-1)
Atomic Energy Act	42 USC § 2011, *et seq.*			
Standards for Protection Against Radiation	10 CFR Part 20	Establishes minimum standards for radioactive waste disposal.	Relevant and appropriate	Not applicable because Rocky Flats is not an NRC licensed facility. It is relevant and appropriate for its standards to protect the public from radiation exposure and radionuclide contamination of waters and soils.
State Laws				
Colorado Solid Waste Disposal Sites and Facilities Act	CRS 30-20-100.5 *et seq.*			
Colorado Solid Waste Disposal Sites and Facilities Regulations	6 CCR 1007-2	Establishes solid waste disposal criteria, including the collection, storage, treatment, utilization, processing, and final disposition of solid wastes.	Relevant and appropriate	Not applicable because OU 7 is not regulated under state standards for solid waste disposal. Closure, monitoring, and post-closure maintenance requirements are relevant and appropriate to the Present Landfill because they apply to facilities that are sufficiently similar to OU 7.
Soil Erosion Dust Blowing Act	CRS 35-72-101, *et seq.*	Creates an actionable duty to all real property owners in the state to prevent soil from blowing to neighboring lands.	Applicable	Intended to apply to all lands in the state of Colorado.

Definitions

§	section
ARAR	applicable or relevant and appropriate requirement
CCR	Colorado Code of Regulation
CDH	Colorado Department of Health
CFR	Code of Federal Regulation
CRS	Colorado Revised Statutes
CWA	Clean Water Act
DOE	U.S. Department of Energy
FFCA	Federal Facility Compliance Agreement
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OU	operable unit
RCRA	Resource Conservation and Recovery Act
USC	United States Code

Table 3-22
Regulatory and Technical Guidance to be Considered

Guidance Source	Citation	Description	ARAR Designation	Comments
A Guide to Delisting of RCRA Wastes for Superfund Remedial Responses	OSWER 9347.3-09FS September 1990	Circumstances delisting wastes may be appropriate and the procedures for delisting a RCRA hazardous waste as part of a Superfund remedial response.	TBC	This guidance document lists maximum allowed concentrations (MACs) for various hazardous constituents, above which solids containing those wastes are not eligible for delisting. Although the guidance states that these levels are not to be used for setting cleanup levels, MACs may be relevant and appropriate for defining an outer boundary where soil contamination may not exceed that level.
Land Disposal Restrictions for Newly Identified and Listed Hazardous Wastes and Hazardous Soil	58 FR 48092, 48097 (1993)	Proposed numerical treatment standards for organic and metal constituents in soil.	TBC	As it is a proposed regulation, it is at most a TBC. Its use is relevant and appropriate for setting chemical-specific standards for soil. If promulgated, it will become an ARAR.
Air Emissions from Municipal Solid Waste Landfills	56 FR 24468 (1991)	Proposed threshold standards for NMOCs at municipal solid waste landfills.	TBC	Relevant and appropriate for determining acceptable NMOC limits before triggering the need for additional treatment.
Presumptive Remedy for CERCLA Municipal Landfill Sites	EPA Directive No. 9355.0-49FS	Containment is the presumptive remedy for CERCLA municipal landfills.	TBC	OU 7 is largely a landfill containing a combination of solid and hazardous wastes consistent with characterization as a municipal landfill.
DOE Orders				
General Environmental Protection Program	DOE Order 5400.1	Specifies environmental protection standards applicable to DOE operations.	TBC	Contains broad requirements for environmental monitoring.
Environment, Safety, and Health Program for Department of Energy Operations	DOE Order 5480.1B	Specifies responsibility of DOE and conditions under which operations are to be curtailed due to risks.	TBC	Applicable as a potential ARAR because onsite remedial activities need to conform to its restrictions.
Environmental Protection, Safety, and Health Protection Standards	DOE Order 5480.4	Specifies environment and safety requirements for facility construction, operation, and decommissioning, including requirements applicable to DOE and subcontractors.	TBC	Applicable as general standards under which remedial activities must be conducted.

187

Table 3-22
Regulatory and Technical Guidance to be Considered

Guidance Source	Citation	Description	ARAR Designation	Comments
Radiation Protection of the Public and the Environment	DOE Order 5400.5	Specifies compliance of DOE and its contractors under Atomic Energy Act radiation protection requirements.	TBC	Contains compliance guidelines for managing residual radioactive material. Basic dose limits, guidelines, and authorized limits for allowable levels of residual radioactive material, and control requirements for radioactive wastes and residues.
Radioactive Waste Management	DOE Order 5480.2A	Specifies environmental protection requirements for management of low-level waste.	TBC	Includes general performance objectives and monitoring requirements.

Definitions

ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
EPA	U.S. Environmental Protection Agency
FR	Federal Register
MAC	maximum allowed concentration
NMOC	non-methane organic compound
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
RCRA	Resource Conservation and Recovery Act
TBC	guidance or recommendation to be considered

Table 3-23
Comparison of PCOC Concentrations in Leachate at the Seep to MACs

Analyte	Maximum Detection	Units	UCL_{95}	Maximum Allowable Concentration (MAC)	Maximum Detection > MAC?
Metals					
Antimony	60	µg/L	27.52	63	no
Barium	1,550	µg/L	742.52	6,300	no
Semivolatile Organic Compounds					
2,4-Dimethylphenol	3	µg/L	5.45	26.24	no
Bis(2-ethylhexyl)phthalate	2	µg/L	6.05	18.93	no
Diethyl phthalate	3	µg/L	4.05	189,000	no
Fluorene	3	µg/L	2.92	12.62	no
Naphthalene	22	µg/L	21.26	63,090	no
Phenanthrene	5	µg/L	4.92	12.62	no
Volatile Organic Compounds					
1,1-Dichloroethane	10	µg/L	7.20	2.524	yes
Acetone	220	µg/L	52.88	25,240	no
Benzene	2	µg/L	2.14	31.66	no
Carbon disulfide	6	µg/L	2.98	25,240	no
Ethylbenzene	18	µg/L	14.42	4,410	no
Tetrachloroethene	1	µg/L	2.53	31.55	no
Toluene	88	µg/L	47.55	12,020	no
Total xylenes	25	µg/L	16.8	63,090	no
Trichloroethene	4	µg/L	2.44	21.55	no
Vinyl chloride	11	µg/L	5.92	12.62	no

Note

All concentrations are for total analytes.

Definitions

PCOC potential contaminant of concern
MAC maximum allowable concentrations

189

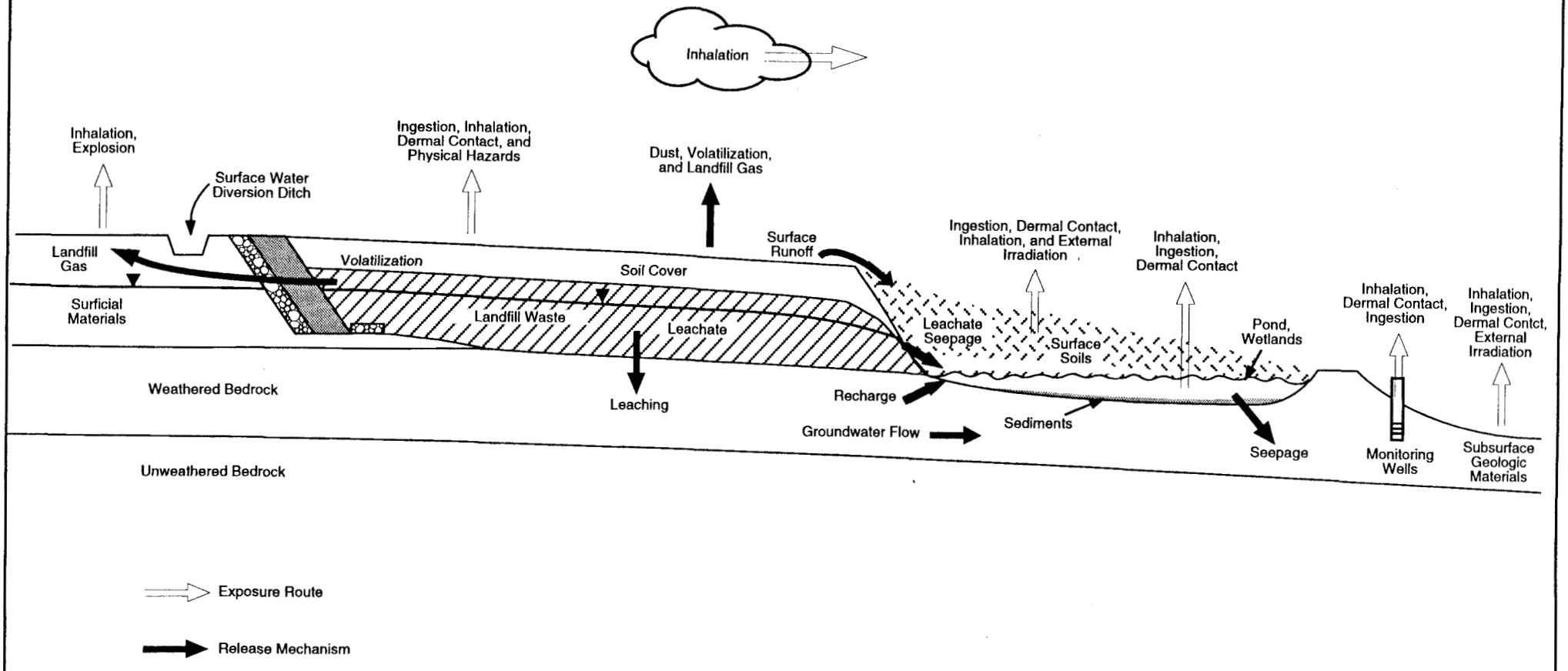
Table 3-24
Evaluation of Remedial Action Objectives for Developing Response Actions

Media Addressed by Remedial Action Objective (RAO)	Potential Exposure Pathways	Analytes Exceed PRGs	Risk Assessment Required?	Human Health Risk carcinogenic: HI > 1E-04 noncarcinogenic: HI > 1	Ecological Risk HI > 1	ARARs Exceedances	Response Action
Present Landfill/ IHSS 203/ Asbestos-Disposal Areas	Eliminated under containment presumptive remedy	NA	no	NA	NA	Cover to be determined by closure ARARs	Presumptive remedy
Landfill Gas	Eliminated under containment presumptive remedy	NA	no	NA	NA	Gas emissions to be determined by air-emission ARARs.	Presumptive remedy
Landfill Leachate at the Seep	Eliminated under containment presumptive remedy	no	no	none	HI = 50, mallard HI = 3, raccoon HI = 3, coyote	Aluminum, manganese, zinc, *naphthalene*, *2-methynaphthalene*, benzene, vinyl chloride	Presumptive remedy
Surface Water in the East Landfill Pond	Inhalation, ingestion, dermal contact	no	yes	none	HI = 10, mallard	Manganese	No action required - no risk to humans, risk to wildlife overestimated
Sediments in the East Landfill Pond	Inhalation, ingestion, dermal contact	no	yes	none	HI > 1,100, aquatic life HI = 6, raccoon HI = 4, coyote HI = 3, mule deer HI = 3, Preble's meadow jumping mouse	No ARARs for soils	No action required - no risk to humans, risk to wildlife overestimated
Surface Soils in Spray Evaporation Area	Inhalation, ingestion, dermal contact, external irradiation	yes	yes	none	NA	No ARARs for soils	No action required - no risk
Subsurface Geologic Materials Downgradient of the Landfill	Inhalation, ingestion, dermal contact, external irradiation	no	no	none	NA	No ARARs for soils	No action required - no risk
Groundwater Downgradient of the Landfill in the Vicinity of East Landfill Pond	*Inhalation, ingestion, dermal* contact	yes	yes	none, carcinogenic risk; HI = 3, noncarcinogenic risk	NA	Selenium	No action required - pathway incomplete
Groundwater Downgradient of the Landfill Downgradient of Dam	Inhalation, ingestion, dermal contact	yes	yes	*none*	NA	Nitrate/nitrite, sulfate	No action required - pathway incomplete

Definitions

PRG preliminary remediation goal
HI hazard index
ARAR applicable or relevant and appropriate requirement
IHSS individual hazardous substance site
NA not applicable

Section 3
Figures



Not to scale

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

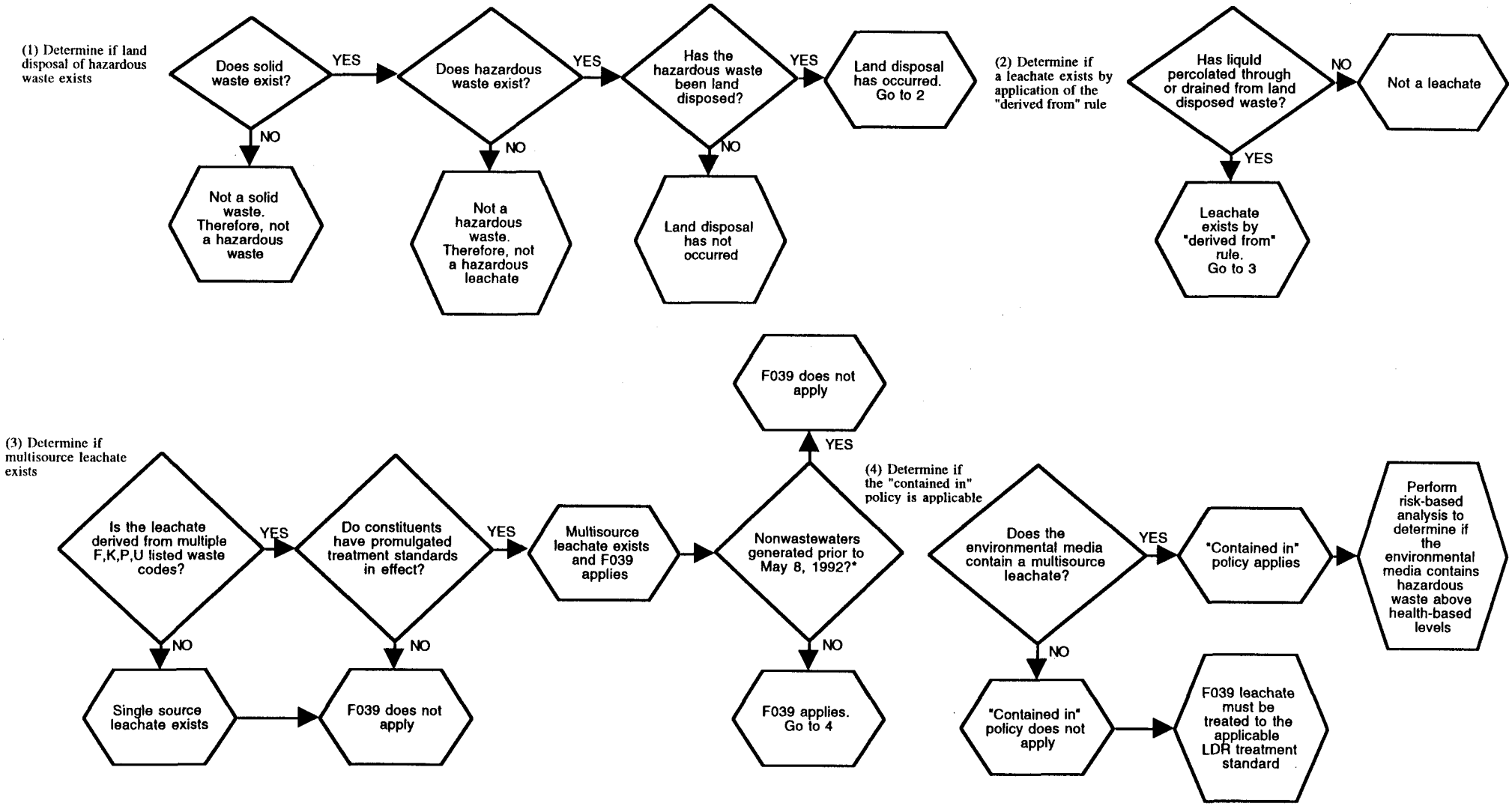
Conceptual Site Model for Defining Risks at OU 7

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 3-1

G95\ES\IM\IRA DD OU 7\Conceptual model for nsk.cdw

Figure 3-2
F039 Determination for Environmental Media



Definitions

Leachate - Any liquid, including any suspended components in the liquid, that has percolated or drained from hazardous waste. (6CCR 1007-3, Part 260.10)

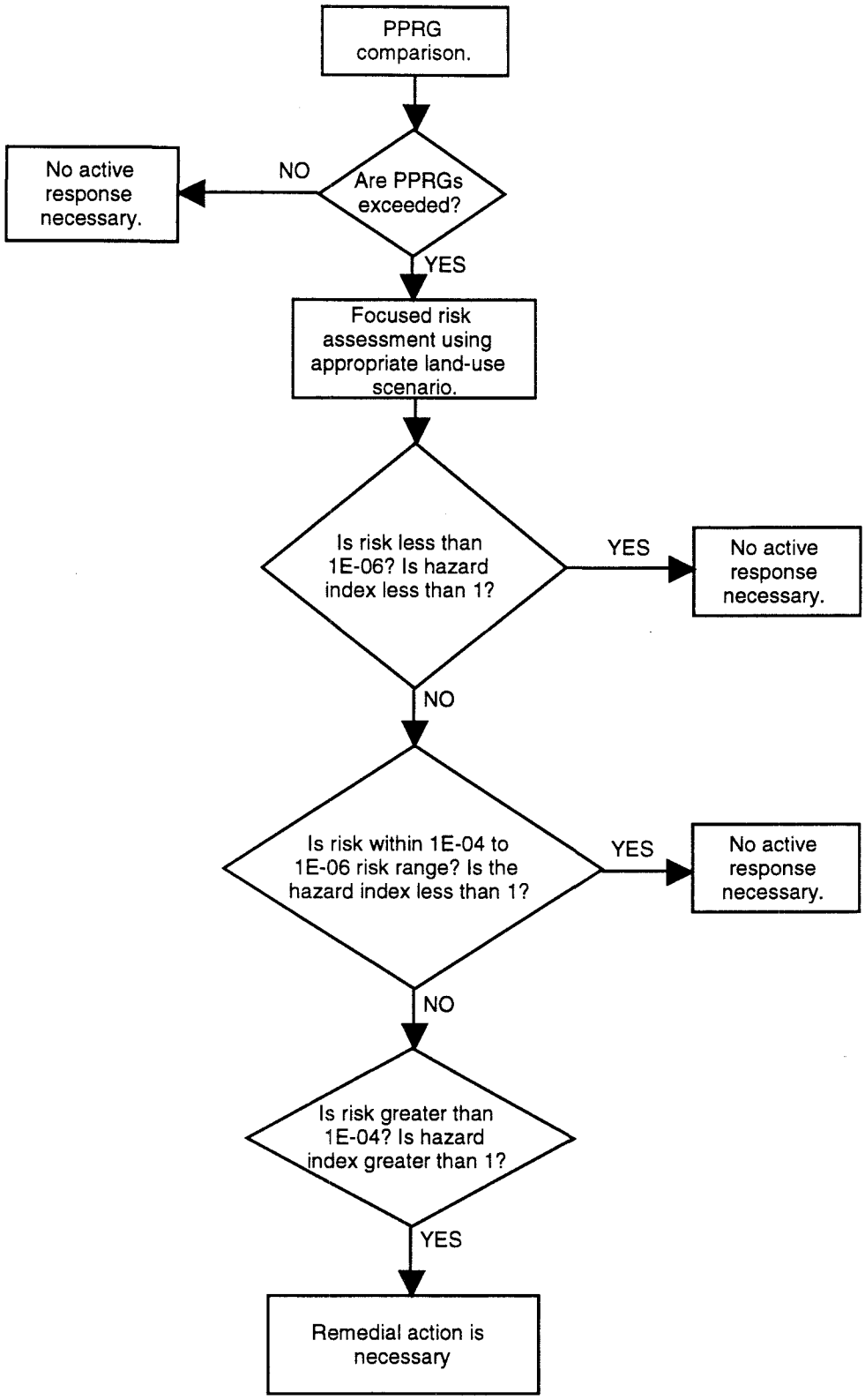
F039 (multi-source leachate) - Leachate (liquids that have percolated through land disposed wastes) resulting from the disposal of more than one restricted waste classified as hazardous under Subpart D (6 CCR 1007-3, Part 261.31)

Land disposal - Placement of hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave. (6 CCR 1007-3, Part 268.2)

Contained in policy - Any environmental media (e.g., groundwater, soil) contaminated with a hazardous waste must be managed as a hazardous waste until the media no longer contains hazardous waste.

* A national capacity variance granted an extension until May 6, 1992 for the F039 nonwastewater.

Modified from the Rocky Flats Field Office Guidance Brief — F039 Multi-Source Leachate (DOE 1995c).



U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

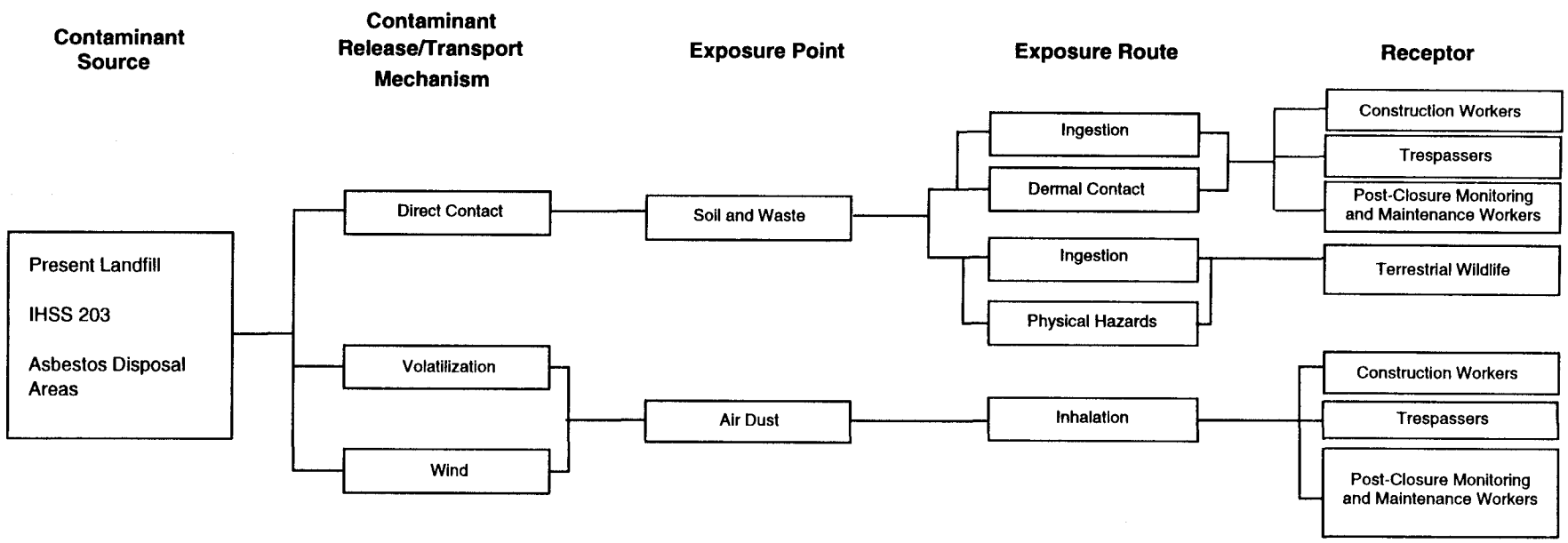
Remediation Determination for Environmental Media

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 3-3

g95\ES\IM\IRA DD OU 7\OU7 Treatm't Det. vertical.CD

194



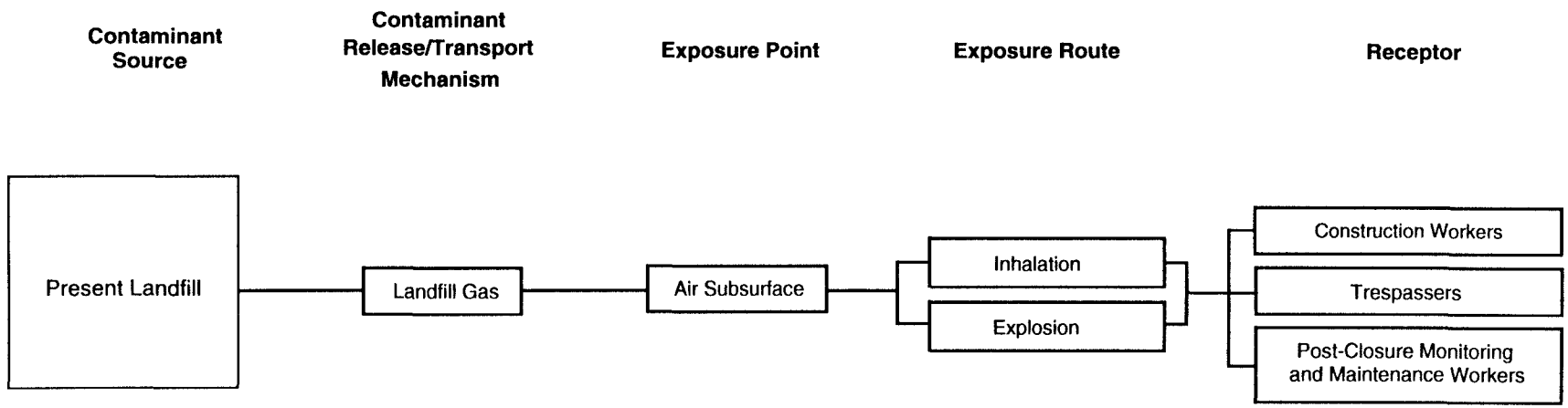
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Conceptual Site Model for the Source Area

Phase I IM/IRA DD	Operable Unit No. 7
July 1995	Figure 3-4

G95/ES/IM/IRA/DD OU 7/Conceptual Site Models.mdw

195



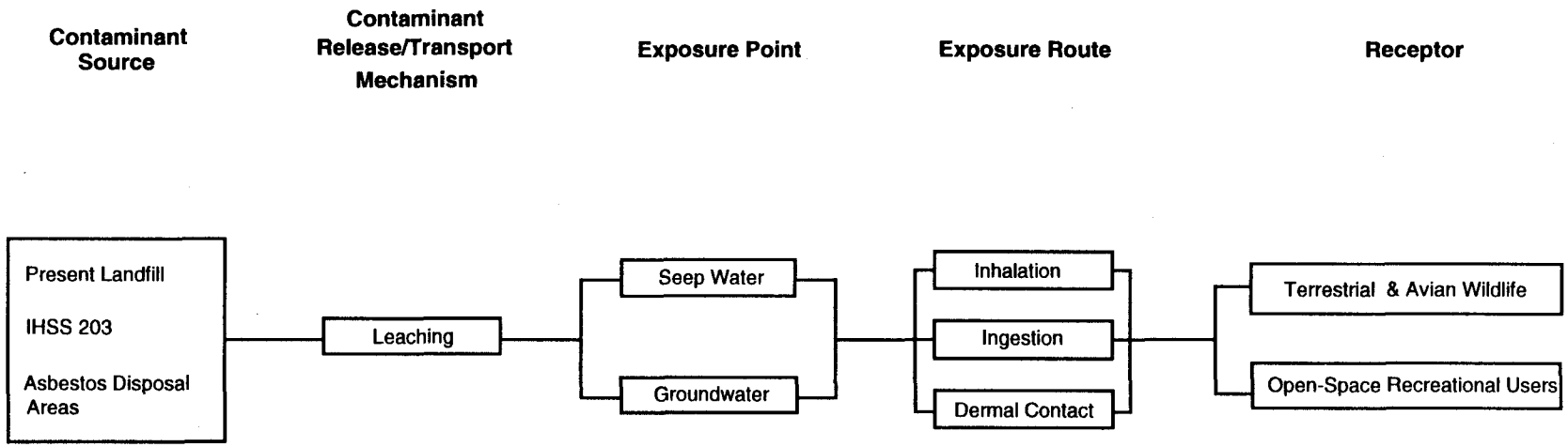
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Conceptual Site Model for Landfill Gas

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 3-5

G95/ES/IM/IRA/DD OU 7/Conceptual Site Models.mdw



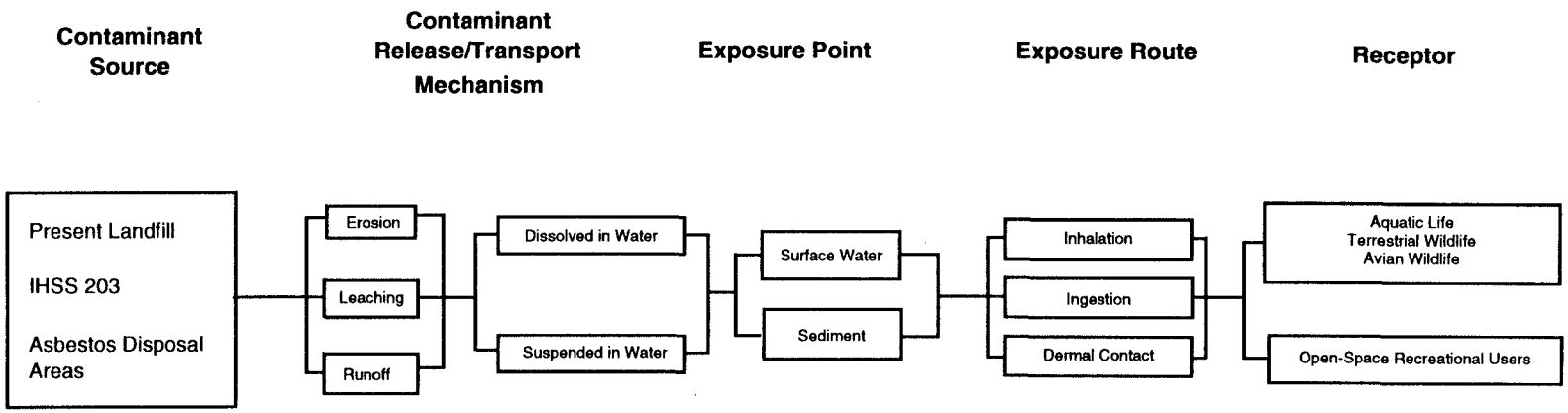
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Conceptual Site Model for Landfill Leachate at the Seep

Phase I IM/IRA DD	Operable Unit No. 7
July 1995	Figure 3-6

G95/ES/IM/IRA/DD OU 7/Conceptual Site Models.mdw

197

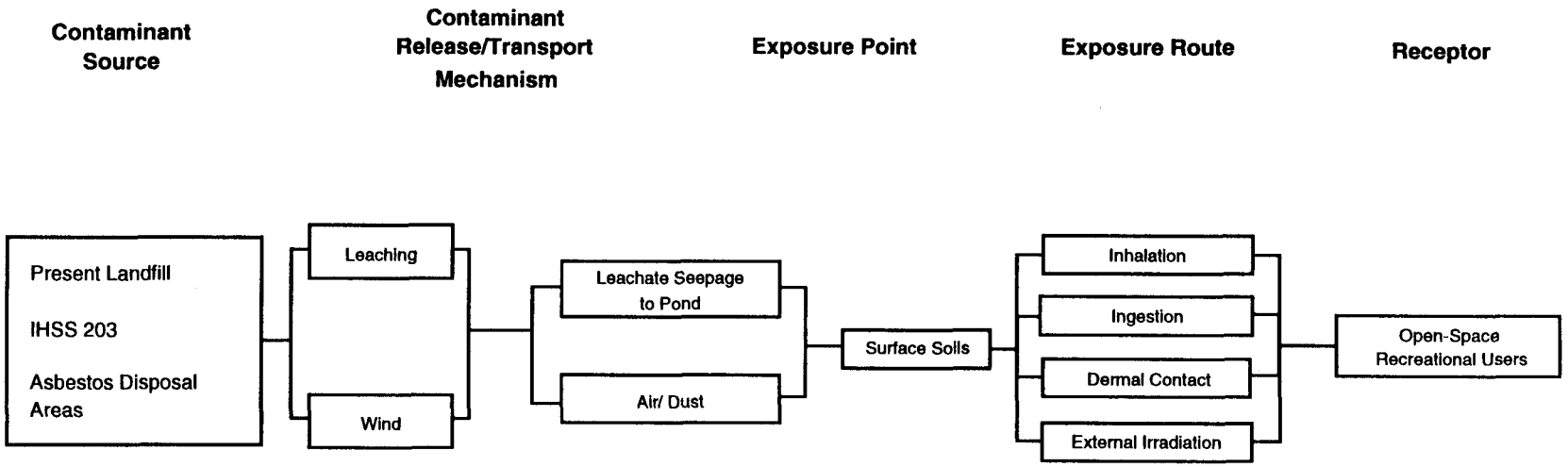


U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Conceptual Site Model for the East Landfill Pond

Phase I IM/IRA DD	Operable Unit No. 7
July 1995	Figure 3-7

G95/ES/IM/IRA/DD OU 7/Conceptual Site Models.mdw



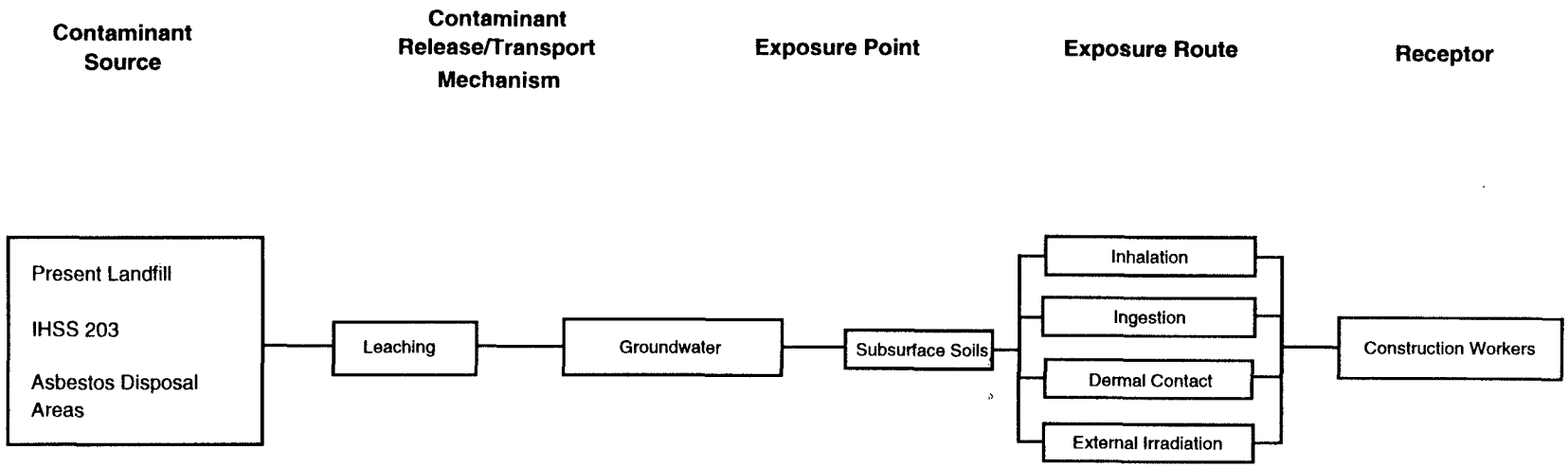
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Conceptual Site Model for Surface Soils in Spray Evaporation Areas

Phase I IM/IRA DD	Operable Unit No. 7
July 1995	Figure 3-8

G95/ES/IM/IRA/DD OU 7/Conceptual Site Models.mdw

199

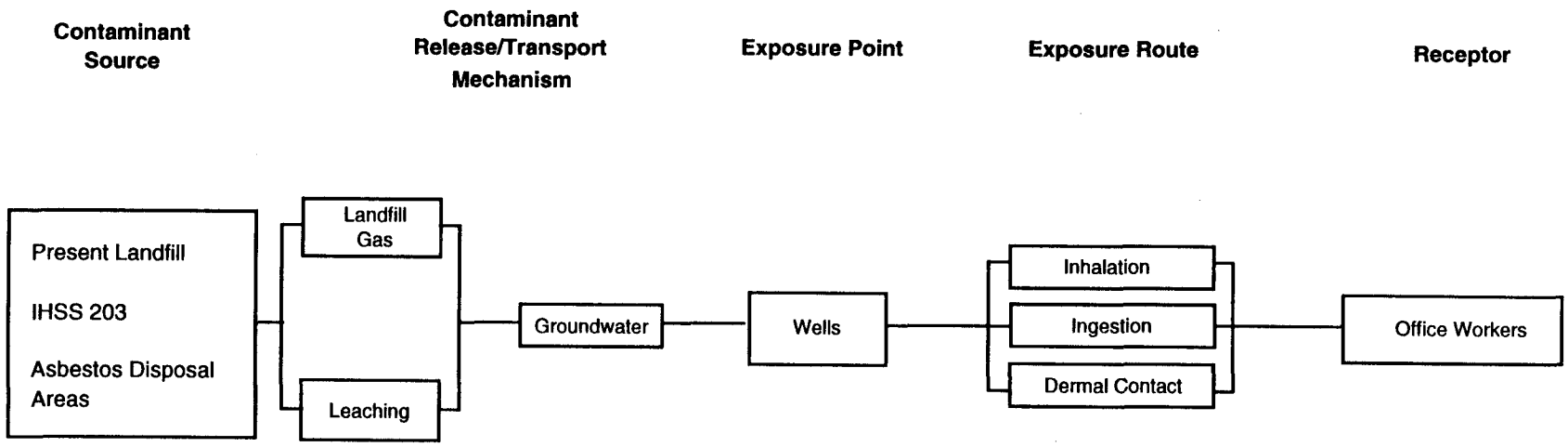


U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Conceptual Site Model for Subsurface Geologic Materials Downgradient of the Landfill

Phase I IM/IRA DD	Operable Unit No. 7
July 1995	Figure 3-9

G95/ES/IM/IRA/DD OU 7/Conceptual Site Models.mdw



U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site,
Golden, Colorado

Conceptual Site Model for Groundwater Downgradient of the Landfill

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 3-10

G95/ES/IM/IRA/DD OU 7/Conceptual Site Models.mdw

201

4. Identification and Screening of Technologies

In this section, technologies are identified and screened to develop a set of usable waste management options that will ensure protection of human health and the environment. The primary purpose is to streamline the selection process to allow the most promising alternatives to be selected for further scrutiny in the detailed analysis (EG&G 1988).

In Section 3, RAOs were identified for various media. Based on these RAOs, general response actions (GRAs) are developed for each medium from the available technologies. The technologies that are considered for the screening are identified in the OU 7 Technology Literature Research Report, compiled in April 1994 to support the selection of an IM/IRA (EG&G 1994c). The initial screening of technologies is performed to eliminate those that are technically not feasible. The remaining options, grouped by technology type, are then evaluated against each other based on effectiveness, implementability, and cost. Technologies carried forward in the screening process will be used for the development and screening of alternatives presented in Section 5.

4.1 General Response Actions

GRAs are general categories of activities that may satisfy the RAOs (EPA 1988) and include no action, institutional controls, containment, removal/collection, disposal, and treatment. For each GRA, there are a number of potentially effective technologies for each medium.

Under the presumptive remedy, certain GRAs have been determined to be most effective for CERCLA landfills. The two primary components of the presumptive remedy at OU 7 are containment of the landfill mass and collection and/or treatment of the landfill gas (EPA 1993a). Institutional controls are also recommended to supplement engineering technologies.

4.2 Identification and Screening of Technologies

For each GRA identified under the presumptive remedy, there are a number of applicable technologies. The technically feasible technologies identified in the OU 7 Technology Literature Research Report (EG&G 1994d) are evaluated relative to each other and screened to reduce the number of technologies used in preparation of the alternatives. This section summarizes the screening process.

202

4.2.1 Screening Process

In the screening process, technologies are evaluated in terms of effectiveness, implementability, and cost (Table 4-1). Comparisons during screening are made between technologies within each category of GRAs, not between categories of GRAs. For example, in Table 4-2 the land-use restrictions, deed restrictions, and zoning ordinances are rated relative to each other but not in comparison to fencing and warning signs, which are access restrictions. Effectiveness in protecting human health and the environment is given the greatest weight. The cost criteria is used only to distinguish between two similarly rated technologies.

The effectiveness criteria include the degree to which a technology meets RAOs and ARARs; reduces toxicity, mobility, or volume through treatment; affords long-term protection; and minimizes short-term impacts.

The implementability evaluation criteria include a determination of the technical and administrative feasibility of implementing the technology. Technical feasibility is used in the OU 7 Technology Literature Research Report (EG&G 1994c) as an initial screen of technology types to eliminate those that were clearly ineffective or unworkable at OU 7. Technical issues relating to implementation include availability of materials, ease of construction, and post-construction repairs. Administrative feasibility addresses the ability to obtain approval from regulatory agencies. The initial screening also emphasizes the institutional aspects of implementability, including the ability to obtain necessary permits and community acceptance and the availability of necessary equipment and skilled workers to implement the technology.

Cost plays a limited role in the screening of technologies; it is used primarily to distinguish between two similarly rated technologies. At this stage, the cost analyses are based on engineering judgment of the relative direct and indirect capital and operation and maintenance (O&M) costs.

4.2.2 No Action

Although no action is not identified in the presumptive remedy as a GRA, it is always used to establish a baseline for comparison. Under no action, no preventive or corrective actions are taken.

4.2.3 Institutional Controls

Institutional controls are methods by which federal, state, and local governments or private citizens can limit exposure to contamination. Most institutional controls take the form of use or access restrictions. These may include simple physical actions such

as fencing and warning signs or more complex regulatory actions such as implementing zoning controls, controlling water use, and deed restrictions.

Each of the four institutional control technologies evaluated in Table 4-2, land-use restrictions, access restrictions, water-use controls, and public education, are retained. All of the technologies are effective and implementable and are included in the alternative development. In addition, all of the technologies are already in place to some extent.

4.2.4 Containment

Containment actions restrict contact with and migration of contaminants. Under the presumptive remedy, a landfill cap is the preferred containment technology. Table 4-3 identifies three types of capping technologies: a native soil cover, a single-barrier cap, and a composite-barrier cap. Although composite-barrier caps are ranked most effective, each cap is considered fully effective for certain site conditions. Therefore, each of the three caps is modeled and evaluated in more detail in the alternative analysis.

As discussed in Section 2.3, the groundwater in the source area is presently contained laterally by the existing groundwater-intercept system and proposed slurry wall, and flow downgradient is significantly reduced by the East Landfill Pond dam. Containment of the groundwater will not be addressed further in this report.

4.2.5 Landfill Gas Collection

Collection response actions partially or completely remove contaminants from their original location. In landfills, gas is generally collected to protect the integrity of the cap. Landfill gas may also be collected prior to treatment (Section 4.2.6).

Table 4-4 shows the evaluation of various types of passive and active collection systems. Both types of systems have been used in municipal landfills for gas collection and control. However, hazardous waste landfills have rarely used active systems because they normally do not produce much gas. Although active gas-extraction wells have been used in municipal landfills, they have had only limited success effectively collecting gas over a large area. Due to the variability in the waste composition, the optimal design of a gas-extraction well is difficult.

A passive gas-extraction system is applicable to sites where offsite migration is limited and gas will be forced to collect in a blanket collection system. Conditions at the Present Landfill are conducive to this type of system. The landfill is underlain by low-permeability weathered bedrock, and the perimeter of the landfill is or will be

surrounded by a low-permeability barrier. This will prevent offsite migration of gas, forcing the gas to be collected under the cover.

Venting trenches are eliminated because they are considered the least effective and the most difficult type of gas-collection system to implement at OU 7.

Both passive vents and permeable layers are carried forward to the development of alternatives in Section 5.

4.2.6 Landfill Gas Treatment

Treatment response actions reduce the toxicity, mobility, and/or volume of contaminants through physical or chemical alteration. Table 4-5 shows the evaluation of landfill gas-treatment systems.

As discussed in Section 3.4, it is not anticipated that landfill gas will exceed ARARs. However, maintenance actions (such as construction of a new slurry wall) and the proposed closure of the landfill may affect gas generation by limiting the migration of gas and decreasing the infiltration of surface water. Due to the unknown impacts on the gas concentration, and flow rates as a result of these actions, it is unknown at this time what, if any, treatment will be required.

Based on these uncertainties, it is recommended that a gas-collection system be installed that would allow for post-closure monitoring of gas composition, concentration, and flow rate until treatment requirements can be determined. The collection system should also be designed to be compatible with gas-treatment units should they be required.

The passive gas-collection system will have vent pipes or gravel columns at various locations across the cover. The vent pipes or gravel columns will extend through the cover and will be logical points for monitoring emissions from the landfill. If required, the vent pipes could be routed directly to a treatment system to reduce emissions from the landfill.

4.3 Results of Screening

Based on the screening presented in this section, the following technologies will be considered in alternatives development:

Institutional Controls (included in all alternatives)

- Use restrictions
- Access restrictions

205

- Water-use controls
- Public education

Containment

- Native soil cover
- Single-barrier cap
- Composite-barrier cap

Gas Collection and Treatment

- Permeable layer
- Vents
- Post-closure gas monitoring and treatment, if needed

Section 4
Tables

Table 4-1
Screening Criteria Summary

Criteria	Assessment Components
Effectiveness	Meet RAOs and ARARs Reduce toxicity, mobility, and volume through treatment Provide long-term protection Minimize short-term impacts
Implementability	Technical feasibility of implementing technology • Availability of materials • Ease of construction • Post-construction repairs Administrative feasibility of implementing technology • Ability to obtain approvals from regulatory agencies
Cost	Comparative costs based on engineering judgment

Table 4-2
Evaluation of Remedial Technologies Institutional Controls

Response Action	Description	Effectiveness	Implementability	Cost	Comments
Institutional Controls					
• **Land Use Restrictions**	Legal restrictions on future use of the site.				Some restrictions already in place.
– Deed Restrictions	Restrictive covenants on deed to the landfill property. May include limitations on excavation and basements in contaminated areas.	Low	High	Low	
– Zoning Ordinances	Zoning change, administrative consent order, or judicial order prohibiting certain land uses.	Moderate	Moderate	Moderate	
• **Access Restrictions**	Physical restrictions to limit access to site.				Some restrictions already in place, including a barbed-wire fence around Rocky Flats and a 4-foot-high fence around the landfill.
– Fencing	Restrict general public and large wildlife from onsite hazards.	Moderate	Moderate	Moderate	
– Written Warnings	Place warning signs in area to warn public of hazards.	Low	High	Low	
• **Water-Use Controls**	Restrictions on use of water associated with site.				
– Well Permit Regulation	Regulate drilling of new wells in potentially contaminated aquifer.	Moderate	Moderate	Low	Alternate water sources exist.
– Inspect and Seal Existing Wells	Wells in contaminated areas.	Low	High	Moderate	Unnecessary. Wells will be plugged and abandoned under a separate action prior to closure.
• **Public Education**	Increase public awareness of site conditions and remedies through written notices, meetings, and news releases.	Low	High	Low	The draft final Phase I IM/IRA DD will be available for public review and comment.

Note

Ratings indicate performance relative to other technologies within the same bulleted category of response action.

209

Table 4-3
Evaluation of Remedial Technologies Containment

Response Action	Description	Effectiveness	Implementability	Cost	Comments
Containment Actions					
• **Capping**	Provides physical barrier between contaminants and the environment. May include surface regrading and revegetation.				
– Native Soil Cover	Reduces exposure to, and migration of, contaminated materials through use of a native soil cover.	Low	High	Low	Allows some infiltration of precipitation.
– Single-Barrier Cap	Uses a cap constructed of a single layer of various media, such as clay, flexible membrane liner, asphalt, or concrete-based material.	Moderate	Moderate	Moderate	Limits infiltration of precipitation.
– Composite-Barrier Cap	Uses multiple barrier layer design. Media include soil and synthetics.	High	Low	High	Minimizes infiltration of precipitation. Creates relatively high volume of clean run-off. Meets RCRA capping guidance.

Note

Ratings indicate performance relative to other technologies within the same bulleted category of response action.

Table 4-4
Evaluation of Remedial Technologies Landfill Gas Collection

Response Action	Description	Effectiveness	Implementability	Cost	Comments
Collection/Removal Actions					
• **Passive**	Control migration of gases by altering the path of flow using high-permeability, preferential pathway.				May be limited by impermeable layers. Potential odor. Low energy. Low O&M.
– Vents	Pipe vents or gravel columns are used for venting gas at points where it is collecting and building up pressure.	Moderate	High	Low	Small zone of influence.
– Venting Trench	Gravel trenches form a path of least resistance for gases.	Low	Moderate	Moderate	Depth limited to 20 feet. Gases may migrate underneath.
– Permeable Layer	High-permeability blanket layer provides preferential pathway for gases.	High	Low	Moderate	Most applicable near sources of gases. May require cover and drainage layer to prevent freezing.
• **Active**	Control gas migration by extraction/collection via vacuum blowers or compressors.				May be limited by impermeable layers. Not sensitive to freezing or saturation of surface or cover soils.
– Extraction Wells	Gases drawn into a perforated pipe surrounded by permeable material by blower or compressor system.	Moderate	High	Low	Good for deep landfills.
– Extraction Trench	Gases drawn into perforated pipe in gravel-filled trench by blower or compressor system.	Low	Moderate	Moderate	Depth limited to 20 feet.
– Permeable Layer	Gases drawn into permeable layer by blower or compressor system.	High	Low	High	Perched water table or impermeable geological layer limits technology.

Note

Ratings indicate performance relative to other technologies within the same bulleted category of response action.

211

Table 4-5
Evaluation of Remedial Technologies Landfill Gas Treatment

Response Action	Description	Effectiveness	Implementability	Cost	Comments
Treatment Actions					
• **Thermal**	Use of heat to destroy contaminants.				May require supplementary fuels for a continuous burn.
– Open Flare	Gases combusted by exposure to open flame.	Moderate	High	Low	Lower combustion efficiency than enclosed flame. Open flame may cause public concern.
– Enclosed Flare	Gases combusted by exposure to flame within a flame enclosure or stack.	High	Moderate	Moderate	For destruction of vapors that are easily burned and have no harmful products of combustion.

Note

Ratings indicate performance relative to other technologies within the same bulleted category of response action.

5. Development of Alternatives

Technologies retained after the initial screening presented in Section 4 are now used to form alternatives to address the OU 7 site as a whole. The resulting alternatives can be individual technologies or a combination of technologies designed to meet RAOs, such that human health and the environment are protected from exposure pathways to contaminated media. As a result of the presumptive remedy approach, the number of alternatives formed is limited and consists of various cap cross sections. Institutional controls and potential gas treatment technologies are included in all options.

The alternatives are further refined and screened based on the following three evaluation criteria: effectiveness, implementability, and cost. Alternatives must be compared at an equal level of analysis with sufficient detail to be able to distinguish among the various alternatives (EG&G 1988).

5.1 Cover Design

The proposed action must meet the CHWA requirements for landfill closure [6 CCR 1007-3 Part 265.310] as follows:

- Provide long-term minimization of migration of liquids through the closed landfill
- Function with minimum maintenance
- Promote drainage and minimize erosion or abrasion of the cover
- Accommodate settling and subsidence so that the integrity of the cover is maintained
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoil present

The alternatives consist primarily of different cap cross sections; however, a number of design parameters are common to all capping alternatives. These include (1) extent of the landfill cover, (2) wetland and sensitive-habitat mitigation, (3) the grading plan, (4) surface-water management, and (5) basic cover components.

5.1.1 Extent of the Landfill Cover

The proposed landfill cap covers the Present Landfill (IHSS 114), Inactive Hazardous Waste Storage Area (IHSS 203), and asbestos-disposal areas, as shown on Figure 5-1, and encompasses approximately 20 acres. The extent of waste material was determined

using historical photographs of OU 7 and field tests performed during the Phase I RFI/RI (DOE 1994a).

Although there is no contamination of soils at IHSS 203 (DOE 1994a), it is located within the boundary of the Present Landfill and therefore will be capped along with the landfill mass.

The asbestos-disposal areas have an existing soil cover that meets disposal requirements for asbestos (40 CFR Part 61). However, the asbestos areas also are located within the boundary of the Present Landfill and therefore will be capped.

5.1.2 Wetland and Sensitive-Habitat Mitigation

Areas in and around the East Landfill Pond have been designated as wetlands by the U.S. Army Corps of Engineers (Figure 2-12), as discussed in Section 2.4. To provide slope stability along the east face of the landfill, the cover must extend over a portion of the designated wetlands. A wetlands assessment is required under 40 CFR Part 6 (Section 3.4.2.1) and will be included as part of the recommended IM/IRA in Section 7. The proposed mitigation plan for onsite wetlands impacted by the remedial action at OU 7 is to use acreage from the wetland mitigation bank currently being developed in association with the Standley Lake Protection Project. Planting of wetland vegetation for the Standley Lake Protection Project is scheduled for summer 1995.

OU 7 has been identified as potential habitat for Preble's meadow jumping mouse, a candidate for listing as a threatened or endangered species (Figure 2-12). The Preble's meadow jumping mouse is currently protected under the Colorado Non-game, Endangered or Threatened Species Conservation Act. DOE will mitigate losses to the Preble's meadow jumping mouse habitat as a result of the remedial action as needed.

5.1.3 Grading Plan

Given the extent of the landfill cover as described in Section 5.1.1, the primary variables in determining the grading plan are the maximum and minimum slopes for the cover. Maximum slopes are generally based on stability and erosion concerns. Minimum slopes are based on providing adequate surface-water drainage for the entire cover area after settlement.

The existing side slopes extending down into the East Landfill have a slope of approximately 33 percent. The slopes on the north side of the East Landfill Pond have exhibited signs of instability in the past, including shallow slumping and seeps. To stabilize these areas, the grading plan includes placement of fill to buttress the slopes. For preliminary planning purposes, it is assumed the slopes are regraded to a slope of approximately 20 percent. This is considered to be a stable slope to prevent slumping

and erosion. A slope angle of less than 20 percent could be used if the slurry wall maintenance action is performed sooner, because the slurry wall will limit groundwater inflow and allow groundwater within the landfill to drain.

Minimum slope angles are selected to provide adequate drainage after settlement. Conservative settlement estimates were made and are based on a variety of landfill-settlement models as summarized in Appendix F. The resulting grading plan for the top surface has a minimum 7 percent grade. Final design analyses may indicate that slightly lower initial grades may be acceptable for the Present Landfill.

Figures 5-2, 5-2a, and 5-2b show the grading plan, which is crowned in the center and slopes outward to the perimeter surface-water diversion ditch. The grading plan addresses the 6 CCR 1007-3 Part 265.310 requirements to promote drainage and minimize erosion or abrasion of the cover and accommodate settling and subsidence so that the integrity of the cover is maintained. Minimizing soil erosion and settlement of the waste will allow the cover to function with minimum maintenance.

5.1.4 Surface-Water Management

The OU 7 cover, as designed, is mounded in the center and graded to drain to the perimeter as shown in Figure 5-2. Along the north, south, and west sides of the landfill, surface water draining off the cover is collected in the existing perimeter surface-water drainage ditch and routed to the east around the landfill, and past the East Landfill Pond dam. The ditch will be rerouted along the south side of the landfill where the cap extends over the existing ditch. The surface-water drainage ditch ultimately discharges into No Name Gulch. Surface-water runoff from the landfill to the east flows directly into the East Landfill Pond. In addition to receiving surface-water runoff from the landfill, the perimeter surface-water drainage ditch will also receive water from the lateral drainage layer in the cover section.

5.1.5 Cover Components

Because some hazardous waste was disposed in the Present Landfill until 1986, a RCRA Subtitle C cover or equivalent is required. Five layers are typically used in a RCRA Subtitle C cover: vegetative cover, lateral drainage, barrier, gas collection, and grading fill. The purpose of each layer and the materials that may be used are discussed in the following sections. Table 5-1 presents a summary of the cover components, including the objectives and materials considered for each component.

5.1.5.1 Vegetative-Cover Layer

The vegetative-cover layer is intended to provide a suitable growth media for local vegetation after construction of the cover. The vegetative-cover soil must provide

suitable moisture retention characteristics to establish and sustain vegetation. A secondary intent of this vegetative-soil cover is to provide an insulation or protective layer over the barrier layers to prevent freezing or drying. This design criterion normally dictates the ultimate depth of the vegetative-cover soil. Frost depth in the Rocky Flats area is approximately 3 feet.

A 36-inch vegetative-soil layer is included in all cover alternatives. The vegetative layer is made up of 2.5 feet of soil under 0.5 feet of topsoil. The main plant species proposed for revegetation consist of tall-prairie grasses: western wheatgrass, blue grama, green needlegrass, and little bluestem (SCS 1983).

5.1.5.2 Lateral-Drainage Layer

This layer intercepts and drains any water that infiltrates through the vegetative cover. The lateral-drainage layer is continuous over the top of the cover and discharges collected water at the perimeter surface-water drainage ditch.

Materials considered for the lateral-drainage layer include: granular soil, geotextiles, geonets, and geocomposites. Each is described in more detail below.

Granular Soil

Granular-soil drainage layers have been used successfully for many years in a variety of drainage-layer applications; however, there are some limitations to their use in cover applications. Media may consist of coarse sands or fine gravels. A geotextile filter fabric is required between the vegetative cover soil and the drainage layer soil to prevent migration of fines into the drainage layer. The drainage-layer material must be reasonably well graded and not too coarse grained to prevent damage to the underlying geomembrane. Alternatively, a geotextile cushion may be required between this geomembrane and the granular soil.

Recently, soil-drainage layers in cover applications have been replaced or supplemented with geosynthetic-drainage layers, which have a higher transmissivity and will not damage underlying geomembranes.

Geotextiles

Geotextiles are commonly used as filter layers between soil materials with differing grain-size distributions (i.e., between drainage layers and barrier layers). The geotextile retains the fines and prevents them from migrating into other layers and causing a reduction in permeability.

Geotextiles are also used as cushion layers between geomembranes and coarse-grained soils that could damage a geomembrane. In some cases, very thick and very high-

transmissivity geotextiles have been used for lateral-drainage layers. However, they are generally used in conjunction with geonet drainage products.

Geonets

Geonets have become the most common type of lateral-drainage layers used in landfill cover and liner designs. Geonets are used for this type of application because of their high transmissivity, low damage potential when used with geomembranes, competitive cost compared to granular drainage layers, ease of installation, and compatibility with leachates of varying compositions.

Geocomposites

Geocomposites are a combination of geonet and geotextile. The geotextile is generally heat bonded to one or both sides of the geonet. A geocomposite provides the high-transmissivity benefits of a geonet and the filtration characteristics of a geotextile but is installed in one step instead of two.

A geocomposite has been selected for the lateral-drainage layer in all cover options for OU 7 due to the benefits of a geocomposite compared to a granular drainage layer or a geotextile or geonet alone.

5.1.5.3 Barrier Layer

The barrier layer is included in the cover design to prevent water from infiltrating into the waste and to prevent uncontrolled venting of gases at the surface. The three types of barrier layers considered for the OU 7 cover can be used alone or in combination and include flexible membrane covers (FMCs), geosynthetic clay liners (GCLs), and compacted clay covers.

FMC

Geosynthetic FMC materials are available in a variety of compositions, thicknesses, surface textures, colors, and other physical properties. FMC material laminated with geonets and geotextiles that serve dual functions as barrier and drainage layers are also available.

The FMCs considered for the OU 7 cover include high-density polyethylene (HDPE) and PVC. Both materials are considered to have permeabilities in the range of 1E-13 cm/sec. Each has advantages and disadvantages in terms of durability, chemical compatibility, strength, elasticity, and ease of installation. The selection of the type of FMC material to be used at OU 7 will be made during the final design.

GCL

A GCL is composed of a commercial bentonite layer sandwiched between sheets of woven or non-woven geotextiles. The bentonite in a GCL is supplied at a relatively low moisture content and can swell to many times the installed thickness if it is exposed to water. The bentonite has a very low inherent permeability (approximately 1E-09 cm/sec). Because the material is supplied at a low initial moisture content, it is not susceptible to desiccation cracking. Research on GCLs has indicated that they will exhibit low permeability even after repeated wetting and drying and/or freezing and thawing cycles (Corser *et al.* 1992). GCLs have been in use for only seven years. No data on their long-term effectiveness are available.

Compacted Clay

Compacted clay covers may consist of any natural soil deposit that can be placed and compacted to achieve a permeability of 1E-07 cm/sec or less. These generally consist of fine-grained soils that exhibit plasticity. Coarse-grained soils can be mixed with various percentages of bentonite to achieve the required permeability and plasticity characteristics. However, admixed soil barrier layers are generally much more expensive than natural clay barrier layers.

Compacted clay covers are generally placed at moisture contents above optimum and therefore are susceptible to desiccation cracking and freeze cracking. After initial cracks are formed, compacted clays in general do not swell and heal like GCLs unless they are placed under very high normal loads. High normal loads are not predicted for the OU 7 cover. However, because they are placed in relatively thick layers (2 feet), they can accommodate minor settlement and some surface cracking or deterioration without complete failure.

The cover alternatives considered for OU 7 utilize various combinations of these materials for the barrier layer.

5.1.5.4 Gas-Collection Layer

The gas-collection layer collects migrating gases across the entire landfill surface and transmits them to selected discharge points. Gases that collect in this layer flow to vent pipes and/or gravel columns where they vent through the cover.

A geocomposite is used for the gas-collection layer in all alternatives. As discussed under lateral drainage, a geocomposite is a geonet drainage layer with geotextile bonded to both sides to prevent infiltration of fine soils.

218

All cover options incorporate monitoring the gas composition, concentration, and flow rate the during post-closure care period until treatment requirements can be determined. The design incorporates provisions to facilitate gas treatment if needed.

5.1.5.5 General Grading Fill Layer

To achieve adequate surface-water drainage off the landfill, general grading fill is required. The intent of the grading fill is to achieve a crown in the center of the landfill to shed water off the slopes. Fill is thickest in the center of the landfill and thinner toward the edges.

The general fill material can consist of almost any natural soil material. There are no specific restrictions on the composition of the soil as long as it can be compacted to a firm, unyielding subgrade. Fill material is expected to come from both onsite and offsite sources (EG&G 1994d).

5.2 Description of Alternatives

Alternatives are developed to cover the range of remedial actions available under the presumptive remedy. The capping options may include the following elements as described in Section 5.1:

- Institutional controls
- 36-inch vegetative cover layer
- Geocomposite lateral-drainage layer
- Various combinations of barrier layers
- Geocomposite gas-collection layer and venting system
- Grading fill

5.2.1 Alternative 1: No Action

Under Alternative 1, no action is taken. The no-action alternative required under the NCP provides a baseline for comparison of other alternatives (55 Federal Register 8704). The cover in the no-action alternative is the interim soil cover material, which is of variable thickness. Under the existing conditions, the waste and fill material in the landfill has a permeability of approximately 1E-02 cm/sec. This alternative is shown in Figure 5-3.

5.2.2 Alternative 2: Institutional Controls

Alternative 2 is similar to the no-action alternative in that the existing interim soil cover material is the final cover; however, the alternative includes institutional controls for both the landfill and groundwater as described below. Under existing conditions, the waste and fill material in the landfill have a permeability of approximately 1E-02

cm/sec. The cover cross section for this alternative is the same as that for no action and is shown in Figure 5-3. Public education and statutory reviews by EPA are also included in this alternative.

5.2.2.1 *Land Use and Access Restrictions*

A 6-foot chain-link fence and warning signs limit access to the landfill. In addition, the Rocky Flats site is fenced. Workers and visitors may enter the Rocky Flats site through the east or west gates; however, access is limited and is enforced by a 24-hour security force.

As part of landfill closure, DOE will record a notation on the property deed to identify it as a hazardous waste landfill and restrict future use. DOE may lease Rocky Flats property for up to 10 years, but because Rocky Flats is listed on the National Priorities List for CERCLA, DOE must obtain EPA approval. EPA will determine if the terms and conditions of the lease agreement are consistent with the safety and protection of public health and the environment (DOE 1993c).

In addition, under the Community Environmental Response Facilitation Act (CERFA), an amendment to CERCLA, DOE is required to notify the state of any lease that will encumber property on which any hazardous substance was stored for one year or more, and on which it plans to terminate federal government operations (DOE 1993c).

5.2.2.2 *Groundwater Controls*

Under this alternative, the existing restrictions on use of groundwater at the site are maintained. There are no existing water supply wells at Rocky Flats. The nearest supply wells downgradient of the landfill are 2 miles from OU 7. Institutional controls include monitoring of one upgradient and three downgradient wells as described in the OU 7 Post-Closure Plan in Section 8.2.3.

The drilling of new wells is regulated by DOE and the state of Colorado. Rocky Flats Environmental Management Department Operating Procedure No. GWT.06, Revision 2 (EG&G 1992b) requires that a Well Installation Notification (WIN) form (GT.6A) be completed to ensure that new well administrative controls are met by the inclusion of requester information, installation methods, purpose, initial well-permit data, environmental-protection measures, and additional information. The requester must also supply information necessary to prepare and file applicable well permits required by the state of Colorado.

5.2.2.3 Public Education

Community relations activities such as posting written notices of public meetings, publishing fact sheets that summarize alternatives being evaluated, holding public meetings to discuss community concerns and explain alternatives, and publishing news releases will increase public awareness of site conditions and the alternatives considered for final closure of OU 7. The public can comment on remedy selection and provide input to the decision-making process during the public comment period for the Draft Final Phase I IM/IRA DD.

5.2.2.4 EPA Reviews

In accordance with CERCLA, Section 121(c) and NCP Section 300.430 (f)(4)(ii), reviews are required of any "remedial action that results in any hazardous substances, pollutants or contaminants remaining at the site." These "Statutory Reviews" are necessary for "any site at which a post-Superfund Amendments and Reauthorization Act (SARA) remedy, upon attainment of the Record of Decision (ROD) cleanup levels, will not allow unlimited use and unrestricted exposure." Reviews must occur at least every five years but may be terminated when hazardous substances, contaminants, and pollutant levels allow for unlimited use and unrestricted exposure.

Reviews ensure that the response action remains protective of human health and the environment. In most cases, a Level I review is adequate. For Level I reviews, a site visit, limited analysis of site conditions, and information gathered during routine operation and maintenance activities will suffice. In the event of new or revised regulations or changes in site conditions, the level of review may be adjusted.

5.2.3 Alternative 3: Native Soil Cover

Alternative 3 consists of a 36-inch native soil cover placed directly over the grading fill. The native soil cover is expected to consist of Rocky Flats Alluvium or other free draining granular material. Furthermore, it was assumed that the native soil cover would be placed in a single lift without compaction. Based on these assumptions, the native soil cover was considered to have a permeability of approximately 1E-02 cm/sec. The cap cross section is shown in Figure 5-3. Institutional controls are included as described in Section 5.2.2.

5.2.4 Alternative 4: Single-Barrier Clay Cover

Alternative 4 consists of a single-barrier clay cover and institutional controls. The cover section consists of the following layers (Figure 5-3):

- 36-inch vegetative-soil layer
- Geocomposite lateral-drainage layer

- 24-inch compacted clay barrier layer
- Geocomposite gas-collection layer and venting system
- Grading fill

The barrier layer is made up of compacted clay with a permeability of approximately 1E-07 cm/sec. The gas-collection system has provisions for gas treatment if needed.

5.2.5 Alternative 5: Single-Barrier FMC Cover

Alternative 5 consists of a single-barrier FMC cover and institutional controls. The cover section consists of the following layers (Figure 5-3):

- 36-inch vegetative-soil layer
- Geocomposite lateral-drainage layer
- FMC barrier layer
- 6-inch bedding layer for the FMC
- Geocomposite gas-collection layer and venting system
- Grading fill

The FMC barrier layer has a permeability of approximately 1E-13 cm/sec. It is placed on 6 inches of a bedding soil to cushion the FMC from the underlying geocomposite. The soil has a permeability of approximately 1E-02 cm/sec and is not designed to act as a barrier layer. The gas-collection system has provisions for gas treatment if needed.

5.2.6 Alternative 6: Single-Barrier GCL Cover

Alternative 6 consists of a single-barrier GCL cover and institutional controls. The cover consists of the following layers (Figure 5-3):

- 36-inch vegetative-soil layer
- Geocomposite lateral-drainage layer
- GCL barrier layer
- Geocomposite gas-collection layer and venting system
- Grading fill

The barrier layer is a GCL with a permeability of approximately 3E-09 cm/sec. Gas treatment will be added if needed.

5.2.7 Alternative 7: Single-Barrier FMC with a Low-Permeability Soil Cover

Alternative 7 consists of institutional controls and a cover with an FMC barrier and a 12-inch layer of low-permeability soil. The cover consists of the following layers (Figure 5-3):

- 36-inch vegetative-soil layer
- Geocomposite lateral-drainage layer
- FMC barrier layer
- 12 inches of a low-permeability soil barrier layer
- Geocomposite gas-collection layer and venting system
- Grading fill

The presence of the low-permeability soil (approximately 1E-05 cm/sec) gives the cover system some of the benefits of a composite cover without the rigorous installation requirements of a full compacted clay. The barrier layer is an FMC with a permeability of approximately 1E-13 cm/sec. The gas-collection system is designed to facilitate gas treatment if needed.

5.2.8 Alternative 8: Composite-Barrier FMC and GCL Cover

Alternative 8 is a true composite barrier with both FMC and GCL. Institutional controls are also included in this alternative. The cover consists of the following layers (Figure 5-3):

- 36-inch vegetative-soil layer
- Geocomposite lateral-drainage layer
- FMC barrier layer
- GCL barrier layer
- Geocomposite gas-collection layer and venting system
- Grading fill

The barrier layers are an FMC with a permeability of approximately 1E-13 cm/sec and a GCL with a permeability of 3E-09 cm/sec. The gas-collection system has provisions for gas treatment if needed.

5.2.9 Alternative 9: Composite-Barrier FMC and Clay Cover

Alternative 9 is a composite barrier with both FMC and compacted clay as well as institutional controls. The cover consists of the following layers (Figure 5-3):

- 36-inch vegetative-soil layer
- Geocomposite lateral-drainage layer
- FMC barrier layer
- 24 inches of a compacted clay barrier layer
- Geocomposite gas-collection layer and venting system
- Grading fill

This cover section follows EPA guidance documents for a RCRA Subtitle C facility (EPA 1989d, EPA 1989e). The FMC has a permeability of approximately 1E-13

223

cm/sec and overlies a compacted clay with a permeability less than or equal to 1E-07 cm/sec. The gas-collection system has provisions for gas treatment if needed.

5.3 Screening of Alternatives

This section documents screening of the nine alternatives presented above to provide sitewide protectiveness based on their effectiveness, implementability, and cost. The screening of alternatives in this section examines each criteria in greater detail than was used in Section 4. This serves to limit the number of alternatives that will be considered and refined in the detailed analysis. The criteria are outlined in Table 5-2 and described below.

5.3.1 Screening Criteria

5.3.1.1 Effectiveness

The effectiveness criteria include the degree to which a technology meets RAOs and ARARs; reduces toxicity, mobility, or volume through treatment; affords long-term protection; and minimizes short-term impacts. Alternatives that are not protective of human health and the environment are eliminated from further consideration.

As described in Section 3.5, RAOs for OU 7 include the following:

- Prevent direct contact with landfill contents
- Minimize infiltration and resulting contaminant leaching to groundwater
- Control surface-water runoff and erosion
- Control landfill gas (treat as needed)
- Remediate wetlands (as needed)

The proposed cover must meet the requirements of 6 CCR 1007-3 Part 265.310. The most important requirement for the evaluation of alternatives is that the cover have a permeability less than the underlying bedrock. As described in Section 2.3, the weathered bedrock has a permeability of 1E-06 to 1E-07 cm/sec.

Each of the alternatives is evaluated using the Hydrologic Evaluation of Landfill Performance (HELP) model (EPA 1994b). A description of the HELP model, inputs used for this evaluation, and output runs are presented in Appendix G. Figure 5-4 shows leakage rates for the nine cover alternatives.

5.3.1.2 Implementability

The implementability evaluation criteria include a determination of the technical and administrative feasibility of implementing the technology. Alternatives that are not technically or administratively feasible are eliminated from further consideration.

Technical issues relating to implementation include availability of materials to construct the cover, ease of construction, and post-construction repairs. Availability of general fill, geosynthetic layer, and vegetative layer materials are equivalent among the alternatives, whereas availability of barrier soil and barrier soil preparation requirements differ. Ease of construction considers equipment, labor, and construction quality assurance (CQA) efforts required for subgrade preparation and cover installation. Post-construction repair considers equipment, labor, and CQA effort required to repair damage to a small area of the cover.

Administrative feasibility addresses the ability to obtain approvals from regulatory agencies and coordinate with other agencies.

5.3.1.3 Cost

A preliminary cost estimate was developed for each alternative. These are conceptual costs and should be used for comparison purposes only. The estimates include direct and indirect capital and O&M costs. Direct costs include site preparation; mobilization; demobilization; landfill cap components; gas monitoring; groundwater monitoring; and fencing, gates, and signs. Indirect costs include project and construction management, CQA, health and safety, administrative costs, and a contingency. The present worth cost is based on a discount rate of 3 percent over the 30-year post-closure period. It is assumed that O&M costs are the same for all capping options. Cost estimates and associated assumptions are provided in Appendix H.

5.3.2 Alternative 1: No Action

5.3.2.1 Effectiveness

The no-action alternative does not meet any of the RAOs, nor does it address the closure requirements. The HELP model shows an average annual leakage rate of 1.4 inches/year.

There is no treatment of waste or leachate in this alternative; therefore, there is no reduction in toxicity, mobility, or volume of waste or leachate through treatment. However, the toxicity of contaminants in leachate may decrease due to natural attenuation. There are no short-term impacts. There is no monitoring, allowing long-term threats to human health and the environment to go undetected.

5.3.2.2 Implementability

The no-action alternative involves no implementation but, because it does not address RAOs or closure requirements, it is unlikely to be approved by CDPHE or EPA.

225

5.3.2.3 Cost

The conceptual cost estimate for Alternative 1, No Action, is:

Total capital cost	$0
Annualized O&M cost	$0
Total present worth cost	$0

5.3.3 Alternative 2: Institutional Controls

5.3.3.1 Effectiveness

Direct contact with the landfill contents can be limited by access and use restrictions if properly enforced. However, the exposure pathway is not eliminated. No attempt is made under this alternative to address infiltration and resulting contaminant leaching to groundwater, surface-water runoff and erosion, or landfill gas control. The leakage rate for this alternative is the same as that for no action. However, groundwater monitoring would detect changes in contamination or migration.

Closure regulations are not met for this alternative. The final interim cover has a permeability of approximately 1E-02 cm/sec, which is greater than the permeability of the underlying bedrock.

As with the no-action alternative, there is no treatment so there is no reduction in the toxicity, mobility, or volume of waste or leachate through treatment. However, there may be some reduction in toxicity of leachate due to natural attenuation. Apart from installing the fence, there is limited construction under this alternative and as a result, short-term impacts are minimal.

5.3.3.2 Implementability

Construction is minimal, groundwater monitoring procedures are standard, and administrative requirements are straightforward. This alternative involves limited implementation, but it is unlikely to be approved by CDPHE or EPA because it does not address RAOs or closure requirements.

5.3.3.3 Cost

The conceptual cost estimate for Alternative 2, Institutional Controls, is:

Total capital cost	$135,700
Annualized O&M cost	$41,700/year
Total present worth cost	$952,600

Cost estimates and associated assumptions are provided in Appendix H.

5.3.4 Alternative 3: Native Soil Cover

5.3.4.1 Effectiveness

The native soil cover provides a physical barrier to minimize the potential for human contact with the landfill contents. Depending on the permeability characteristics of the native soil, this cover may reduce infiltration into the groundwater. The HELP model shows an average annual leakage rate of 1.1 inches/year (Figure 5-4). The leakage rate for this alternative is slightly less than the leakage rate for the no-action alternative. This alternative does not include treatment of waste or leachate, so there is no reduction in toxicity, mobility, or volume through treatment. The alternative reduces infiltration and will ultimately reduce leachate generation through time. The cover is designed to control surface-water runoff and erosion but does not address landfill gas control.

The permeability of the native soil cover is approximately 1E-02 cm/sec. This does not meet the requirement under 6 CCR 1007-3 Part 265.310 that the cover must have a permeability less than the permeability of the underlying bedrock (1E-06 to 1E-07 cm/sec).

With proper maintenance, the cover has a design life of 30 years and therefore affords long-term protection. Institutional controls to address access and use should be effective in preventing a breach of the cap. The construction of the cover may have some short-term impacts due to dust generation and erosion during construction. However, these are easily mitigated using standard construction techniques.

5.3.4.2 Implementability

The native soil cover can consist of any mineral soil and can be obtained from either onsite or offsite sources (EG&G 1994d). Placement of the native soil cover is limited to placing and spreading the material in a single lift directly over the existing interim soil cover. The material is end dumped from haul trucks and spread with a bulldozer to the desired depth. The surface is graded to design lines and grades with motor graders and then revegetated.

Based on the above description of the construction procedures, this implementation is straightforward. Materials should be easily obtained, construction methods are standard, and CQA is minimal. Post-construction repairs involving replacement of soil or vegetation would be relatively simple. Administratively, Alternative 3 is unlikely to be approved by the regulatory agencies because it does not meet closure requirements.

5.3.4.3 Cost

The conceptual cost estimate for Alternative 3, Native Soil Cover, is:

Total capital cost	$5,408,400
Annualized O&M cost	$51,700/year
Total present worth cost	$6,421,400

Cost estimates and associated assumptions are provided in Appendix H.

5.3.5 Alternative 4: Single-Barrier Clay Cover

5.3.5.1 Effectiveness

The single-barrier clay cover meets all of the RAOs. The cover, in conjunction with institutional controls, prevents direct contact with landfill contents and minimizes infiltration of precipitation and resulting contaminant leaching to groundwater. The cover is designed to control surface-water runoff, erosion, and landfill-gas migration.

The clay barrier layer has a permeability of approximately 1E-07 cm/sec, which is equal to the permeability of the underlying bedrock and therefore meets the closure requirement.

This alternative does not include treatment of waste or leachate; therefore, there is no reduction of toxicity, mobility, or volume through treatment. However, the cover reduces the average annual leakage rate to 1.0 inch, which will decrease leachate production through time.

The cover has a design life of 30 years and therefore affords long-term protection. Institutional controls to address access and use should be effective in preventing a breach of the cap. However, because there is no FMC or vapor barrier above the clay, there is potential for desiccation. Construction of the cover may have some short-term impacts due to dust generation and erosion during construction; however, these are readily mitigated using standard construction techniques.

5.3.5.2 Implementability

Implementation of this cover option requires that a borrow source of fine-grained soil that meets the design specifications be identified. At this time, there are no known borrow sources at Rocky Flats that meet specifications (EG&G 1994d). Therefore, it is expected that an offsite borrow source will be required. Alternatively, alluvium from onsite could be used if it is screened and mixed with bentonite. However, this may increase the cost for soil.

After a source is located, the material is hauled to the site for processing and conditioning. Processing consists of reducing the maximum particle size to 1 inch or less and moisture conditioning to the specified moisture-content range. This generally requires the use of a mixing table where the material is spread in thin lifts (6 to 12 inches) to allow processing and conditioning. Particle-size reduction is achieved with discs and/or soil mixers. Water is generally added during processing to facilitate particle-size reduction and increase moisture content to the desired range.

When the material meets particle-size and moisture-content requirements, it is hauled to the landfill and placed in controlled lifts. Each lift is compacted and tested. Prior to placing a new lift of clay, the underlying lift surface is scarified to facilitate bonding between lifts. This process is repeated until the desired thickness of clay cover is obtained. The surface of the completed clay cover is then graded to the design contours. Equipment for preparation of the clay usually includes bulldozers, water pulls, pavement recyclers or soil mixers, and large-diameter earth-turning discs.

CQA monitoring of the clay preparation is also required to ensure that the clay material meets specifications when it is placed. The clay preparation process is sensitive to frost and heavy rains, and special steps must be taken to control rainwater runoff at the prepared clay stockpiles.

Two geocomposite layers, one for lateral drainage and one for gas collection, are also required. These materials are readily available and easy to install. Geotextiles are unrolled and seams are either overlapped, heat bonded, or sewn together. CQA involves material conformance testing and observation of the deployment and seaming operations to document conformance with plans and specifications.

Because compacted clay covers are placed wet of optimum to achieve the minimum permeability, there is an increased potential for desiccation. In this cover section, there is no FMC or other vapor barrier above the compacted clay cover. Therefore, it is expected that over time the clay will dry and crack (Corser *et al.* 1992). Without substantial confining pressure, compacted clay covers that desiccate and crack will not re-heal even if subjected to free moisture.

A stockpile of clay can be maintained on the site to ensure that a suitable source is available should repairs become necessary. Alternatively, GCLs or other appropriate materials can be warehoused for the same purpose. CQA testing of the clay material used for repair is the same as CQA testing during construction; therefore, mobilization of those resources is required. If the area is large enough, special designs of clay layer tie-ins to existing clay may be necessary.

Based on the above description of the construction of a compacted clay cover, this alternative is technically feasible. Equipment, labor, and materials required for construction are commonly available. The single-barrier clay cover meets RAOs and closure requirements and therefore should be administratively feasible.

5.3.5.3 Cost

The conceptual cost estimate for Alternative 4, Single-Barrier Clay Cover, is:

Total capital cost	$10,179,400
Annualized O&M cost	$51,700/year
Total present worth cost	$11,192,400

Cost estimates and associated assumptions are provided in Appendix H.

5.3.6 Alternative 5: Single-Barrier FMC Cover

5.3.6.1 Effectiveness

The single-barrier FMC cover meets all RAOs. Institutional controls will prevent access and use of the area, which may result in breaching of the cap. The cover will prevent direct contact with landfill contents and minimize infiltration and resultant leaching of contaminants to groundwater. The cover is designed to control surface-water runoff, erosion, and landfill-gas migration.

The FMC barrier layer has a permeability of approximately 1E-13 cm/sec, which is less than the permeability of the underlying bedrock, meeting the closure requirements.

This alternative does not include treatment and therefore does not reduce toxicity, mobility, or volume of waste or leachate through treatment; however, the cover reduces the average annual leakage rate to 0.021 inches, which reduces infiltration and ultimately reduces leachate generation. The 30-year design life provides long-term protection. Short-term impacts during construction, such as dust generation and erosion, are easily mitigated.

5.3.6.2 Implementability

Although specialized, numerous sources exist for the purchase and installation of an FMC. Thickness, composition, and type of FMC will be determined during design. The geocomposite layers used for drainage and gas collection are also readily available and relatively easy to install as discussed under Alternative 4.

Adequate quality control and quality assurance during fabrication, placement, and seaming of the FMC are essential. Prior to the material arriving at the site, quality

control certifications from the manufacturer are reviewed to confirm that the material meets the specifications. After the material arrives onsite, quality assurance samples are obtained to confirm that specifications are met.

After the FMC is laid out, the panels are seamed together using fusion and/or extrusion welding methods. A hot wedge or chemical is used to melt the panel surfaces in fusion seaming. The panels then bond directly to each other. In extrusion welding, molten polymer is extruded over the edge or between the panels, melting the surface of the sheets. The panels and polymer then cool and bond together.

All seaming methods require extensive CQA. Destructive and nondestructive testing is generally performed. In destructive tests, a piece of the seam is cut out and removed for onsite or laboratory testing. The sample undergoes shear and peel testing to give an indication of the overall quality of the seaming. Nondestructive testing attempts to validate the integrity of all seams. Common methods include the air lance, pressurized dual seam, and vacuum chamber box. Each method is applicable to certain seam configurations and types of FMC.

To repair an FMC, special welding equipment and qualified personnel would have to be mobilized. The FMC welding processes are sensitive to the presence of dust or moisture on the sheet and the ambient sheet temperature. CQA must generally be performed during daylight hours to enable adequate visual inspection of the material. Both nondestructive and destructive seam testing are required. Thus, weather and work schedule can greatly influence the cost and quality of an FMC repair.

Depending on the location of the repair, geotextile seaming personnel also may be required. Otherwise simply overlapping or heat bonding the material may be sufficient. In either case, CQA personnel need to observe and document repair work.

Based on the description of construction above, this alternative is technically feasible. All equipment, materials, and labor required for construction are commonly available. The single-barrier FMC cover alternative meets RAOs and closure requirements and therefore should be administratively feasible.

5.3.6.3 Cost

The conceptual cost estimate for Alternative 5, Single-Barrier FMC, is:

Total capital cost	$7,908,500
Annualized O&M cost	$51,700/year
Total present worth cost	$8,921,500

Cost estimates and associated assumptions are provided in Appendix H.

231

5.3.7 Alternative 6: Single-Barrier GCL Cover

5.3.7.1 Effectiveness

The single-barrier GCL cover meets all RAOs. The GCL barrier layer has a permeability of 3E-09 cm/sec, which is less than the permeability of the underlying bedrock and therefore meets the closure requirement.

There is no treatment of waste or leachate, so this alternative does not reduce toxicity, mobility, or volume through treatment. However, the cover reduces infiltration by reducing the average annual leakage rate to 0.035 inches and will ultimately reduce the volume of leachate through time. The cover is designed to last 30 years; however, GCLs have been in use only for about seven years, and the long-term protectiveness of this technology is not proven. Short-term impacts during construction include dust generation and erosion, which can be mitigated using standard construction techniques.

5.3.7.2 Implementability

GCL materials are generally available as composites of geotextile or HDPE. Geosynthetic drainage and gas collection materials are available as single layers of geonet or laminated combinations of geotextile and geonet. No soil material, other than the vegetative layer, is required.

A gas-collection layer is placed directly above the waste or interim soil cover followed by placement of overlying GCL, lateral-drainage, and vegetative layers. Although the gas-collection layer also serves as a cushion layer for the GCL, it is necessary to prepare the general fill for geosynthetic placement. This surface is graded and rolled until it is smooth and firm without any protrusions or depressions.

Due to the large absorptive capacity of GCLs, they must be stored to prevent exposure to snow or rain. This generally requires that the material be stored in a covered container or enclosed building.

Placement of the GCL as part of the cover construction is relatively simple. GCL is unrolled over the surface of the landfill with an overlap of 6 to 12 inches. The construction process must be sequenced to allow all of the GCL that is deployed in one day to be covered by the end of the day to ensure that the exposed GCL is not damaged by precipitation.

CQA observation and testing associated with the placement of a GCL are limited to review of quality control testing of the material prior to shipment, conformance testing of the material delivered to the site, and observation of the deployment to confirm overlaps between rolls.

Post-construction repairs to GCLs can be accomplished by removing the vegetative soil cover and drainage layer and overlapping a section of new GCL over the damaged area. No seaming is required with a GCL. The drainage layer and vegetative soil are then replaced. Very minor defects in the GCL will be healed without specific repair measures by the swelling characteristics of the GCL when exposed to any free liquids.

Based on the description of construction above, this alternative is technically feasible. All of the equipment, materials, and labor required for the construction are commonly available. The single-barrier GCL cover meets RAOs and closure requirements and therefore is considered administratively feasible.

5.3.7.3 Cost

The conceptual cost estimate for Alternative 6, Single-Barrier GCL, is:

Total capital cost	$8,391,300
Annualized cost	$51,700/year
Total present worth cost	$9,404,300

Cost estimates and associated assumptions are provided in Appendix H.

5.3.8 Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover

5.3.8.1 Effectiveness

The single-barrier FMC with low-permeability soil cover meets all RAOs. The FMC barrier layer has a permeability of approximately 1E-13 cm/sec, which is less than the permeability of the underlying bedrock and therefore meets the closure requirements.

This alternative does not include treatment and therefore does not reduce toxicity, mobility, or volume of waste or leachate through treatment. However, the cover reduces the average annual leakage rate to 0.00016 inches, which reduces infiltration and ultimately reduces the volume of leachate. This leakage rate is substantially less than any of the previous cover alternatives. The reduction in leakage is primarily the result of the presence of the low-permeability soil below the FMC. The low-permeability soil serves two functions: to provide a good bedding layer for the FMC and to reduce the effect of a small leak in the geomembrane by containing the leak with a second barrier.

The 30-year design life with institutional controls to protect the cover ensures long-term protection. Short-term impacts during construction, including dust generation and erosion, are readily mitigated.

233

5.3.8.2 Implementability

Geosynthetic FMC materials are available in a wide variety of compositions, thicknesses, surface textures, colors, and other physical properties. FMC material laminated with geonets and geotextiles that serve dual functions as barrier and drainage layers are also available. The type and weight of the FMC will be determined during design. Placement and seaming of the FMC is similar to Alternative 5.

The low-permeability soil required in this alternative should be available from nearby borrow sources (EG&G 1994d). Some screening to remove oversize particles or admixture of clay material may be required to meet the gradation and permeability requirements of 1E-05 cm/sec. These requirements are significantly less than the clay-barrier layer in Alternative 9, which needs to meet a much more rigid specification for gradation, moisture content, and compaction in order to achieve its required 1E-07 cm/sec permeability. The vegetative soil, drainage, and gas-collection layers are all readily available.

Alternative 7 calls for a geocomposite gas-collection layer to be placed above the waste followed by, from bottom up, the low-permeability soil, FMC, drainage layer, and vegetative layer. The gas-collection layer could also be placed on top of the low-permeability soil instead of directly on the waste surface, provided that the soil can readily transmit gas from the waste mass. This eliminates the need to prepare the waste surface for geosynthetic deployment. This option will be evaluated during final design.

Placement of geosynthetic materials for gas collection and drainage employs standard construction equipment, labor, and CQA techniques as described in Alternative 4.

Based on the construction techniques, this alternative is technically feasible. All of the equipment, materials, and labor required for construction are commonly available. The single-barrier FMC and low-permeability soil cover meets RAOs and closure requirements and provides two layers of protection. Therefore, it is considered administratively feasible.

5.3.8.3 Cost

The conceptual cost estimate for Alternative 7, Single-Barrier FMC Cover with Low-Permeability Soil Cover, is:

Total capital cost	$8,623,700
Annualized O&M cost	$51,700/year
Total present worth cost	$9,636,700

Cost estimates and associated assumptions are provided in Appendix H.

5.3.9 Alternative 8: Composite-Barrier FMC and GCL

5.3.9.1 Effectiveness

The composite-barrier FMC and GCL cover meets all RAOs. The FMC barrier layer has a permeability of approximately 1E-13 cm/sec, and the GCL has a permeability of approximately 1E-09 cm/sec. Both are less than the permeability of the underlying bedrock and therefore meet the closure requirement.

This alternative does not reduce toxicity, mobility, or volume of landfill waste through treatment because there is no treatment of waste or leachate. However, the cover reduces the average annual leakage rate to 0.00000002 inches, which reduces infiltration and ultimately reduces the volume of leachate. Limited long-term experience with GCLs results in uncertainty regarding the long-term effectiveness of this technology. Potential short-term impacts during construction include dust generation and erosion.

5.3.9.2 Implementability

As mentioned earlier, geosynthetic materials can be readily obtained. The 36-inch vegetative layer is the same as that used in the other alternatives. No other soil or clay is required for this alternative; therefore, soil availability is not a factor.

This cover system could be constructed in two separate layers: a GCL and an FMC. The implementability criteria would be similar to those described for Alternative 5 (single FMC cover) and Alternative 6 (single GCL cover). Alternatively, some manufacturers are producing a single material that consists of a GCL bonded to an FMC. This material can be deployed in one step. As a minimum, the seams are overlapped. However, this system has the potential for FMC components to be welded to each other in a fashion similar to Alternative 5.

Post-construction repairs to this cover system would be made to each component individually as described in Alternatives 5 and 6. As a minimum, repairs to the combined materials would consist of placing a bonded GCL/FMC over the damaged area with sufficient overlap around the damage. To further secure the patch, a single layer of FMC could be placed over the patch and welded to the surrounding FMC.

Based on the above description of construction, this alternative is technically feasible. All of the equipment, materials, and labor required for construction are commonly available. The composite-barrier FMC and GCL cover fulfills RAOs and closure requirements and provides two barrier layers. Thus, it is considered an administratively feasible alternative.

5.3.9.3 Cost

The conceptual cost estimate for Alternative 8, Composite-Barrier FMC and GCL Cover, is:

Total capital cost	$8,927,500
Annualized O&M cost	$51,700/year
Total present worth cost	$9,940,500

Cost estimates and associated assumptions are provided in Appendix H.

5.3.10 Alternative 9: Composite-Barrier FMC and Clay Cover

5.3.10.1 Effectiveness

The composite-barrier FMC and clay cover meets all RAOs. It also follows EPA guidance on the recommended cover cross section for a RCRA Subtitle C cap (EPA 1989d, EPA 1989c). The FMC barrier layer has a permeability of approximately 1E-13 cm/sec, and the compacted clay has a permeability of approximately 1E-07 cm/sec. Both are less than or equal to the permeability of the underlying bedrock and therefore meet the closure requirements.

This alternative does not reduce toxicity, mobility, or volume of landfill waste through treatment because there is no treatment of waste or leachate. However, the cover reduces the average annual leakage rate to 0.00001 inches, which reduces infiltration and ultimately reduces the volume of leachate generated. The 30-year design life with institutional controls to preserve the cover assures long-term protection. Potential short-term impacts during construction include dust generation and erosion.

5.3.10.2 Implementability

The geotextile and FMC materials are readily available. The clay material used for the barrier layer may have to be developed by modifying a local borrow source material or importing it from offsite. A recently constructed landfill at Rocky Flats used a shale material purchased from a local aggregate company as a low-permeability barrier in the landfill-liner system (EG&G 1994d). Alternatively, screening local borrow source material and adding bentonite admixture is also a possible source for low-permeability clay. Inclusion of the FMC over the clay tends to inhibit desiccation when intimate contact between the clay and FMC is maintained. Installation methods for compacted clay liners are discussed under Alternative 4. Equipment, labor, and CQA requirements for installation are similar to those previously discussed for Alternatives 4 and 5.

Post-construction repairs are complicated by having two barrier layers. Repair of the clay layer is discussed in Alternative 4; repair of the FMC is discussed in Alternative 5.

236

Based on the construction process discussed above, this alternative is technically feasible. All of the equipment, materials, and labor required for construction are commonly available. The composite-barrier FMC and clay cover meet RAOs and closure requirements in addition to following EPA guidance on the recommended cover cross section. It is considered likely to receive approval from CDPHE and EPA.

5.3.10.3 Cost

The conceptual cost estimate for Alternative 9, Composite-Barrier FMC and Clay Cover, is:

Total capital cost	$10,680,000
Annualized O&M cost	$51,700/year
Total present worth cost	$11,693,000

Cost estimates and associated assumptions are provided in Appendix H.

5.4 Summary of Screening

The screening of alternatives is based on effectiveness, implementability, and cost as described in Section 5.3. Table 5-3 summarizes the permeability and leakage rates for each of the alternatives. These parameters, in addition to long-term permanence, are used to compare the effectiveness of each alternative. Figure 5-4 shows leakage rates for each alternative graphically. Table 5-4 summarizes the costs for each alternative. Table 5-5 presents a summary of the comparative analysis of the alternatives.

Institutional controls, native soil cover, and the single-barrier clay cap are eliminated because they do not meet basic effectiveness and implementability criteria.

Although GCLs have good permeability and low leakage rates, they have been in use for less than 10 years and, as a result, long-term effectiveness is unproven. Because the panels are not seamed, settlement or movement in the cap may cause leakage at these joints over the long term. Therefore, those alternatives with GCLs were eliminated from further evaluation.

Based on the alternative screening, three alternatives are refined and evaluated in the detailed analysis:

- Alternative 5: Single-Barrier FMC Cover
- Alternative 7: Single-Barrier FMC with a Low-Permeability Soil Cover
- Alternative 9: Composite-Barrier with FMC and Clay Cover

The no-action alternative is retained as a baseline for comparison.

237

Section 5
Tables

Table 5-1
Summary of Landfill Cover Components

Cover Component	Objectives	Materials
Vegetation and Vegetation Cover Soil	Growth media for cover vegetation Insulation for barrier layer Limits erosion of cover	General fill Top soil at surface Tall-prairie grasses
Lateral-Drainage Layer	Allows drainage of water that infiltrates through vegetative cover Controls head build up on barrier layer Discharges water to perimeter drainage ditch	Granular soil (sand/gravel) Geotextile Geonet Geocomposite (geotextile/geonet/geotextile)
Barrier Layer	Prevents infiltration of surface water into waste Prevents uncontrolled releases of gas from waste	Flexible membrane cover (FMC) Geosynthetic clay liner (GCL) Compacted clay
Gas-Collection Layer	Allows collection and controlled discharge of gases at selected locations from beneath cover	Geocomposite (geotextile/geonet/geotextile)
General Grading Fill	Fill to achieve design surface grades to promote runoff without erosion after settlement	Any locally available soil

239

Table 5-2
Screening Criteria Summary

Criteria	Assessment Components	Discussion of Evaluation
Effectiveness	Meets RAOs and ARARs	
	RAOs	
	• Prevent contact with landfill contents	Engineering judgment
	• Minimize infiltration and resulting loading	HELP analysis
	• Control surface-water runoff and erosion	Erosion analysis
	• Control landfill gas (and treat if necessary)	Engineering judgment
	• Remediate wetlands (as needed)	
	ARARs	
	• Provide long-term minimization of migration of liquids through closed landfill	Engineering judgment and HELP analysis
	• Function with minimum maintenance	Erosion and settlement analysis
	• Promote drainage and minimize erosion of cover	Erosion analysis
	• Accommodate settling and subsidence	Settlement analysis
	• Have permeability less than or equal to permeability of any bottom liner or natural subsoil	Analysis of cover sections
	Reduce toxicity, mobility, and volume through treatment	
	Provide long-term protection	
	Minimize short-term impacts	
Implementability	Technical feasibility	
	• Availability of materials	All materials are considered available with exception of the clay barrier soil
	• Ease of construction	
	• Post-construction repairs	
	Administrative feasibility	
	• Ability to obtain approvals from regulatory agencies	
Cost	Comparative cost estimates	
	• Direct and indirect capital costs	Compare total present worth cost
	• Direct and indirect O&M costs	

Table 5-3
Comparison of Effectiveness Factors

Alternative		Permeability (cm/sec)	Average Annual Leakage (in/year)
Alternative 1	No Action	1E-02	1.4
Alternative 2	Institutional Controls	1E-02	1.4
Alternative 3	Native Soil	1E-02	1.1
Alternative 4	Single-Barrier Clay	1E-07	1.0
Alternative 5	Single-Barrier FMC	1E-13	0.021
Alternative 6	Single-Barrier GCL	3E-09	0.035
Alternative 7	Single-Barrier FMC with Low-Permeability Soil	1E-13	0.00016
Alternative 8	Composite-Barrier FMC and GCL	1E-13	0.00000002
Alternative 9	Composite-Barrier FMC and Clay	1E-13	0.00001

Definitions

cm/sec centimeter per second
in/year inches per year
FMC flexible membrane cover
GCL geosynthetic clay liner

241

Table 5-4
Conceptual Cost Estimate Summary

Alternative	Annualized O&M Costs	O&M Present Worth Cost	Capital Cost	Total Present Worth Cost
1	$0	$0	$0	$0
2	$41,700	$816,900	$135,700	$952,600
3	$51,700	$1,013,000	$5,408,400	$6,421,400
4	$51,700	$1,013,000	$10,179,400	$11,192,400
5	$51,700	$1,013,000	$7,908,500	$8,921,500
6	$51,700	$1,013,000	$8,391,300	$9,404,300
7	$51,700	$1,013,000	$8,623,700	$9,636,700
8	$51,700	$1,013,000	$8,927,500	$9,940,500
9	$51,700	$1,013,000	$10,680,000	$11,693,000

242

Table 5-5
Summary of Comparative Analysis Alternatives Screening

Alternative		Effectiveness[1]	Implementability[2]	Subtotal[3]	Cost (millions)	Action
Alternative 1	No Action	—	—	0	$0	Retain
Alternative 2	Institutional Controls	—	—	0	$.95	Eliminate
Alternative 3	Native Soil	—	—	0	$6.4	Eliminate
Alternative 4	Single-Barrier Clay	1	2	3	$11.2	Eliminate
Alternative 5	Single-Barrier FMC	2	2	4	$8.9	Retain
Alternative 6	Single-Barrier GCL	2	1	3	$9.4	Eliminate
Alternative 7	Single-Barrier FMC with Low-Permeability Soil	3	2	5	$9.6	Retain
Alternative 8	Composite-Barrier FMC and GCL	3	1	4	$9.9	Eliminate
Alternative 9	Composite-Barrier FMC and Clay	3	3	6	$11.7	Retain

Notes

[1] No rating was given to alternatives that did not meet basic effectiveness criteria. For alternatives that meet basic criteria, a rating of 1, 2, or 3 was made. Ratings are defined below.

1 Infiltration 1 inch/year or more
2 Infiltration between 1 and 1E-03 inch/year
3 Infiltration between 1E-03 and 1E-08 inch/year

[2] No rating was given to Alternatives that did not meet basic implementability criteria. A rating of 1, 2, or 3 was indicated for alternatives that met basic implementability criteria. Ratings are defined below.

1 Includes non-proven construction material
2 Includes components that are similar to those in EPA guidance
3 Follows existing EPA guidance documents

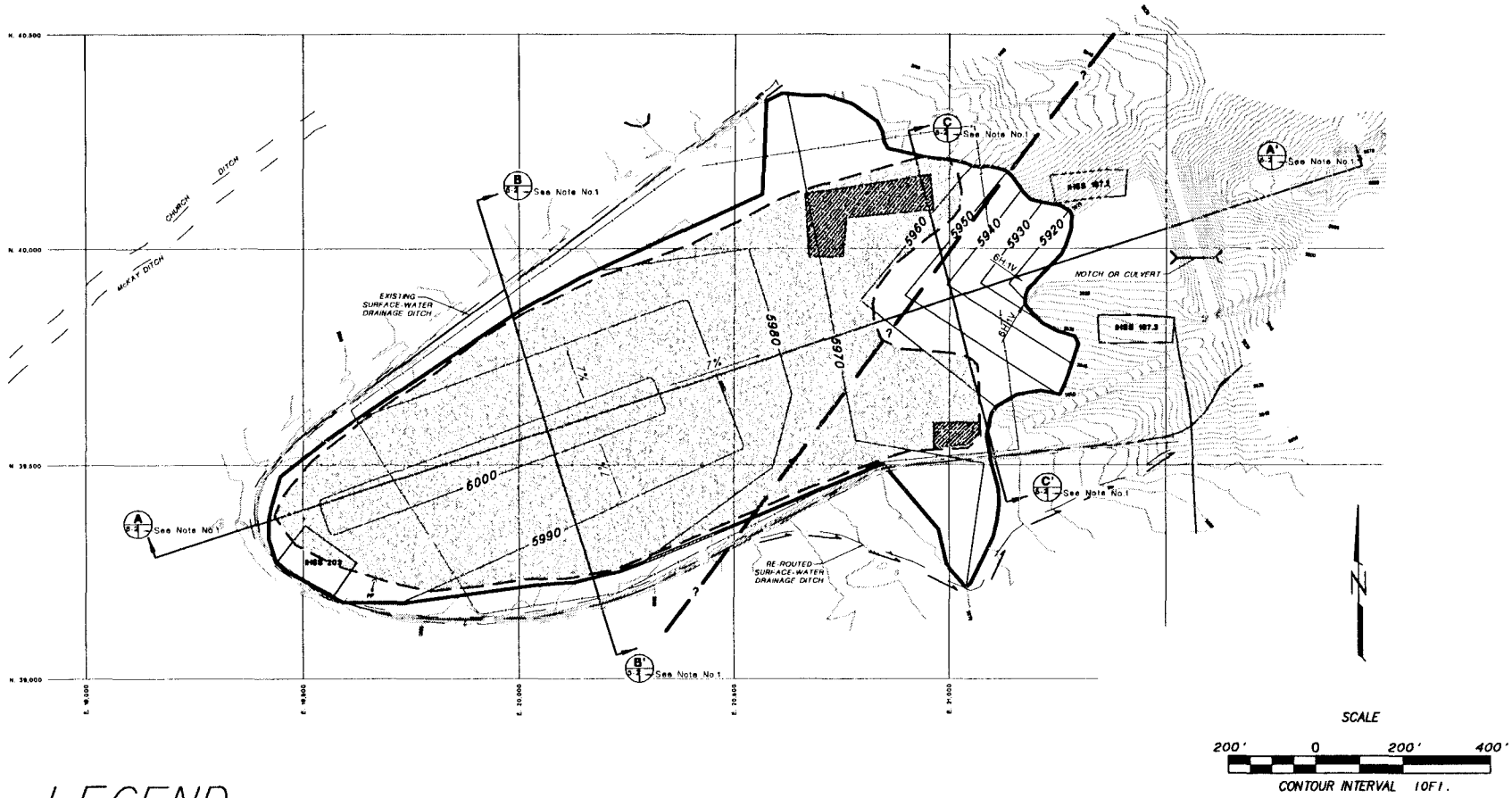
[3] Subtotal is addition of ratings for effectiveness and implementability. The higher the subtotal the better the alternative.

Definitions

FMC flexible membrane cover
GCL geosynthetic clay liner

243

Section 5
Figures



LEGEND

- FAULT
- DITCH
- CONCEPTUAL GRADING PLAN CONTOURS
- EDGE OF REGRADE AREA (AREA : 1,210,414 FT.²)
- EDGE OF LANDFILL (AREA : 770,332 FT.²)
- ASBESTOS AREA
- COVER AREA (AREA : 770,332 FT.²)

NOTES:

1.) REFERENCED ON DRAWINGS 5-2A AND 5-2B

2.) BASE TOPOGRAPHY AND FEATURES (DECEMBER 1994).

DETAIL/SECTION NUMBER

DRAWING No. WHERE DETAIL/SECTION IS REFERENCED

DRAWING No. WHERE DETAIL/SECTION IS SHOWN

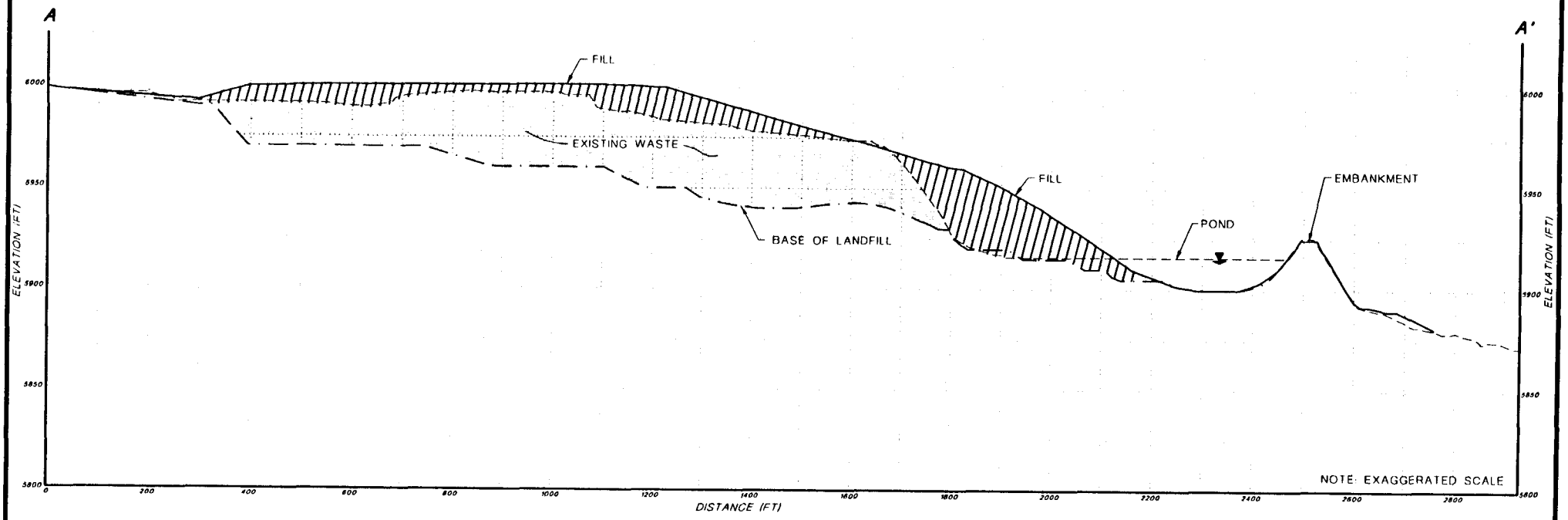
U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Proposed Conceptual Grading Plan, Extent of Cover, and Surface-Water Control Plan

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 5-2

246



See Note No.1 (A/4)

CROSS-SECTION A-A'

HORIZONTAL SCALE
0 100' 200'

VERTICAL SCALE
0 25' 50'

LEGEND

- CURRENT SURFACE
- BASE OF LANDFILL SURFACE
- PROPOSED CONCEPTUAL GRADING PLAN
- FILL
- EXISTING LANDFILL

NOTE:
1.) REFERENCED ON DRAWING, 5-2

(A/6 | 6)
DETAIL/SECTION NUMBER
DRAWING No. WHERE DETAIL/SECTION IS REFERENCED
DRAWING No. WHERE DETAIL/SECTION IS SHOWN

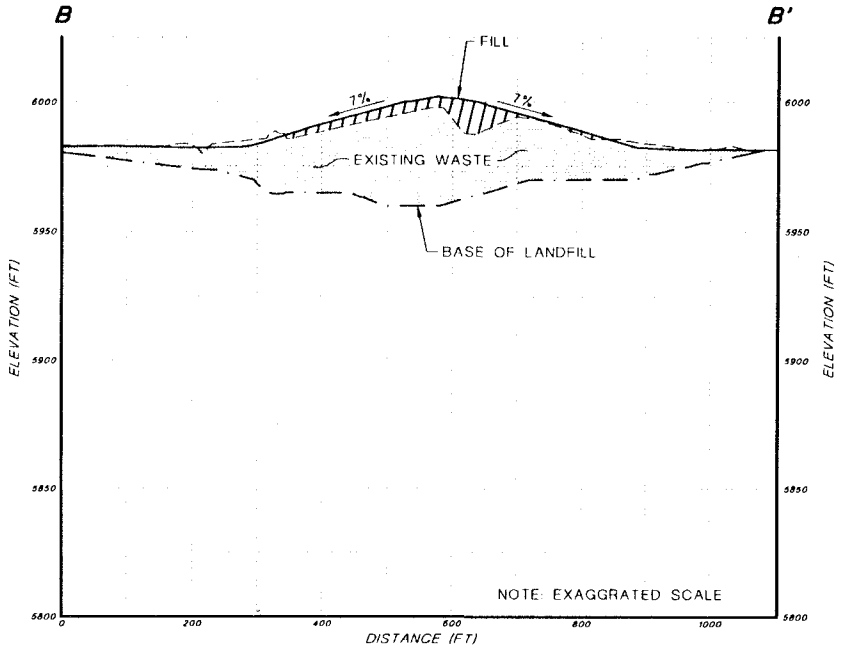
U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Landfill Cover Cross-Section A-A'

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 5-2A

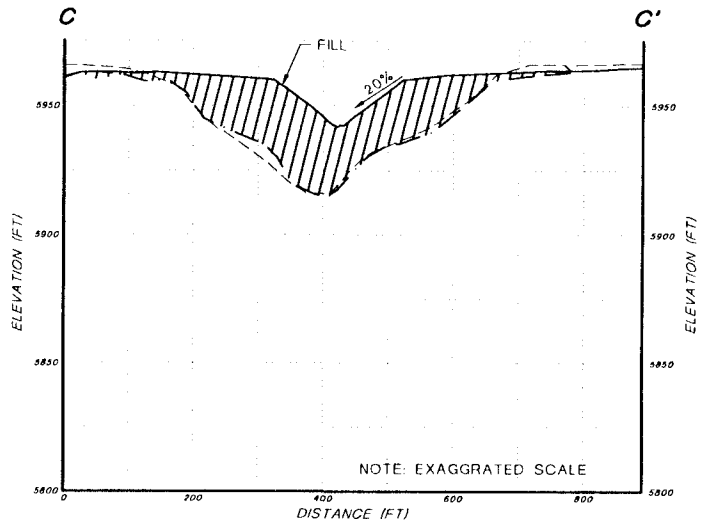
247



See Note No.1 — B/4 **CROSS-SECTION B-B'**

HORIZONTAL SCALE
0 100' 200'

VERTICAL SCALE
0 25' 50'



See Note No.1 — C/4 **CROSS-SECTION C-C'**

HORIZONTAL SCALE
0 100' 200'

VERTICAL SCALE
0 25' 50'

LEGEND

- CURRENT SURFACE
- BASE OF LANDFILL SURFACE
- PROPOSED CONCEPTUAL GRADING PLAN
- FILL
- EXISTING LANDFILL

NOTE:

1.) REFERENCED ON DRAWING, 5-2

A/6 6 — DETAIL/SECTION NUMBER; DRAWING No. WHERE DETAIL/SECTION IS REFERENCED; DRAWING No. WHERE DETAIL/SECTION IS SHOWN

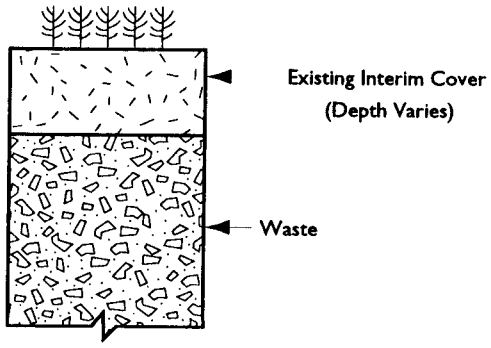
U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Landfill Cover Cross-Sections B-B' & C-C'

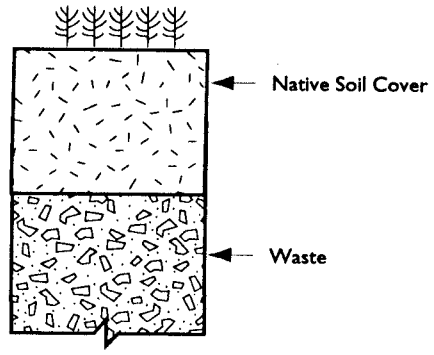
Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 5-2B

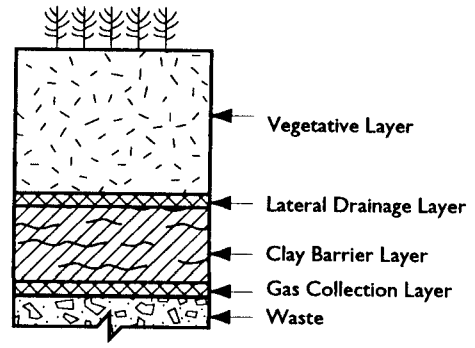
348



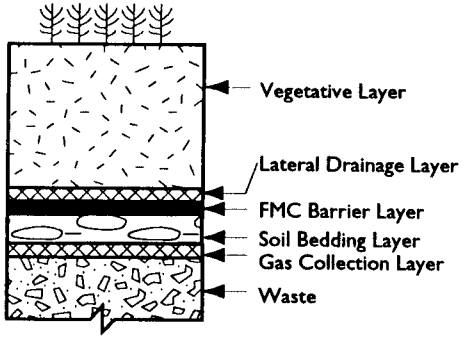
Alternative 1: No Action
Alternative 2: Institutional Controls



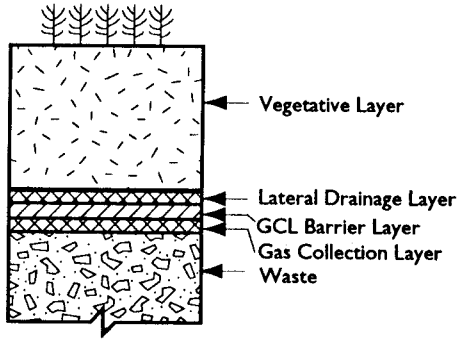
Alternative 3: Native Soil Cover



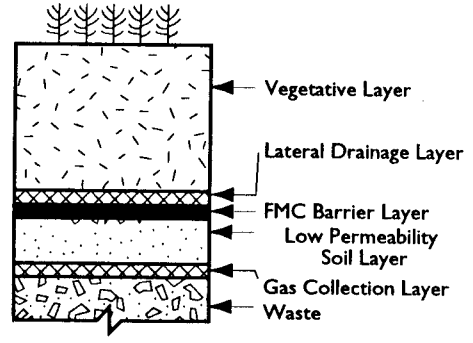
Alternative 4: Single-Barrier Clay Cover



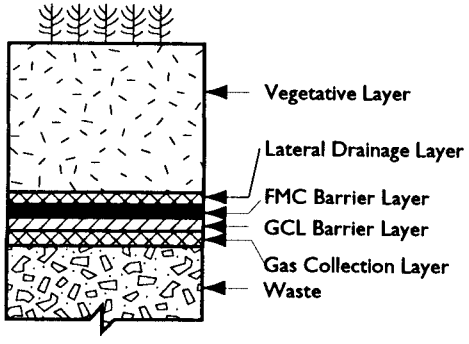
Alternative 5: Single-Barrier FMC Cover



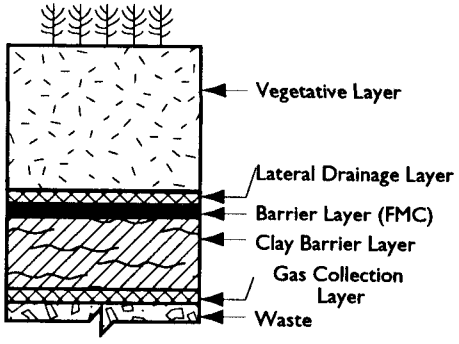
Alternative 6: Single-Barrier GCL Cover



Alternative 7: Single-Barrier
FMC and Low-Permeability Soil Cover



Alternative 8: Composite Barrier -
FMC and GCL Cover



Alternative 9: EPA's Composite-
Barrier FMC and Clay Cover

U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

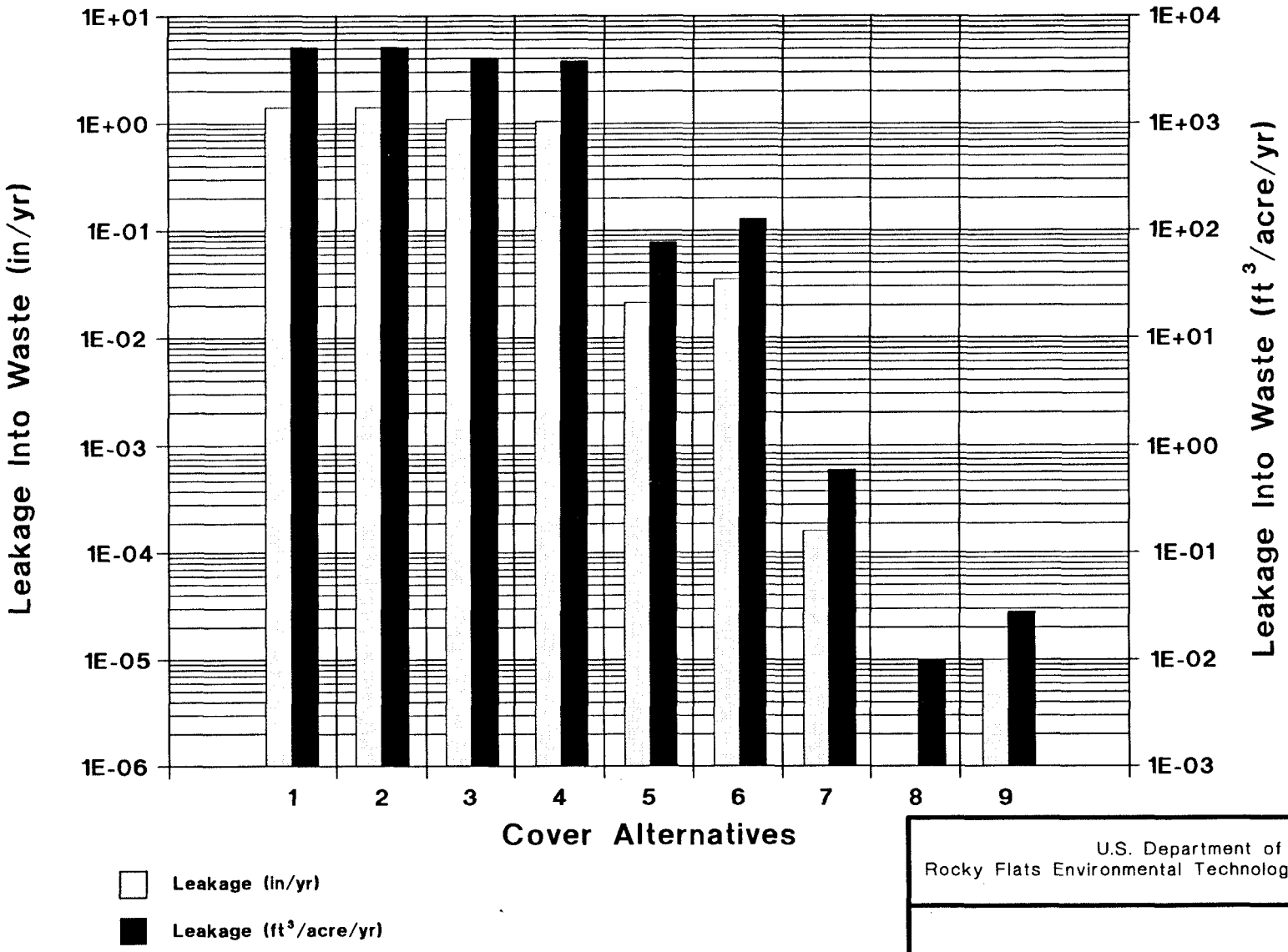
Cover Cross-Section Alternatives

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 5-3

G95\ES\IM/IRA DD OU 7/Cover Alt-2510.III

249



U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Leakage Rates for Cover Alternatives

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 5-4

290

6. Detailed Analysis of Alternatives

The purpose of the detailed analysis of alternatives is to analyze existing data and provide decision makers with sufficient information to adequately compare alternatives, select an appropriate remedy for OU 7, and demonstrate that CERCLA remedy selection requirements have been met (EPA 1988).

The detailed analysis process consists of describing each alternative in detail to evaluate the alternatives using the nine CERCLA criteria and performing a comparative analysis among the alternatives to assess the relative performance of each alternative with respect to the evaluation criteria (EPA 1988). The screening process presented here is more detailed than the effectiveness, implementability, and cost screening presented in Section 5.

Three of the alternatives are carried forward through the screening process presented in Section 5. The no-action alternative is retained as a baseline for comparison. The alternatives evaluated during the detailed analysis include the following:

- Alternative 1: No Action
- Alternative 5: Single-Barrier FMC Cover
- Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover
- Alternative 9: Composite-Barrier FMC and Clay Cover

6.1 Screening Process

The NCP identifies nine criteria to be used as evaluation criteria in the detailed analysis of alternatives. EPA separates the criteria into three groups (EPA 1988). The first two criteria are considered threshold criteria that relate to statutory requirements and must be met. The next five criteria are technical criteria used to compare the alternatives and balance the advantages and disadvantages. The final two criteria are modifying criteria that will be evaluated by CDPHE and EPA after the public comment period and will be incorporated into the CAD/ROD. The nine criteria are as follows:

Threshold Criteria

1. Overall Protection of Human Health and the Environment
2. Compliance with ARARs

Primary Balancing Criteria

3. Long-Term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, and Volume through Treatment
5. Short-Term Effectiveness

251

6. Implementability
7. Cost

Modifying Criteria

8. Regulatory Agency Acceptance
9. Community Acceptance

Each of the criteria is divided into specific factors to facilitate consistent analysis of alternatives. The factors are briefly described below and are presented in Table 6-1.

Evaluation of overall protectiveness of human health and the environment draws on long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. This criterion provides a final check to assess whether each alternative provides adequate protection.

Compliance with ARARs is evaluated for chemical-specific, location-specific, and action-specific ARARs identified in Section 3.4. The detailed analysis should summarize which requirements are applicable or relevant and appropriate to an alternative and describe how the requirements are met. When an ARAR is not met, the analysis should include justification for an ARARs waiver under CERCLA if appropriate (EPA 1988).

Long-term effectiveness and permanence is used to assess risks remaining after treatment or risks due to untreated waste. This criterion also focuses on the adequacy and reliability of controls used to manage treatment residuals or untreated waste. It includes an assessment of the potential need to replace components of the proposed action over the 30-year post-closure care period.

Reduction of toxicity, mobility, and volume through treatment addresses the statutory preference for treatment technologies that produce a significant, permanent reduction in hazardous waste. Treatment is not part of the presumptive remedy. Therefore, this criterion does not strictly apply to the screening process for cover sections at OU 7. The criterion is used in reference to reductions in volume of landfill leachate.

Short-term effectiveness addresses the risks to human health and the environment during implementation of the remedial action. This criterion evaluates protection of the community, construction workers, and the environment and includes an estimate of the time required to complete construction.

Evaluation of implementability includes technical feasibility, administrative feasibility, and the availability of services and materials. This criterion includes potential difficulties associated with construction and operation, reliability of the technology,

ease of undertaking additional remedial actions if needed, likelihood of obtaining agency approvals, steps required to coordinate with agencies, and availability of equipment, specialists, and technologies.

Costs are evaluated using detailed estimates developed for each alternative. A present worth analysis is used to discount all future costs to the current year to facilitate comparison among alternatives. The present worth costs are based on a 3-percent discount rate over a 30-year post-closure period. Detailed cost estimates are a refinement of the conceptual cost estimate presented in Section 5. Additional costs include wetlands mitigation, Preble's meadow jumping mouse habitat mitigation, surface-water diversion ditch rerouting, equipment decontamination, certification of final closure, and a notation on the property deed.

The regulatory agency acceptance criterion addresses the concerns of the Natural Resource Trustees, including DOE, CDPHE, the U.S. Department of the Interior (DOI), the state of Colorado Attorney General, and the state of Colorado Department of Natural Resources (CDNR). A Memorandum of Understanding (MOU) (DOE 1994f) has been signed between the trustees and EPA to provide broad guidance for natural resource trustee cooperation at Rocky Flats under Section 104 (b)(2) of CERCLA. This cooperative relationship is intended to encourage an interchange of technical expertise and ensure protection and restoration of natural resources during planning and implementation of the IM/IRA for OU 7. Potential environmental impacts of the remedial action and mitigation measures are addressed in this document in accordance with the MOU and the NCP (40 CFR Part 300.430). Comments from the regulatory agencies and the Natural Resource Trustees on the Phase I IM/IRA DD and the Proposed Plan will be addressed in the CAD/ROD.

The community acceptance criterion addresses concerns raised by the public during public meetings and the formal public comment period. As with regulatory acceptance, the community acceptance criterion is not addressed in this report. Comments from the public will be incorporated into the CAD/ROD.

6.2 Evaluation of Alternatives

Each of the four alternatives is evaluated using seven of the nine CERCLA criteria outlined above. In accordance with EPA guidance, the modifying criteria (regulatory agency acceptance and community acceptance) are not used at this stage of the screening process (EPA 1988). The analysis of individual alternatives includes a description of the technology components and construction procedures and an assessment of how each of the evaluation criteria are addressed by the alternative.

253

6.2.1 Alternative 1: No Action

6.2.1.1 Description

Under Alternative 1, no action is taken (Figure 6-1). The cover for the no-action alternative consists of existing interim soil cover material of variable thickness. The no-action alternative is required under the NCP and provides a baseline for comparison of other alternatives.

6.2.1.2 Evaluation

Overall Protection of Human Health and the Environment

None of the RAOs or closure requirements are met under the no-action alternative. Potential risks to human health and the environment are not addressed and will not be monitored. Because no action is taken, there are no short-term effects.

Compliance with ARARs

The no-action alternative will not meet chemical-specific ARARs for surface water or groundwater. Leachate at the seep exceeds Colorado Water Quality (CWQ) standards for aluminum, benzene, manganese, and zinc; Safe Drinking Water Act (SDWA) MCLs for vinyl chloride; and PQLs for 2-methylnaphthalene and naphthalene. Surface water in the East Landfill Pond exceeds CWQ standards for manganese. Groundwater downgradient of the landfill exceeds SDWA MCLs for nitrate/nitrite, CWQ standards for sulfate, and the PQL for selenium. Tables showing mean concentrations of contaminants and their respective chemical-specific ARAR are included in Section 3. An ARARs waiver under Section 121 of CERCLA is not justified for this alternative.

Location-specific ARARs that are generally applicable for OU 7 do not necessarily apply for the no-action alternative. This alternative poses no threat to wetlands (40 CFR Part 6) or to threatened and endangered species habitat (CRS 33-2-101). Because the pond will be left undisturbed, permitting requirements for dredging under Section 404 of the CWA do not apply.

Action-specific ARARs under the CHWA, including closure requirements (6 CCR 1007-3 Part 265.310), post-closure maintenance requirements (6 CCR 1007-3 Part 265.117), and post-closure groundwater-monitoring requirements (6 CCR 1007-3 Part 265.228) will not be met. In addition, the existing interim soil cover will not meet requirements of the Soil Erosion Dust Blowing Act (CRS 35-72-101). No ARARs waiver is justified for any of these action-specific ARARs.

Long-Term Effectiveness and Permanence

The no-action alternative does not reduce the risk at the site. Existing interim cover and fencing will degrade and become ineffective over time. The average annual leakage rate for the no-action alternative is 1.4 inches. A description of leakage rates is included in Appendix G.

Reduction of Toxicity, Mobility, and Volume through Treatment

The no-action alternative relies on natural biodegradation for any reductions in toxicity or mobility. There is no expected reduction in volume of waste material or leachate.

Short-Term Effectiveness

No construction or implementation is required; therefore, there are no short-term impacts to the community, workers, or the environment. The RAOs will not be achieved during the 30-year life of the project.

Implementability

The no-action alternative requires no technical implementation; however, because it does not meet closure regulations, administrative approval is unlikely.

Cost

The costs for Alternative 1: No Action are:

Total capital cost	$0
Annualized O&M cost	$0/year
Total present worth cost	$0

6.2.2 Alternative 5: Single-Barrier FMC Cover

6.2.2.1 Description

Alternative 5 consists of a single-barrier FMC cover and institutional controls. The existing dam is left in place to control groundwater migration. Institutional controls, including use and access restrictions, are described in detail in Section 5.2.2. The barrier layer is made up of an FMC with a permeability of approximately 1E-13 cm/sec. Approximately 885,240 ft^2 of landfill and surrounding area will be covered in this design option. A cross section of this cover is shown in Figure 6-2.

Mobilization and Demobilization

Mobilization and demobilization of individual contractors takes place at different times during the construction project. Peak labor loading also varies between contractors depending on the type of work being performed. Geosynthetic contractors commonly have several mobilization and demobilization periods during a liner or closure project. This enables earthwork contractors, whose mobilization and demobilization periods are more costly, to perform their work in a continuous fashion.

Site Preparation

Water levels in the East Landfill Pond must be lowered to provide access for cover construction and slope stabilization. Water is pumped to the A-series ponds using the existing pumping system. The required water-level elevation for construction is based on final cover extent and slope buttress design and is determined during final design.

Soil material is required to buttress unstable slopes. It is placed by first establishing a bench of material on the lower toe of slope areas. Additional material then is placed in uniform lifts gradually proceeding up slope until the design elevation is reached. Trimming operations begin at the top of the slope and progress downward to remove excess material. In seep areas, a blanket or French drain is constructed below the grading fill or cover section.

A storage area is designated near the construction zone for geosynthetic material. Geotextile material is shipped in plastic covers to protect the material from truck exhaust fumes, road grit, and solar degradation. Deliveries are inspected and sampled for conformance testing. Rolls of geosynthetic material are stacked on heavy wooden pallets above the ground surface to protect the material from dirt and mud. The stacks are arranged to allow easy access for handling and sampling.

Rerouting of the Surface-Water Drainage Ditch

The existing perimeter surface-water drainage ditch is incorporated into the cover design to collect surface-water run-off from the cover and to intercept surface-water run-on to the landfill. The capacity of the existing ditch is compared to the expected design flows for the final design. Select portions of the perimeter ditch are rerouted to accommodate the grading plan (Figure 5-2).

Landfill Cap

A summary of quantities of material for landfill cover construction is presented in Table 6-2. Individual cover layers are described below.

Fill Layer

Construction of the cover begins with placement of general fill. Thickness varies from 3 to 15 feet, depending on the grading plan. The grading plan is designed to promote drainage off the cover to the perimeter drainage ditch. In central areas of the cell, where design elevations are greatest, the fill is thickest. In lower elevation areas near the perimeter of the cell, fill is thinner.

The grading of the fill layer is determined by two factors: the upper bound for the slope is based on stability and erosion control and the lower bound is to provide adequate surface-water drainage after settlement, as discussed in Section 5.1.3. Based on these conditions, approximately 131,400 yd^3 of fill will be placed.

The thickness of the general fill may also be affected by the final waste configuration. It is assumed that additional waste placement at OU 7 will not occur after the new landfill is operational (early 1997).

It is likely that onsite alluvial materials are satisfactory borrow sources for fill material (EG&G 1994d). Special preparation of this material is generally not required, except for the top 6 inches of the placed layer. In this area, the fill material should be free of rocks or particles larger than 1 inch to prevent puncture of the geosynthetic layer of the gas-collection system.

Gas-Collection Layer

A composite made up of geonet with filter fabric on each side is rolled out over the general fill for gas collection. The geonet is sandwiched between two layers of filter fabric to prevent fines from clogging the geonet. The composite panels are overlapped, heat bonded, or tied together.

Gas vents extend through the cover and vent at the surface at regular intervals. The vents consist of PVC or HDPE pipe (depending on the FMC material selected) or gravel columns. Gas monitoring will be conducted after closure in accordance with the post-closure plan.

Soil Bedding Layer

Soil bedding is placed on top of the upper gas-collection filter fabric layer using low ground pressure bulldozers. The surface of the soil layer is then trimmed with motor graders and compacted with a smooth drum vibratory roller to provide a smooth firm surface upon which to place the FMC.

257

FMC Layer

The FMC geomembrane is rolled out and seamed using both fusion-welding and extrusion-welding techniques. Long, straight seams are fusion seamed while extrusion welding is used in smaller, confined areas or where sharp turns in the weld are required. Patches for destructive seam sample areas and fusion welder entry and exit holes are examples of extrusion weld applications.

Destructive and nondestructive testing is performed on the geomembrane seams to document seam strength and seam integrity. Samples of the seam are extracted and pulled apart in a tensiometer to test the weld strength. Vacuum box tests and seam air-pressure tests are used to determine if the seam is airtight.

Drainage Layer

The drainage layer composite geonet and filter fabric is placed over the FMC. The lower filter fabric provides a cushion so that the geonet does not damage the FMC. Panels are overlapped, heat bonded, or tied together.

Vegetative and Top Soil Layers

Placement of soil material on geosynthetic layers can cause damage to the geosynthetic material if not done properly. Typically, soil material is placed in thick lifts, generally 2 to 3 feet, and spread with low ground pressure equipment. Care must be taken not to cause the geosynthetic material to wrinkle during soil placement and to maintain adequate lift thickness to reduce the chance of puncturing the material.

Top soil, fertilizer, and seeding complete the cover construction. Top soil can be readily acquired from local offsite sources or, potentially, onsite sources could be amended with soil additives to create a suitable vegetative substrate (EG&G 1994d). Revegetation occurs in late fall. Seeds are dormant through the winter and germinate the following spring.

Decontamination

Decontamination activities for personnel and equipment are expected to be minimal because no waste excavation is planned. Construction and other equipment used during landfill closure activities is decontaminated at the main decontamination facility at Rocky Flats as needed. Air quality monitoring is conducted periodically by contractor and site personnel to ensure that workers are not exposed to potentially hazardous materials. If monitoring indicates the presence of hazardous materials, appropriate personal protective equipment (PPE) is used and decontamination

258

procedures are followed. This may include the establishment of different contamination level zones and contamination reduction zones in the OU 7 work area.

Certification of Final Closure

Construction activities are typically summarized in a final certification report, which is prepared by the third-party CQA contractor. All facets of the cover installation, material testing, and final as-built drawings, etc. are included in this report.

6.2.2.2 Evaluation

Overall Protection of Human Health and the Environment

The single-barrier FMC cover alternative meets all RAOs. The cap, fence, and institutional controls prevent direct contact with landfill contents. The cap has a permeability of approximately 1E-13 cm/sec and therefore minimizes infiltration, leaching, and resulting contaminant loading to groundwater. The surface is graded and revegetated to control surface-water run-off and erosion. A gas-collection system controls landfill gas. Gas treatment may be added to the system if needed.

Properly installed and maintained, the FMC provides protection to human health and the environment over the 30-year post-closure care period. Short-term impacts due to implementation are minimal and easily mitigated. The alternative does not comply with EPA guidance for a RCRA Subtitle C cap (EPA 1989e); however, the single-barrier FMC cover is equally protective of human health and the environment and meets state and federal regulations for closure.

Compliance with ARARs

Alternative 5 meets all chemical-specific ARARs for surface water except one. Surface water in the East Landfill Pond exceeds CWQ standards for manganese; however, manganese is a naturally occurring element common in the geologic materials surrounding the pond and in pond sediments. Discharge of leachate into the pond may have resulted in mobilization of manganese from the pond sediments. Because the cap reduces leachate generation, mobilization of manganese is not expected to continue. Alternative 5 does not meet chemical-specific ARARs for groundwater. Groundwater downgradient of the landfill exceeds SDWA MCLs for nitrate/nitrite, CWQ standards for sulfate, and PQLs for selenium. However, the exposure pathway for groundwater is incomplete. Tables showing mean concentrations of contaminants and their respective chemical-specific ARAR are included in Section 3. Flow modeling, particle tracking, and contaminant transport modeling performed for this report (Appendices C and E) indicate that the East Landfill Pond dam significantly reduces groundwater flow. The clay in the dam core and in bedrock naturally attenuates contaminants. As a result,

contaminant migration down No Name Gulch is expected to be minimal. Concentrations of nitrate/nitrite, selenium, and sulfate are not expected to exceed ARARs at the compliance wells downgradient of the East Landfill Pond dam. In addition, the exposure pathway is incomplete.

Location-specific ARARs that are generally applicable for OU 7 are met. The cap extends over areas designated as wetlands by the U.S. Army Corps of Engineers and areas identified as potential habitat for the Preble's meadow jumping mouse (Figure 2-12). A wetlands assessment, required under 40 CFR Part 6, is provided in Section 7. Injury to wetlands is mitigated using acreage from the wetlands mitigation bank currently being developed in association with the Standley Lake Protection Project. Injury to Preble's meadow jumping mouse habitat is mitigated as needed. Although the portion of the pond not covered by the landfill cap remains in place, dredge and fill requirements under Section 404 of the CWA are applicable. Alternative 5 meets substantive requirements of permitting under the CWA.

Action-specific ARARs under the CHWA, including closure requirements (6 CCR 1007-3 Part 265.310), post-closure maintenance requirements (6 CCR 1007-3 Part 265.117), and post-closure groundwater-monitoring requirements (6 CCR 1007-3 Part 265.228) are met for Alternative 5.

The single-barrier FMC cover meets the following requirements for landfill closure (6 CCR 1007-3 Part 265.310):

- Provides long-term minimization of migration of liquids through the closed landfill
- Functions with minimum maintenance
- Promotes drainage and minimizes erosion or abrasion of the cover
- Accommodates settling and subsidence to maintain the integrity of the cover
- Has a permeability less than or equal to the permeability of any bottom liner system or natural subsoil present

The natural subsoil under the landfill has a permeability of 1E-06 to 1E-07 cm/sec. The single-barrier FMC cover has a permeability of approximately 1E-13 cm/sec. Although the cover for Alternative 5 meets all regulatory requirements for closure, this cap does not follow EPA guidance for a RCRA Subtitle C cap (EPA 1989e). The guidance recommends a composite barrier with an FMC layer and a clay layer, similar to the cover of Alternative 9. Engineering analyses have shown that Alternative 5 is equally protective. Construction procedures during installation of the landfill cap meet requirements of the Soil Erosion Dust Blowing Act (CRS 35-72-101). Alternative 5

meets MACs for delisting leachate under 40 CFR 260.20. Compliance with NPDES (40 CFR Part 125) occurs by meeting substantive requirements for a discharge permit for periodic surface-water discharge to decrease water levels in the East Landfill Pond.

Long-Term Effectiveness and Permanence

The landfill, which is the source of contamination, remains in place. However, risks due to direct contact with waste material and leaching of source contaminants into the groundwater are minimized by the cap and institutional controls.

The single-barrier FMC cover is considered a proven technology and, if properly installed and maintained, is effective over the 30-year life of the project. The cap is designed to prevent breaching from settling, erosion, and freeze/thaw cycles. The average annual leakage rate for this alternative is 0.021 inches. A description of leakage rates is included in Appendix G.

Maintenance of the cap is not difficult or labor intensive but inspections must be conducted on a periodic basis and if portions of the cap are damaged, must be repaired immediately. DOE is responsible for conducting routine semiannual inspections of the final cover, surface-water drainage ditch, surveyed benchmarks, security fence, groundwater-monitoring system, and gas-monitoring system. Defects will be repaired.

Long-term effectiveness will be monitored and additional measures will be taken as required. The groundwater-monitoring system consists of one well upgradient of the landfill and three wells downgradient of the landfill. DOE will monitor the wells semiannually as outlined in the OU 7 Closure Plan.

The effectiveness of the remedial action will be evaluated every 5 years. Mandated under Section 121(c) of CERCLA and Section 300.430 (f)(4)(ii) of the NCP, reviews are required of any site where contaminants remain onsite after remediation. Reviews are required minimally every 5 years or until contaminant levels allow for unlimited use and unrestricted exposure. The purpose of the reviews is to assure that the remedial action remains protective of human health and the environment. The level of the reviews will be at the discretion of CDPHE and EPA; however, it is expected that a Level 1 review, consisting of a site visit, review of operation and maintenance activities, and a brief site inspection, will be sufficient.

Reduction of Toxicity, Mobility, and Volume through Treatment

Although there is no treatment with this option, there may be some decrease in toxicity and mobility of the waste material over time due to natural attenuation processes. The cap also decreases infiltration into the waste, which then limits the generation and migration of leachate.

Short-Term Effectiveness

The contaminants are currently under a 12- to 36-inch-thick soil cover. No excavation into contaminated areas is required to implement this option. Therefore, risks to the community and site workers are minimal. The possibility exists that workers could be exposed to contamination accidentally during construction; however, this is unlikely and proper use of PPE limits such exposure.

The remedial action would result in dust generation during excavation, transport, and placement of fill and vegetative soil. The primary method of dust emissions control requires frequent periodic water spray of high traffic roadways, particularly dirt or gravel roads. An alternate method is application of chemical polymer soil binders, but due to the short-term nature of this project, application of soil binders may not be justifiable from a cost standpoint.

During construction, there is potential for increased erosion and therefore increased solids loading to the surface-water drainage ditch. Erosion of the cover soil diminishes as vegetation proliferates on the surface. Until that time, however, berms and hay bales are used to intercept surface-water run-off and prevent the offsite transport of solids. Erosional features such as rills and gullies will need to be repaired. This post-closure maintenance work will involve importation and placement of top-soil material. Earthwork equipment and manpower to spread material in the required areas will also be necessary. The extent of this repair work will be largely dependent on the severity of the weather.

As described in the ARARs section, potential adverse environmental impacts to wetlands and Preble's meadow jumping mouse habitat may result from construction and implementation of this alternative (Figure 2-12). These impacts are mitigated as needed using acreage from the wetlands mitigation bank currently being developed in association with the Standley Lake Protection Project.

Implementation, including design and construction, takes approximately one year.

Implementability

Installing an FMC is a labor-intensive operation that includes extensive CQA. However, industry standards are well developed and companies specializing in installation of geosynthetics are readily available.

The long-term durability of FMCs has been evaluated through field testing of actual installations and through laboratory compatibility testing designed to simulate exposure to leachate for long periods of time. Both PVC and HDPE have been proven reliable as barrier layers for at least 30 years. In all of the cover options being considered, the

FMC component is covered with a 36-inch-thick vegetative soil. The vegetative soil layer prevents exposure of the FMC to ultraviolet radiation and prevents punctures by plant roots and burrowing animals.

The FMC will be exposed to surface water that infiltrates through the vegetative soil and to landfill gas. The rain water is expected to be nonhazardous and the gases are expected to contain only low concentrations of hazardous components.

Because the cap is the presumptive remedy for the landfill, it is unlikely that future actions would be required to address the waste itself. It is more likely that containment, collection, or treatment systems would be added to modify or enhance the existing remedy. In the event that additional remedial actions are required, alternatives could be developed that do not breach the cap or, if necessary, an area of the cap could be excavated and replaced.

The effectiveness of the remedy will be monitored by post-closure monitoring programs as described in Section 8.

Cost

The costs for Alternative 5: Single-Barrier FMC Cover are:

Total capital cost	$8,390,100
Annualized O&M cost	$55,000/year
Total present worth cost	$9,469,100

Detailed cost estimates are provided in Appendix H.

6.2.3 Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover

6.2.3.1 Description

Alternative 7 consists of institutional controls and a single-barrier FMC with a 12-inch layer of low-permeability soil. The presence of the low-permeability soil gives the cover system some of the benefits of a composite cover without the strict installation requirements of a full clay liner. The existing dam is left in place to contain the groundwater. The barrier layer is an FMC with a permeability of approximately 1E-13 cm/sec. This cover section is illustrated in Figure 6-3.

The construction procedures for this alternative are the same as those for Alternative 5 except that a low-permeability soil replaces the soil bedding layer under the FMC. The low-permeability soil layer is placed in a single 1-foot lift using low ground pressure bulldozers. Subsequently, this surface is compacted using sheepsfoot or wedgefoot

compactors. The surface of the soil is then trimmed. Material placed is tested for moisture content, compaction, and conformance with source material index tests.

6.2.3.2 Evaluation

Overall Protection of Human Health and the Environment

Alternative 7 provides protection of human health and the environment by meeting all RAOs. The cap prevents direct contact with the landfill contents. Security measures limit access to Rocky Flats. Fencing and other institutional controls limit access to the landfill at OU 7. The cap minimizes infiltration and, in conjunction with the new slurry wall, limits leaching and contaminant loading to groundwater. The cover is designed to direct the majority of the surface-water run-off to the surface-water drainage ditch and the remainder to the East Landfill Pond. The cover is graded and revegetated to limit erosion to 2 tons/acre/year. A landfill gas-collection layer and venting system is installed to protect the integrity of the cap. The design accommodates future landfill gas treatment if needed.

The FMC is relatively easy to install and the low-permeability layer provides an additional barrier without the strict installation requirements of clay. The cap provides protection to human health and the environment over the 30-year post-closure care period. Short-term impacts to the community, workers, and the environment are minimal because there is no excavation of waste. The alternative does not comply with EPA guidance for a RCRA Subtitle C cap (EPA 1989e); however, the single-barrier FMC with low-permeability soil cover is equally protective of human health and the environment and meets state and federal regulations for closure.

Compliance with ARARs

As with Alternative 5, Alternative 7 meets all but one chemical-specific ARARs for surface water. Surface water in the East Landfill Pond exceeds CWQ standards for manganese. However, installation of the cap reduces leachate generation and migration, and therefore, mobilization of manganese from pond sediments is not expected to continue. Alternative 7 does not meet chemical-specific ARARs for groundwater. Groundwater downgradient of the landfill exceeds SDWA MCLs for nitrate/nitrite, CWQ standards for sulfate, and the PQL for selenium. Particle tracking and contaminant transport modeling indicate that concentrations of nitrate/nitrite, selenium, and sulfate are not expected to exceed ARARs at compliance wells downgradient of the East Landfill Pond dam. In addition, the groundwater exposure pathway is incomplete.

Location-specific ARARs that are generally applicable for OU 7 are met. The cap extends over areas designated as wetlands by the U.S. Army Corps of Engineers and

areas identified as potential habitat for the Preble's meadow jumping mouse (Figure 2-12). Injury to wetlands and to Preble's meadow jumping mouse habitat are mitigated as needed. Although the portion of the pond not covered by the landfill cap will remain in place, dredge and fill requirements under Section 404 of the CWA are applicable. Alternative 7 meets substantive requirements of permitting under the CWA.

Action-specific ARARs under the CHWA, including closure requirements (6 CCR 1007-3 Part 265.310), post-closure maintenance requirements (6 CCR 1007-3 Part 265.117), and post-closure groundwater-monitoring requirements (6 CCR 1007-3 Part 265.228) are met for Alternative 7. The single-barrier FMC with low-permeability soil cover has a permeability of approximately 1E-13 cm/sec. As with Alternative 5, the cover for Alternative 7 meets all of the regulatory requirements for closure but does not follow EPA guidance for a RCRA Subtitle C cap (EPA 1989e). Construction procedures during installation of the landfill cap meet requirements of the Soil Erosion Dust Blowing Act (CRS 35-72-101). As with the other alternatives, Alternative 7 meets MACs for delisting leachate under 40 CFR 260.20. Compliance with NPDES (40 CFR Part 125) occurs by meeting substantive requirements for a discharge permit for periodic surface-water discharge to decrease water level in the East Landfill Pond.

Long-Term Effectiveness and Permanence

The FMC barrier is considered a proven technology and, if properly installed and maintained, is effective over the 30-year life of the project. In addition, this alternative has a second, low-permeability layer to act as backup, which increases the reliability of the technology. The average annual leakage rate for Alternative 7 is 0.00016 inches. A description of cap leakage rates is included in Appendix G.

The maintenance and monitoring are the same as discussed under Alternative 5.

As directed under the presumptive remedy, the source of contamination remains. However, risks associated with the direct contact and leaching of source contaminants into the groundwater are minimized by the cap and institutional controls. As with Alternative 5, CDPHE and EPA will evaluate the effectiveness of the remedial action every 5 years.

Reduction of Toxicity, Mobility, and Volume through Treatment

There is no active treatment with this option. However, there may be some decrease in toxicity and mobility over time due to natural attenuation processes. Leachate generation and migration will be reduced as a result of the cap.

265

Short-Term Effectiveness

No excavation into contaminated areas is required to implement this alternative. The contaminants are currently under a 12- to 36-inch-thick interim soil cover. Therefore, risks to the community and site workers are minimal. The possibility exists that workers could be exposed to contamination accidentally; however, proper use of PPE would limit potential exposure.

Dust is generated during excavation, transport, and placement of fill, the low-permeability soil layer, and the vegetative layer. The dust emissions are controlled by water spraying or possibly soil binders. Erosion during construction is controlled by berms and hay bales.

As described in the ARARs section, construction and implementation of this alternative may result in potential adverse environmental impacts to wetlands and Preble's meadow jumping mouse habitat (Figure 2-12). These impacts are mitigated as needed using acreage from the wetlands mitigation bank currently being developed in association with the Standley Lake Protection Project.

Cap construction would be complete within one year.

Implementability

The addition of the low-permeability soil does not add significantly to the installation of this cap in comparison with the FMC barrier as discussed under Alternative 5. The low-permeability soil is placed on top of the gas-collection layer and spread in a single 1-foot lift. The surface of the 1-foot lift is compacted and rolled to form a smooth, low-permeability surface for placement of the FMC. Some minor grading of the low-permeability soil may be required to maintain surface grades and prevent ponding. Addition of the low-permeability soil increases the reliability of the technology because the low-permeability soil acts as a backup barrier for the FMC layer.

Cost

The costs for Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover are:

Total capital cost	$9,070,000
Annualized O&M cost	$55,000/year
Total present worth cost	$10,149,000

Detailed cost estimates are provided in Appendix H.

6.2.4 Alternative 9: Composite-Barrier FMC and Clay Cover

6.2.4.1 Description

Alternative 9 is a composite barrier with both FMC and 24 inches of compacted clay. As with all of the alternatives, the existing dam remains in place to control groundwater migration away from the source. Use and access restrictions are described in Section 5.2.2. The design follows EPA guidance for a RCRA Subtitle C facility. This cover section is shown in Figure 6-4.

This cover differs from Alternative 5 in that a clay barrier layer with a permeability of approximately 1E-07 cm/sec replaces the low-permeability soil. Clay must be transported, processed, and conditioned as described in Section 5.3.5.2. Prepared clay material is placed on top of the filter fabric of the upper gas-collection layer in a 1 foot or thicker lift using low ground pressure bulldozers. Subsequent lifts are placed in 6- to 9-inch-thick loose lifts and compacted using sheepsfoot or wedgefoot compactors. The surface of the clay layer is tested and scarified to increase bonding between lifts.

During placement, care must be taken to protect the clay from moisture loss during dry periods or over moisturizing during rainy periods. After the clay is placed and before it is covered with the geomembrane, similar steps must be taken to prevent desiccation, over moisturizing, or erosion.

6.2.4.2 Evaluation

<u>Overall Protection of Human Health and the Environment</u>

The composite-barrier FMC and clay cover alternative meets all RAOs. The cap, fence, and institutional controls prevent direct contact with landfill contents. The cap has a permeability of approximately 1E-13 cm/sec and therefore minimizes infiltration, leaching, and resulting contaminant loading to groundwater. The surface is graded and revegetated to control surface-water run-off and erosion. A gas-collection system is designed to control landfill gas. Treatment may be added to the system if needed.

The compacted clay liner provides a secondary barrier; however, the clay requires intensive effort for proper installation. The cap provides protection over the 30-year life of the project. Because there is no planned excavation into landfill waste, short-term impacts are minimal.

<u>Compliance with ARARs</u>

As with Alternatives 5 and 7, Alternative 9 meets all chemical-specific ARARs for surface water except one. Surface water in the East Landfill Pond exceeds CWQ standards for manganese. Manganese is a naturally occurring element that is likely

261

mobilized from pond sediment by leachate. Containment of the leachate is expected to reduce manganese mobilization. Alternative 9 does not meet chemical-specific ARARs for groundwater. Groundwater downgradient of the landfill exceeds SDWA MCLs for nitrate/nitrite, CWQ standards for sulfate, and PQLs for selenium. Particle tracking and contaminant transport modeling indicate that concentrations of nitrate/nitrite, selenium, and sulfate are not expected to exceed ARARs at the compliance wells downgradient of the East Landfill Pond dam. In addition, the exposure pathway for groundwater is incomplete.

Location-specific ARARs that are generally applicable for OU 7 are met. The cap extends over areas designated as wetlands by the U.S. Army Corps of Engineers and areas identified as potential habitat for the Preble's meadow jumping mouse (Figure 2-12). Injury to wetlands and Preble's meadow jumping mouse habitat is mitigated as needed. Although the portion of the pond not covered by the landfill cap remains in place, dredge and fill requirements under Section 404 of the CWA are applicable. Alternative 9 meets substantive requirements of permitting under the CWA.

Action-specific ARARs under the CHWA, including closure requirements and post-closure maintenance and groundwater-monitoring requirements are met for Alternative 9. The composite-barrier FMC and clay cover has a permeability of approximately 1E-13 cm/sec. The cover for Alternative 9 meets all of the regulatory requirements for closure and follows EPA guidance for a RCRA Subtitle C cap (EPA 1989e), which recommends a composite barrier with an FMC layer and a clay layer. Construction procedures during installation of the landfill cap meet requirements of the Soil Erosion Dust Blowing Act (CRS 35-72-101). As with the other alternatives, Alternative 9 meets MACs for delisting leachate under 40 CFR 260.20. Compliance with NPDES (40 CFR Part 125) occurs by meeting substantive requirements for a discharge permit for periodic surface-water discharge to decrease water levels in the East Landfill Pond.

Long-Term Effectiveness and Permanence

Both the FMC and clay barriers are considered proven technologies. If properly installed and maintained, they are effective over the 30-year life of the project. However, the compacted clay layer is subject to desiccation cracking. The 5-year average annual leakage rate for Alternative 9 is 0.00001 inches. A description of cap leakage rates is included in Appendix G.

The schedule for maintenance and monitoring is the same for all capping alternatives and is described under Alternative 5.

Landfill waste material, which is the source of contamination, remains at OU 7. However, the cap and institutional controls minimize risks that result from direct contact with waste material and leaching of source contaminants into the groundwater.

Every 5 years, CDPHE and EPA will evaluate the effectiveness of the action, as mandated under Section 121(c) of CERCLA and Section 300.430 (f)(4)(ii) of the NCP. The level of the reviews will be at the discretion of CDPHE and EPA; however, it is expected that a Level 1 review will be sufficient.

Reduction of Toxicity, Mobility, and Volume through Treatment

This alternative does not include active treatment. However, as with the other alternatives, there may be some decrease in toxicity and mobility over time due to natural attenuation processes. In addition, the cap minimizes infiltration into the waste thus decreasing generation and migration of leachate.

Short-Term Effectiveness

As with the other alternatives, no excavation into contaminated areas is required to implement this alternative. Therefore, risks to the community and site workers are minimal. Workers could be exposed to contamination accidentally during construction; however, proper use of PPE limits exposure.

This remedial action results in dust generation during excavation, transport, and placement of fill, clay, and vegetative layers. The dust emissions are readily mitigated using standard dust suppression techniques. Erosion during construction is addressed by using hay bales and berms.

Potential adverse environmental impacts to wetlands and Preble's meadow jumping mouse habitat may result from implementation of this alternative (Figure 2-12). These impacts are mitigated as needed using acreage from the wetlands mitigation bank currently being developed in association with the Standley Lake Protection Project.

Cap construction could be complete within one year.

Implementability

Installation of the clay barrier layer requires a significant level of effort. The clay material must be mined, sized, moisture conditioned, and allowed to cure before it can be placed. Implementation of other elements of this alternative are the same as those for Alternative 5.

Cost

The costs for Alternative 9: Composite-Barrier FMC and Clay Cover are:

Total capital cost	$11,024,600
Annualized O&M cost	$55,000/year
Total present worth cost	$12,103,600

Detailed cost estimates are provided in Appendix H.

6.3 Comparative Analysis

In the previous sections, each of the alternatives is evaluated individually against the seven CERCLA criteria. This section provides a relative comparison of their performance based on the same criteria. The purpose of this analysis is to identify the strengths and weaknesses of the alternatives relative to each other.

With the exception of the no-action alternative, all the alternatives meet the threshold criteria of overall protection of human health and the environment and compliance with ARARs. Reduction of toxicity, mobility, and volume through treatment (a primary balancing criterion) is the same for all alternatives. None of the remedial actions include treatment although decreasing leakage rates will decrease the volume of leachate in the landfill.

All of the alternatives are compared based on the remaining primary balancing criteria: long-term effectiveness and permanence, short-term effectiveness, implementability, and cost. The focus is on the soil layer beneath the geomembrane, which is the only difference among the three alternatives.

6.3.1 Long-Term Effectiveness and Permanence

For long-term effectiveness, the focus is on the two main functions of the soil layer beneath the geomembrane:

- Ability of the soil to support and enhance the function of the geomembrane
- Long-term permeability of the soil barrier itself

Alternatives 7 and 9 have similar degrees of long-term effectiveness. The soil bedding layer of Alternative 5 serves to support the FMC as do the low-permeability soil layer of Alternative 7 and the clay-barrier layer of Alternative 9; however, if a breach in the membrane occurs, the soil bedding layer would not impede the movement of liquids as well as either the low-permeability soil or the clay barrier layer. On this basis, Alternative 5 presents a higher long-term risk than the other two alternatives.

Alternatives 7 and 9 have leakage rates approaching zero. The leakage rate for Alternative 5 is the highest of the three alternatives at 0.021 cm/sec.

During the life of the project, the key difference between the low-permeability soil and clay barrier is resistance to desiccation. Studies indicate that covers constructed with clay materials at high moisture contents may be subject to greater desiccation than covers constructed of soil materials at lower moisture contents (Corser *et al.* 1992). The desiccation cracking provides pathways for liquids to travel through the clay barrier layer thus increasing its permeability and reducing its long-term effectiveness. The low-permeability soil layer, which is placed at lower moisture contents, may have a higher initial permeability when placed, but in the long term may be less permeable than the clay barrier layer due to its resistance to desiccation. Alternative 7 affords the highest degree of long-term effectiveness and permanence.

6.3.2 Short-Term Effectiveness

None of the alternatives present a significant danger to the community, construction workers, or the environment during construction. Alternatives 5, 7, and 9 may be differentiated in terms of dust generation and potential for erosion due to the varying quantities of soil. Alternative 5 has the greatest short-term effectiveness because it has only 6 inches or 16,393 yd^3 of bedding soil. Alternative 7 has 12 inches or 32,787 yd^3 of low-permeability soil. Alternative 9 has 24 inches or 65,573 yd^3 of compacted clay. In addition to having the greatest quantity of soil, the compacted clay in Alternative 9 requires the most labor during construction and, therefore, has the potential for the most dust generation of the three alternatives.

6.3.3 Implementability

The three alternatives are compared in terms of technical feasibility, administrative feasibility, and availability of services and materials.

6.3.3.1 Technical Feasibility

<u>Ability to Construct and Operate</u>

Alternative 5 would be simplest to construct. Repairs are most easily made to Alternatives 5 and 7 because clay materials do not have to be prepared or maintained onsite. If, in the future, new clay borrow sources are selected to repair the clay layer in Alternative 9, it may be necessary to complete a new test fill and chemical compatibility tests for that clay material.

The clay barrier in Alternative 9 is more difficult to construct than the low-permeability soil layer or the bedding soil layer due to required moisture conditioning and

271

maintenance of exposed clay during construction. The clay typically is moisture conditioned and allowed to cure on stockpiles in advance of scheduled placement in the cell. Care must be taken to protect the clay from moisture loss during dry periods or over moisturizing during rainy periods. After the clay is placed and before it is covered with the geomembrane, similar steps must be taken to prevent desiccation, over moisturizing, or erosion.

Reliability of Technology

All three alternatives have an FMC barrier layer that has proven reliable in field and laboratory testing. Alternative 7 includes a low-permeability soil layer and would be most reliable. Alternative 9 provides a second barrier for added reliability but the clay is subject to desiccation. The 2-foot-thick clay barrier in Alternative 9 may tolerate more differential settlement than the other alternatives. However, due to the volume of general fill to be placed over the waste as part of the grading plan, the potential for localized differential settlement is limited.

Ease of Additional Remediation

In the event that additional action is required, it is unlikely that the cap will interfere. However if action must be taken below the cap, Alternative 5 is simplest to repair and Alternative 9 the most difficult to repair.

Monitoring

Monitoring the condition of the cover will be the same for Alternatives 5, 7, and 9. Details of inspections and maintenance are presented in the OU 7 Post-Closure Plan (Section 8.2.2).

6.3.3.2 Administrative Feasibility

All alternatives meet RAOs. However, proposed design alternatives that differ from suggested EPA guidance may undergo more scrutiny during technical review (EPA 1989c, EPA 1989d). Alternative 9, which most closely follows prescribed EPA guidance (EPA 1989e), would likely garner the most support. Alternative 7, which includes an FMC-barrier layer with a low-permeability soil, is equally protective and is significantly less expensive.

6.3.3.3 Availability of Services and Materials

Alternatives 5, 7, and 9 employ standard industry materials, equipment, and skilled labor types. Onsite clay borrow sources have not been located; however, clay materials are available from a local offsite supplier (EG&G 1994d).

6.3.4 Cost

Table 6-3 summarizes the detailed cost estimate. The total present worth costs for the alternatives are as follows:

Alternative 1:	No Action	$0
Alternative 5:	Single-Barrier FMC Cover	$9,469,100
Alternative 7:	Single-Barrier FMC with Low-Permeability Soil Cover	$10,149,000
Alternative 9:	Composite-Barrier FMC and Clay Cover	$12,103,600

The O&M costs are the same for all alternatives because inspection, maintenance, and monitoring of the cover are the same for all capping alternatives. Periodic inspections will minimize repairs to the barrier layer. Capital costs are different for each alternative: lowest for Alternative 5 and highest for Alternative 9. As a result of the difference in capital costs, total present worth costs are different for each alternative. The total present worth cost for Alternative 7 is 7 percent higher than the cost for Alternative 5. The total present worth cost for Alternative 9 is 22 percent higher than the cost for Alternative 5 and 16 percent higher than the cost for Alternative 7.

6.4 Summary of Comparative Analysis

Table 6-4 summarizes the detailed analysis of alternatives. Each of the seven CERCLA criteria is weighted from 0 to 20 based on its relative importance at OU 7. Overall protection of human health and the environment is the most important criterion. Compliance with ARARs; long-term effectiveness and permanence; reduction in toxicity, mobility, and volume; and cost are next and are equally important criteria. They are followed by implementability and short-term effectiveness. Short-term effectiveness is the least important of the balancing criteria because OU 7 is located within a large buffer zone, and implementation of the remedial action will cause few adverse impacts to the community or the environment. Each of the three alternatives is then ranked based on performance for each criteria. Weighting factors are multiplied by the rating to reach a weighted score. The weighted scores are summed for each alternative. Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover, has the highest total score and is proposed as the preferred IM/IRA for OU 7.

Section 6
Tables

Table 6-1
Evaluation Criteria for the Detailed Analysis of Alternatives

Nine CERCLA Criteria	Assessment Components	Discussion of Evaluation
Threshold Criteria		
Overall Protection of Human Health and the Environment	Long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs	Focused risk evaluation, ARARs, engineering judgment
Compliance with ARARs	Chemical-Specific ARARs	Federal and state standards
	Location-Specific ARARs	CWA, 40 CFR 6.3.02[a] (wetlands), Endangered Species Act
	Action-Specific ARARs	RCRA and CHWA closure, air-emission, delisting, discharge, and groundwater-monitoring requirements
	Compliance with other criteria, advisories, and guidance	EPA guidance on RCRA Subtitle C caps
Primary Balancing Criteria		
Long-Term Effectiveness and Permanence	Magnitude of residual risk	Engineering judgment, HELP analysis, erosion analysis, settlement analysis
	Adequacy and reliability of controls	
Reduction of Toxicity, Mobility, and Volume through Treatment	Treatment process used and materials treated	Treatment of landfill waste, leachate, and groundwater are not part of the presumptive remedy and therefore, this criterion does not apply; criterion is used in reference to reduction in volume of landfill leachate
	Amount of hazardous materials destroyed or treated	
	Degree of expected reduction in toxicity, mobility, and volume	
	Degree to which treatment is irreversible	
	Type and quantity of residuals remaining after treatment	
Short-Term Effectiveness	Protection of community during implementation of remedial actions	Engineering judgment, air-quality modeling, gas-emission modeling
	Protection of workers during implementation of remedial actions	
	Environmental impacts during implementation of remedial actions	
	Time until remedial action objectives are achieved	
Implementability	Technical feasibility	Construction and operation, reliability, monitoring effectiveness, and ease of additional remedial action
	Administrative feasibility	Regulatory approval and coordination with other agencies
	Availability of services and materials	Offsite treatment, storage, and disposal capacity; equipment and specialists; and prospective technologies
Cost	Capital costs (direct and indirect)	Detailed cost estimates
	Annual O&M costs	
	Total present worth costs	

275

Table 6-1
Evaluation Criteria for the Detailed Analysis of Alternatives

Nine CERCLA Criteria	Assessment Components	Discussion of Evaluation
Modifying Criteria		
Regulatory Agency Acceptance	CPHE, EPA, and Natural Resource Trustee Approval	Engineering judgment, risk management, and political issues
Community Acceptance	Public approval	Personal issues and concerns

216

Table 6-2
Quantities of Material for Landfill Cover Construction

Landfill Cover Material	Volume (yd^3)	Area (ft^2)
Fill	131,400	
Vegetative	82,000	
Top Soil	16,400	
Soil Bedding	16,400	
Low-Permeability	32,800	
Clay	65,600	
GCL		885,240
FMC		885,240
GCL/FMC		885,240
Geocomposite		
Drainage Layer		885,240
Gas-Collection		885,240

Definitions

ft^2 square feet
yd^3 cubic yards
GCL geosynthetic clay liner
FMC flexible membrane cover

277

Table 6-3
Detailed Cost Estimate Summary

Alternative	Annualized O&M Cost	O&M Present Worth	Capital Cost	Total Present Worth Cost
1	$0	$0	$0	$0
5	$55,000	$1,079,000	$8,390,100	$9,469,100
7	$55,000	$1,079,000	$9,070,000	$10,149,000
9	$55,000	$1,079,000	$11,024,600	$12,103,600

Definitions

O&M Operation and Maintenance

218

Table 6-4
Summary of Comparative Analysis

	Weighting Factor	Alternative 5 Single-Barrier FMC		Alternative 7 Single-Barrier FMC with Low-Permeability Soil		Alternate 9 Composite-Barrier FMC and Clay	
		Rating*	Weighted Score	Rating*	Weighted Score	Rating*	Weighted Score
Threshold Criteria							
Overall Protectiveness	20	2	40	3	60	3	60
Compliance with ARARs	15	2	30	2	30	3	45
Balancing Criteria							
Long-Term Effectiveness and Permanence	15	1	15	3	45	2	30
Reduction in Toxicity, Mobility, and Volume	15	1	15	2	30	3	45
Short-Term Effectiveness	5	3	15	2	10	1	5
Implementability	10	3	30	2	20	1	15
Cost	15	3	45	2	30	1	15
Total			**190**		**225**		**215**

***Rating**

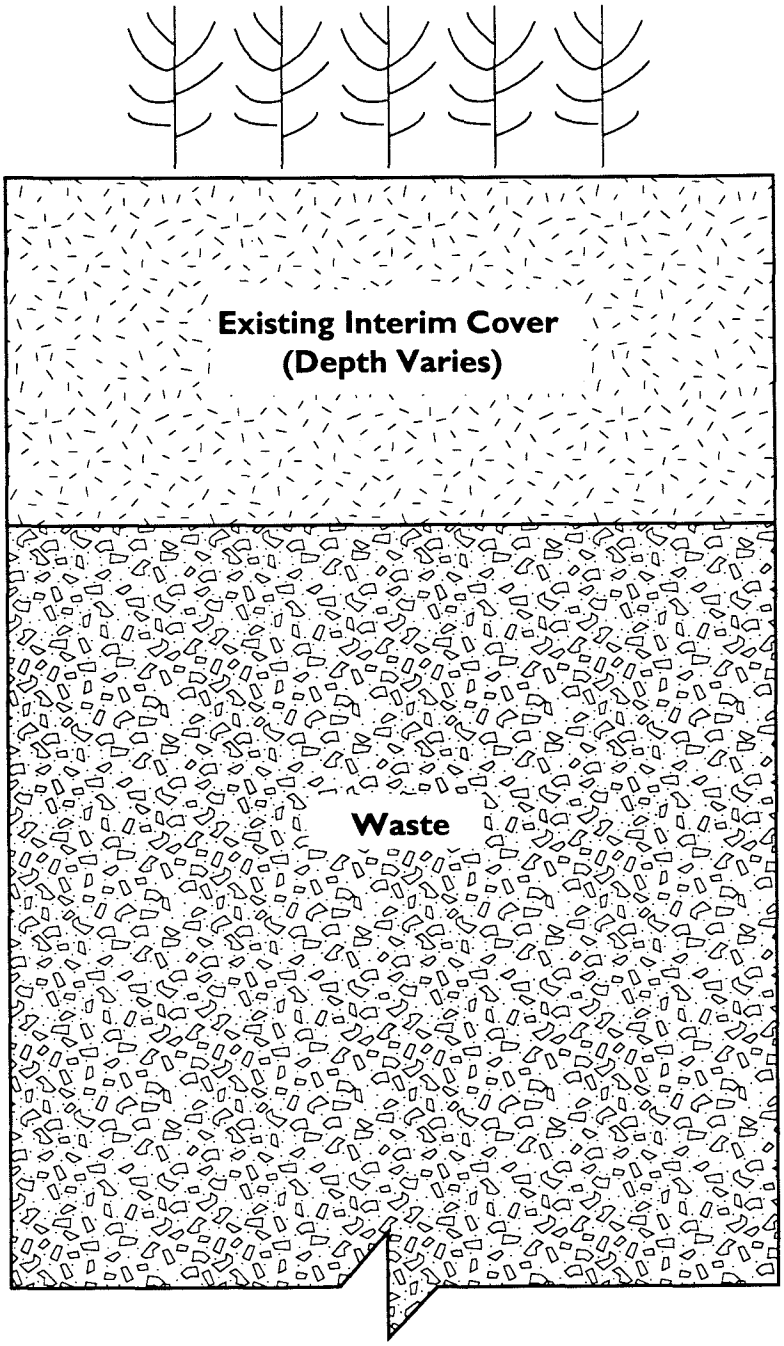
1 Poor
2 Moderate
3 Good

Definitions

FMC flexible membrane cover
ARAR applicable or relevant and appropriate requirements

Section 6
Figures

280



U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

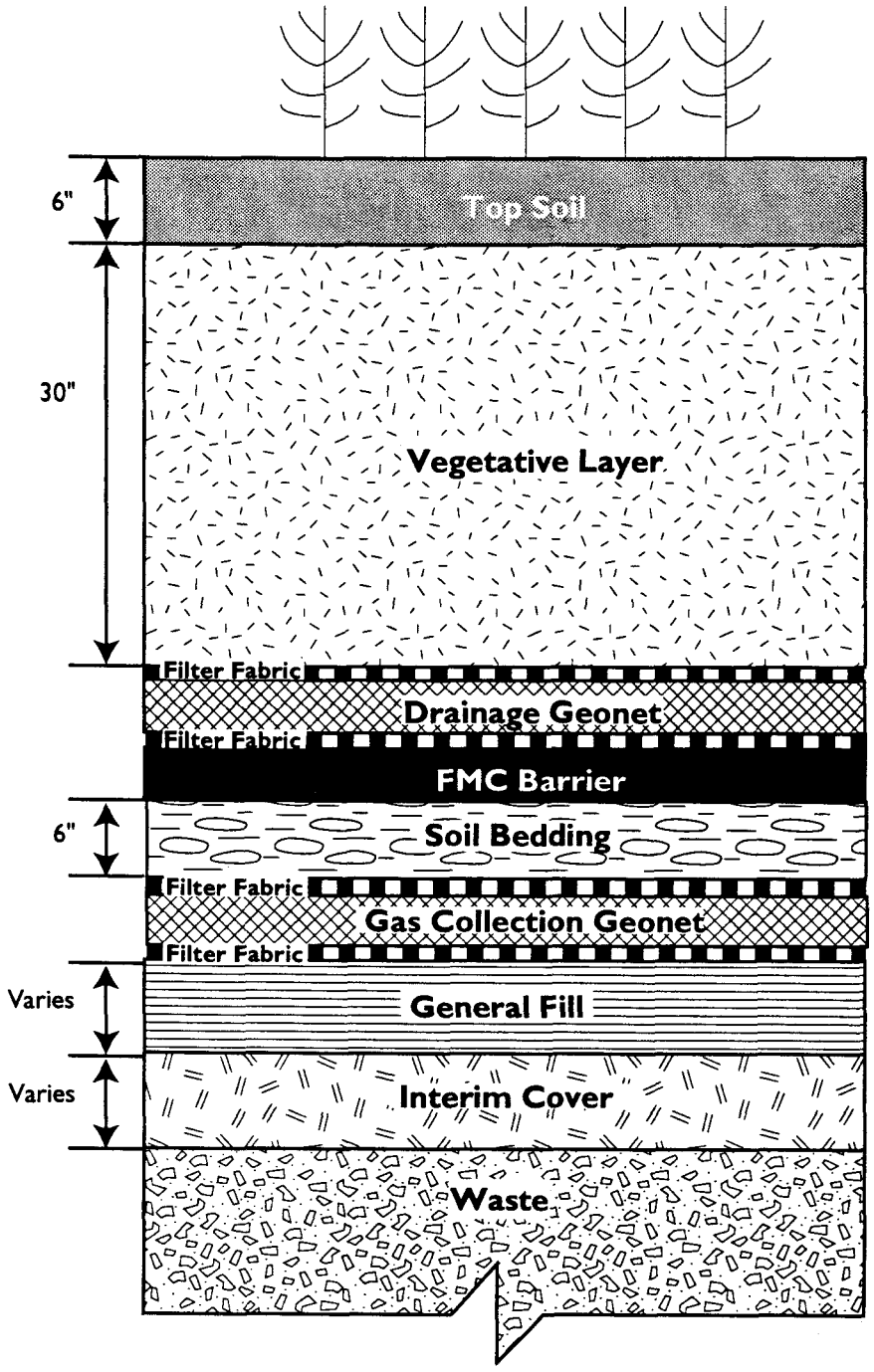
Alternative 1: No Action

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 6-1

G95\ES\IM/IRA DD OU7/Cover Alt -No Action-2510.ill

281



U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

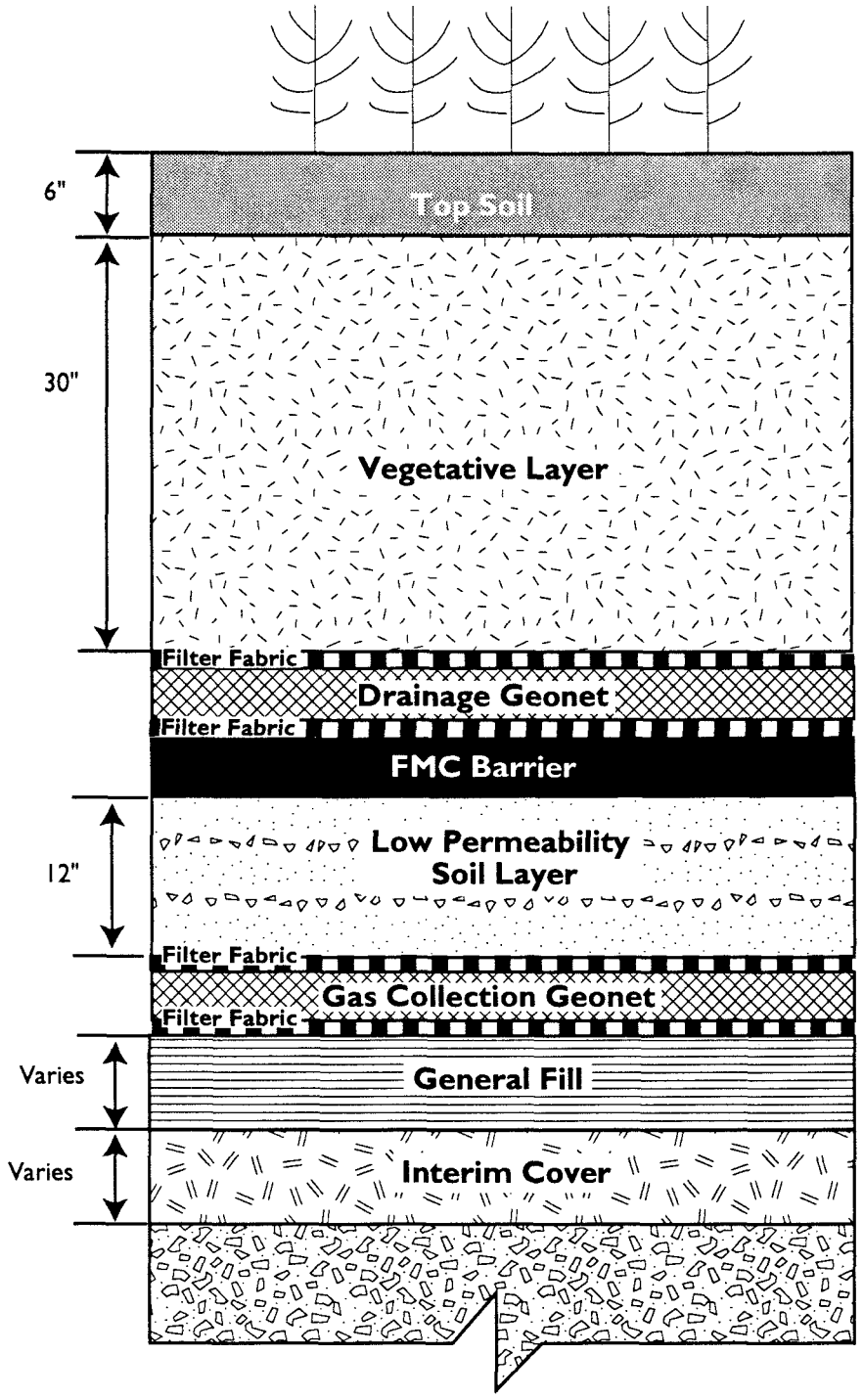
Alternative 5: Single-Barrier FMC Cover Cross Section

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 6-2

G95\ES\IM\IRA DD OU 7/Cover Alt #5-2510.ill

282



U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

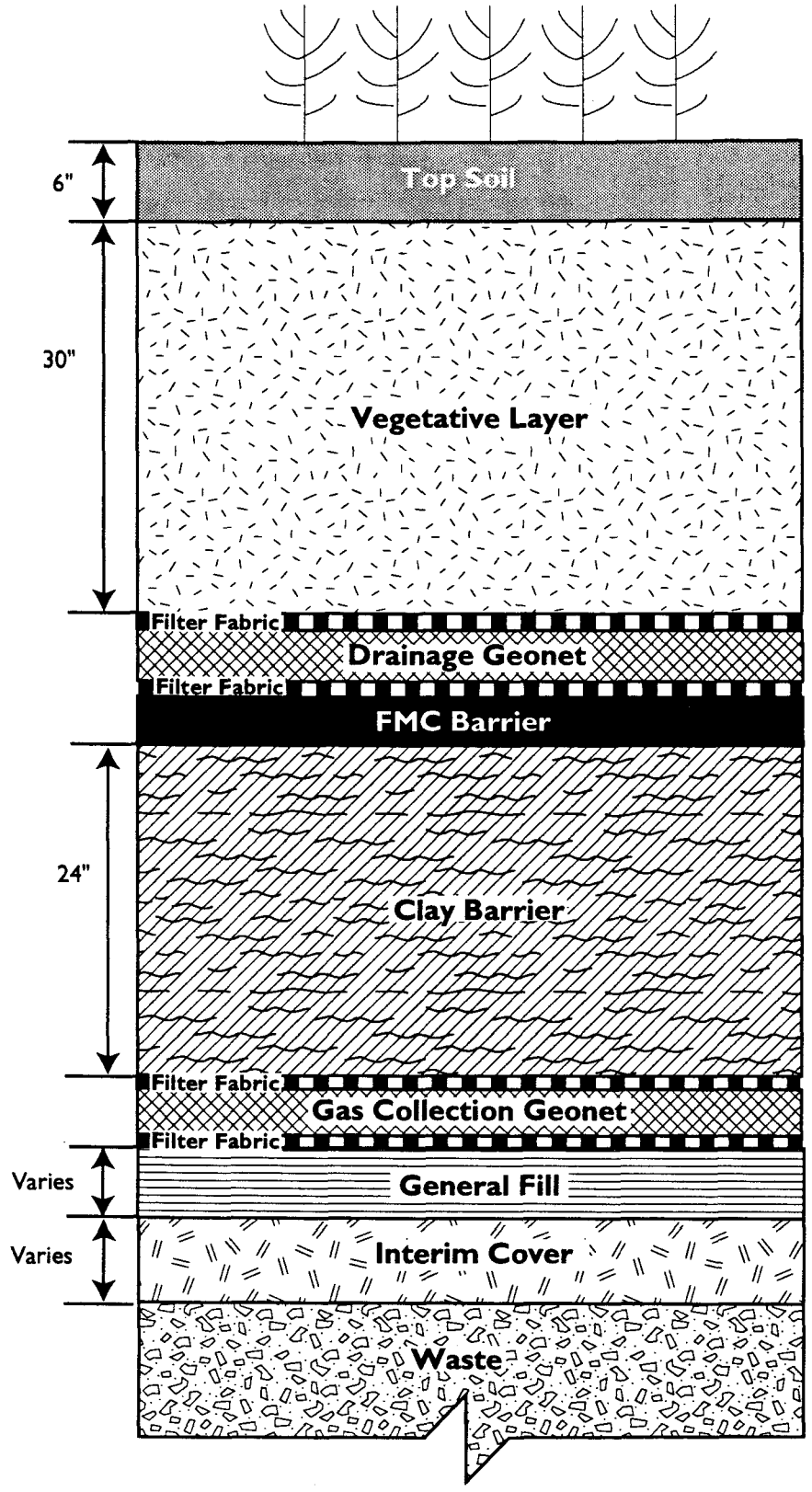
Alternative 7: Single-Barrier FMC & Low-Permeability Soil Cover Cross Section

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 6-3

G95\ES\IM/IRA DD OU7/Cover Alt #7-2510.ill

283



U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Alternative 9: Composite-Barrier FMC and Clay Cover Cross Section

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 6-4

G95\ES\IM/IRA DD OU 7/Cover Alt #9-2510.ill

284

7. Recommended Alternative

The detailed analysis of alternatives and the comparative analysis presented in Section 6 highlight the relative advantages and disadvantages of each alternative to identify key tradeoffs. Tradeoffs coupled with risk management decisions serve as the basis for selection of the preferred alternative. The recommended alternative is Alternative 7, a single-barrier cap with FMC and low-permeability soil.

A draft Proposed Plan has been developed around selection of the recommended alternative and is presented as an attachment to this report. The Phase I IM/IRA DD, along with the Proposed Plan, will be submitted for public review and comment in December 1995. Results of the detailed analysis support the final selection of a remedial action and the foundation for the CAD/ROD for OU 7.

The objective of this section is to describe the components of the recommended action in detail and to document how the final RAOs, ARARs, and other regulatory criteria are met. Design analyses have been completed to support the selection of the major design components that are described in this section. Additional design analyses will be completed as part of the Title II design.

7.1 Description

The recommended alternative for OU 7 consists of a single-barrier cover over the Present Landfill (IHSS 114), Inactive Hazardous Waste Storage Area (IHSS 203), and asbestos-disposal areas, and institutional controls to prevent unauthorized access. The cover consists of the following layers:

- 36-inch vegetative-soil layer
- Geocomposite lateral-drainage layer (geonet and filter fabric)
- FMC barrier layer
- 12-inch low-permeability soil layer
- Geocomposite gas-collection layer and venting system (geonet and filter fabric)
- Grading fill

This cover section is shown in Figure 7-1. The presence of the low-permeability soil gives the cover system some of the benefits of a composite cover, without the rigorous installation requirements, costs, and potential for desiccation of a full clay layer.

The conceptual site model for the source area shown in Figure 3-4 indicates that the exposure points are soil, waste, and dust. The containment presumptive remedy eliminates these exposure points. The cap covers an area of approximately 20 acres, most of which encompasses the landfill. One-third of the East Landfill Pond and

adjacent wetlands area is also covered by the cap as a result of the general fill needed to achieve design grades.

Based on Figure 3-6 there are two potential exposure points for leachate: seep water and groundwater. Before closure, leachate is intercepted at the seep and treated using a passive system as a separate accelerated action for OU 7. Potential exposure to leachate after closure is addressed by the presumptive remedy for source containment. The landfill cap covers the seep and thus eliminates exposure to the seep. A gravel blanket or French drain beneath the general fill prevents leachate from building up and creating a seep in the new cap. The groundwater pathway is already incomplete.

Based on the screening-level risk evaluation and the comparison to MACs for delisting presented in Section 3, the leachate is nonhazardous, does not pose a threat to human health, and therefore should be delisted. After the leachate is delisted, it is no longer subject to CHWA and RCRA Subtitle C hazardous waste regulations.

The landfill cap eliminates infiltration of approximately 99.999 percent of the precipitation, which reduces leachate generation and migration and contaminant loading to groundwater. In addition, the proposed slurry wall eliminates 93 percent of the groundwater inflow as discussed in Section 2.3. Leachate control for the landfill exceeds regulatory requirements. Under 40 CFR Parts 265.118 and 265.310(b)(2), existing units at interim status landfills are not required to have leachate collection and removal systems and are not required to manage leachate during the post-closure period (EPA 1987a).

Surface water in the East Landfill Pond does not require remediation because it does not pose a risk to human or ecological receptors. The pond and the dam currently act as barriers to groundwater flow and contaminant migration and they remain in place and continue to impede flow after landfill closure.

Groundwater downgradient of the landfill does not require remediation. Potential exposure pathways associated with UHSU groundwater (Figure 3-10) are incomplete because there are no plans for future development of groundwater for any use at OU 7. One-third of the pond area is covered by the landfill cap, which reduces the amount of recharge to groundwater in this area. The pond and the dam impede the flow of groundwater to the east in No Name Gulch.

7.2 Design Requirements

Design of the landfill cover must consider all RAOs, ARARs, and requirements set forth by 6 CCR 1007-3 Part 265.310. The regulatory requirements are broadly based and allow for individually tailored designs to meet site-specific conditions such as

climate, topography, and waste characteristics. This section describes how the RAOs, ARARs, and guidance requirements are met for the recommended alternative.

7.2.1 Compliance with RAOs

In order to meet the overall objective of protecting human health and the environment, RAOs developed in Section 3 must be met. All of the RAOs except one (remediate wetland areas) are for presumptive remedy components of OU 7 and are specified in EPA guidance (EPA 1993a). Media-specific RAOs for other components were developed using exposure pathways, risk, and compliance with ARARs. With the exception of remediating wetland areas, media-specific RAOs were eliminated from the final response action because (1) there is no risk to the potential receptor, (2) analytes do not exceed ARARs, or (3) the exposure pathway is incomplete. The final RAOs for OU 7 are as follows:

- Prevent direct contact with landfill contents
- Minimize infiltration and resulting contaminant leaching to groundwater
- Control surface-water run-off and erosion
- Control landfill gas (treat as needed)
- Remediate wetland areas (as needed)

The single-barrier cover with FMC and low-permeability soil addresses each RAO.

Direct contact with soil or waste material in the Present Landfill, Inactive Hazardous Waste Storage Area, and asbestos-disposal areas is prevented by the landfill cover. Because the continued effectiveness of the containment remedy depends on the integrity of the containment system, institutional controls are necessary to prevent access to the site. A deed notation under CHWA limits future development of the landfill area.

The cover minimizes infiltration and resulting contaminant leaching. Contaminant leaching is decreased by reducing infiltration of precipitation through the landfill cover and controlling surface-water flow by diverting it around the landfill. Routine maintenance actions, such as replacing the slurry wall on the north side of the landfill, reduce contaminant leaching by controlling groundwater inflow into the landfill area.

Grading of the landfill surface requires minimum slopes to provide adequate surface-water drainage after settlement. Promoting drainage minimizes erosion or abrasion of the cover. The vegetative-cover layer provides suitable media for the growth of vegetation and reduces erosion. Grading of the landfill surface forces surface water to drain to the perimeter of the landfill, where it is collected in the perimeter surface-water drainage ditch and is routed around the landfill and past the East Landfill Pond dam.

287

Exposure to landfill gas is controlled by a gas-collection system. The gas-collection layer collects migrating gases across the landfill surface and transmits them to selected discharge points. Gas collected in this layer flows to vent pipes or gravel columns and vents to the surface through the cover. The system has the capability for adding gas treatment as needed.

Wetlands mitigation is in progress. Acreage from the wetlands mitigation bank currently being developed in association with the Standley Lake Protection Project is used to mitigate the loss of wetland areas that fall under the landfill cover and injury to surrounding wetland areas. Injury to Preble's meadow jumping mouse habitat is mitigated as needed.

7.2.2 Compliance with ARARs

In order to meet the overall objective of protecting human health and the environment pursuant to the IAG (DOE 1991b), the recommended alternative for OU 7 must address all ARARs developed in Section 3. Compliance with applicable chemical-specific, location-specific, and action-specific ARARs is addressed in the following sections.

7.2.2.1 Chemical-Specific ARARs

The recommended alternative meets all but one chemical-specific ARAR for surface water and all but three chemical-specific ARARs for groundwater (Section 3.4.1).

Surface water in the East Landfill Pond exceeds CWQ standards for manganese. However, manganese is a naturally occurring element common in the geologic materials surrounding the pond and in pond sediment. Discharge of leachate into the pond may have resulted in mobilization of manganese from the pond sediments. It is expected that concentrations of manganese and other PCOCs will decrease in response to reductions in leachate generation and migration resulting from the landfill cap. Based on the results of the focused risk assessment, there is no associated risk to human or ecological receptors from pond water.

Groundwater downgradient of the landfill exceeds SDWA MCLs for nitrate/nitrite, CWQ standards for sulfate, and the PQL for selenium. Flow modeling indicates that the East Landfill Pond dam significantly reduces groundwater flow and attenuates contaminants. As a result, contaminant migration down No Name Gulch is expected to be minimal. Particle tracking and contaminant transport modeling indicate that concentrations of nitrate/nitrite, selenium, and sulfate are not expected to exceed ARARs at the compliance wells downgradient of the East Landfill Pond dam. On the basis of the focused risk assessment, carcinogenic risk from ingestion of UHSU groundwater is within the acceptable risk range (1E-05 in groundwater in the vicinity of the pond and below 1E-06 in groundwater downgradient of the dam); however, the

noncarcinogenic risk is above the acceptable risk or HI of 1 (HI = 3) in groundwater in the vicinity of the pond. The primary contributor to noncarcinogenic risk is selenium. UHSU groundwater in wells 4287, 52894, and 53194 meets ARARs.

7.2.2.2 *Location-Specific ARARs*

Location-specific ARARs are met. Construction of the recommended alternative is conducted in a manner that minimizes destruction, loss, or degradation of wetlands (40 CFR 6.302[a]) and Preble's meadow jumping mouse habitat (CRS 33-2-101). A wetlands assessment is included in this section of the report in accordance with 40 CFR Part 6 and with wetlands/floodplains environmental review requirements under 10 CFR Part 1022. Draining water from the pond to dry out the area before construction is considered dredging and triggers substantive requirements for a permit under Section 404 of the CWA.

Wetlands Assessment

Wetlands Effects

Placement of fill to achieve design grades covers approximately 1.1 acres of wetlands, including submerged and emergent species. It was assumed that another 10 percent or 0.1 acre may be injured during placement of the various cover layers at the east end of the landfill. Because two-thirds of the East Landfill Pond and wetland areas remain in place after closure, the proposed activities have only negligible positive or negative, direct or indirect, short-term or long-term effects on the survival, quality, or natural and beneficial values of the wetlands.

Alternatives

Three other alternatives were evaluated in the detailed analysis of alternatives. Two of the alternatives, Alternative 5 and Alternative 9, would have adverse impacts to wetland areas very similar to those of the recommended alternative. The other alternative, Alternative 1: No Action, would result in no adverse impacts to wetlands areas. However, the no-action alternative would not meet applicable state and federal water-quality standards nor would it meet closure requirements (6 CCR 1007-3 Part 310) and post-closure maintenance and monitoring requirements (6 CCR 1007-3 Part 265.117 and Part 265.228).

Mitigation of Wetland Impacts

Wetlands mitigation is in progress. Acreage from the wetlands mitigation bank at the Standley Lake Protection Project is used to mitigate loss or injury to wetland areas.

281

Wetlands mitigation is based on a 3:1 mitigation to injury ratio. As a result, 3.6 acres of wetlands are mitigated for closure of OU 7.

Preble's Meadow Jumping Mouse Habitat Mitigation

It was assumed that 7.26 acres of Preble's meadow jumping mouse habitat are injured during placement of fill, grading, and placement of the cover layers. Preble's meadow jumping mouse habitat mitigation is based on a 1:1 mitigation to injury ratio. An estimated 7.26 acres of Preble's meadow jumping mouse habitat may require mitigation.

7.2.2.3 Action-Specific ARARs

Action-specific ARARs include requirements for closure, air emissions, groundwater monitoring, and delisting leachate.

Closure Requirements

Because hazardous waste was disposed in the landfill after 1980, the cover is designed to meet RCRA Subtitle C design requirements. The proposed action must meet the following requirements for landfill closure under CHWA (6 CCR 1007-3 Part 265.310):

- Provide long-term minimization of migration of liquids through the closed landfill
- Function with minimum maintenance
- Promote drainage and minimize erosion or abrasion of the cover
- Accommodate settling and subsidence to maintain the integrity of the cover
- Have a permeability less than or equal to the permeability of any bottom-liner system or natural subsoil present

The cap is designed with a multi-layer system that minimizes migration of liquids through the landfill over the long term. The vegetative layer promotes evaporation and transpiration, the drainage layer provides pathways to divert water off the cover, and the barrier layer limits infiltration to the waste. HELP modeling indicates that 99.999 percent of the precipitation on the landfill is diverted as discussed in Section 7.3.3.

Future maintenance is minimized by designing for post-settlement slopes of 3 to 5 percent, to minimize damage to the cover from surface water. Settlement issues are described further in Section 7.3.1.1. Institutional controls are used to limit access and control use to protect the integrity of the cap. The vegetative cover is planted with native species that require low maintenance.

Final slopes are selected to promote drainage and minimize erosion of the cover. As described in Section 7.3.1.2, the maximum erosion rate does not exceed guidance requirements (EPA 1989d, EPA 1989e). The existing surface-water drainage ditch is modified as necessary to accommodate a 100-year, 24-hour storm (Section 7.3.2).

The grading plan accommodates settling and subsidence to safeguard cover integrity. As described in Section 7.3.1, settlement has been analyzed and design slopes of 7 percent ensure post-settlement slopes that meet guidance requirements (Table 7-1). Unstable areas have been identified along the west end of the pond. These areas are buttressed and subsurface drainage is incorporated into the design.

The permeability of the FMC barrier layer is 1E-13 cm/sec, which is less than the permeability of natural subsoils at the landfill (1E-06 to 1E-07 cm/sec).

EPA has issued various guidance documents on the design and construction of cover systems for hazardous waste facilities. These documents, along with state and federal regulations for closure, are as follows:

- CWHA Hazardous Waste Regulation, 6 CCR 1007-3, Colorado Department of Health, August 1992
- Title 40 - Code of Federal Regulations (40 CFR) Part 265
- U.S. Environmental Protection Agency Technical Guidance Document: Covers for Uncontrolled Hazardous Waste Sites, EPA/540/2-85-002, September (EPA 1985)
- U.S. Environmental Protection Agency Draft Minimum Technology Guidance on Double Liner Systems for Landfills and Surface Impoundments - Design, Construction and Operations, EPA/530-SW-85-014, April (EPA 1987b)
- U.S. Environmental Protection Agency Technical Guidance Document: Final Covers on Hazardous Waste and Surface Impoundments, EPA/530-SW-89-047, July (EPA 1989d)
- U.S. Environmental Protection Agency Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182, September (EPA 1993c)

Table 7-1 provides a summary of EPA guidance criteria for design of landfill cover systems, which addresses the vegetative cover, drainage layer, and barrier layers. Table 7-2 describes how individual design components of the recommended alternative address closure requirements and EPA guidance. Because the landfill waste remains in place, the post-closure requirements of 6 CCR 1007-3 Parts 265.117 through 265.120

291

apply. Details of the 30-year post-closure care period are presented in the OU 7 Post-Closure Plan in Section 8.

Air Emission Requirements

Closure of the landfill at OU 7 requires an APEN, a construction permit, development of a fugitive emission control plan, and implementation of standard dust-control procedures during construction. The existing Plan for Prevention of Contaminant Dispersion for Rocky Flats (DOE 1992c) addresses the requirement for development of a fugitive emission control plan. Periodic watering during construction addresses the requirement for implementation of standard dust-control procedures and can reduce dust emissions by up to 50 percent. Specific controls for gas emissions from the landfill are not expected to be required based on estimated emission rates of NMOCs (Appendix I). Due to potential future changes in gas emissions resulting from construction of the proposed slurry wall maintenance action and the final cover, it is proposed that the landfill gas be monitored and technology for treatment added if needed. Post-closure gas monitoring is described in the OU 7 Post-Closure Plan (Section 8.2).

Groundwater Monitoring Requirements

6 CCR 1007-3 Subpart F states that groundwater monitoring is required for all landfills. At minimum, one hydraulically upgradient well and three downgradient wells are required. Well 70393, located due west of the landfill near the headwaters of the former drainage is proposed as the upgradient well to provide background data. Three wells, 4287, 52894, and 53194, located downgradient of the landfill in the No Name Gulch drainage beyond the area where groundwater flow in surficial materials is impeded by the dam, are proposed as the downgradient monitoring wells. These locations will ensure that potential contaminants are detected if they migrate away from the landfill and provide information regarding improvement or degradation of groundwater quality.

Groundwater monitoring continues during closure under the existing sitewide groundwater-monitoring program. A streamlined groundwater-monitoring program is proposed for the 30-year post-closure care period. Two categories of sampling and analysis are required. Contamination parameters, which include pH, specific conductance, TOC, and TOX, are required semiannually, whereas, groundwater quality parameters, which include chloride, iron, manganese, phenols, sodium, and sulfate, are at a minimum, required annually.

Delisting Requirements

Alternative 7 meets MACs for delisting leachate under 40 CFR 260.20. Under the presumptive remedy, it is proposed that the leachate, which is considered F039 RCRA-listed waste contained in groundwater, be delisted. Based on the screening-level risk evaluation and the comparison to MACs for delisting presented in Section 3, the leachate is nonhazardous, does not pose a threat to human health, and therefore should be delisted. After the leachate is delisted, it is no longer subject to CHWA and RCRA Subtitle C hazardous waste regulations.

7.3 Conceptual Design

The landfill cover extends over the limits of the Present Landfill (IHSS 114), Inactive Hazardous Waste Storage Area (IHSS 203), and the north and south asbestos-disposal areas. The existing topography and surface features are shown on Figure 7-2. The limits of the cover are shown on Figure 7-3. To construct the cover over these areas and maintain minimum slopes, the general fill extends beyond the limits of the cover in some locations.

The conceptual design incorporates the proposed grading plan, settlement, soil erosion, buttressing requirements, general fill, surface-water control, cover section, seepage control, gas control, ancillary facilities, and costs.

7.3.1 Proposed Grading Plan

The existing landfill operations plan for OU 7 envisions mounding waste to 6-percent slopes in the center of the landfill to provide surface-water drainage to the perimeter of the waste before closure. However, given the current and projected waste inflow rates, the waste does not reach these design grades before closure of the facility in early 1997. Therefore, a large volume of general fill is required to achieve grades that drain surface water off of the facility and meet regulatory requirements.

Figure 7-3 shows the conceptual grading plan for OU 7. Figures 7-4 and 7-5 are cross sections through the landfill that show the extent of the general fill. The grading plan incorporates a 7-percent surface grade across the majority of the landfill that drains to the perimeter. Along the east slope of the landfill, the grade increases to approximately 20 percent. Based on this plan, a total of approximately 131,400 yd^3 of fill material is required to achieve the design grades.

293

7.3.1.1 Settlement

The 7-percent surface grade is established based on the EPA guidance criteria of 3- to 5-percent minimum post-closure surface grades and the expected amount of surface settlement from placement of the general fill and decomposition of the waste.

Settlements at representative points on the landfill surface were estimated using a simple percent of thickness assessment, Sowers method, Gibson and Lo method, and power creep law. Details of the settlement analysis calculations are presented in Appendix F. These methods yielded maximum settlements ranging from 2.9 to 5.5 feet in areas where the waste fill is thickest. The change in surface elevations resulting from these settlements was computed, and the resulting surface slopes remained within the recommended 3- to 5-percent range.

7.3.1.2 Soil Erosion

Grasses and topsoil indigenous to Rocky Flats are used for the vegetative cover. Grasses include prairie grass, wheat grass, and green needle grass. It is expected that topsoil from onsite sources of the Flatirons soil formation can be amended with fertilizers to form a suitable substrate to establish cover vegetation.

Erosion analyses using the Flatirons as a base, typical Rocky Flats site climatic information, and the design topography indicate that the 20-percent slopes surrounding the East Landfill Pond yield soil erosion rates of 1.8 tons per acre per year. The 7-percent slopes yield soil erosion rates of 0.5 tons per acre per year after vegetation is established. These soil erosion rates are less than the maximum allowable value of 2 tons per acre per year, recommended by EPA guidance (EPA 1989d). Assumptions, methodologies, and erosion calculations for annual soil loss are presented in Appendix J. These erosion rates are not expected to cause higher than normal sedimentation in the pond or perimeter drainage ditches. It should be noted that this erosion analysis considered only average vegetation conditions and that a well established vegetative cover reduces the erosion yields significantly.

7.3.1.3 Buttress East Side

As previously mentioned (Sections 2.2 and 2.3), the northeast slope of the landfill that extends down to the East Landfill Pond exhibits signs of slumping. Seeps have been observed in this area. Due to the presence of these features, the grading plan has incorporated a large buttress fill in this area. The buttress fill results in 20 to 25 feet of material at the base of the slumps and is sloped at approximately 20 percent. In addition, a blanket drain or system of French drains is planned in and around the seep areas to allow drainage if the seep flow continues after closure. This system will be designed as part of Title II design. It is expected that seep flow will decrease

294

significantly due to the combined effects of the proposed slurry wall and cap. Preliminary stability analyses indicate that the effect of placing buttress fill, reducing the slope from 33 percent to approximately 20 percent, and installation of the subsurface drains results in long-term stability.

7.3.1.4 General Fill

The requirements for the general fill material used to achieve design grades are minimal. The purpose of the fill is to achieve design grades while minimizing the potential for future settlement. Therefore, the type of material used does not greatly impact the performance of the cover system. The only requirements for the general fill are that it is placed and compacted to form an unyielding subgrade for construction of the cover system and that it is sufficiently permeable to allow vertical migration of gases generated in the waste. Based on these requirements, almost any type of granular soil is used. A low-plasticity soil could also be used provided that some gravel columns are incorporated into the fill to allow gas to migrate to the gas-collection system within the cover section.

Based on the performance requirements and to control costs, limited requirements for placing, spreading, and compacting this material will be included in the specifications. The fill is obtained from nearby borrow sources. Several onsite and offsite borrow sources have been evaluated for use at OU 7 in terms of material type, estimated costs, and other environmental, technical, and institutional factors (EG&G 1994d).

7.3.2 Surface-Water Control

The majority of the surface-water run-off is controlled by grading the surface to shed water to the landfill perimeter drainage ditches. Surface water in these ditches discharges into No Name Gulch below the East Landfill Pond dam. The eastern slope of the landfill cover drains into the pond. The central portion of the landfill is mounded and slopes toward the perimeter. Slopes are approximately 7 percent. Existing surface-water drainage ditches on the north and south side of the landfill are rerouted to accommodate regrading of surface contours in these areas (Figure 7-3). These ditches handle surface-water run-off from the cover as well as intercept the run-on to the landfill from the surrounding area.

During final design, the volume of run-off from the landfill and run-on to the landfill will be determined to size the drainage ditches around the perimeter of the landfill. The design analyses will be conducted to determine the amount of run-off and run-on for a 100-year, 24-hour storm as required by state regulations for hazardous waste landfills (6 CCR 1007-3). The existing ditches are upgraded as required prior to closure.

295

7.3.3 Cover Section

As previously described in Sections 5 and 6, the recommended alternative, Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover, best meets the evaluation criteria considered in the IM/IRA screening process. In addition to meeting CERCLA criteria, Alternative 7 is compatible with the cover elements and functions described in previous sections. For example, if settlement occurs in the central portion of the landfill, the cover becomes compressed. The physical flexibility properties of the soil and geosynthetic material components allow the cover to sustain minor displacements without rupturing. Similarly, the geosynthetic materials are flexible when thermal expansion or contraction takes place. The local soils and vegetation used in the vegetative layer, which serve to resist erosion and promote evaporation of precipitation, are visually compatible with the surrounding landscape. The cover materials are also adaptable to the penetrations made for the gas-collection system piping. Geosynthetic boots designed to restrict infiltration around the pipe penetration are commonly used in landfill cover construction.

The individual layers of the recommended alternative, Alternative 7: Single-Barrier FMC with Low-Permeability Soil Cover, are illustrated in Figure 7-1. The components from top down are the vegetative layer, a drainage layer, the FMC barrier, a low-permeability soil layer, the gas-collection layer, and a general fill layer that lies directly on the interim soil cover overlying the waste. Each of these components plays an important role in the overall hydrologic performance of this cover system as described in Section 5.1.

Groundwater modeling has shown that 60 percent of the leachate is from inflow through the groundwater-intercept system and 40 percent from infiltration. The proposed slurry wall addresses the subsurface inflow and the landfill cap addresses infiltration. The top soil component and underlying vegetative layer provide a substrate for vegetation development and evapotranspiration of precipitation. Water leaving the system in this manner does not contribute to leachate generation. HELP analyses indicate that 61.7 percent of the precipitation that falls onto the surface of the cover is removed from the system through evapotranspiration and 0.2 percent through direct run-off.

Most of the remainder percolates through the soil and geotextile filter fabric into the geonet drainage layer that lies directly on the FMC. Another 38.1 percent of the percolating water is removed from the system via the drainage geonet.

Of the surface water that originally entered the system, this leaves 0.001 percent, which is either stored in the interim cover or waste layer, or flows out of the landfill as leachate. With the proposed slurry wall diverting upgradient groundwater around the

246

landfill flow and the cover diverting surface water away from the landfill, water levels inside the landfill are expected to decrease. Eventually, the leachate outflow and groundwater baseflow will be reduced substantially.

7.3.4 Seepage Control

Previous field investigations at OU 7 have documented seeps at the toe of the eastern slope of the landfill. The proposed slurry wall along the north side of the landfill is expected to reduce the amount of groundwater entering the landfill, and therefore, may reduce the flow or even stop the flow at the seep. A gravel blanket or French drain prevents seep water from building up and creating a seep in the new cap.

7.3.5 Gas Control

Gas generation and discharge from the landfill has been well documented (DOE 1994a). The final cover is designed to collect and discharge the gas in a safe and controlled manner. The cover section includes a gas-collection layer at the base of the cover section directly on top of the general fill layer. Gas is routed to a series of collection pipes or gravel columns that penetrate through the cover at select locations to vent gas to the surface.

Based on the gas monitoring that has been completed to date, an assessment of the requirements for permitting the gas discharge was made and is presented in Appendix I. This analysis indicates that gas treatment is not required. Due to potential future changes in gas emissions resulting from construction of the proposed slurry wall and final cover, landfill gas will be monitored during the post-closure care period and gas will be treated if needed.

7.3.6 Surface-Water Controls

Recharge to the East Landfill Pond is greatly decreased as a result of the proposed slurry wall and landfill cap. Water levels in the pond are monitored and water is pumped down as necessary. The water is presently pumped to the A-ponds for treatment and discharge under the existing surface-water management plan. Over the 30-year post-closure care period other alternatives may be considered.

7.3.7 Institutional Controls

A 6-foot-high chain-link fence that entirely surrounds the landfill prohibits access by unauthorized personnel. The fence is located outside the limits of the cover and its construction does not impact the cover. Gates allow access to the cover for maintenance and inspections. In addition, the area is identified with signs indicating

297

the nature of the facility and warning the public about the dangers of excavation in the area and a notation is made on the deed. No groundwater wells are anticipated at OU 7.

7.3.8 Cost Estimate

Detailed written cost estimation must be provided for closure and O&M post-closure care as mandated by 6 CCR 1007-3 Parts 265.142 and 265.144, respectively. The cost estimate is based on expenses when hiring a third party and does not include salvage value. Cost estimates were developed using the Guidance Manual: Cost Estimates for Closure and Post-Closure Plans (Subparts G and H) (EPA 1987a) and the Rocky Flats Plant Cost Estimating Handbook (DOE 1994g) to identify applicable activities to be costed. Vendors and site operators were contacted to provide accurate unit costs for each activity. Other resources used include the Means Cost Handbook (Means 1994) and previous closure activities. Quantities are site specific, developed using engineering judgment and design considerations.

The total present worth for the recommended IM/IRA design is $10,149,000. The cost is higher than average for capping a landfill because a large volume of general fill is needed to achieve design grade. Normally, waste material would be accepted until the landfill reached capacity, which would require much less general fill to achieve grade. Detailed cost estimates and assumptions are provided in Appendix H.

7.4 Title II Design

The Title II design attempts to meet environmental, safety, security, and quality assurance requirements following good engineering and construction practices and simultaneously minimizes project costs. The Title II design should include the following information: further development of the Conceptual/Title I design; a detailed cost estimate and construction schedule; analysis of health, safety, and environmental impacts; identification of relevant quality verification test plan and permits; a procurement plan; any necessary utility services; and determination of job/work task assessments and training required. The Title II Design Document, which will be submitted for review, will contain a summary of the Title II design, final technical specifications and drawings, design calculations, a construction cost estimate and a CQA plan.

Initiation of Title II design will begin with approval of the Phase I IM/IRA DD by CDPHE and EPA. A preliminary list of Title II design drawings is provided in Table 7-3. A preliminary list of technical specifications is presented in Table 7-4.

7.5 Justification for Recommended Alternative

The recommended alternative for OU 7 consists of a single-barrier cover over the Present Landfill, Inactive Hazardous Waste Storage Area, and asbestos-disposal areas and institutional controls to prevent unauthorized access.

The single-barrier FMC with low-permeability soil cover meets RAOs and location-specific and action-specific ARARs. The recommended alternative meets all but one chemical-specific ARAR for surface water and all but three chemical-specific ARARs for groundwater. However, there is no associated risk to human or ecological receptors from surface water in the East Landfill Pond, and potential exposure pathways associated with UHSU groundwater are incomplete. UHSU groundwater in downgradient compliance wells 4287, 52894, and 53194 meets ARARs.

The single-barrier FMC with low-permeability soil cover best meets the evaluation criteria considered in the IM/IRA screening process. Alternative 7 is the best alternative for long-term effectiveness and permanence. The presence of the low-permeability soil gives the cover system some of the benefits of a composite cover, without the rigorous installation requirements, costs, and potential for desiccation of a full clay liner. The physical flexibility properties of the soil and geosynthetic material components allow the cover to sustain minor displacements without rupturing. Similarly, the geosynthetic materials are flexible when thermal expansion or contraction takes place. The FMC barrier has proven reliable in field and laboratory testing. The combination of the FMC and the low-permeability soil layer in the recommended alternative is the most reliable technology of all alternatives evaluated.

The recommended alternative in conjunction with the proposed slurry wall eliminates 93 percent of the water flowing into the landfill. Forty percent of the total water flowing into the landfill is from surface water such as precipitation. The cap eliminates 99.999 percent of this flow. The remaining 60 percent is subsurface flow and is addressed by the slurry wall.

Section 7
Tables

300

Table 7-1
Summary of EPA Guidance Criteria for Design of Cover Systems

Component	Design Criteria
Vegetative Cover	Thickness greater than or equal to 2 feet.
	Minimal erosion and/or maintenance.
	Vegetative root growth not to extend below 2 feet.
	Final top slope between 3 to 5 percent after settlement or subsidence. Slopes greater than 5 percent not to exceed 2.0 tons/acre erosion (USDA Universal Soil Loss Equation).
	Surface-water drainage system capable of conducting run-off across cover without rills and gullies.
Drainage Layer	Thickness greater than or equal to 1 foot.
	Saturated hydraulic conductivity greater than or equal to 1E-03 cm/sec.
	Bottom slope greater than or equal to 2 percent (after settlement).
	Overlain by graded granular filter or synthetic filter to prevent clogging.
	Allow lateral flow and discharge of liquids.
Barrier Layer - FMC Component	Thickness greater than or equal to 20 mil.
	Final upper slope greater than or equal to 2 percent (after settlement).
	Located wholly below the average depth of frost penetration in the area.
Barrier Layer - Soil Component	Thickness greater than or equal to 2 feet.
	Saturate hydraulic conductivity less than or equal to 1E-07 cm/sec.
	Installed in 6-inch lifts.

Note

The above design components are only recommendations by EPA. Alternative designs can be suggested provided that they result in comparable performance of the cover system.

Sources

EPA 1989d, EPA 1991a

Definitions

USDA U.S. Department of Agriculture
cm/sec centimeters per second
FMC flexible membrane cover

301

Table 7-2
Design Components that Meet Closure ARARs

Regulatory Criteria	Design Components that Address Regulatory Criteria
6 CCR 1007-3 (Colorado Department of Public Health and Environment) CHWA Hazardous Waste Regulation	
Minimize fluid migration through the closed landfill	Based on HELP modeling, the cover system only allows 0.001 percent of rainfall to infiltrate the waste.
Function with minimum maintenance	The grading plan meets minimum recommended surface grades after settlement of the waste; therefore, grading maintenance should be minimized.
Promote drainage and minimize erosion or abrasion of the cover	The grading plan directs surface water off the cover to the perimeter of the landfill. Estimates of erosion off the cover indicate that they are less than EPA recommended levels of 2 tons/acre/year (EPA 1989d).
Accommodate settling so that the integrity of the cover is maintained	The grading plan allows for settlement of the waste. The settlements are expected to put the cover in compression rather than tension, which will protect the cover integrity.
Have permeability less than or equal to the permeability of any bottom liner system or material subsoils present	The permeability of the FMC in the cover is 1E-13 cm/sec, which is less than the permeability of the subsoils (1E-06 to 1E-07 cm/sec).
EPA Guidance Documents	
Vegetative Cover Thickness greater than or equal to 2 feet Minimize erosion and/or maintenance Vegetative root depth not to extend below 2 foot depth Final top surface slope between 3 to 5 percent after settlement or subsidence. Slopes greater than 5 percent not to exceed 2 tons/acre/year. Surface water drainage system capable of conducting run-off across cover without rills and gullies	The vegetative cover soil is a total of 36-inches thick to provide adequate protection against frost penetration. The vegetation prevents excessive erosion, which minimizes maintenance. The grading plan has been prepared and allows settlement to take place and result in cover slopes that are in the range of 3 to 5 percent. Erosion estimates for the steep slopes on the cover indicate that the erosion is less than 2 tons/acre/year.
Drainage Layer Thickness greater than or equal to 1 foot Saturated hydraulic conductivity greater than or equal to 1E-03 cm/sec Bottom slope greater than or equal to 2 percent after settlement Overlain by graded granular filter or synthetic filter to prevent clogging Allow lateral flow and discharge of liquids	The drainage layer consists of a geocomposite drainage layer, which is composed of a geonet sandwiched between two geotextiles. The drainage capacity of the geocomposite exceeds that of a 1-foot granular soil material. The upper geotextile provides a filter for the overlying vegetative soil cover. The lateral drainage layer drains to the perimeter surface-water drainage ditch.

Table 7-2
Design Components that Meet Closure ARARs

Regulatory Criteria	Design Components that Address Regulatory Criteria
Barrier Layer FMC Component Thickness greater than or equal to 20 mil Final upper slope greater than or equal to 2 percent (after settlement) Located wholly below the average depth of frost	The FMC component has a minimum thickness of 30 mils. The final slope of the barrier layer is the same as the surface slope and is expected to be in the range of 3 to 5 percent. The FMC is located under the 36-inch vegetative soil layer, which is the average depth of frost in the area.
Barrier Layer Soil Component Thickness greater than or equal to 2 feet Saturated hydraulic conductivity less than or equal to 1E-07 cm/sec Installed in 6-inch lifts	The barrier soil layer in the proposed cover section is 1 foot thick and consists of a very low plasticity to non-plastic soil with a permeability of 1E-05 cm/sec or less. The low-permeability soil layer is placed directly over the gas collection geocomposite. In order to protect the gas collection layer from being damaged, the low-permeability soil layer is placed in one single lift and compacted. The barrier soil layer is the only component in the cover system that deviates from the EPA guidance documents. However, based on HELP modeling and experience with desiccation cracking of compacted clay covers, the proposed low-permeability layer is expected to have comparable or better performance than EPA guidance recommendations.

Table 7-3
Preliminary List of Drawings for the Title II Design

Drawing Number	Drawing Title
1	Cover Sheet
2	Existing Topography
3	Existing Topography Grid Point Locations
4	Landfill Cover General Arrangement
5	Cover Cross Sections and Details (2 sheets)
6	Cover Section
7	Proposed Filling Plan
8	Top of Vegetative Layer Contours
9	Top of Vegetative Layer Grid Point Locations and Staking Plan
10	Top of Top-Soil Layer Contours
11	Top of Top-Soil Layer Grid Point Locations and Staking Plan
12	Top of Low-Permeability Soil Contours
13	Top of Low-Permeability Soil Grid Point Locations and Staking Plan
14	North Slope Buttress Plan and Details (2 sheets)
15	Surface-Water Drainage Plan and Details (2 sheets)
16	Gas Monitoring and Collection System Plan and Details (2 sheets)
17	Access Road Details
18	Fence and Security System Details
19	Lighting and Electrical Plan

Table 7-4
Preliminary List of Technical Specifications for Landfill Closure

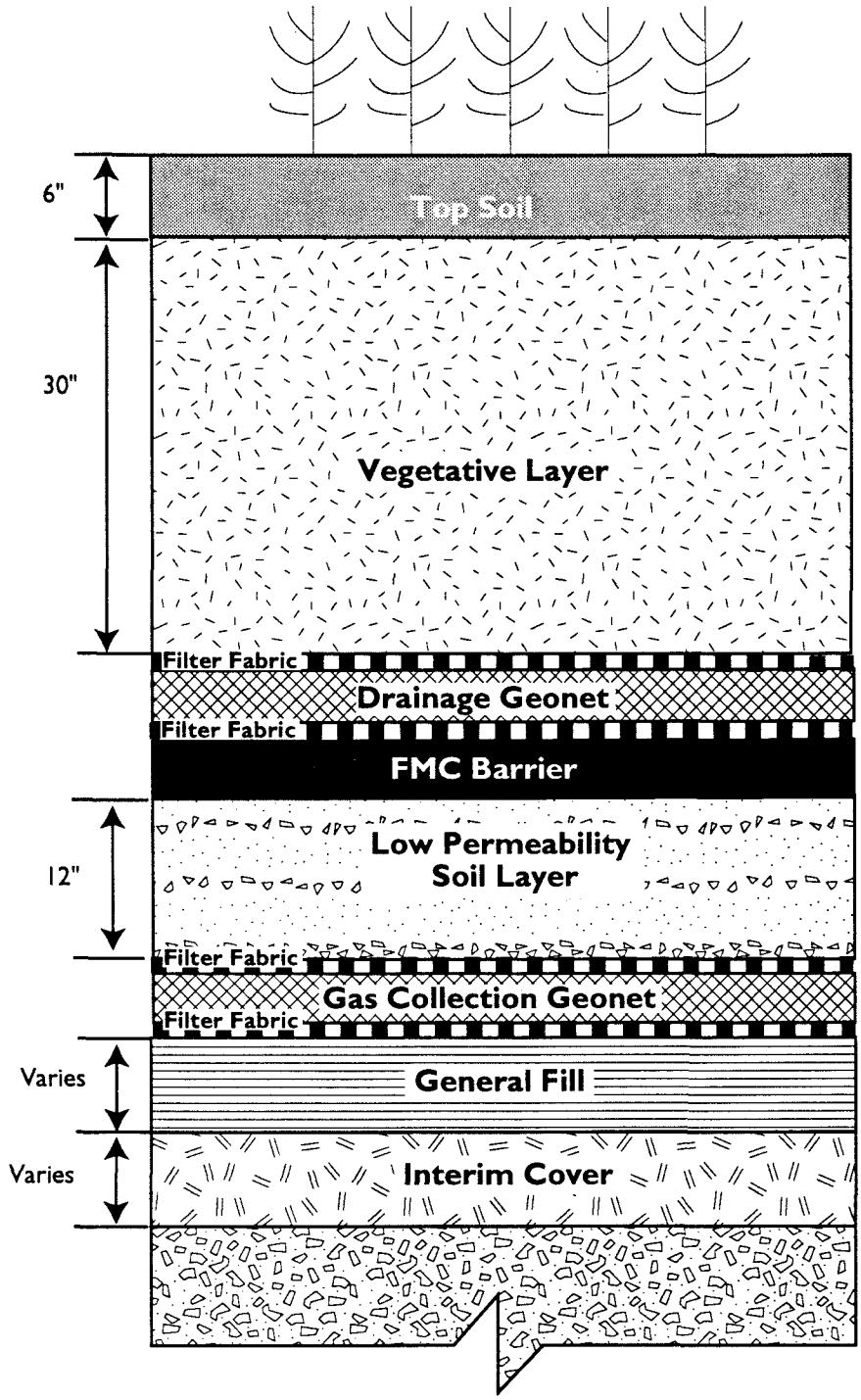
Division I	**General Requirements**
01100	Special Subcontract Requirements
01300	Submittals
01400	Quality Control/Quality Assurance
01500	Temporary Facilities, Controls, and Special Project Requirements
01600	Material and Equipment
Division 2	**Site Work**
02080	Gas Management System (included for information only, not for construction)
02102	Clearing and Grubbing
02200	Earthwork
02210	Test Fill
02220	Excavation, Trenching, Backfill, and Compaction
02231	Aggregate Base Course
02271	Geomembranes
02272	Geotextile
02273	Geonet
02278	Geocomposite Clay Layer
02667	Site Water Lines
02781	Site Grounding
02800	Signage
02830	Chain-Link Fencing
02900	Topsoil and Revegetation
02930	Erosion Control Measures
Division 10	**Specialties**
10800	Toilet and Bath Accessories
10820	Emergency Eyewash and Body Spray Equipment
Division 11	**Equipment**
11600	Gas Monitoring Instrumentation
11700	Alternative Daily Cover System

305

Table 7-4
Preliminary List of Technical Specifications for Landfill Closure

Division 13	**Special Construction**
13200	Liquid Storage Tanks
13210	Pumping Equipment
13215	Piping
13410	Instrumentation
13420	Control Panels
Division 15	**Mechanical**
15050	Basic Mechanical Materials and Methods
Division 16	**Electrical**
16050	Basic Electrical Materials and Methods

Section 7
Figures



U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

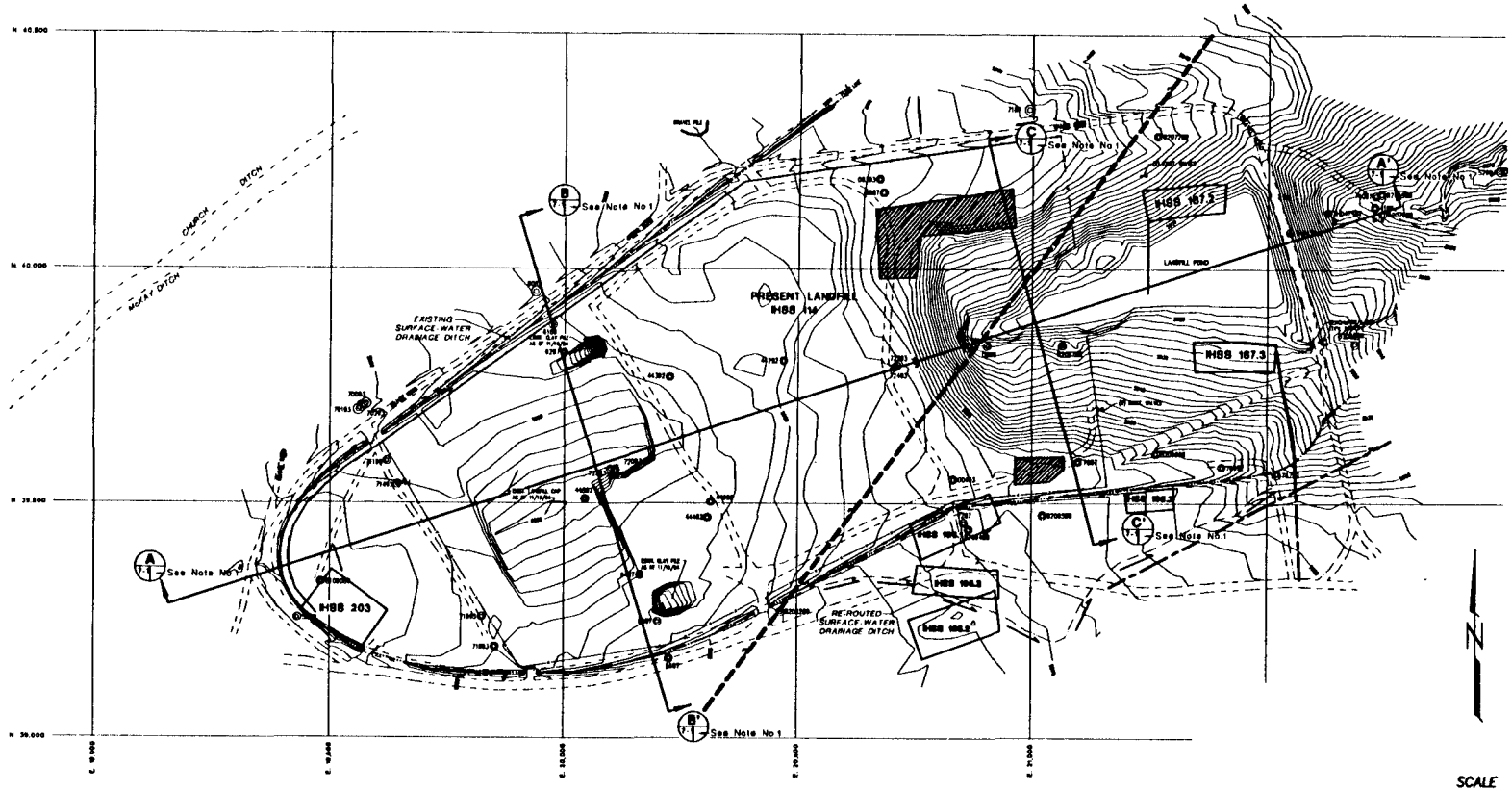
Recommended Alternative: Single-Barrier FMC & Low-Permeability Soil Cover Cross Section

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 7-1

G95\ES\IM/IRA DD OU7/Cover Alt #7-5 -2510.ill

308



SCALE

200' 0 200' 400'

CONTOUR INTERVAL 10FT.

LEGEND

- FAULT
- DITCH
- ROADS
- TRANSMISSION LINE
- ASBESTOS AREA (APPROXIMATE)
- 71893 EXISTING WELL OR OR EXPLORATION BOREHOLE

NOTES:

1) REFERENCED ON DRAWINGS 7-3 AND 7-4
2) BASE TOPOGRAPHY AND FEATURES (DECEMBER 1994)

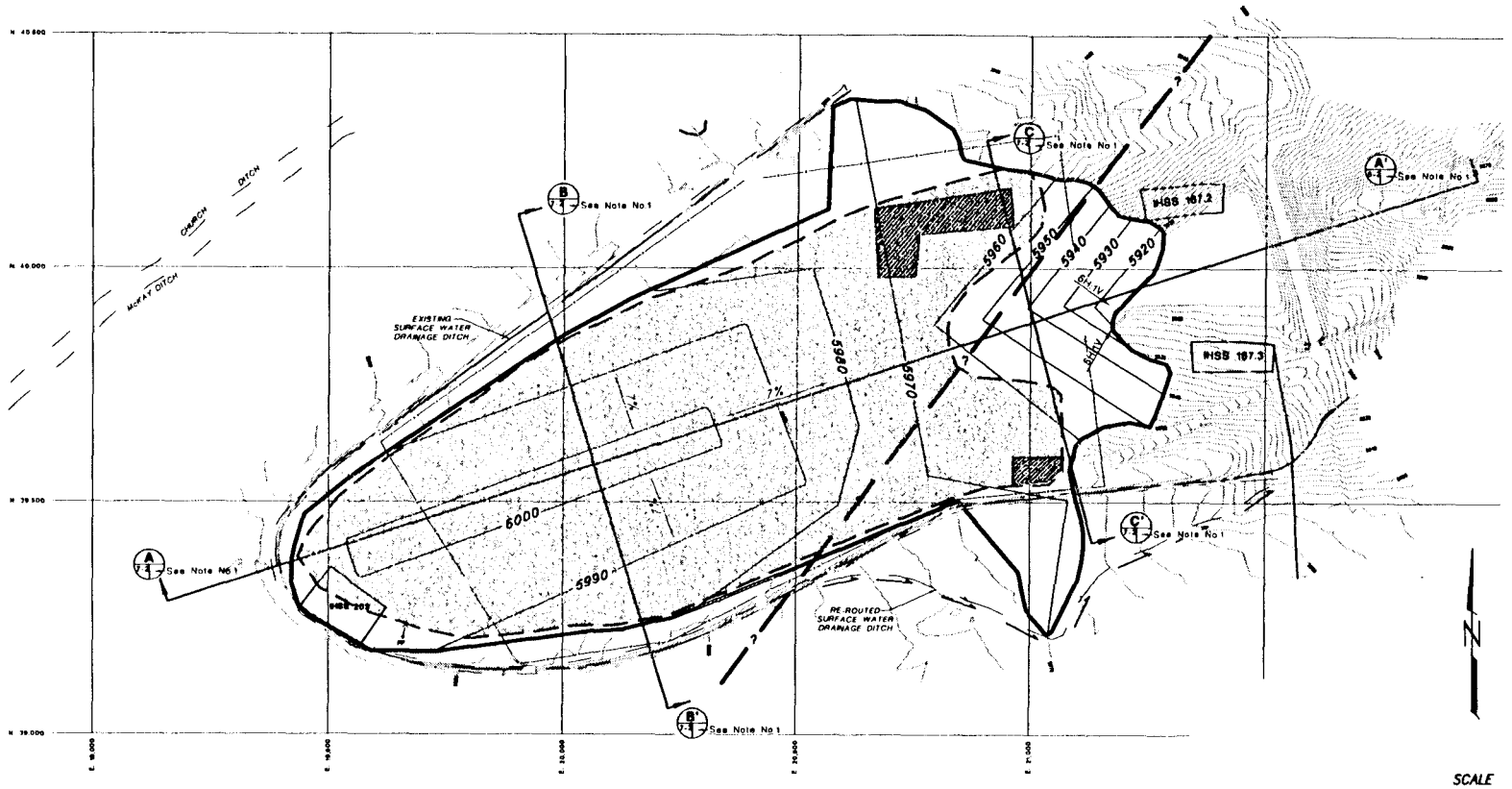
DETAIL/SECTION NUMBER
DRAWING No. WHERE DETAIL/SECTION IS REFERENCED
DRAWING No. WHERE DETAIL/SECTION IS SHOWN

U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Existing Topography and Surface Features

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 7-2



SCALE

200' 0 200' 400'

CONTOUR INTERVAL 10FT.

LEGEND

- FAULT
- DITCH
- CONCEPTUAL GRADING PLAN CONTOURS
- EDGE OF REGRADE AREA (AREA : 1,210,414 FT.²)
- EDGE OF LANDFILL (AREA : 770,332 FT.²)
- ASBESTOS AREA
- COVER AREA (AREA : 770,332 FT.²)

NOTES

1) REFERENCED ON DRAWINGS 7-3 AND 7-4
2) BASE TOPOGRAPHY AND FEATURES (DECEMBER 1994)

DETAIL/SECTION NUMBER

DRAWING No. WHERE DETAIL/SECTION IS REFERENCED

DRAWING No. WHERE DETAIL/SECTION IS SHOWN

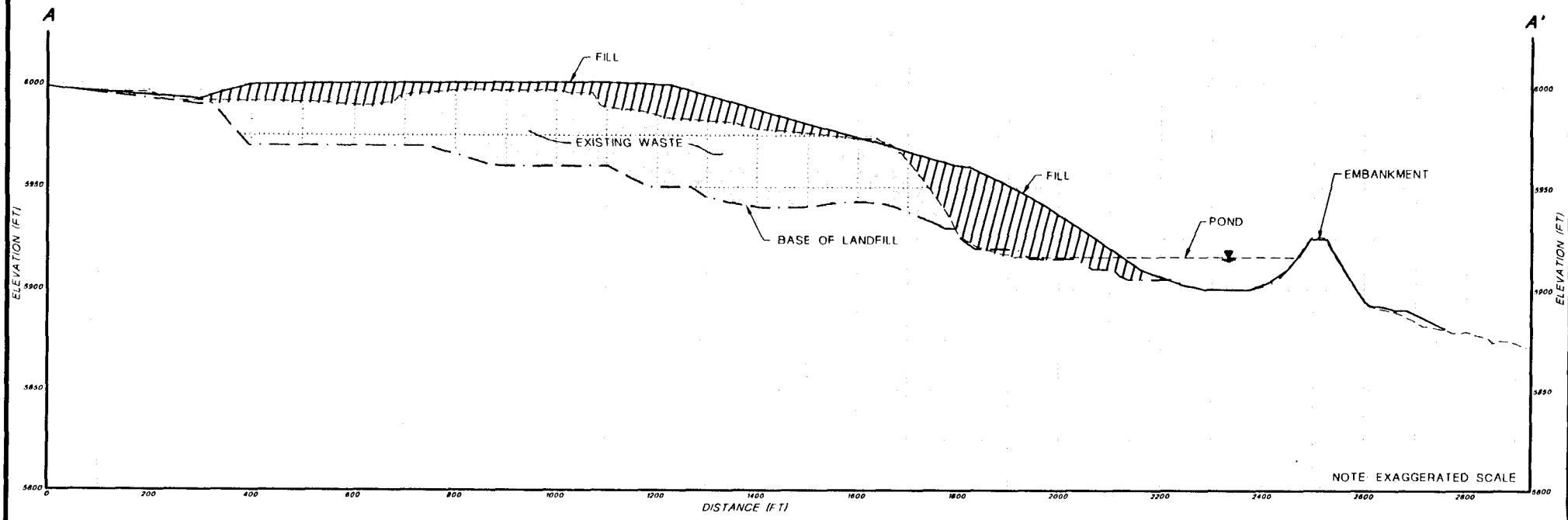
U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Proposed Conceptual Grading Plan, Extent of Cover, and Surface-Water Control Plan

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 7-3

310



See Note No.1 (A/4) **CROSS-SECTION A-A'**

HORIZONTAL SCALE
0 100' 200'

VERTICAL SCALE
0 25' 50'

LEGEND

- CURRENT SURFACE
- BASE OF LANDFILL SURFACE
- PROPOSED CONCEPTUAL GRADING PLAN
- FILL
- EXISTING LANDFILL

NOTE:

1.) REFERENCED ON DRAWING, 7-1 AND 7-2

(A/6|6) — DETAIL/SECTION NUMBER; DRAWING No. WHERE DETAIL/SECTION IS REFERENCED; DRAWING No. WHERE DETAIL/SECTION IS SHOWN

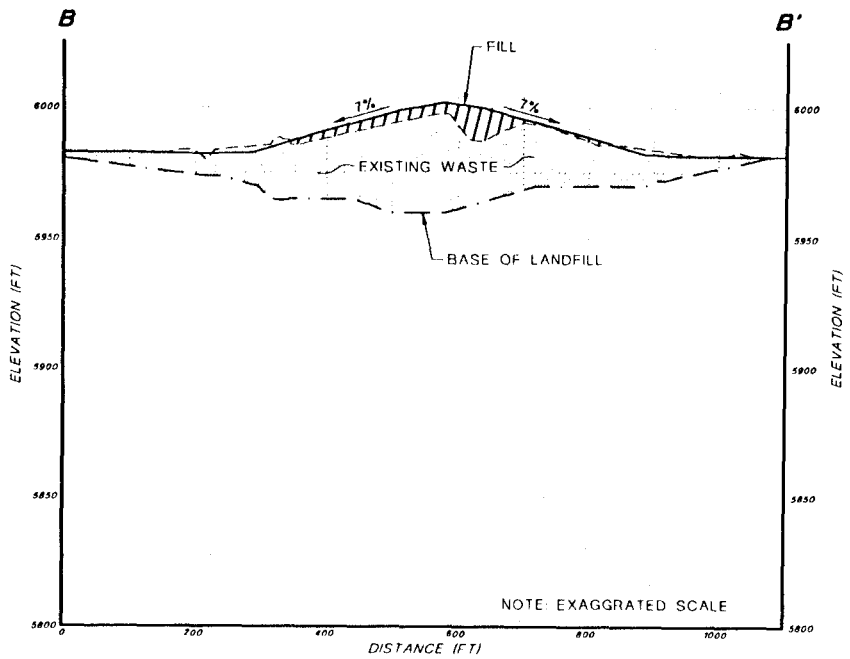
U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Landfill Cover Cross-Section A-A'

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 7-4

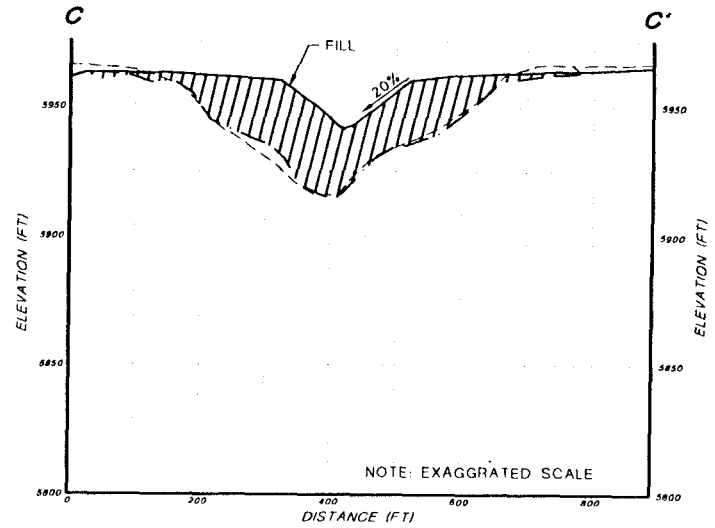
311



See Note No 1 — B/4 **CROSS-SECTION B-B'**

HORIZONTAL SCALE
0 100' 200'

VERTICAL SCALE
0 25' 50'



See Note No 1 — C/4 **CROSS-SECTION C-C'**

HORIZONTAL SCALE
0 100' 200'

VERTICAL SCALE
0 25' 50'

LEGEND

- CURRENT SURFACE
- BASE OF LANDFILL SURFACE
- PROPOSED CONCEPTUAL GRADING PLAN
- FILL
- EXISTING LANDFILL

NOTE:

1.) REFERENCED ON DRAWING, 7-1 AND 7-2

A/8/8 — DETAIL/SECTION NUMBER; DRAWING No. WHERE DETAIL/SECTION IS REFERENCED; DRAWING No. WHERE DETAIL/SECTION IS SHOWN

U.S. Department of Energy
Rocky Flats Environmental Technology Site, Golden, Colorado

Landfill Cover Cross-Sections B-B' & C-C'

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 7-5

312

8. Closure and Post-Closure Plans

Closure of OU 7 is being implemented under CHWA regulations for hazardous waste landfills (6 CCR 1007-3). The Phase I IM/IRA DD and the Phase I RFI/RI Report constitute the OU 7 Closure Plan (CDPHE 1992). General closure requirements for interim status units are contained in Part 265, Subpart G. Specific closure requirements for interim status units are contained in Part 265, Subparts I through Q.

The CHWA/RCRA closure process includes the following steps:

- Identification of a treatment, storage, or disposal unit that needs to be closed from a hazardous waste management perspective
- Development of a closure plan
- Implementation of the closure plan
- Certification of closure
- Performance of a post-closure residual risk assessment, if needed
- Development of a post-closure plan
- Implementation of the post-closure plan through the CAD/ROD
- Certification of completion of post-closure activities

OU 7 was identified as an interim status unit undergoing closure in the IAG. In accordance with the Rocky Flats Cleanup Agreement in the IAG, DOE agrees to "clean close" any unit for which clean closure performance standards are reasonably achievable using decontamination, treatment, and/or removal actions (DOE 1991b). Because of the size of the landfill, clean closure is not possible and the post-closure requirements of 6 CCR 1007-3 Parts 265.117-265.120 apply.

This section presents the closure plan for OU 7, which addresses the necessary CHWA requirements for interim status closures and can be used for implementation. Because a focused risk assessment was performed for this Phase I IM/IRA DD, a post-closure residual risk assessment is not needed. The evaluation of risks, presented in Section 3.3, shows that the risk to human health is within the acceptable risk range for carcinogens (1E-04 to 1E-06) and below the HI of 1 for noncarcinogens for surface water and sediment in the East Landfill Pond, surface soils in spray evaporation areas, and subsurface geologic materials downgradient of the landfill. Exposure pathways are incomplete for leachate at the seep and groundwater downgradient of the landfill.

Risks to ecological receptors are above the HI of 1, but risks were conservatively overestimated because it was assumed that ecological receptors spend 100 percent of their time at the East Landfill Pond. This section also presents the post-closure plan for OU 7, which addresses CHWA requirements for the 30-year post-closure care period.

8.1 Closure Plan

Closure of the landfill at OU 7 meets CHWA requirements, which state that closure will minimize the need for further maintenance and control, minimize or eliminate, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products to the ground or surface waters or to the atmosphere (6 CCR 1007-3 Part 265.111). The final action complies with closure requirements of Subpart G and 6 CCR 1007-3 Subpart N Part 265.310, which are ARARs for OU 7.

This closure plan describes the facility, extent of operations and management of maximum inventory, notification of closure, final cover, decontamination procedures, groundwater monitoring, ancillary closure activities, emergency response, closure certification, survey plat, record of wastes, and deed notation. A closure schedule is included in accordance with the regulation.

8.1.1 Facility Description

The Present Landfill encompasses approximately 20 acres and has been used for disposal of hazardous and nonhazardous wastes from 1968 to 1986. Since 1986, only nonhazardous wastes have been disposed. Asbestos was disposed in discrete pits near the eastern limit of the landfill. The Inactive Hazardous Waste Storage Area is located at the southwest corner of the Present Landfill. It encompasses approximately one-half acre but is included within the acreage of the Present Landfill. The area was used to store drummed liquids and solids between 1986 and 1987. All drums were removed in May 1987. The East Landfill Pond is located east of the landfill and was constructed to control leachate from the landfill. The Pond Area Spray Field and South Area Spray Field are adjacent to the pond. Spray evaporation areas each encompass approximately 1 acre. Water from the East Landfill Pond was periodically sprayed in these areas to prevent the pond from exceeding capacity by evaporating the water. Spray evaporation activities ceased in September 1994.

Groundwater in the UHSU at OU 7 generally flows to the east; however, localized flow follows topographic slopes toward the pond or toward the drainage below the dam. The depth to groundwater in the UHSU is approximately 5 feet in No Name Gulch east of the landfill. Groundwater flows to the east within the valley-fill alluvium; however, flow is intermittent. Certain UHSU groundwater-monitoring wells east of the East

Landfill Pond dam are often dry. Groundwater is diverted around the landfill by an existing groundwater-intercept system and slurry walls. Some of the groundwater flows under the groundwater-intercept system on the north side of the landfill. The depth to groundwater within the landfill is approximately 20 feet. Leachate and groundwater discharge from the landfill at a seep located at the base of the east face of the landfill. Seep water flows into the East Landfill Pond.

Under the presumptive remedy, it is proposed that the leachate, which is considered F039 RCRA-listed waste contained in groundwater, be delisted and thus no longer be subject to CHWA and RCRA Subtitle C hazardous waste regulations. Section 3.4.3.3 has shown that the leachate is nonhazardous and does not pose a threat to human health or the environment.

Criteria and standards for NPDES (40 CFR Part 125) under the CWA and CWQA are applicable. Because OU 7 is an onsite CERCLA action, only substantive provisions of these acts must be met. A NPDES permit is not required for discharges from the East Landfill Pond to No Name Gulch. However, discharge requirements will be negotiated with CDPHE and EPA.

8.1.2 Extent of Operations and Management of Maximum Inventory

Operation of the Present Landfill began in August 1968 and will end in early 1997. The active portion of the landfill and the known extent of the waste are shown on Figure 5-1. All wastes will remain within the landfill, including soils in IHSS 203 and asbestos in the disposal areas, and will be covered during closure.

Given the current and projected waste generation rates (DOE 1994a), the landfill will not reach capacity before closure in 1997. For this reason, a large volume of general fill will be required to achieve grades that will drain surface water and allow for landfill settlement. The volume of fill material required to achieve grade was determined by subtracting the total volume from the total capacity.

8.1.3 Notification of Closure

DOE will notify CDPHE of the impending closure of the landfill in February 1997, at least 60 days before closure is to begin (6 CCR 1007-3 Part 265.112[e]). No specific form is required for notification of closure. Closure must begin no later than 30 days after receipt of the final volume of waste material. Disposal of the final volume of waste is assumed to be in April 1997. Completion of closure activities must occur within 180 days of receipt of the final volume of waste, which is October 1997. Closure requirements are described below.

8.1.4 Final Cover

The construction specifications for each material will be presented in the OU 7 Title II Design Document. Placement of the individual components of the cover system is governed by technical specifications provided in the OU 7 Title II Design Document. The contractor performing construction of the final cover system will be held in strict conformance to the Title II construction design drawings and specifications.

Quality control (QC) and quality assurance (QA) inspection and testing will be performed during construction of the final engineered cover system. The Title II Design Document will include a CQA plan that outlines specific inspection and testing requirements for all materials and construction performance, necessary documentation, procedures for correcting nonconforming items, and the party responsible for each portion of the CQA. All materials and placement of materials for the cover system construction will be subject to inspection and testing to assure conformance to the specifications. Documentation of the inspection and testing will be presented in the final closure certification to be submitted upon completion.

8.1.5 Decontamination Procedures

Construction and other equipment used during landfill closure activities will be decontaminated at the main decontamination facility at Rocky Flats, as needed. The waste is covered by a 12- to 36-inch interim soil cover, and no excavation into the waste is anticipated. Decontamination will be conducted in accordance with EMD Operating Procedure 5-21000-OPS, Field Operations; FO.04, Decontamination of Equipment at Decontamination Facilities (EG&G 1995c); and FO.12, Decontamination Facility Operations (EG&G 1994e).

8.1.6 Groundwater Monitoring

Groundwater monitoring during the closure period is consistent with the quarterly monitoring conducted at the landfill during its operation. Twenty-six of the monitoring wells at OU 7 that fall under the footprint of the landfill cap have been abandoned as a separate maintenance action. The 28 remaining groundwater-monitoring wells are sampled during closure (Figure 8-1). The sitewide groundwater-monitoring program is outlined in the Groundwater Protection and Monitoring Program Plan (EG&G 1993d). Routine sampling and analysis is performed quarterly in accordance with EMD Operating Procedure 5-21000-OPS, GW.6, Groundwater Sampling (EG&G 1992b). Samples are collected for analysis in the following sequence: radiation screening, VOCs, SVOCs, indicator parameters, gross alpha, gross beta, uranium, dissolved and total metals, other radionuclides, cyanide, and orthophosphate.

316

Water-level measurements are collected quarterly as part of the groundwater-monitoring program. Water levels are measured in accordance with EMD Operating Procedure 5-21000-OPS, GW.1, Water Level Measurements in Wells and Piezometers (EG&G 1992c). Well maintenance activities, including routine assessment of sediment buildup in well sumps, sediment removal and redevelopment, well pad repair, and an overall assessment of well condition, are also performed during routine monitoring.

The monitoring program for OU 7 will be streamlined after landfill closure. The post-closure groundwater-monitoring program is described in Section 8.2.3.

8.1.7 Ancillary Closure Activities

Activities performed concurrently with the closure operation include wetlands mitigation, Preble's meadow jumping mouse habitat mitigation, surface-water management, and site security. Leachate management will be performed as a continuation of the accelerated action until the seep is covered. Gas monitoring will not be performed until after closure.

Wetlands mitigation is in progress. Acreage from the wetlands mitigation bank at the Standley Lake Protection Project is used to mitigate the loss of wetland areas that fall under the landfill cover and injury to surrounding wetland areas. Approximately 1.1 acres of wetlands are mitigated. Injury to Preble's meadow jumping mouse habitat is mitigated as needed. Approximately 7.26 acres of habitat is mitigated.

Surface-water run-on and run-off will be controlled by grading the surface of the landfill. Surface water will drain to the perimeter drainage ditches and be routed to No Name Gulch. The Title II design for the drainage ditches will be based on run-off and run-on for a 100-year, 24-hour storm as required by CHWA (6 CCR 1007-3). The water level in the East Landfill Pond will be lowered to allow better access for construction activities during closure by transferring water to the A-series ponds.

Site security will be maintained during construction activities for closure. A chain-link fence surrounds the landfill and prohibits access by unauthorized personnel. Gates will be installed for construction access. Signs will be posted warning the public of the potential dangers at the landfill.

8.1.8 Emergency Response

Hazardous waste facilities are required under 40 CFR 265.50 Subpart D to provide contingency plans and emergency procedures. The purpose of the emergency response plan is to minimize danger to human health and the environment in the event of a fire, explosion, or release of hazardous waste. The plan outlines the actions facility personnel; describes agreements made with local hospitals, state and local response

317

teams, and police and fire departments; specifies the emergency coordinator; provides updated lists of emergency equipment and their physical locations and descriptions; and includes an evacuation plan. The Rocky Flats Environmental Technology Site Emergency Plan (EG&G 1994f) contains the necessary information to satisfy these requirements.

8.1.9 Closure Certification

DOE will submit a certification that closure has been conducted in accordance with the approved OU 7 Closure Plan to CDPHE in December 1997. The certification must be signed by an independent registered professional engineer and DOE and submitted no later than 60 days after closure. Supporting documentation will include inspection reports made by the professional engineer and results of sampling and analyses.

8.1.10 Survey Plat

DOE will submit a survey plat to the Jefferson County Clerk and CDPHE in December 1997, no later than submission of the certification of closure. The plat will be prepared and certified by a professional land surveyor licensed in the state of Colorado. The plat will include a note that states the obligation of the owner or operator to restrict disturbance of the hazardous waste disposal unit in accordance with 6 CCR 1007-3 Subpart G. The survey plat will indicate the location and dimensions of the landfill with respect to surveyed benchmarks. Locations of temporary benchmarks in the vicinity of OU 7 are shown on Figure 8-2.

8.1.11 Record of Wastes

DOE will submit a record of wastes to the Jefferson County Clerk and CDPHE in February 1998, no later than 60 days after certification of closure. The record of wastes will document the type, location, and quantity of hazardous wastes in the landfill.

8.1.12 Deed Notation

Within 60 days of certification of closure (February 1998), DOE must record a notation on the property deed that states that hazardous wastes have been disposed on the property and that use is restricted under 6 CCR 1007-3 Part 265.119(b)(1). Current holders of easements may be notified to ensure that they are aware of the restriction on the property. The deed notation should include the owner's name and address, the address and legal description of the property, a reference to the use of the property as a hazardous waste disposal facility, the date the landfill began to receive hazardous waste, a reference to Subpart G land-use restrictions, a statement informing future purchasers and lessees of the regulations and the types and locations of wastes on the property, a reference to the survey plat and record of waste, and a notarized signature of

the owner or operator. In addition, DOE must submit a signed certification to CDPHE stating that the deed notation has been recorded. A copy of the document in which the notation has been placed should be included with the certification.

8.1.13 Final Closure Schedule

The schedule for final closure was developed in accordance with the RCRA Guidance Manual for Subpart G: Closure and Post-Closure Care Standards (EPA 1987a). It was assumed that the Present Landfill would receive the final volume of waste for disposal and the new landfill would be operational in April 1997. The closure timeline is presented in Table 8-1.

8.2 Post-Closure Plan

This OU 7 Post-Closure Plan addresses the requirements for post-closure care outlined in 6 CCR 1007-3 Part 265.117-120 and describes the monitoring and maintenance activities that will be performed during the 30-year post-closure care period.

8.2.1 Post-Closure Permit

A post-closure permit is required for all landfills under 40 CFR 270.1(c) to detail the requirements of post-closure care. The landfill closure action must comply only with the substantive aspects of this requirement. Post-closure permits generally include a copy of the post-closure inspection schedule, the post-closure plan, and a notation to the property deed. Floodplain information, applicable groundwater and landfill gas monitoring data, and information demonstrating compliance or corrective action are also included. Permits also describe IHSSs, provide information on corrective actions for releases from those IHSSs, and information on the potential for the public to be exposed to hazardous wastes released from the site.

The Draft Proposed Plan and Draft Modification of the Colorado Hazardous Waste Permit for the Rocky Flats Environmental Technology Site is included as an attachment to this report. The Draft Permit Modification is used to incorporate remedial action decisions at Rocky Flats into the site's RCRA permit. CDPHE issues the Final Hazardous Waste Permit Modification after the remedial decision process is complete.

8.2.2 Post-Closure Inspection and Maintenance

Post-closure inspection and maintenance activities include routine facility inspections and repairs, repair of the vegetative cover due to erosion damage, maintenance of surveyed waste management area boundary markers, and inspection and maintenance of monitoring systems. The proposed frequency of inspection and maintenance activities that will be performed by DOE is provided in Table 8-2. Routine facility

319

inspections will be performed semiannually. Components of the facility that will be inspected include the final cover, East Landfill Pond and dam, surface-water drainage ditches, surveyed benchmarks, groundwater-monitoring system, gas-monitoring system, and security system.

The integrity and effectiveness of the final cover will be maintained by fertilizing, reseeding, and mulching bald spots and eroded areas; replacing soil lost to erosion; and controlling rodents. Wind dispersion of particulates will also be controlled. Severe erosion or frost damage will require spreading a new layer of topsoil and revegetating the area. These activities may be needed more frequently early in the 30-year post-closure care period before the vegetation becomes established.

Inspections of the East Landfill Pond and dam will be performed semiannually. Water levels in the pond will be controlled in accordance with the sitewide surface-water management plan. Water will be discharged if the pond becomes too full. Perimeter surface-water drainage ditches will be cleaned and repaired as necessary. Silt deposits and organic material will be removed from the channel. Ditches will be regraded or revegetated to prevent erosion.

The gas-monitoring system and groundwater-monitoring system will be inspected annually. Maintenance may include replacing or redrilling monitoring wells, repairing well pads, removing sediment from the sump, redeveloping wells as needed, replacing piping or caps, and other routine equipment maintenance. Most of these activities will be needed at irregular intervals during the post-closure care period.

The security system will be inspected and maintained annually. Fencing, gates, posts, and warning signs may be periodically replaced. Fencing should last for 30 years but sections of the fence may need to be replaced due to normal wear, weather conditions, or vandalism. Standard signs last about 7 years. Warning signs posted around the landfill will be periodically replaced.

8.2.3 Post-Closure Monitoring

Post-closure monitoring consists of gas monitoring to determine if gas treatment is needed and groundwater monitoring to detect future releases from the landfill. Existing units at interim status landfills are not required to have leachate collection and removal systems and are not required to manage leachate during the post-closure period (40 CFR 264.118 and 264.310[b][2]). Leachate at the seep is routed to the edge of the cover system and discharges to the East Landfill Pond.

320

8.2.3.1 Gas Monitoring Program

Landfill gas monitoring will be performed quarterly using the system of passive gas vents installed within the engineered cover. The objective of the gas-monitoring program is to monitor emissions to determine if gas treatment is needed. Gas monitoring is performed in accordance with the requirements of 40 CFR Part 258.23.

Gas monitoring will be performed manually at each gas vent location using a portable combustible gas indicator (CGI) and a photoionization detector (PID) or equivalent. The CGI detects and measures the concentration of combustible gases and oxygen levels to quantify the explosive potential and levels of asphyxiant gases and vapors. The PID will be used to detect and measure volatile organic constituents.

An instrument, such as a hot wire anemometer or equivalent, will be used to obtain gas-flow measurements. Generally, these field measurements can be accomplished by one person equipped with a portable combustible gas meter and velocity/temperature measuring instrumentation. Precise field flow measurements of landfill gas are difficult to achieve. However, these measurements can be improved by conversion charts that relate the cooling effect of, for example, methane versus typical ambient air. Conversions can also be made to relate recorded readings to actual flow readings using standard conditions.

Quarterly gas-monitoring data will be used to evaluate the effectiveness of the passive gas-collection system at the landfill and to assess compliance with air emission requirements under CAQCC Regulation No. 3.

8.2.3.2 Point of Compliance

Post-closure groundwater-monitoring requirements are relevant and appropriate to interim status facilities such as the Present Landfill and require implementation of a groundwater-monitoring program capable of determining the impact of the landfill on groundwater quality in the UHSU (6 CCR 1007-3 Part 265.90[a]). The requirement does not address the point of compliance for remediation activities. Because interim status units and regulated units are addressed in a similar manner, the point-of-compliance provision that applies to regulated units is relevant and appropriate to the remediation of interim status units (6 CCR 1007-3 Part 264.92).

The point of compliance is defined as the vertical surface that extends down into the UHSU at the downgradient limit of the waste-management area. Remediation levels should generally be attained "at and beyond the edge of the waste-management area when waste is left in place" (55 Federal Register 8753). Although the downgradient limit of the waste-management area is currently at the toe of the landfill face, the cap extends out toward the middle of the East Landfill Pond to achieve design grade

321

required for closure. As a result, the downgradient limit of the waste-management area shifts to the east. Rather than installing monitoring wells in the middle of the pond, monitoring wells located downgradient of the dam are proposed as compliance wells. Wells immediately downgradient of the dam are currently used as compliance wells for the annual RCRA groundwater-monitoring report, but these wells rarely yield enough groundwater for sampling. Wells farther downgradient are proposed as compliance monitoring wells.

Well 53194, which is located east of the dam and routinely yields enough groundwater for sampling, is proposed as the compliance well. The point of compliance is the hydrologically downgradient limit of the area in which contamination exists. The compliance well ensures that hazardous constituents detected in groundwater do not exceed concentration limits in the uppermost "aquifer" (or UHSU) underlying the waste-management area beyond the point of compliance (6 CCR 1007-3 Parts 264.93 and 264.94). The regulations also provide that the owners or operators conduct a corrective-action program to remove or treat any hazardous constituents that exceed ARARs between the compliance point and the downgradient property boundary (6 CCR 1007-3 Part 264.95). Wells 4287 and 52894 are proposed as monitoring wells for the detection-monitoring program at OU 7 to detect releases before groundwater reaches the point of compliance.

There is no potential for exposure to contaminated groundwater at OU 7. Future land use for the buffer zone, which includes the area downgradient of the landfill, is open space (DOE 1995d). Groundwater will not be used as a source of drinking water. In addition, No Name Gulch is a losing stream, which means that vertical gradients are downward and surface water recharges the groundwater in the UHSU. Groundwater is not discharged to surface water in No Name Gulch.

The NCP states that attaining ARARs at the proposed point of compliance will ensure protection of human health and the environment at all points of potential exposure (55 Federal Register 8753). DOE proposes a point of compliance for OU 7 downgradient of the dam, which is protective of human health and the environment. There is no potential exposure because there are no plans for future development of groundwater for any use at OU 7. Chemical-specific ARARs can be met at this point.

8.2.3.3 Groundwater-Monitoring Program

This section describes the proposed groundwater-monitoring program that will serve as the detection-monitoring program for post-closure activities. The primary objective of the groundwater-monitoring program is to detect potential future releases that migrate beyond the boundary of OU 7.

One upgradient and three downgradient monitoring wells are required for post-closure groundwater monitoring (6 CCR 1007-3 Part 265.90[a]). The proposed upgradient monitoring well is 70393, which is due west of the landfill near the headwaters of the former drainage (Figure 8-2). This location will provide information on groundwater quality upgradient of the landfill. The proposed downgradient monitoring wells for UHSU groundwater are 4287, 52894, and 53194. These wells are downgradient of the landfill in the No Name Gulch drainage (Figure 8-2). These locations will ensure that contaminants are detected if they migrate away from the source and provide information regarding improvement or degradation of groundwater quality. All proposed wells are alluvial wells.

The four downgradient weathered bedrock wells (B206789, B206889, B206989, and 52994) (Figure 8-1) were considered for post-closure monitoring but were rejected for several reasons. Location B206789 falls under the proposed footprint of the landfill cap. Well B206989 does not exhibit a strong connection with the surficial materials. The difference in potentiometric surfaces between surficial materials and weathered bedrock exceeds 20 feet at well cluster 4087/B206989. Both wells B206889 and B206989 consistently exhibit water levels 12 to 15 feet below the top of bedrock elevation, indicating only partial saturation of weathered bedrock and a "perched" water table condition for surficial materials. Neither well produces enough water for a full suite of chemical analyses. For most historical sampling events, the wells yielded only enough groundwater for a VOC sample (40 milliliters). Well 52994 is dry. Downgradient weathered bedrock wells were rejected for post-closure monitoring because they were beneath the cap, not hydraulically connected to alluvial wells at well clusters, partially saturated, or dry.

Groundwater sampling will be performed at the proposed compliance wells in accordance with EMD Operating Procedure 5-21000-OPS, GW.6, Groundwater Sampling (EG&G 1992b). Water-level measurements will be collected as part of the groundwater-monitoring program. Water levels are measured in accordance with EMD Operating Procedure 5-21000-OPS, GW.1, Water Level Measurements in Wells and Piezometers (EG&G 1992c). Groundwater monitoring will be limited to the background (upgradient) well and the three compliance/detection (downgradient) wells. Table 8-3 provides a list of parameters that will be used for sampling and analysis in accordance with 6 CCR 1007-3 Part 265.92. Groundwater samples will be collected annually for indicator parameters and semiannually for contamination parameters.

The semiannual groundwater-monitoring data will be reviewed and analyzed to evaluate groundwater quality at OU 7. New groundwater data will be compared to historical data to detect trends in potential groundwater contamination. Statistical methods of analysis will be used to determine if significant changes in contaminant

concentrations occur within individual wells, within well groups, and within the monitoring system.

8.2.4 5-Year Review

Under CERCLA, Section 121(c) and the NCP (Section 300.430[f][4][ii]), statutory reviews are required at least every 5 years to assure that the remedial action remains protective of human health and the environment. The level of the reviews will be at the discretion of CDPHE and EPA; however, it is expected that a Level I review, consisting of a site visit, review of operation and maintenance activities, and a brief site inspection, will be sufficient.

8.2.5 Post-Closure Certification

DOE will submit a certification that post-closure care has been completed in accordance with the approved OU 7 Post-Closure Plan to CDPHE no later than 60 days after completion of the 30-year post-closure care period. The post-closure certification must be signed by an independent registered professional engineer and DOE. Supporting documentation will include inspection reports made by the professional engineer and results of sampling and analyses.

8.2.6 Financial Assurance and Cost Estimates

State and federal governments are exempt from the financial assurance requirements of 40 CFR 265.140(c) Subpart H.

The estimated capital cost for closure of the landfill is $9,070,000. The annualized O&M cost for post-closure is $55,000 per year over the 30-year post-closure period. The total present worth cost is $10,149,000. The detailed cost estimate is provided in Appendix H.

Section 8
Tables

326

Table 8-1
Closure Timeline

Activity	Date
Notification of Closure	February 1997
Receipt of Final Volume	April 1997
Completion of Closure Activities	October 1997
Submittal of Survey Plat	December 1997
Submittal of Certification of Closure	December 1997
Submittal of Record of Wastes	February 1998
Submittal of Deed Notation	December 1998

Note

Assumes final volume of waste received in April 1997.

Table 8-2
Post-Closure Inspection, Maintenance, and Monitoring Schedule

Item	Frequency
Inspection and Maintenance	
Routine facility inspection	semiannually
Final cover survey	annually
East Landfill Pond	semiannually
Drainage ditch cleanout	annually
Fence inspection	annually
Gas-monitoring system	annually
Groundwater-monitoring system	annually
Monitoring	
Gas monitoring	quarterly
Groundwater monitoring	
Indicator parameters	annually
Contamination parameters	semiannually

Table 8-3
Groundwater-Monitoring Parameters

	Parameter	Frequency	Reference
Groundwater-Quality List	Chloride	annually	6 CCR 10077-3 265.91(2)
	Iron	annually	
	Manganese	annually	
	Phenols	annually	
	Sodium	annually	
	Sulfate	annually	
Groundwater-Contamination List	pH	semiannually	6 CCR 1007-3 265.91(3)
	Specific conductance	semiannually	
	Total organic carbon	semiannually	
	Total organic halogens	semiannually	

328

Section 8
Figures

9. Environmental Assessment

The proposed IM/IRA for landfill closure is the final action for OU 7. Implementation of the remedy has some potential impacts to OU 7 and the surrounding area when compared to the impacts expected from the no-action alternative. This section presents potential environmental and human health effects resulting from the proposed IM/IRA activities and is the functional equivalent of an environmental impact statement (EIS). Human health exposures during construction of the final remedy, and during post-closure maintenance and monitoring activities, and exposures resulting from possible accidents are analyzed for risks to workers involved with IM/IRA activities, other workers at Rocky Flats, and the public. Environmental impacts to ecology, and air, surface-water, and groundwater are also evaluated. The commitment of personnel and material resources and potential impacts to transportation and other short-term, long-term, and cumulative impacts are also evaluated.

Proposed construction activities for the recommended alternative include placement of general fill and regrading to achieve adequate surface drainage, placement of the engineered cover system, placement of the final vegetative cover, and upgrading the run-off/run-on drainage-ditch system. A post-closure inspection, maintenance, and monitoring program will be performed for 30 years after landfill closure. The post-closure inspection and maintenance program will include routine facility inspections and repairs, repair of the vegetative cover due to erosion damage, maintenance of surveyed waste management area boundary markers, and inspection and maintenance of monitoring systems. Post-closure monitoring consists of gas monitoring and groundwater monitoring.

9.1 Screening-Level Human Health Risk Assessment

The purpose of this screening-level risk assessment is to identify and qualitatively examine the potential risks to human receptors associated with the installation and maintenance of the engineered cover under the IM/IRA at the Present Landfill. This assessment includes:

- Identification of potential contaminants of concern or activities of concern
- Characterization of potential exposure
- Estimation of potential magnitude of risk
- Identification of uncertainties associated with the assessment

Assessment of potential risks associated with IM/IRA activities will allow risk managers to ensure that measures are taken to mitigate any significant risks that are identified. This screening-level risk assessment does not examine risks associated with

332

leaving landfill contents in place, nor does it examine the individual risks to receptors following interim measures. Only risks associated with the process of implementing interim measures are evaluated.

9.1.1 Identification of Potential Contaminants of Concern or Activities of Concern

Construction activities anticipated for the IM/IRA and included in this screening-level risk assessment are as follows:

- Construction of an unpaved haul road between an offsite borrow source and the Present Landfill
- Transportation of the fill and cover material on the haul road
- Placement of the fill and engineered cover at the landfill

Post-construction activities will include inspection and maintenance of the cover. The landfill contents are covered daily with interim soil, therefore, the waste is not exposed when IM/IRA construction activities begin. No construction activities are anticipated that require intrusion into the landfill contents or asbestos-disposal areas or contact with landfill leachate, adjacent surface water or pond sediments, or groundwater downgradient from the landfill. In the event that intrusion or contact becomes likely, worker safety and any necessary precautions will be addressed by the site-specific health and safety plan. Long-term risks evaluated as part of the presumptive remedy process are described in Section 3.3.

Methane and carbon dioxide gases are generated by biodegradation of the landfill contents; however, as they are emitted from the landfill, these simple asphyxiants are expected to be greatly diluted and dispersed by the wind. Because they are not expected to displace the oxygen present in the air, they pose negligible risk at the low concentrations anticipated in the breathing zone. Therefore, the identification of PCOCs focuses on the material used for the fill and engineered cover.

The material used to construct the haul road is expected to be road-base aggregate, and materials for the fill and engineered cover include general fill and topsoil vegetative cover. During earth moving activities, there is a potential to generate dust. Because the earthen materials used are uncontaminated materials, the potential concern is the nuisance associated with dust emissions.

An occupational activity of concern is the operation of heavy equipment when transporting the road-base aggregate and fill and cover material. However, these activities are addressed under routine occupational standards designed to reduce risks and are typically incorporated into the health and safety plan.

In summary, construction activities do not involve intrusion into the landfill contents, and the fill and cover materials used are uncontaminated. Therefore, the only PCOC identified for the OU 7 IM/IRA is nuisance dust.

9.1.2 Characterization of Exposure

The objective of characterizing exposure is to estimate the type and potential magnitude of exposures to the PCOCs that are present at the site or that may migrate from the site. The results of the exposure assessment are combined with guidelines for nuisance dust to characterize potential risks.

The exposure assessment consists of the following components:

- Characterize potentially exposed human populations (i.e., receptors)
- Identify exposure pathways
- Qualitatively determine the extent of exposure

9.1.2.1 Potentially Exposed Populations and Exposure Pathways

Potential scenarios and exposure pathways are identified onsite and offsite. Activities planned for OU 7 include capping, inspecting, and maintaining the engineered cover of the closed landfill, and post-closure monitoring. These activities involve construction workers for capping and maintenance and field technicians for monitoring activities. Because the potential for dust generation is higher during the earth-moving activities, the exposure to dust is greater for construction workers at OU 7 than for technicians.

Offsite land uses are considered according to current and future uses, which are identified through county zoning maps and observation or projections based on growth patterns and community development plans. Current land uses around Rocky Flats include open space, limited agricultural, commercial or industrial, and residential. Although there is currently no residential use adjacent to Rocky Flats, a hypothetical residential receptor is conservatively assumed for this screening-level analysis.

Two potentially exposed human receptors are selected for pathway analysis in this screening-level human health risk assessment: onsite worker and offsite resident.

9.1.2.2 Exposure Pathway Analysis

An exposure pathway describes a specific environmental pathway by which a receptor can be exposed to PCOCs that are present at or migrating from the site. Five elements

comprise an exposure pathway. These elements, identified to determine potential exposure pathways at OU 7, are as follows:

- Source
- Mechanism of release to the environment
- Environmental transport medium for the released constituent (e.g., air, groundwater)
- Point of contact between the contaminated medium and the receptor (i.e., the exposure point)
- Exposure route (e.g., inhalation of dust) at the exposure point

All five of these elements must be present for an exposure pathway to be potentially complete.

An exposure route is the pathway through which a contaminant enters or impacts an organism. There are four basic human exposure routes:

- Inhalation
- Ingestion
- Dermal absorption
- External irradiation, if radionuclides are present

Potential exposure pathways during implementation of the IM/IRA at OU 7 include inhalation of airborne particulates, soil ingestion, and dermal contact with soil. Because no chemicals are present in the earthen fill and cover materials, no impacts are expected from inadvertent ingestion of soil or from absorption through the skin. Inhalation of nuisance dust is generally unpleasant but is not expected to have any impact except to individuals who may have severe pre-existing respiratory problems. Therefore, the pathway that is qualitatively evaluated for the onsite worker and hypothetical offsite receptor is inhalation of nuisance dust.

9.1.3 Potential Magnitude of Exposure and Risk

The potential magnitude of exposure and risk to nuisance dust is dependent on the emission rates and airborne concentrations, which are evaluated in Section 9.3, Impact to Air Quality.

No adverse health impacts are anticipated for offsite residents or construction workers. As presented in Section 9.3.2, it is unlikely that air-quality standards for respirable dust will be exceeded at the Rocky Flats property boundary. The total sampled particulate

concentration in the work area is controlled through the application of water by a truck such that the occupational limit will not be exceeded. A typical occupational exposure limit for nuisance dust is 10 milligrams per cubic meter (mg/m^3), a level under which it is believed that nearly all workers can be repeatedly exposed day after day without adverse health effects.

Occupational risks associated with operation of heavy equipment and transportation of the road-base aggregate and fill and cover material are expected to be low and are controlled through occupational regulations or standards. Furthermore, transportation associated with OU 7 will occur on private roads and at lower speeds than are associated with most vehicle accident data. Therefore, these risks are not addressed quantitatively.

9.1.4 Identification of Uncertainty

The uncertainty analysis characterizes the uncertainty associated with each step of the process of assessing risk. These uncertainties are driven by uncertainty in assumptions of work activities, identification of PCOCs, estimation of emission rates, the screening-level transport model used to estimate concentrations at receptor locations, and assumed receptor locations. Uncertainties associated with this risk assessment are summarized in Table 9-1.

Of the uncertainties identified, a key assumption is that there is no intrusion into the landfill contents or asbestos-disposal areas, as part of the IM/IRA. It is also assumed that there is no direct contact with leachate, adjacent surface water or pond sediments, or groundwater downgradient from the landfill. In the event that intrusion or contact becomes likely, worker safety and any necessary precautions will be addressed by the site-specific health and safety plan. The health and safety plan describes potential hazards and locations, entry and exit requirements for controlled areas, use of monitoring equipment, and use of PPE such as protective clothing and respirators. Emergency response is addressed by the Rocky Flats Environmental Technology Site Emergency Plan (EG&G 1994e). Occupational risk is expected to be maintained well within standards under these controls.

9.2 Ecological Risk

Construction of the proposed IM/IRA requires soil materials obtained from offsite commercial operations. The excavation of borrow materials may have potential impacts to wildlife and vegetation habitats and nearby wetlands and floodplains. These potential impacts are considered in operational permits issued for these facilities by the state of Colorado and local county governments.

The following subsections describe potential ecological impacts at OU 7 as a result of construction activities associated with the proposed IM/IRA.

9.2.1 Wildlife and Vegetation

9.2.1.1 Short-Term (Construction Period) Impacts

Some IM/IRA construction activities would have impacts to wildlife habitats within the proposed landfill resurfacing area and surrounding areas. Potential habitat for the Preble's meadow jumping mouse and wetland areas in and around the East Landfill Pond will be significantly affected by construction activities for the eastern end of the cap, which extends across part of the existing pond.

Temporary loss of mid-grass prairie wildlife habitat is expected because of the surface disturbance (stripping of vegetation) and construction activities (equipment traffic, human activities, etc.). The total area of disturbed vegetation would be approximately 39 acres, including the area of the landfill resurfacing (28 acres), borrow material haul roads (9 acres), and miscellaneous construction activities (2 acres). It should be noted that the numbers used in this estimate are preliminary. More recent numbers indicate that the area of disturbed vegetation is closer to 35 acres. The existing minimal vegetation on the surface of the landfill is considered a minor wildlife habitat and would be significantly enhanced by the revegetation plan proposed for the Phase I IM/IRA. Temporary loss of mid-grass prairie wildlife habitat would be expected at the offsite material borrow source. In addition, noxious weeds could be introduced during revegetation and would be controlled until adequate native vegetation is established.

Temporary loss of habitat may cause direct mortality to small and less mobile animals such as rodents and reptiles resident in the area. Indirect mortality may occur due to displacement and loss of habitat of larger or more mobile animals such as birds and mule deer and may occur from loss of habitat effectiveness in undisturbed areas next to the construction activities.

Increased equipment and human activities associated with construction inevitably result in increased noise levels and vehicle traffic. These activities probably have the least disturbance to wildlife because surrounding areas are already in industrial use and wildlife is habituated. Habitat loss is expected to be temporary and would continue only until adequate revegetation is established. With the use of straw mulch, adequately spaced silt fences, and other appropriate measures, the final vegetative cover would be established within two to three years.

337

9.2.1.2 Long-Term Impacts

Construction of the East Landfill Pond to control landfill leachate has created persistent wetlands and aquatic habitats that are small but important components of a dry environment such as the environment at Rocky Flats. As a result, species drawn to the aquatic resources around the East Landfill Pond are potentially exposed to contaminants from landfill leachate. Contaminant migration from the landfill is minimized after the engineered cover is in place. A screening-level ecological risk assessment performed for OU 7 provides baseline information on the potential ecotoxicity and ecological risk of PCOCs in leachate at the seep and in surface water and sediments in the East Landfill Pond (Appendix D, Screening-Level Ecological Risk Assessment). Leaving approximately two-thirds of the East Landfill Pond in place results in minimal risk to aquatic life and wildlife.

Risks to aquatic life in the pond appear to be minimal. Results of the literature-based toxicity screen and laboratory toxicity testing indicate that surface water in the pond represents negligible risk to aquatic life. Results of site-specific surface water and sediment toxicity tests indicate no toxicity.

Low potential toxicity to mammalian and avian wildlife is also observed; seep water is the main contributor to overall risk for mallards, raccoons, and coyotes (Appendix D). However, the seep is eliminated as an exposure point during implementation of the proposed remedy. Pond sediments may pose a risk to raccoons, coyotes, and Preble's meadow jumping mice (Appendix D). The primary risks are from naturally occurring metals such as aluminum, vanadium, and arsenic, but the relatively low HI values (HI = 3 to 6) for exposure to the metals suggest low potential toxicity. Risks are conservatively overestimated because it was assumed that receptors spend all of their time at the East Landfill Pond.

Risks to wildlife from surface water in the pond appear to be limited to exposure of mallards and other waterfowl to bis(2-ethylhexyl)phthalate and di-n-butylphthalate. Risks to mallards are conservatively overestimated because it was assumed that they spend all of their time at the East Landfill Pond (Appendix D).

9.2.1.3 Sensitive Habitats and Endangered Species

The shoreline of the East Landfill Pond and the No Name Gulch drainage is potential habitat for the Preble's meadow jumping mouse. Construction of the engineered cover reduces Preble's meadow jumping mouse habitat near the west end of the pond. Habitat mitigation is proposed as needed.

378

9.2.2 Wetlands/Floodplains

Approximately two-thirds of the wetlands area located on the east edge of the landfill boundary in and along the East Landfill Pond remain in place after the landfill closure activities are completed. One-third of the pond and wetlands fall under the proposed engineered landfill cover. A wetlands assessment which describes the recommended alternative, is included in Section 7. The proposed mitigation plan is to use acreage from the wetlands mitigation bank currently being developed in association with the Standley Lake Protection Project.

The closest 100-year floodplain to the proposed IM/IRA activities is along Woman Creek (approximately 1 mile to the south) (DOE 1992d). The proposed action does not alter or impact the 100-year floodplain configuration.

9.2.2.1 Short-Term (Construction Period) Impacts

Potential impacts to the wetlands can occur from sediment loading from stormwater run-off and surface disturbance during construction activities. Surface-water control measures are used to minimize surface water from contacting potentially contaminated soil or groundwater and minimize erosional effects during the construction activities. Most of the precipitation falling on areas where construction is in progress is diverted to existing drainage ditches along the north and south boundaries of the OU 7. Other shallow ditches and silt fences may be constructed to prevent significant sediment from flowing into the landfill pond. Newly constructed soil surfaces are properly protected using methods described in Section 9.5 to minimize soil erosion until the required vegetation is established.

9.2.2.2 Long-Term Impacts

The East Landfill Pond includes approximately 3 percent of the open water habitat and 6 percent of the available shoreline habitat at Rocky Flats; the adjacent wetlands represent approximately 1.6 percent of the total (COE 1994). Because the East Landfill Pond was constructed only about 20 years ago, it is probably not a historically important component of the local ecosystem.

The importance of the East Landfill Pond to aquatic life at Rocky Flats and the Big Dry Creek basin appears to be minimal (Appendix D). The pond apparently does not contain fish or crayfish populations; if it does, the populations are very small. Without a complex aquatic food web that includes upper-level aquatic consumers, the pond is a limited resource for aquatic-feeding wildlife and potential transfer of contaminants via food web interactions is limited. Because the pond lacks predaceous fish such as bass, it may be a resource for breeding amphibians such as tiger salamanders, chorus frogs, and bullfrogs.

The East Landfill Pond does not empty directly into a stream under normal flow conditions; however, large rainstorms could cause the pond to overflow into No Name Gulch. Because this has not occurred, sensitive fish such as common shiners and stonerollers are not at risk from release of contaminants into streams.

9.3 Impact to Air Quality

The purpose of this section is to assess the potential impacts to air quality associated with the proposed installation and maintenance of the engineered cover and the potential off-gases from the OU 7 landfill. This assessment includes:

- Estimation of potential fugitive-dust emissions
- Estimation of downwind airborne particulate concentrations at the Rocky Flats property boundary using an EPA screening-level model
- Comparison to EPA air-quality standards
- Estimation of potential methane emissions

9.3.1 Estimation of Potential Fugitive-Dust Emissions

Fugitive-dust emissions arising from construction activities are estimated by identifying the type of equipment and capacities expected to be used, volume of earthen materials, travel distances, and climate conditions. Construction involved with the IM/IRA includes three representative tasks:

- Construction of a haul road between an offsite borrow source and the landfill
- Transport of fill and cover material to the landfill
- Installation of the engineered cover over the landfill

Post-construction activities include inspection and maintenance of the cover and post-closure monitoring. The landfill contents are covered daily with interim soil as waste is placed; therefore, the landfill contents are covered before IM/IRA construction activities begin. Materials used for the fill and engineered cover include general fill, low-permeability soil, topsoil, and a vegetative cover after construction is complete.

The construction tasks require the use of bulldozers, compactors, water trucks, and haul trucks. Because of the transport distances, the use of scrapers is probably not economically feasible. EPA has developed empirical equations for estimating dust emissions from typical construction equipment (EPA 1995b). The equations used to represent emission rates from anticipated OU 7 construction activities include operation of haul trucks on unpaved roads, dumping of haul truck contents, and operation of bulldozers and compactors.

340

$$\text{Bulldozer EF} = 1.0(s)^{1.5}(M)^{-1.4}$$

where:

EF	=	Emission factor (lb/hr)
s	=	Silt content of soil (assumed 10 percent)
M	=	Moisture content of soil (assumed 10 percent)

Two bulldozers and two compactors are assumed. A 25-percent reduction was applied to estimate respirable particulate matter (PM-10) emissions (EPA 1995b). A 50-percent reduction is applied to account for dust control from periodic watering using watering trucks.

$$\text{Dumping EF} = K(0.0032)\left(\frac{U}{5}\right)^{1.3}\left(\frac{M}{2}\right)^{-1.4}$$

where:

EF	=	Emission factor (lb dust per ton dumped [lb/ton])
K	=	Particle size multiplier = 0.35 (PM-10) (EPA 1995b)
U	=	Mean wind speed, miles per hour (mph) (assumed 8 mph)
M	=	Moisture content of soil (assumed 10 percent)

Approximately 25 to 30 haul trucks are used. The silt content of soil is assumed to be 10 percent. A 50-percent reduction is applied to account for dust control from watering.

$$\text{Transportation EF} = K(5.9)\left(\frac{s}{12}\right)\left(\frac{S}{30}\right)\left(\frac{W}{3}\right)^{0.7}\left(\frac{w}{4}\right)^{0.5}\left(\frac{365-p}{365}\right)$$

where:

EF	=	Emission factor (lb per vehicle mile traveled [lb/VMT])
K	=	Particle size multiplier = 0.36 (PM-10) (EPA 1995b)
s	=	Silt content of onsite soil (assumed 10 percent)
S	=	Mean vehicle speed (assumed 15 mph)
W	=	Mean vehicle weight (assumed 25 tons)
w	=	Mean number of wheels (assumed 18)
p	=	Number of days per year with precipitation greater than or equal to 0.01 inches = 87 (EPA 1995b)

Approximately 25 to 30 haul trucks are used. A 99-percent reduction is applied to account for dust control from periodic watering using contractor watering trucks, e.g., near 100-percent effectiveness has been obtained with applications of 0.125 gallons per square yard every 20 minutes (DOE 1992c).

Each of the three representative construction tasks involves different assumptions regarding distances, material volumes, and equipment usage, which result in different estimated emission rates. These emission rates are then used as input to the conservative EPA screening model Screen2, which is a module of TSCREEN (EPA 1994c). Screen2 was used assuming worst-case downwind dispersion conditions to calculate airborne particulate concentrations at the Rocky Flats property boundary. The emission rate for dumping truck contents assumes a higher wind speed (8 mph) than that assumed in the air-dispersion model (2.2 mph). These are reasonable worst-case assumptions because greater emissions result during higher wind speeds, but the least amount of dispersion occurs during low wind speeds. The assumptions, estimated emissions, and dispersion modeling results are presented in the following sections for each of the three representative construction tasks.

9.3.1.1 Haul Road Construction

The construction haul road is built between a nearby borrow and the landfill. The distance required is assumed to be 2.5 miles. With an approximate width of 30 feet, the total area is approximately 9 acres. The road is built with approximately 8,000 yd^3 of aggregate road base, with an assumed silt content of 10 percent. At 15 yd^3 per truck, 533 round trips (loads or number of dumps) are required to build the road. Trucks need to travel only short distances as the road is started and travel the entire length of the road as it is finished. Using half the length to represent the average round trip distance, 1,333 vehicle miles are required. Construction of the road requires approximately 10 working days using two bulldozers and two compactors.

These estimations of vehicle miles traveled and durations of activities are used as input to the equations for estimating fugitive-dust emissions. The emissions from constructing the haul road, which are displayed in the second column of Table 9-2, indicate that haul truck transportation is expected to contribute the majority of emissions for this task.

For use as input to the air model, the emissions are input as grams per second (g/s), and the area of the road as 9 acres (36,400 square meters [m^2]). Because the trucks traveling back and forth along the road, and the distance to the west (closest) property boundary changes continuously, the average emissions location is assumed to be the midpoint between the borrow pit and the landfill. The distance to the fence line at this point is approximately 1,300 meters (m). The estimated airborne particulate concentrations are summarized in Section 9.3.2.

9.3.1.2 Transport of Fill and Cover Material to the Landfill

An estimated 243,480 yd^3 of general fill, low-permeability soil, vegetative soil, and topsoil are needed as fill and cover material. At 15 yd^3 per truck and a round trip

34 2

distance of 5 miles, 81,160 vehicle miles are required during an estimated duration of 500 work-hours. Because the transport and installation of the cover are overlapping activities, and the dumping of the haul truck loads occurs at the landfill, dumping is considered part of the cover installation (Section 9.3.1.3). The estimation of vehicle miles traveled is used as input to the equations for estimating emissions, along with standard default values. The emissions from transporting the fill and cover material are displayed in the third column of Table 9-3. Note that more recent estimates indicate a volume of only 229,800 yd^3 of fill and cover material, which is less conservative.

Similar to the discussion in Section 9.3.1.1, the transport emissions are input as g/s, the area of emissions is assumed to be 36,400 m^2, and the average distance to the fence line is assumed to be approximately 1,300 m. The estimated airborne particulate concentrations are summarized in Section 9.3.2.

9.3.1.3 Installation of Engineered Cover over the Landfill

Installation of the fill and cover material at the landfill includes dumping of the haul truck loads, spreading with two bulldozers, and compaction with two compactors. It is estimated that 500 work-hours are needed to install the material. This duration is input to the equations for dumping haul truck loads and operating bulldozers, along with standard default assumptions. The results for installation of fill and cover material, which are presented in the fourth column of Table 9-3, indicate that bulldozer and compactor operations are expected to contribute the majority of emissions for this task.

These estimated emissions are input to the Screen2 air model as g/s; the area of emissions is assumed to be slightly larger than the area of the landfill, 28 acres or 113,300 m^2; and the distance to the fence line is assumed to be approximately 2,550 m. The estimated airborne particulate concentrations are summarized in Section 9.3.2.

Emissions of fugitive dust from the cover surface are not addressed quantitatively due to the extensive watering by the contractor. The earthen materials of the cover layers are installed in many sub-layers as the work progresses. Each sub-layer is watered to ensure proper moisture content and compaction. The exposed cover must be kept moist during workdays, nights, and weekends to prevent drying and cracking (loss of the cover integrity). Keeping the cover moist is typically accomplished through the application of water by watering trucks or by covering the completed sub-layer with a loose lift of moist clay clumps. The clay clumps tend to dry over weekends but have low potential as a source of respirable particulates.

9.3.2 Comparison to EPA Air Quality Standards

The state and federal 24-hour PM-10 standards and annual standards are 150 micrograms per cubic meter ($\mu g/m^3$) and 50 $\mu g/m^3$, respectively. Table 9-3 presents

the modeled and cumulative PM-10 concentrations for the reasonable worst-case scenario.

As presented in Table 9-3, under reasonable worst-case conditions, respirable dust concentrations are not expected to exceed the 24-hour standard of 150 $\mu g/m^3$ at the property boundary during the construction activities. Similarly, emissions are also expected to be well below the annual standard.

9.3.3 Estimation of Potential Methane Emissions

Methane emissions from the OU 7 landfill may be estimated from the volume of the waste contents. The approximate volume of waste is expected to be approximately 404,000 yd^3 in 1997, with 124,000 yd^3 of daily soil cover (DOE 1994a). The methane and carbon dioxide content of the soil gas is 60 percent and 40 percent, respectively, indicating anaerobic conditions (DOE 1994a). Concentrations of these gases are highest in the younger, eastern portions of the landfill.

Measurements of other landfills with similar conditions support an average emissions factor for landfill gas of 0.1 cubic feet per pound (ft^3/lb) refuse per year (DOE 1994a). This value is typical of landfills in drier climates, as compared to values 10 or more times greater in moist climates (Tchobanoglous *et al.* 1992). To use this empirical approach to estimate landfill gas emissions, it is necessary to calculate the weight of landfill contents. The density of the individual items in the landfill varies, but the average density of contents is assumed to be approximately 1,000 pounds per cubic yard (lb/yd^3) (DOE 1994a). Multiplying 404,000 yd^3 times 1,000 lb/yd^3 provides a total weight of landfill contents of 4.04E+08 lb.

The emission rate of landfill gas is calculated by multiplying the average emissions factor, 0.1 ft^3/lb refuse/yr, by the total weight of the landfill contents, 4.04E+08 lb. The calculated result, 4.04E+07 lb landfill gas per year, is multiplied times the percent methane content, 60 percent, to determine methane emission rates. The resulting average annual emission rate of methane is 2.42E+07 cubic feet per year (ft^3/yr) and is characteristic of the low generation rates of medium size landfills in drier climates (Tchobanoglous *et al.* 1992). The result is a conservative overestimate because it assumes the older wastes are producing methane at the same rate as younger wastes. The generation rate is also similar to that expected from the new Rocky Flats landfill (DOE 1994h).

9.4 Impact to Surface-Water Quality

9.4.1 Short-Term (Construction Period) Impacts

Construction activities associated with installation of the engineered cover would result in surface disturbance from the clearing of vegetation, excavation and salvage of topsoil material, blading and leveling of land preceding construction, and the potential for accidental uncovering of contaminated media. Potential impacts to surface water during the construction phase include increased erosion, contamination from inadvertent water contact with uncovered wastes, and subsequent sediment loading to drainage ditches and to the East Landfill Pond during storm events. The absence of vegetative cover and the steepening of slopes result in increased potential for both sheet and channelized run-off and wind and water erosion, resulting in increased sedimentation of ditches and the East Landfill Pond.

The proposed action is limited to constructing an engineered cover system for containment of the landfill waste. Construction requires soil obtained from offsite commercial operations. Excavation of these borrow materials has impacts similar to those identified above, which are addressed in permits issued for the offsite facilities. The proposed construction activities are not expected to have any physical contact with contaminated soils or waste material. In the event that equipment and personnel come in contact with potentially contaminated materials during construction, decontamination is performed at the Rocky Flats main decontamination facility to reduce potential impacts to surface water. Given the expected conditions, no significant surface-water impacts are expected.

The total area of disturbed soils is approximately 39 acres, including the area of the landfill to be resurfaced (28 acres), haul roads to the offsite borrow areas (9 acres), and miscellaneous construction activities (2 acres). (As previously noted these numbers are preliminary; more recent estimates show a total of 35 acres will be disturbed.) Surface-water control measures are used to minimize surface-water contact with potentially contaminated soils or groundwater and minimize erosional effects during the construction activities. Precipitation falling on areas where construction is in progress is diverted to existing surface-water drainage ditches along the north and south boundaries of OU 7. Other shallow ditches are temporarily constructed as needed to prevent sediment-laden stormwater from flowing directly into the East Landfill Pond.

Newly constructed soil surfaces are properly protected using soil terracing, hydromulch, straw-mulch, silt fencing, etc., to minimize soil erosion and surface-water degradation until the required vegetation is established. Average potential loss of soils from newly constructed surfaces due to water erosion is estimated at 6 tons/acre/year for the first two years during and after construction activities. This loss is estimated

using the Universal Soil Loss Equation (USLE) (SCS 1983, SCS 1984). The use of straw-mulch, adequately spaced silt fences, and other appropriate measures minimizes soil loss and allows the final vegetative cover to be established within 2 to 3 years. Potential soil loss from surfaces with established vegetation similar to surrounding areas is estimated at 0.5 tons/acre/year as presented in Appendix J.

9.4.2 Long-Term Impacts

Long-term protection is maximized because the proposed IM/IRA engineered cover minimizes infiltration of precipitation and subsequent contact with contaminants and incorporates surface drainage features to prevent run-on/run-off and to provide erosion control. The proposed action ultimately results in a decrease in the risk of contaminants reaching surface water by eliminating the possibility of precipitation contacting contaminated soils or waste material. Precipitation falling within the boundary of the landfill is drained off the cover and diverted away from the landfill. Surface-water drainage from areas outside the landfill boundary would be prevented from flowing onto the landfill and diverted around the boundary. Using appropriate surface-reclamation measures, adequate vegetation cover should be established on the final surface of the landfill in 2 to 3 years. The establishment of vegetative cover on stabilized slopes, contours of the landfill, and the surrounding disturbed surfaces greatly reduces erosional hazards to levels similar to surrounding areas.

Post-closure monitoring activities would include inspections of the landfill surface and associated drainage ditch conditions and will continue for 30 years on a semiannual basis. Observations of the vegetative cover and evidence of soil erosion and loss would be included in the routine inspection and maintenance efforts. Further erosion-control measures, regrading, and revegetation would be implemented if maintenance inspections indicate that the landfill surface reclamation is not effective as planned.

9.5 Impact to Groundwater Quality

Sources of groundwater recharge to the UHSU include infiltration of precipitation, snowmelt, storm run-off, and downward seepage from the East Landfill Pond. The level of groundwater rises annually in response to spring and summer recharge and declines during the remainder of the year. Groundwater generally flows to the east; however, localized flow follows topographic slopes toward the pond or toward the drainage below the dam. Groundwater intermittently flows to the east within the saturated valley-fill alluvium. The average depth to groundwater in the landfill mass is approximately 20 feet; the average saturated thickness is 11 feet.

9.5.1 Short-Term (Construction Period) Impacts

Local impacts to hydraulic gradient are expected because the engineered cover reduces surface-water infiltration; however, enhanced groundwater quality results from reducing water flow through waste. The proposed slurry wall installed as part of the landfill maintenance program is expected to greatly reduce the volume of upgradient groundwater flowing through the landfill mass and the groundwater-flow direction in the vicinity of the landfill. The engineered cover system also minimizes outflow to surface water.

An estimate of potential infiltration and percolation through the proposed engineered cover system was performed using the HELP Version 3 computer model (EPA 1994b). A summary of the HELP modeling and model runs is presented in Appendix G. The results of the HELP model computations for the proposed engineered cover design indicate that the potential average annual leakage through the engineered cover is approximately 0.00016 inches/year. The leakage rate of the existing interim soil cover is estimated to be 1.4 inches/year. This indicates that the engineered cover would reduce the amount of infiltration that would potentially flow through the landfill waste by 99.99 percent. The HELP model does not account for capillary flow in the variably saturated components, and as a consequence, provides a conservative estimate of percolation through the engineered cover.

As described in Section 2.3, a water balance was performed for the landfill mass using the MODFLOW (McDonald and Harbough 1991) computer model with site-specific data for the no-action alternative. The water balance calculations indicate that approximately 60 percent of the inflow to the landfill is upgradient groundwater from the alluvium and 40 percent is recharge by infiltration of precipitation. Most of the groundwater inflow (87 percent) occurs on the north side of the landfill. Contributions from the west side (6 percent) and the south side (7 percent) are relatively insignificant. The water balance shows that both the proposed engineered cover system and proposed slurry wall on the north side of the landfill would minimize additional water inflow and leachate generation. Water balance calculations are presented in Appendix C.

The surface-water drainage ditch would divert stormwater run-off around the landfill, resulting in further reduction of surface infiltration and groundwater recharge through waste material.

9.5.2 Long-Term Impacts

The eventual effects of constructing the low-permeability cover would be a 99.99-percent reduction in precipitation reaching the waste. This would cause a significant reduction in saturated thickness of the waste material. In conjunction with the slurry wall diverting upgradient groundwater around the landfill mass and the

reduction of surface-water infiltration, a 96-percent reduction of water flow through the waste mass is expected. A significant reduction of saturated waste would result in reduced leachate generation and migration, which would ultimately reduce contaminant loading to groundwater.

The overall impact to groundwater from the proposed IM/IRA would be enhanced groundwater quality at the site. No significant negative impact to groundwater quality is expected from the proposed action.

9.6 Commitment of Irreversible and Irretrievable Resources

The proposed IM/IRA results in some permanent commitments of resources but is not expected to result in a substantial loss of valuable resources. Most of the resources used for construction of the engineered cover are permanently committed to the implementation of the remedial action. Irreversible and irretrievable resources are defined as resources that are either consumed, committed, or lost. For OU 7, irreversible and irretrievable resources include the following:

- Consumptive use of geological resources (e.g., quarried rock, clay, sand, and gravel for road construction) is required for construction activities. Supplies of these materials are provided by the construction contractor. The preferred alternative requires a permanent commitment of 243,480 yd^3 of fill, topsoil, and vegetative cover from offsite sources to construct the final landfill cover. However, adequate supplies are available without affecting local demand for these products.

- Fuel consumed in construction equipment and vehicles for the construction of the landfill cover will not be recovered.

- Soil at OU 7 is disturbed by construction activities. Many impacts are temporary, pending completion of remedial activities and associated restoration programs.

- Resources that underlie the landfill are lost. However, there appear to be no commercially exploitable mineral resources at Rocky Flats (DOE 1980).

- Commitment of up to 28 acres of land as a landfill permanently commits and constrains the area to limited land-use options.

- Wetlands and associated natural resources are reduced at OU 7 but will be mitigated offsite. Long-term direct impacts to the floodplain resulting in changes of flood elevations do not occur.

- Long-term commitment of personnel and funds to perform post-closure inspection, maintenance, and monitoring activities.

- Maintenance activities are performed as necessary. Long-term negative environmental impacts are not expected to occur from the OU 7 selected remedy. Monitoring and periodic site inspections would be performed to ensure long-term protection of human health and the environment.

As a result of the constructed engineered cover and the network of monitoring wells to remain in-place, commercial, industrial, and residential land use are permanently prohibited within the landfill boundaries. Appropriate landfill surface reclamation results in an acceptable appearance of the remediated site, and the ecological succession of the closed landfill and adjacent land are improved by surface revegetation. Vegetation and habitat eventually become similar to surrounding areas.

Incidental resources that are consumed, committed, or lost on a temporary and/or partial basis during construction include construction personnel and equipment, the construction water source, and the construction materials used for equipment haul roads. During construction of the proposed IM/IRA, it is expected that 20 to 35 personnel are required for the duration of the construction activities (less than 1 year). The raw water supply available at Rocky Flats is used to conserve water that is treated by the onsite water treatment plant. The compacted soil portion of the engineered cover system would require 8 to 10 million gallons of water during construction activities. Approximately 7,000 to 8,000 yd^3 of material are temporarily used for construction of haul roads. This material is salvaged and available for reuse.

9.7 Impact to Transportation

The proposed IM/IRA is expected to cause minimal direct and indirect impacts to the transportation systems in and around Rocky Flats. Most materials necessary for the construction of the engineered cover system are transported using tandem semi-trucks from a nearby offsite borrow source (EG&G 1994d). A construction haul road (approximately 2.5 miles long) is constructed from the offsite borrow pit to the site. The construction haul road is paved with aggregate road base only. The new haul road results in no impact to State Highway 93 west of Rocky Flats. Transport of other construction materials and supplies, as well as construction mobilization equipment and construction personnel, use existing transportation systems. The traffic impact from these activities are expected to be minor.

9.8 Impact to Cultural, Historical, and Archaeological Resources

No known significant cultural, historical, or archaeological resources are expected to be impacted by the proposed IM/IRA activities (CHS 1992).

349

9.9 Cumulative Impacts

Cumulative impacts may result from the combination of incremental impacts from past, present, and reasonably foreseeable future actions. Cumulative impacts could have the potential of being more significant than the individual impacts due to synergism between types and areas of impact or the individual impacts collectively resulting in significant effects to the environment.

There are no other activities scheduled for the OU 7 area that are expected to cause significant impacts. Ongoing maintenance and groundwater and landfill gas monitoring are limited to short-period events. Construction activities at other OUs at Rocky Flats will also continue in the future, but these activities are not likely to overlap due to the lengthy process of design, approval, and implementation. Therefore, expected short-term future cumulative effects are substantial. Long-term cumulative impacts (i.e., IM/IRA activities in conjunction with other Rocky Flats restoration activities) facilitate future beneficial use of Rocky Flats land and fulfill mandated cleanup objectives.

The following types of cumulative impacts may occur:

- Additional construction personnel have an additive effect on existing workload for site operations. This effect is short-term; however, maintenance and monitoring activities would continue during the post-closure period. The anticipated workload of these personnel would be significantly less than what is currently required.

- Potential waste generated by this proposed action is very limited and may include small amounts of soil from construction activities, potentially contaminated water from decontamination operations and water generated from sampling activities during groundwater monitoring. The small amounts of waste generated are insignificant and any impacts are negligible.

- Wetlands mitigation is necessary to replace the portion of the East Landfill Pond that is covered by implementation of the engineered cover system. Potential cumulative impacts, such as mitigation of other onsite wetland areas, can be expected because the mitigation plan is to use acreage from the offsite wetlands mitigation bank near the Standley Lake Protection Project.

9.10 Comparison of the Preferred IM/IRA to the No-Action Alternative

The potential adverse and beneficial impacts of the Preferred Alternative and No Action are expected to be significantly different in the magnitude to which they affect the quality of the environment. Implementation of the proposed IM/IRA is not expected to have any substantial adverse impacts to human health or the environment and is consistent with long-term remediation goals for Rocky Flats. Where potential

impacts may occur, effects are expected to be small, temporary and appropriate mitigation measures implemented.

The no-action alternative could have potentially adverse impacts to both human health and the environment by allowing landfill waste to remain uncovered, resulting in continued leachate generation and migration, and potentially resulting in exposure to human and ecological receptors. Therefore, the no-action alternative potentially allows for direct or indirect receptor intake. A comparison of how the two alternatives could impact human health and the environment is presented in Table 9-4.

Section 9
Tables

Table 9-1
Uncertainties Associated with Assessing Risk

Issue	Remarks	Potential Impact on Exposure
Assumptions regarding duration of work activities	Actual durations of activities at OU 7 may differ from planning assumptions.	Slightly overestimate or underestimate exposure.
Assumptions regarding construction materials	The potential for particulate emissions from actual construction materials used at OU 7 may differ from planning assumptions.	Slightly overestimate or underestimate exposure.
Assumption that construction activities will not involve intrusion into landfill contents	Intrusion into landfill contents is not anticipated. However, if this became necessary or occurred accidentally, worker protection would be addressed by health and safety precautions.	Slightly underestimate exposure.
Estimation of emission rates	Emission rates are estimated for construction activities using empirically derived EPA algorithms.	Moderately overestimate or underestimate exposure.
Use of a screening-level transport model (gaussian dispersion in air)	Screening-level models are based on conservative, bounding assumptions and algorithms.	Moderately overestimate exposure.
Assumptions about receptor locations	Worker exposure may vary depending on the proximity to the dust emission sources. Dust concentrations were modeled at the Rocky Flats boundary, but current residential receptors are located more than 1 mile away from this point.	Moderately overestimate exposure.
Occupational exposure limit for nuisance dust	Limits are based on observation of human exposure and are reasonable upper bound values.	Moderately overestimate exposure.
Heavy equipment and vehicle accident risk	These are addressed by occupational regulations. Transportation will be on private roads at low speeds.	Slightly underestimate or overestimate exposure.

Table 9-2
Fugitive-Dust Emissions from IM/IRA Construction

Source	Construct Haul Road (g/s)	Transport Fill and Cover (g/s)	Install Fill and Cover (g/s)
Haul Truck	0.132	0.721	NA
Dumping Load	0.001	NA	0.010
Bulldozer	0.238	NA	0.238
Total	0.37	0.72	0.25

Table 9-3
Modeled and Cumulative PM-10 Concentrations for IM/IRA Construction

Task	Averaging Period	Model Input (g/s)	Modeled Concentration ($\mu g/m^3$)	Background[1] Concentration ($\mu g/m^3$)	Cumulative[2] Concentration ($\mu g/m^3$)
Haul Road Construction	24-hour	0.37	26.1	47	73
	Annual		2.1	15	17
Transport of Fill and Cover Material	24-hour	0.72	52.1	47	99
	Annual		8.9	15	24
Installation of Engineered Cover	24-hour	0.25	6.6	47	54
	Annual		1.1	15	16

Notes

1 Rocky Flats Plant Site Environmental Report (DOE 1993c).
2 Cumulative concentrations are estimated by adding the modeled concentrations to the measured PM-10 background concentrations.

Definitions

N/A not applicable
g/s grams per second
$\mu g/m^3$ micrograms per cubic meter

354

ts:

ction

No-Action
to onsite and offsite persons as a result of long-term exposure to tial contaminated soil, airborne contaminants, contaminated surface and groundwater. ks of exposure to construction workers. tial risks to personnel as a result of inadvertently disturbing landfill areas with high levels of contamination. tial risks of contaminating groundwater and surface water downgradient landfill.
minated media remains in place with potential for exposure to humans nvironment. ntrolled contaminants and waste could negatively affect vegetation and e and impact receiving surface water and groundwater. ast Landfill Pond wetlands area is potentially affected by leachate groundwater contamination. odplain, critical habitats, or threatened and endangered species are ed.
ll off-gases could potentially impact the air quality at and near OU 7 ontinue to be uncontrolled. rease in dust emissions.

Table 9-4
Summary of Potential Impacts: Preferred IM/IRA versus No Action

Impact	Preferred IM/IRA	No-Action
Groundwater Quality	The eventual effect of constructing the low-permeability cover is a significant reduction of the saturated waste, leachate generation, migration of contaminants, and contaminant loading. Potential effects on local hydrogeologic characteristics by reducing groundwater inflow and changing topography in a groundwater recharge area.	Downward migration of water through the waste continues, resulting in leachate generation. Potential for contaminant migration to downgradient groundwater.
Surface-Water Quality	Coverage of waste under engineered cover minimizes or eliminates potential for contaminated surface-water run-off. Construction activities disturb surfaces and erosion from storm run-off would impact surface-water quality until vegetation is established.	Potential for surface-water run-off to contact waste and transport contamination into surface-water bodies.
Cultural, Historical, and Archaeological Resources	No resources present.	No resources present.
Transportation	Minor increase in traffic volume and patterns during construction activities; negligible impact on surrounding transportation infrastructure.	No increase in traffic volume.
Short-Term vs. Long-Term Uses	Implementation of the proposed IM/IRA is not expected to have substantial adverse short-term or long-term impacts to human health or the environment. The IM/IRA is consistent with long-term remediation goals for Rocky Flats.	The no-action alternative has no significant short-term impacts, with the exception of land use. Wetlands and wildlife habitat would remain undamaged. The no-action alternative has potentially adverse long-term impacts to both human health and the environment because contaminated media remaining in place may result in potential exposure.
Irreversible and Irretrievable Resource Commitments	Clean fill from offsite borrow areas, construction materials, and very limited land use or resources beneath the site. Resources to implement the proposed IM/IRA are lost or consumed (i.e., capital, fuel, manhours, construction, water, etc.)	Very limited land use and resources beneath the site.
Cumulative Impacts	Implementation of the IM/IRA is consistent with the long-term mission of remediating Rocky Flats. Implementation may interfere slightly with other activities in progress at Rocky Flats. Short-term increases in personnel at the site would result from the implementation of the IM/IRA. Wetlands mitigation is necessary.	Implementation of the no-action alternative impedes or delays long-term sitewide remediation goals. The no-action alternative has potentially adverse impacts to both human health and the environment because contaminated media are contained and not removed such that the exposure to humans and environment exist.

356

Table 9-4
Summary of Potential Impacts:
Preferred IM/IRA versus No Action

Impact	Preferred IM/IRA	No-Action
Mitigation Measures	Because a portion of the existing wetlands at the East Landfill Pond will be under the engineered cover, it is necessary to mitigate lost or injured wetlands. Potential mitigation of surface run-off and erosion from the construction area may be necessary. Potential mitigation of Preble's meadow jumping mouse habitat if needed.	Future mitigation of leachate may be necessary.

10. References

ASI (Advanced Sciences, Inc.). 1991. Threatened and Endangered Species Evaluation. Rocky Flats Plant Site. Prepared for EG&G. April 4.

Beadecker, M.J., and W. Back. 1979. Modern Marine Sediments as a Natural Analog to the Chemically Stressed Environment of a Landfill. Journal of Hydrology, 43:393-414.

Blaha, F. 1994. Personal communication. F. Blaha of Wright Water Engineers, Inc. with W. Cheung of The S.M. Stoller Corporation, October 19.

Burney, M.S., S.F. Mehls, and M.P. Grant. 1989. An Archaeological and Historical Survey of Selected Parcels within the Department of Energy, Rocky Flats Plant, Northern Jefferson County, Colorado, Burney and Associates.

CDPHE. 1992. Closure Process for RCRA Units under the Interagency Agreement. Letter from G. Baughman of CDPHE to F. Lockhart of DOE. May 29.

CDPHE. 1994. Operable Unit No. 7 Process Improvement Proposal. Letter from J. Schieffelin of CDPHE to S. Slaten of DOE. October 21.

CDPHE. 1995. OU 7 Area Well Abandonment Proposal. Letter from J. Schieffelin of CDPHE to S. Slaten of DOE. February 13.

CDPHE/EPA/DOE (Colorado Department of Public Health and Environment, U.S. Environmental Protection Agency, U.S. Department of Energy). 1994. Presentation on the Conservative Screen Process for Identification of Source Areas and Data Aggregation for Calculation of Exposure-Point Concentrations. June 3.

CHS (Colorado Historical Society). 1992. Rocky Flats Cultural Resource Study. Letter from J.E. Hartman, State Historical Preservation Officer, to F.R. Lockhart, Director of Environmental Restoration Division of the DOE. August 25.

COE. 1994. U.S. Army Corps of Engineers, Omaha District, Wetlands Mapping and Resource Study. August.

Corser, P.G., J. Pellicer, and M. Cranston. 1992. Observations on Long-Term Performance of Composite Clay Liners and Covers. Geosythetic Fabrics Report. November.

358

DOE. 1980. Final Environmental Impact Statement: Rocky Flats Plant Site, Golden and Jefferson Counties, Colorado. Volumes 1, 2, and 3. U.S. Department of Energy, Washington, D.C. DOE/EIS-0064.

DOE. 1986. Comprehensive Environmental Assessment and Response Program Phase I, Draft Installation Assessment, Rocky Flats Plant. U.S. Department of Energy, Safety and Health Division of Environmental Programs Branch, Albuquerque Operations Office, New Mexico. April.

DOE. 1991a. Final Phase I RFI/RI Work Plan for Operable Unit 7, Present Landfill (IHSS 114) and Inactive Hazardous Waste Storage Area (IHSS 203). U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado. December.

DOE. 1991b. Federal Facility Agreement and Consent Order (Interagency Agreement [IAG] among the U.S. Department of Energy, U.S. Environmental Protection Agency, and the Colorado Department of Health). U.S. Department of Energy, Washington D.C. January 22.

DOE. 1992a. Final Historical Release Report for the Rocky Flats Plant. U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado. June.

DOE. 1992b. Phase I RFI/RI Work Plan for Operable Unit 6 - Walnut Creek Priority Drainage, Manual No. 21100-WP-OU 6.01. U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado. June.

DOE. 1992c. Final Plan for Prevention of Contaminant Dispersion. U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado. February.

DOE. 1992d. Flood Plain Delineation, Hydrologic Analysis. U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado. September.

DOE. 1993a. Final Groundwater Assessment Plan. U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado.

DOE. 1993b. Final Phase III RFI/RI, Rocky Flats Plant, 881 Hillside Area (Operable Unit No. 1). U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado. November.

DOE. 1993c. Rocky Flats Plant Site Environmental Report, January-December, 1992: U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado. April.

DOE. 1994a. Final Work Plan Technical Memorandum for Operable Unit No. 7–Present Landfill (IHSS 114) and Inactive Hazardous Waste Storage Area (IHSS

203). U.S. Department of Energy, Rocky Flats Site, Golden, Colorado. September.

DOE. 1994b. Landfill Pond Leachate Collection (Operable Unit 7). Memorandum from DOE-RFO to EG&G. ER: DFG: 04395. April 22.

DOE. 1994c. OU 7 Area Well Abandonment Proposal. Letter from S. Slaten of DOE to M. Hestmark of EPA and J. Schieffelin of CDPHE. January 13.

DOE. 1994d. Final Operable Unit No. 7 Process Improvement Proposal. Letter from Jessie Roberson of DOE to Martin Hestmark of EPA and Gary Baughman of CDPHE. May 23.

DOE. 1994e. Guidance on the Application of Floodplain Regulations to Rocky Flats Plant. Memorandum from S.J. Olinger, Acting Assistant Manager of Environment, Safety, and Health at DOE to T.G. Hedahl, Associate General Manager of Environment and Waste Management at EG&G. May 3.

DOE. 1994f. Rocky Flats Environmental Technology Site Natural Resource Trustee Memorandum of Understanding (MOU among DOE, U.S. Department of the Interior, Colorado Department of Natural Resources, State of Colorado Attorney General, CDPHE, and EPA). November.

DOE. 1994g. Rocky Flats Plant Environmental Restoration Management Cost Estimating Handbook. Document Number RFP/ERM-94-00009 Rev. 1. May.

DOE. 1994h. Environmental Assessment, New Sanitary Landfill at Rocky Flats Plant. DOE/EA-0914. U.S. Department of Energy, Rocky Flats Plant. January.

DOE. 1995a. Modified Proposed Action Memorandum for Passive Seep Collection and Treatment at Operable Unit No. 7—Present Landfill (IHSS114) and Inactive Hazardous Waste Storage Area (IHSS 203). Final Report. U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado. July.

DOE. 1995b. Ecological Risk Assessment Methodology Technical Memorandum No. 2: Sitewide Conceptual Model. Draft Final. U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado. February.

DOE. 1995c. Rocky Flats Field Office Guidance Brief, F039 Multi-Source Leachate. RCRA/CERCLA Environmental Guidance Division, Environment, Safety and Health. U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado. Draft. May.

360

DOE. 1995d. Preliminary Remediation/Remedial Action Objectives for Buffer Zone Operable Units. Letter from J. Wienard of DOE to E. Mast, A. Primrose, and J. Hopkins of EG&G. February 28.

DOE. 1995e. Programmatic Risk-Based Preliminary Remediation Goals. Final. Revision 2. Prepared for the U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado. February.

DOE. 1995f. Draft Programmatic Preliminary Remediation Goals for the Rocky Flats Plant--Open Space. March 29.

DOE. 1995g. Programmatic Preliminary Risk-Based Remediation Goals for RFETS. U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado. June, 22.

DOE. 1995h. Rocky Flats Site-Specific Exposure Factors for Quantitative Human Health Risk Assessment. U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado. May.

DOE. 1995i. Open-Space Exposure Parameters. U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado. May.

DOE. 1995j. Ecological Risk Assessment Methodology Technical Memorandum No. 3: Ecological Chemical of Concern Screening Methodology. Draft. U.S. Department of Energy, Rocky Flats Environmental Technology Site, Golden, Colorado. April.

Domenico, P.A., and G.A. Robbins, 1985. A New Method of Contaminant Plume Analysis. Groundwater, 23:4:476-485.

EG&G. 1990. Rocky Flats Plant Well Abandonment/Replacement Program Plan. EG&G Rocky Flats, Inc., Golden, Colorado. November.

EG&G. 1991. Groundwater Monitoring and Protection Plan. EG&G Rocky Flats, Inc., Golden, Colorado. November.

EG&G. 1992a. Surface Geologic Mapping of the Rocky Flats Plant and Vicinity, Jefferson and Boulder Counties, Colorado. Phase II Geologic Characterization Data Acquisition. EG&G Rocky Flats, Inc., Golden, Colorado. March.

EG&G. 1992b. EMD Operating Procedures 5-21000-OPS, Volume II: Groundwater Manual, GW.6, Groundwater Sampling. Revision 2. EG&E Rocky Flats, Inc., Golden, Colorado. March.

361

EG&G. 1992c. EMD Operating Procedures 5-21000-OPS, Volume II: Groundwater Manual, GW.1, Water Level Measurements in Wells and Piezometers. Revision 2. EG&G Rocky Flats, Inc., Golden, Colorado. March.

EG&G. 1993a. Adoption of Presumptive Remedies in Process Improvement Proposal. Letter from R. Benedetti of EG&G to R. Schassburger of DOE. June 17.

EG&G. 1993b. Geotechnical Engineering Report for Geotechnical Analysis of Earthen Dams A-3, B-1, B-3, and Landfill Dam, Rocky Flats Plant. EG&G Rocky Flats, Inc., Golden, Colorado. January.

EG&G. 1993c. Background Geochemical Characterization Report for 1993. Rocky Flats Plant. EG&G Rocky Flats, Inc., Golden, Colorado.

EG&G. 1993d. Groundwater Protection and Monitoring Program Plan for Rocky Flats Plant. EG&G Rocky Flats, Inc., Golden, Colorado. October.

EG&G. 1994a. Annual RCRA Groundwater Monitoring Report for Regulated Units at Rocky Flats Plant. EG&G Rocky Flats, Inc., Golden, Colorado. February.

EG&G. 1994b. Statistical Comparisons of Site-to-Background Data in Support of RFI/RI Investigations. Rocky Flats Plant Guidance Document. Draft B. EG&G Rocky Flats, Inc., Golden, Colorado. January.

EG&G. 1994c. Technology Literature Research. Operable Unit No. 7–Present Landfill (IHSS 114) and Inactive Hazardous Waste Storage Area (IHSS 203). Final Report. EG&G Rocky Flats, Inc., Golden, Colorado. April 15.

EG&G. 1994d. Borrow Source Evaluation for Closure of the OU 5 and OU 7 Landfills—Rocky Flats Environmental Technology Site. EG&G Rocky Flats, Inc., Golden, Colorado. November.

EG&G. 1994e. EMD Operating Procedures 5-21000-OPS, Volume I: Field Operations Manual, FO.12, Decontamination Facility Operations. Revision 2. EG&G Rocky Flats, Inc., Golden, Colorado. December.

EG&G. 1994f. Rocky Flats Environmental Technology Site Emergency Plan, E-Plan-94. EG&G Rocky Flats, Inc., Golden, Colorado. September.

EG&G. 1995a. Geologic Characterization Report for the Rocky Flats Environmental Technology Site, Sitewide Geoscience Characterization Study, Volume I. Final Report. EG&G Rocky Flats, Inc., Golden, Colorado. March.

362

EG&G. 1995b. Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site, Sitewide Geoscience Characterization Study, Volume II. Final Report. EG&G Rocky Flats, Inc., Golden, Colorado. April.

EG&G. 1995c. EMD Operating Procedures 5-21000-OPS, Volume I: Field Operations Manual, FO.4, Decontamination of Equipment at Decontamination Facilities. 4-502-ENV-OPS-FO.04, Revision 3. EG&G Rocky Flats, Inc., Golden, Colorado. March.

Emcon Associates. 1982. Methane Generation and Recovery from Landfills. Ann Arbor Science Publishers, Inc. Ann Arbor, Michigan.

EPA. 1985. Technical Guidance Document: Covers for Uncontrolled Hazardous Waste Sites, EPA/504/2-85-002. U.S. Environmental Protection Agency. September.

EPA. 1987a. RCRA Guidance Manual for Subpart G Closure and Post Closure Care Standards and Subpart H Cost Estimating Requirements, PB87-158978. U.S. Environmental Protection Agency. January.

EPA. 1987b. Draft Miminum Technology Guidance on Double Liner Systems for Landfills and Surface Impoundments—Design, Construction and Operations, EPA/530-85-014. U.S. Environmental Protection Agency. April.

EPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA: Interim Final, EPA/540/6-89/004. U.S. Environmental Protection Agency. October.

EPA. 1989a. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final, EPA/540/1-89/002. U.S. Environmental Protection Agency. December.

EPA. 1989b. CERCLA Complicance with Other Laws Manual: Interim Final, EPA/540/G-89/009. U.S. Environmental Protection Agency. August.

EPA. 1989c. CERCLA Compliance with Other Laws Manual, RCRA ARARs: Focus on Closure Requirements, 9234.2-04FS. U.S. Environmental Protection Agency. October.

EPA. 1989d. Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Surface Impoundments, EPA/530-SW-89-047. U.S. Environmental Protection Agency. July.

363

EPA. 1989e. Requirements for Hazardous Waste Landfill Design, Construction, and Closure, EPA/625/4-89/022. U.S. Environmental Protection Agency. Cincinnati, Ohio.

EPA. 1990a. National Oil and Hazardous Substances Pollution Contingency Plan (NCP). 55 Federal Register Section 8666, 8746. U.S. Environmental Protection Agency. March 8.

EPA. 1990b. A Guide to Delisting of RCRA Wastes for Superfund Remedial Responses. Office of Solid Waste and Emergency Response Quick Reference Fact Sheet 9347.3-09FS. U.S. Environmental Protection Agency. September.

EPA. 1991a. Conducting Remedial Investigations/Feasibility Studies for CERCLA Municipal Landfill Sites, OSWER Directive 9355.3-11, EPA/540/P-91/001. U.S. Environmental Protection Agency. February.

EPA. 1991b. Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part B), Development of Risk-Based Preliminary Remediation Goals, Interim Final, EPA/54-/R-92/003. U.S. Environmental Protection Agency. December.

EPA. 1993a. Presumptive Remedy for CERCLA Municipal Landfill Sites. Directive No. 9355.0-49FS, EPA/540-F-93-035, PB93-963339. U.S. Environmental Protection Agency. September.

EPA. 1993b. Petition to Delist Hazardous Wastes—A Guidance Manual, EPA 1530-R-93-007, PB93-169365. U.S. Environmental Protection Agency. March.

EPA. 1993c. Technical Guidance Document: Quality Assurance and Quality Control of Waste Containment Facilities, EPA/600/R-93-182. U.S. Environmental Protection Agency. September.

EPA 1994a. Health Effects Assessment Summary Tables FY 1994, Supplement Number 2. Office of Solid Waste and Emergency Response, EPA/540/94-R/114. U.S. Environmental Protection Agency. November.

EPA. 1994b. The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3. U.S. Environmental Protection Agency. September.

EPA. 1994c. User's Guide to TSCREEN, A Model for Screening Toxic Air Pollutant Concentrations (Revised), EPA-454/B-94-023. Office of Air and Radiation, Office of Air Quality Planning and Standards. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. July.

364

EPA. 1995a. Exposure Scenarios for the Baseline Risk Assessment. Letter from M. Hestmark of EPA to S. Slaten of DOE. March 3.

EPA. 1995b. Compilation of Air Pollution Emissions Factors, AP-42, Office of Air and Radiation, Office of Air Quality Planning and Standards. U.S. Environmental Protection Agency. Research Triangle Park, North Carolina. January.

Freeze, R. A., and J. A. Cherry. 1979. Groundwater, Prentice-Hall, Inc.

Golder Associates Inc. 1989. TPLUME 1.02.

McDonald, M. G., and A. W. Harbaugh, 1991. MODFLOW PC, A Modular Three-Dimensional Finite-Difference Groundwater Flow Model., Version 3.3. March.

Means. 1994. Means Cost Handbook.

Merck Index. 1989. An Encyclopedia of Chemicals, Drugs, and Biologicals, Eleventh Edition. Merck & Co., Inc., Rahwah, New Jersey.

Rockwell International. 1982. Sanitary Landfill Extension Detail Sheet, Drawing Number 27915-006, D-size, Sheet 6, Rocky Flats Plant, Golden, Colorado. August.

Rockwell International. 1986. Resource Conservation and Recovery Act Part B - Post-Closure Care Permit Application for U.S. Department of Energy Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes. Unnumbered Report. Rocky Flats Plant, Golden, Colorado.

Rockwell International. 1987. Resource Conservation and Recovery Act Part B-Operating Permit Application for U.S. DOE Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes, Revision 1. Rocky Flats Plant, Golden, Colorado.

Rockwell International. 1988a. Present Landfill Hydrogeologic Characterization Report, Rocky Flats Plant (Appendix 6 of Closure Plan, Inactive Interim Status Facilities, Hazardous Waste Storage Area SWMU #203), Rocky Flats Plant, Golden, Colorado.

Rockwell International. 1988b. Closure Plan, Inactive Interim Status Facilities, Hazardous Waste Storage Area SWMU #203, Rocky Flats Plant, Golden, Colorado.

Rockwell International. 1988c. Present Landfill Closure Plan, Rocky Flats Plant, Golden, Colorado.

Soil Conservation Service (SCS). 1983. Soils of Colorado, Loss Factors and Erodibility of Hydrologic Groupings. U.S. Department of Agriculture (USDA).

Soil Conservation Service (SCS). Revised 1984. A Guide for Predicting Soil Loss from Water Erosion in Colorado. Technical Note 50. U.S. Department of Agriculture (USDA).

Spencer, F.D. 1961. Bedrock Geology of the Louisville Quadrangle, Colorado, U.S. Geological Survey Quadrangle Map GQ-151.

Tchobanoglous, G., H. Theisen, and S. Vigil. 1992. Integrated Solid Waste Management, Engineering Principles and Management Issues. McGraw-Hill, New York.

Van Horn, R. 1972. Surficial and Bedrock Geologic Map of the Golden Quadrangle, Jefferson County, Colorado. U.S. Geological Survey Miscellaneous Geologic Investigation Map I-761-A.

Weimer, R.J. 1976. Cretaceous Stratigraphy, Tectonics, and Energy Resources, Western Denver Basin. In R.C. Epis and R.J. Weimer, eds. Studies in Colorado Field Geology, Colorado School of Mines Professional Contributions 8, p. 180-223.

DRAFT PROPOSED PLAN AND DRAFT MODIFICATION OF COLORADO HAZARDOUS WASTE PERMIT FOR ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE OPERABLE UNIT 7: PRESENT LANDFILL

United States Department of Energy (DOE) | Jefferson County, Colorado | July 27, 1995

DOE Announces Preferred Alternative for OU 7, Present Landfill

The responsibility for the cleanup of the Rocky Flats Environmental Technology Site (Rocky Flats) (formerly known as the Rocky Flats Plant) has been assigned to the United States Department of Energy (DOE). The site is located north of Golden, Colorado, in Jefferson County.

Cleanup at Rocky Flats is being administered under both the ***Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)***[1] and the ***Resource Conservation and Recovery Act (RCRA)***. The specific requirements and responsibilities for Rocky Flats cleanup are outlined in the ***Interagency Agreement (IAG)*** among DOE, the United States Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE). CDPHE is the lead regulatory agency for this action.

The subject of this document, which is a combination ***Corrective and Remedial Action Proposed Plan (PP)*** and Draft Hazardous Waste Permit Modification, is Rocky Flats ***Operable Unit*** (OU) 7, the Present Landfill. OU 7 consists of four ***individual hazardous substance sites (IHSSs)*** including and associated with the Present Landfill. This PP applies only to OU 7.

The purpose of the PP is to announce DOE's ***preferred alternative*** for OU 7. The PP serves as the basis for the ***Corrective Action Decision/ Record of Decision (CAD/ROD)*** for OU 7. The Draft Permit Modification is used to incorporate remedial action decisions at Rocky Flats into the site's RCRA permit. CDPHE issues the Final Hazardous Waste Permit Modification after the remedial decision process is complete. Closure requirements for OU 7 under RCRA and the Colorado Hazardous Waste Act (CHWA) can be achieved through two actions, an accelerated action for passive leachate collection and treatment and an interim/final action of landfill containment. Landfill containment is the preferred remedy for CERCLA municipal landfills and can thus be pursued as a presumptive remedy. The accelerated action for passive leachate collection and treatment was approved by EPA and CDPHE in June 1995. It will be completed by December 1995. This PP addresses only the presumptive remedy for landfill containment.

The preferred alternative for landfill containment proposed in this plan is Alternative 7: Single-Barrier Flexible Membrane Cover (FMC) with Low-Permeability Soil. This alternative is one of nine originally identified and represents the best solution relative to seven of the

---

MARK YOUR CALENDAR: OPPORTUNITIES FOR PUBLIC INVOLVEMENT

Public Comment Period: December 15, 1995 - February 16, 1996

Public Hearing: December ___, 1995
Time: 7:00 - 8:00 PM
Location: Arvada Center, 6901 Wadsworth Blvd., Arvada

Send Comments to:
DOE's External Affairs Office
P.O. Box 928, Golden, CO 80402-0928

W. Carl Spreng, Geologist
Colorado Department of Public Health and Environment HMWMD-HWC-B2
4300 Cherry Creek Drive South
Denver, CO 80222-1530
Phone: (303) 692-3358

Information Repositories:
Rocky Flats Public Reading Room
Front Range Community College
Level B
3645 W. 112th Avenue
Westminster, CO 80030

Colorado Department of Public Health and Environment
Hazardous Materials and Waste Management Division
4300 Cherry Creek Drive South
Denver, CO 80222-1530

Rocky Flats Citizens Advisory Board
9035 Wadsworth Parkway
Suite 2250
Westminster, CO 80021

Standley Lake Library
8485 Kipling
Arvada, CO 80005

U.S. Environmental Protection Agency
Superfund Records Center
999 18th Street, 5th floor
Denver, CO 80202-2466

[1] Words shown in italics on the first mention are defined in the glossary at the end of this Proposed Plan.

tp\251078\proplan.doc

367

nine CERCLA evaluation criteria. The final two criteria, regulatory and community acceptance, will be addressed in the CAD/ROD. Four of the nine alternatives were carried through the EPA detailed analysis of alternatives process. The three alternatives considered in detail in addition to Alternative 7 include Alternative 1: No Action, Alternative 5: Single-Barrier FMC Cover, and Alternative 9: Composite-Barrier FMC with Clay Cover.

The alternative presented here is DOE's recommended alternative for OU 7. DOE, CDPHE, and EPA will make the final remedy selection after considering comments from the public. A summary of responses to all comments will be prepared and included in the ***Responsiveness Summary*** section of the CAD/ROD. The CAD/ROD will be prepared and published by DOE following the public comment period.

PUBLIC INVOLVEMENT PROCESS

Community acceptance is one of the criteria that DOE and the regulatory agencies must evaluate during the process of selecting a final remedy. Evaluation of community acceptance can be accomplished through a formal public involvement program. DOE's program consists of (1) continuing dialogue with citizens on issues of concern such as the OU 7 Draft Phase I ***Interim Measure/Interim Remedial Action*** (IM/IRA) Decision Document (IM/IRA DD) and (2) seeking citizen participation in the selection of the final remedy at the site. This PP is issued for public input in support of both components of DOE's process. Public interaction is critical to the successful implementation of the RCRA/CERCLA programs.

Although this plan identifies a single-barrier FMC cap with a low-permeability soil layer as the preferred alternative for OU 7, the public is encouraged to review and comment on all the alternatives. The final alternative may be different from the preferred alternative depending on new information or arguments that the agencies consider as a result of public comments. Details on the individual alternatives can be found in the OU 7 Draft Phase I IM/IRA DD, located in the information repositories listed on page 1 of this plan.

A public comment period will be held for the PP and Draft Permit Modification. The public comment period will be from December 15, 1995 to February 16, 1996. A public hearing will be held on December __, 1995. Comments on the PP, Draft Permit Modification, and OU 7 Draft Phase I IM/IRA DD may be submitted orally or in writing at the public hearing. Alternatively, written comments, postmarked no later than February 12, 1996, can be sent to the addresses listed on page 1 of this plan.

Upon timely request, the comment period may be extended. Such a request must be submitted in writing to DOE, postmarked no later than February 12, 1996. FAILURE TO RAISE AN ISSUE OR PROVIDE INFORMATION DURING THE PUBLIC COMMENT PERIOD MAY PREVENT THE PUBLIC FROM RAISING THAT ISSUE OR SUBMITTING SUCH INFORMATION IN AN APPEAL OF THE AGENCIES' FINAL DECISION.

SITE BACKGROUND

Rocky Flats is located in northern Jefferson County, Colorado (see Figure 1). Rocky Flats occupies approximately 6,550 acres of federal land and is a government-owned, contractor-operated facility in the nationwide nuclear weapons production complex. DOE's former mission at Rocky Flats was to produce components for nuclear weapons from plutonium, uranium, and non-radioactive materials. The facility's current mission is to manage wastes and materials and to cleanup and convert the Rocky Flats site to beneficial use in a manner that is safe, environmentally and socially responsible, physically secure, and cost-effective.

Most plant buildings are located within the Rocky Flats industrial area, which occupies approximately 400 acres. This area is surrounded by a buffer zone of approximately 6,150 acres. OU 7, the Present Landfill, is located in the Rocky Flats buffer zone, north of the industrial area.

OU 7 began receiving hazardous and nonhazardous plant waste in 1968. Since 1986, only nonhazardous plant waste such as office trash, construction debris, scrap metal, dried sanitary sewage sludge, and miscellaneous containers has been disposed. Landfill operations will continue until the new landfill opens in 1997. As is common practice at municipal landfills, waste delivered to the landfill is spread across the work area, compacted, and covered with soil.

OU 7 includes four areas previously identified as IHSSs where past operational practices may have resulted in environmental impacts. Brief descriptions of the OU 7 IHSSs are presented below. Figure 2 shows the IHSS locations.

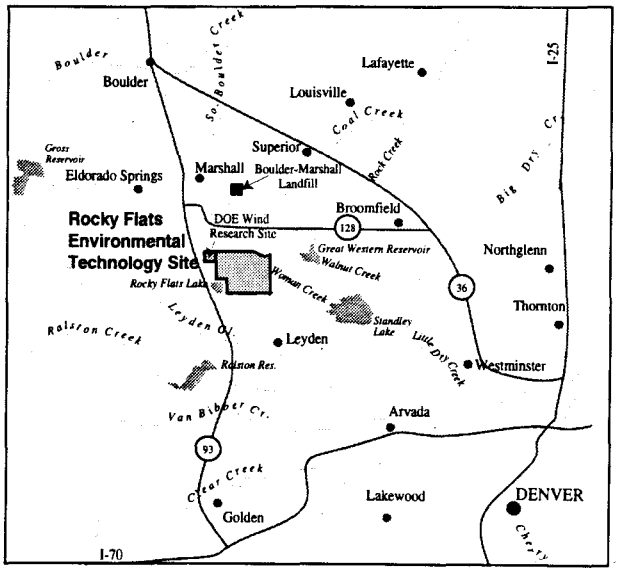


Figure 1

368

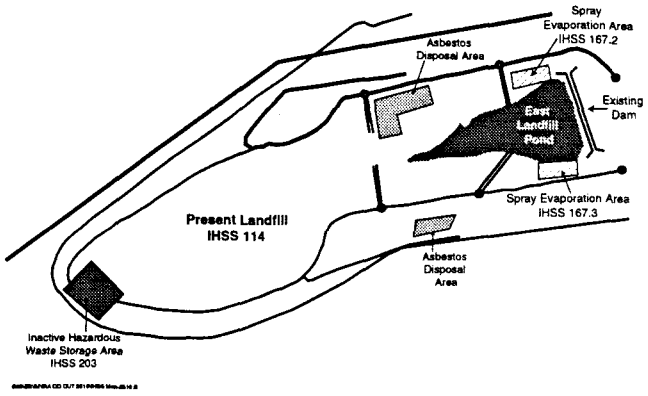


Figure 2

- **IHSS 114, Present Landfill.** The Present Landfill is located north of the industrial area, on the western end of No Name Gulch. It encompasses approximately 20 acres. Initially, soils were hauled in from an onsite borrow area and deposited in the natural drainage to provide a 5-foot-thick base to start landfilling. Rocky Flats hazardous waste was disposed between 1968 and 1986; nonhazardous wastes have been disposed at the landfill since 1968. Asbestos was disposed in pits near the eastern edge of the landfill.

- **IHSS 203, Inactive Hazardous Waste Storage Area.** The Inactive Hazardous Waste Storage Area is located at the southwest corner of the Present Landfill. The area was actively used between 1986 and 1987 as a hazardous waste storage area for both drummed liquids and solids. Cargo containers on the ground contained drums with liquid waste; solid waste in drums was stored outside the cargo containers. All drums and cargo containers were removed in May 1987.

- **IHSSs 167.2 and 167.3, Spray Evaporation Areas.** These IHSSs are two discrete areas adjacent to the landfill that received spray waters from the East Landfill Pond between 1975 and 1994. Waters collected in the East Landfill Pond were periodically sprayed in the two locations to maintain the pond level at 75 percent capacity.

Several interim response actions have been implemented at OU 7 since 1973 to control landfill leachate. They include construction of a surface-water diversion ditch, two detention ponds east of the landfill, a subsurface groundwater-intercept system, and a subsurface leachate-collection trench.

SUMMARY OF SITE RISKS

The ***risks*** to human health and the environment associated with OU 7 were characterized through two phases of field investigations and are summarized in the OU 7 Draft Phase I IM/IRA DD. Under the presumptive remedy approach, a quantitative ***baseline risk assessment*** is not necessary if the containment remedy addresses pathways and contaminants of concern associated with the source. Rather, all potential exposure pathways can be identified using the conceptual site model and compared to the pathways addressed by the presumptive remedy. This comparison is provided in the OU 7 Draft Phase I IM/IRA DD.

The risks present in pathways at OU 7 that will not be addressed by the presumptive remedy were quantified using a focused risk assessment approach. The focused risk assessment process consists of comparing the maximum concentration of each PCOC occurring at OU 7 against the sitewide preliminary remediation goal (PRG) established for Rocky Flats. PCOCs occurring at concentrations exceeding the PRG are then subjected to the focused quantitative risk assessment analysis, including quantification of exposure and toxicities. This process is undertaken for both human and ecological receptors. No significant environmental risks were identified outside of the acceptable range beyond the proposed containment. Average concentrations of PCOCs were also compared to ***applicable or relevant and appropriate requirements (ARARs)***. Post-closure monitoring for 30 years is included as part of the PP to confirm that risk remains in the acceptable range.

The following ***Remedial Action Objectives (RAOs)*** have been set in accordance with EPA guidance for protection of human health and environmental receptors from potential adverse effects associated with the landfill:

1. prevent direct contact with landfill contents
2. minimize infiltration and resulting contaminant leaching to groundwater
3. control surface-water run-off and erosion
4. control landfill gas (treat as needed)
5. remediate wetland areas (as needed)

These RAOs were used to formulate appropriate remedial action alternatives for the OU 7 Present Landfill.

SUMMARY OF REMEDIAL ACTION ALTERNATIVES

The following remedial action alternatives were identified and subjected to a detailed analysis to identify a preferred remedy for OU 7.

- **Alternative 1: No Action.** This alternative, as required under the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), provides a baseline for comparison of other alternatives. Under this alternative, the landfill remains as is and the existing interim soil cover serves as the final cover.

- **Alternative 5: Single-Barrier FMC Cover.** This alternative consists of a single-barrier FMC cover and institutional controls. The membrane cover has a permeability of 1×10^{13} cm/sec and is underlain by a 6-inch soil bedding layer and a geocomposite gas-collection layer. This soil has a permeability of 1×10^{-2} cm/sec. The cover is overlain by a geocomposite lateral drainage layer and a 3-foot vegetative layer.

- **Alternative 7: Single-Barrier FMC with a Low-Permeability Soil Cover.** This alternative parallels Alternative 5 in every feature, except for the soil layer immediately underlying the membrane cover. Alternative 7 proposes a 12-inch layer of soil

369

with a permeability of 1 x10^{-5} cm/sec, reducing the overall potential for migration through the cover.

- **Alternative 9: Composite-Barrier FMC and Clay Cover**. This alternative includes a membrane cover underlain by 24 inches of compacted clay with a permeabilty of 1 x 10^{-7} cm/sec and a geocomposite gas-collection layer. The membrane is overlain with a geocomposite lateral drainage layer and a 3-foot vegetative layer. The alternative also includes institutional controls. This composite cover follows EPA guidance for a RCRA Subtitle C cover.

SUMMARY OF DETAILED ANALYSIS OF ALTERNATIVES

The detailed analysis of alternatives, conducted as part of the IM/IRA decision process, evaluated each of the alternatives with respect to nine criteria identified by the NCP. Figure 3 graphically summarizes comparisons of the alternatives. Each of the criteria is discussed briefly below.

1. **OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT.** All of the alternatives, with the exception of the no-action alternative, meet the criteria for overall protection of human health and the environment.

2. **COMPLIANCE WITH ARARS.** Each of the alternatives for containment achieve the same level of compliance with ARARs. The surface water ARAR for manganese is not addressed by any of the alternatives. However, manganese is naturally occurring in sediments in the East Landfill Pond. Discharge of leachate into the pond may have resulted in mobilization of manganese from the sediments. Containment of leachate under the cap is expected to reduce concentrations of manganese. In addition, results of the focused risk assessments have shown that there is no associated risk to human or ecological receptors from pond water. Groundwater ARARs for nitrate/nitrite, sulfate, and selenium are not addressed by any of the alternatives. However, the cap will reduce recharge to groundwater and as a result, contaminant migration away from the landfill is expected to be minimal. Potential exposure pathways associated with groundwater are incomplete because there are no plans for future development of groundwater at OU 7.

3. **REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT.** Because there is no treatment in any of the alternatives, this criteria does not apply. However, there may be some decrease in toxicity and mobility over time due to natural attenuation. In addition, the cap minimizes infiltration into the waste thus decreasing generation and migration of leachate.

4. **LONG-TERM EFFECTIVENESS AND PERMANENCE.** Long-term effectiveness and permanence is very similar between the three cover alternatives. Alternative 7, with the low-permeability soil, affords the highest degree of long-term protection due to its increased resistance to eventual desiccation.

5. **SHORT-TERM EFFECTIVENESS.** Short-term effectiveness is not variable between the cover alternatives. Alternative 5 is deemed slightly better because it involves the least soil quantities and therefore poses the lesser risk to construction workers from dust generation.

6. **IMPLEMENTABILITY.** Implementability is comparable among the three cover alternatives. Alternative 7 is the most reliable and Alternative 9 is the most difficult to construct and maintain.

7. **COST.** Cost is a significant distinguishing factor among the three containment alternatives. The total present worth costs are:

Alternative 1	$0
Alternative 5	$9,469,100
Alternative 7	$10,149,000
Alternative 9	$12,103,600

8. **REGULATORY AGENCY ACCEPTANCE.** This criterion is evaluated after the public involvement process, before the final decisions regarding the PP.

9. **COMMUNITY ACCEPTANCE.** This criterion is evaluated after the public involvement process, before the final decisions regarding the PP.

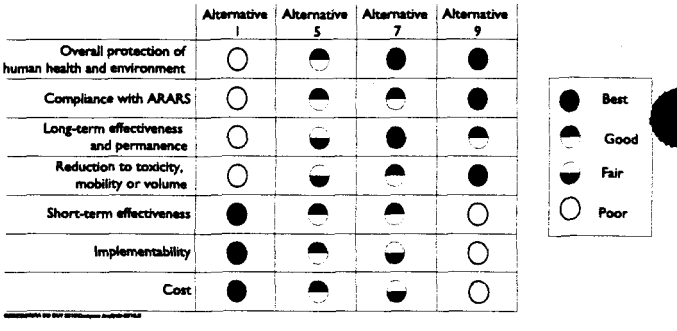


Figure 3

SUMMARY OF PREFERRED ALTERNATIVE

The OU 7 detailed analysis of alternatives concludes that Alternative 7, the Single-Barrier FMC with Low-Permeability Soil Cover best meets the RAOs of the IM/IRA. Major factors, including the long-term and short-term effectiveness and implementability, coupled with the technical performance, made this the preferred alternative. In addition to the cover and the institutional controls, the IM/IRA document proposes a 30-year post-closure maintenance and monitoring plan to be implemented once the cover is installed. This plan includes semiannual upgradient and downgradient groundwater monitoring, quarterly gas monitoring, and annual cover surveys and facility inspections.

310

GLOSSARY

Applicable or Relevant and Appropriate Requirements (ARARs): ARARs are criteria, standards, or limitations promulgated under state or federal law that may be selected to establish cleanup levels a remedial action is to obtain.

Baseline Risk Assessment (BRA): An assessment of the risks to human health and the environment at a site. The methodology employed in risk assessment uses contaminant concentrations and potential exposure routes to quantify risks associated with present and future site conditions.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund): A law passed in 1980 and amended in 1986 to establish a program to identify abandoned hazardous waste sites, ensure that they are cleaned up, and evaluate damages to natural resources.

Corrective Action Decision/Record of Decision (CAD/ROD): A public document that explains which cleanup alternative(s) are selected at a RCRA/CERCLA site. The CAD/ROD is based on information obtained from the RFI/RI, the CMS/FS, and community participation.

Corrective and Remedial Action Proposed Plan (PP): The public document that first introduces the lead agency's preferred alternative for site remediation. The PP is produced through the cooperation of the lead and regulatory agencies and is reviewed by the public.

Individual Hazardous Substance Site (IHSS): An area that may be contaminated as a result of previous operations and disposal practices.

Interagency Agreement (IAG): The January 22, 1991, document prepared by representatives from DOE, EPA, and CDPHE. It presents the objectives and general protocols for addressing the cleanup or evaluation of each of the operable units at Rocky Flats.

Interim Measure/Interim Remedial Action (IM/IRA): An early action taken to control a release or threatened release of hazardous substances.

Operable Unit (OU): A term defined by CERCLA used to describe a certain portion of a CERCLA site. An operable unit may be established based on a particular type of contamination, contaminated media (e.g., soils, water), source of contamination, and/or geographical location.

Preferred Alternative: The preliminary recommendation that is judged to best address the CERCLA criteria of overall protection of human health and environment, compliance with ARARs, long- and short-term effectiveness, implementability, cost, and the reduction of contaminant toxicity, mobility, or volume through treatment.

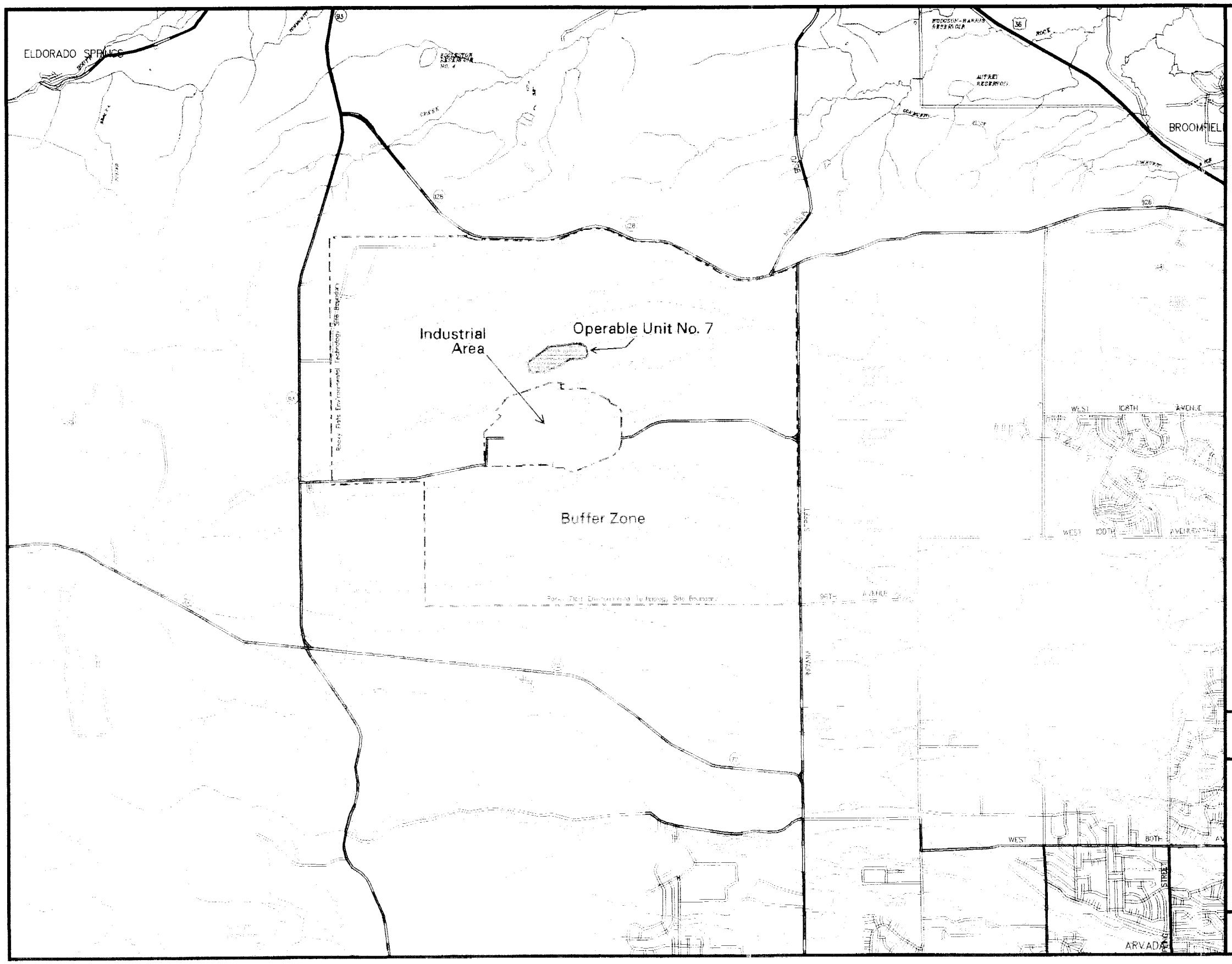
Remedial Action Objectives (RAOs): RAOs are medium-specific goals for protecting human health and the environment.

Resource Conservation and Recovery Act (RCRA): A law passed in 1976 by the U.S. Congress to require the "cradle-to-grave" management of hazardous wastes. CDPHE, through the Hazardous Materials and Waste Management Division, implements RCRA in Colorado.

Responsiveness Summary: The part of the CAD/ROD that summarizes public and agency comments and provides responses to those comments.

Risk: The likelihood of an adverse effect on the health of a human or ecological population as a result of exposure to chemical and/or radiological constituents.

371 \ 371



EXPLANATION

- Streams
- Rocky Flats Environmental Technology Site Boundary
- Primary Roads
- Secondary Roads
- Light-Duty Roads
- OU 7

0 Miles 1 2

0 Feet 4500 9000

Scale: 1 inch = 4500 feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Location of Operable Unit No. 7

Phase I IM/IRA DD

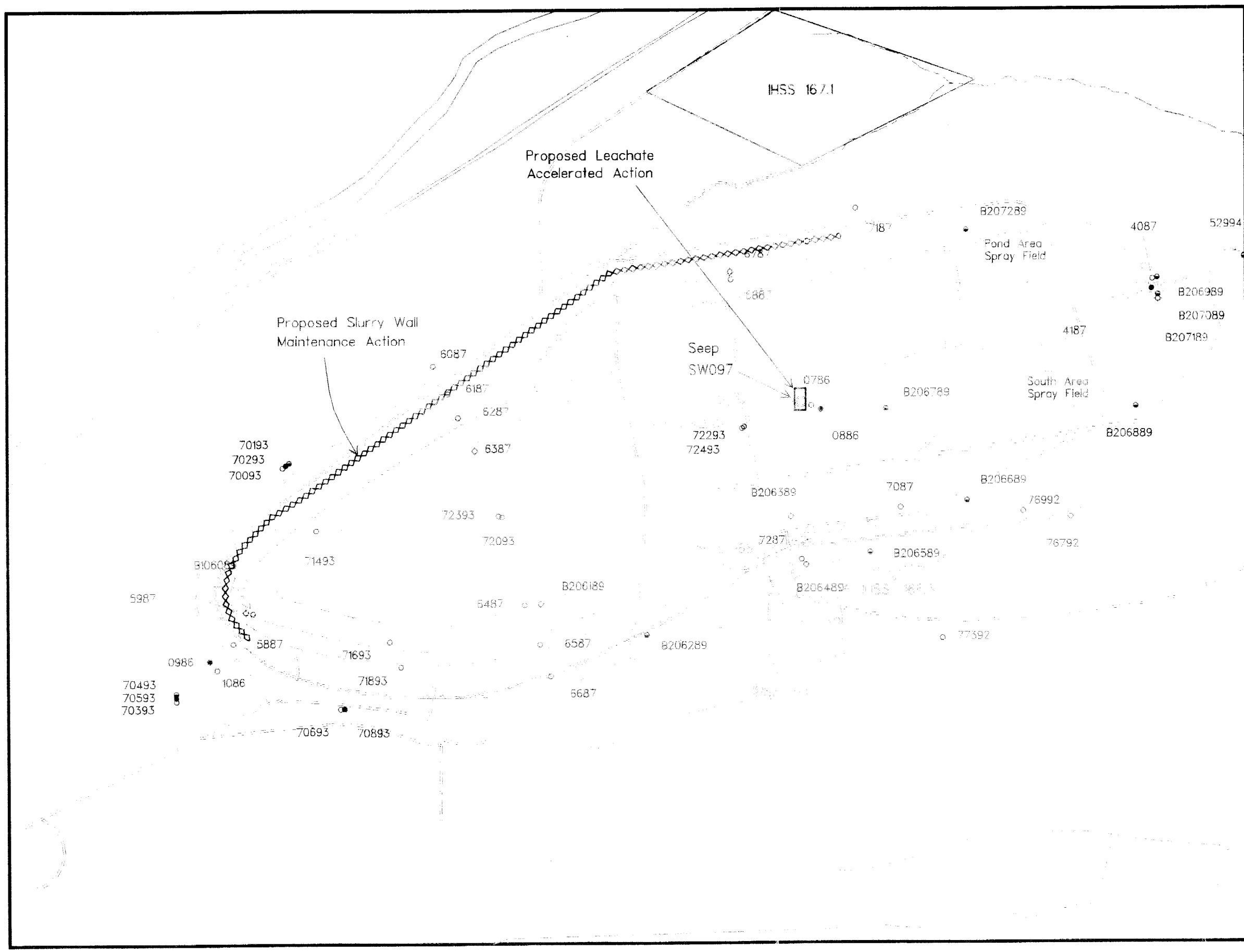
Operable Unit No. 7

July 1995

Figure 1-2

07/10/95 VICINITY2.MAP

39



EXPLANATION

- OU 6 IHSS Boundary
- OU 7 IHSS Boundary
- Ditch and Drainage Feature
- Intermittent Stream
- Dirt Road
- Existing Surface-Water Diversion Ditch
- Existing Slurry Wall
- Existing Groundwater Intercept System (perforated) (non-perforated)
- Leachate Collection Trench

0 Feet 250 500

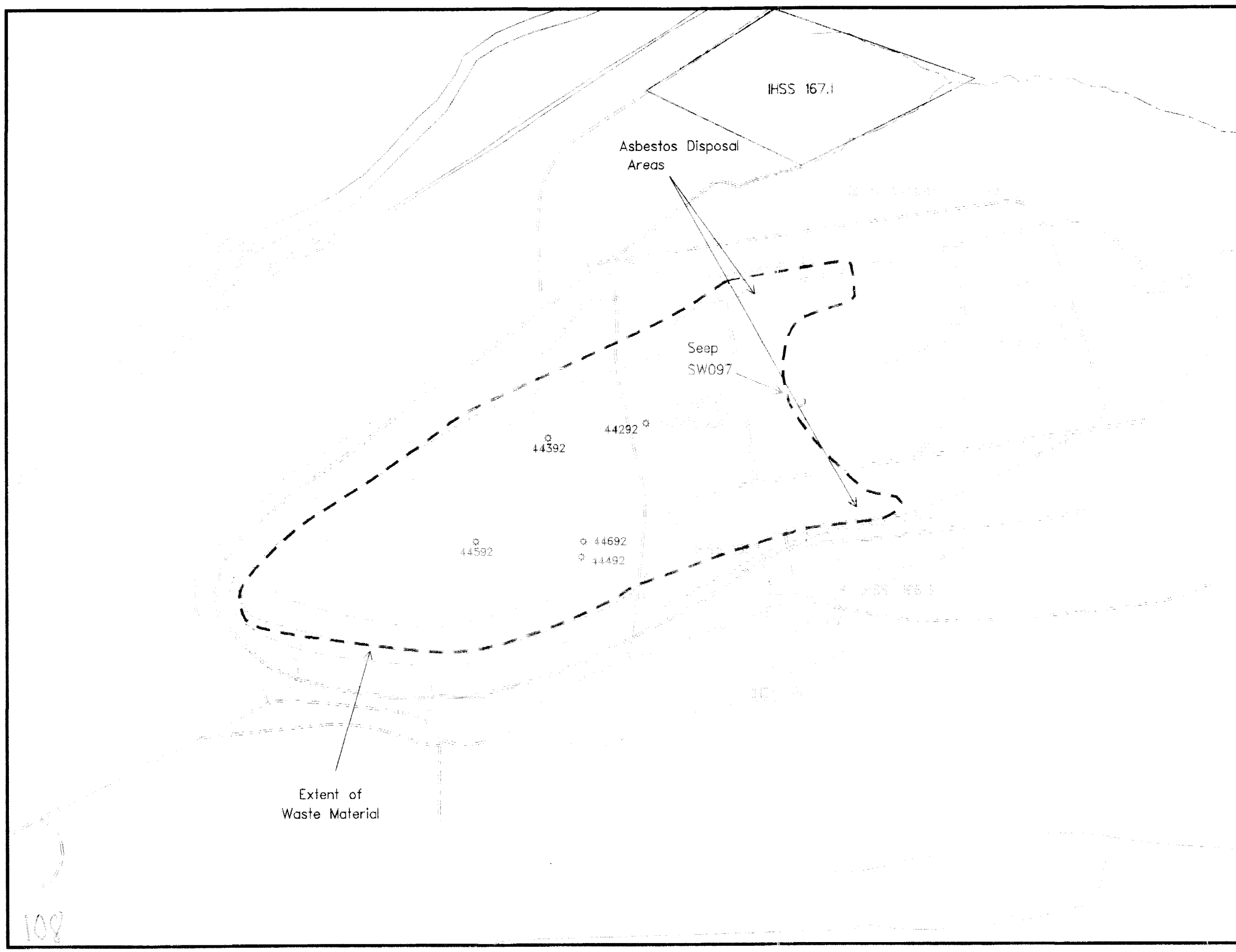
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Location of Other Maintenance and Remedial Actions

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 1-4

07/13/95 MAINTENANCE.MAP



EXPLANATION

- OU 6 IHSS Boundary
- OU 7 IHSS Boundary
- Ditch and Drainage Feature
- Intermittent Stream
- Dirt Road
- Existing Surface-Water Diversion Ditch
- Existing Slurry Wall
- Groundwater Intercept System
  - (perforated)
  - (non-perforated)
- Leachate Collection Trench
- Approximate Extent of Asbestos Disposal
- Extent of Waste Material

0 Feet 250 500

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

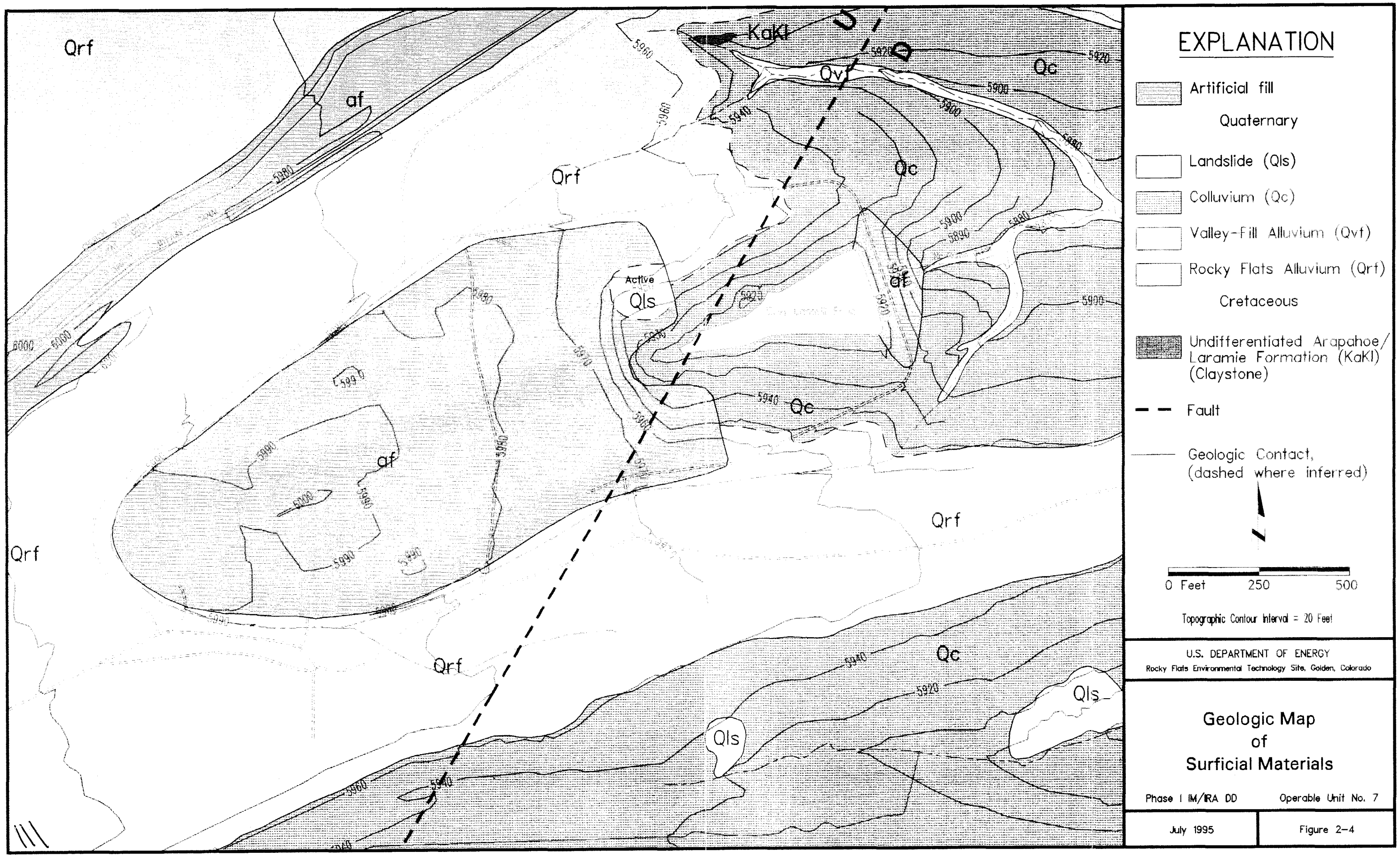
Locations of IHSSs and Historical Interim Response Actions

Phase I IM/IRA DD | Operable Unit No. 7

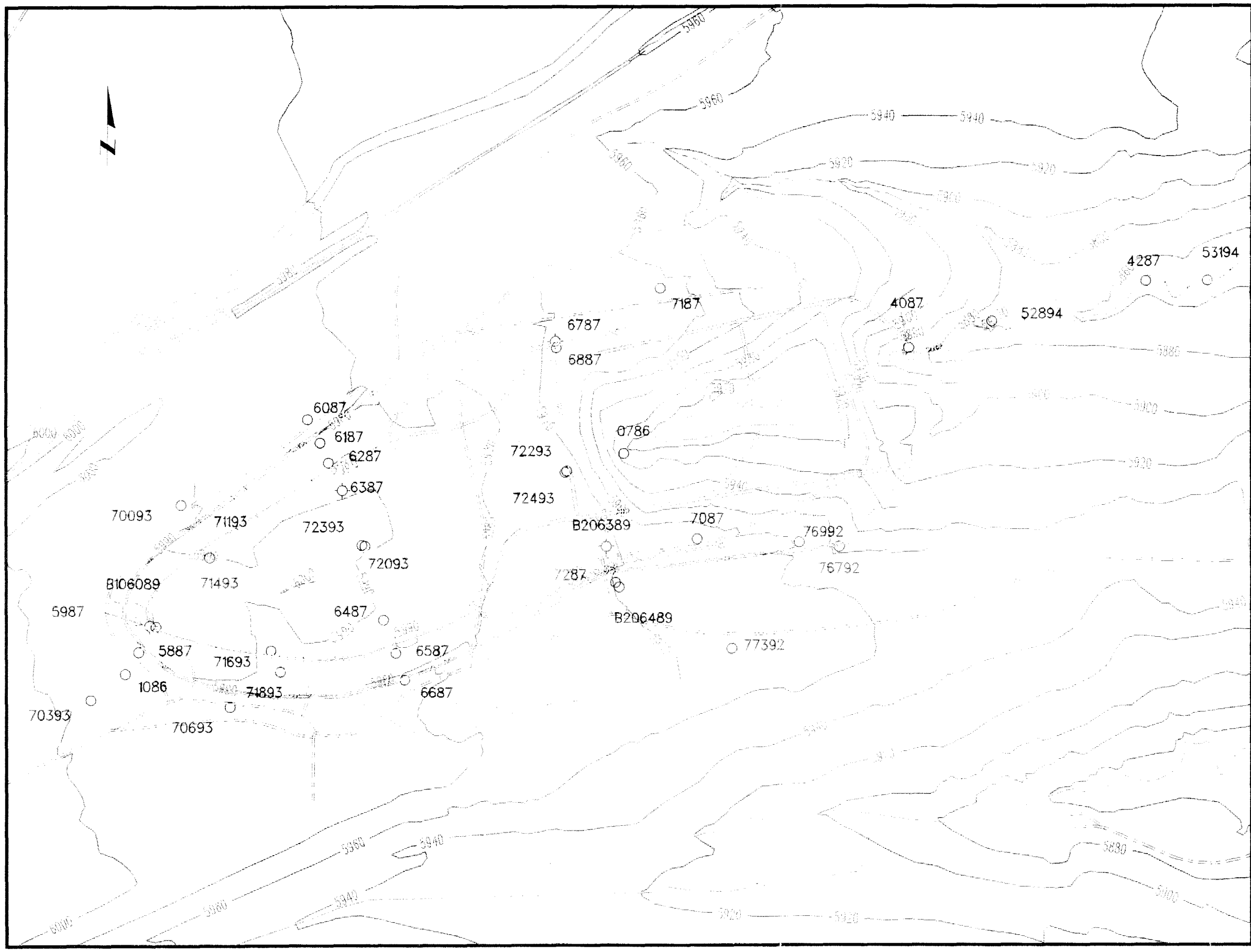
July 1995 | Figure 2-1

108

07/13/95 IHSS.MAP



07/10/95 GEOLOGY.MAP



EXPLANATION

- Alluvial Well
- Abandoned Well
- Ditch
- Intermittent Stream
- Dirt Road
- Surface-Water Diversion Ditch
- Slurry Wall
- Groundwater Intercept System
  - (perforated)
  - (non-perforated)
- Line of Equal Saturated Thickness (dashed where inferred)

(Contour Interval = 2.5 feet)

Unsaturated Areas (dashed where inferred)

Not deep enough to penetrate entire saturated thickness

0 Feet 300 600

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

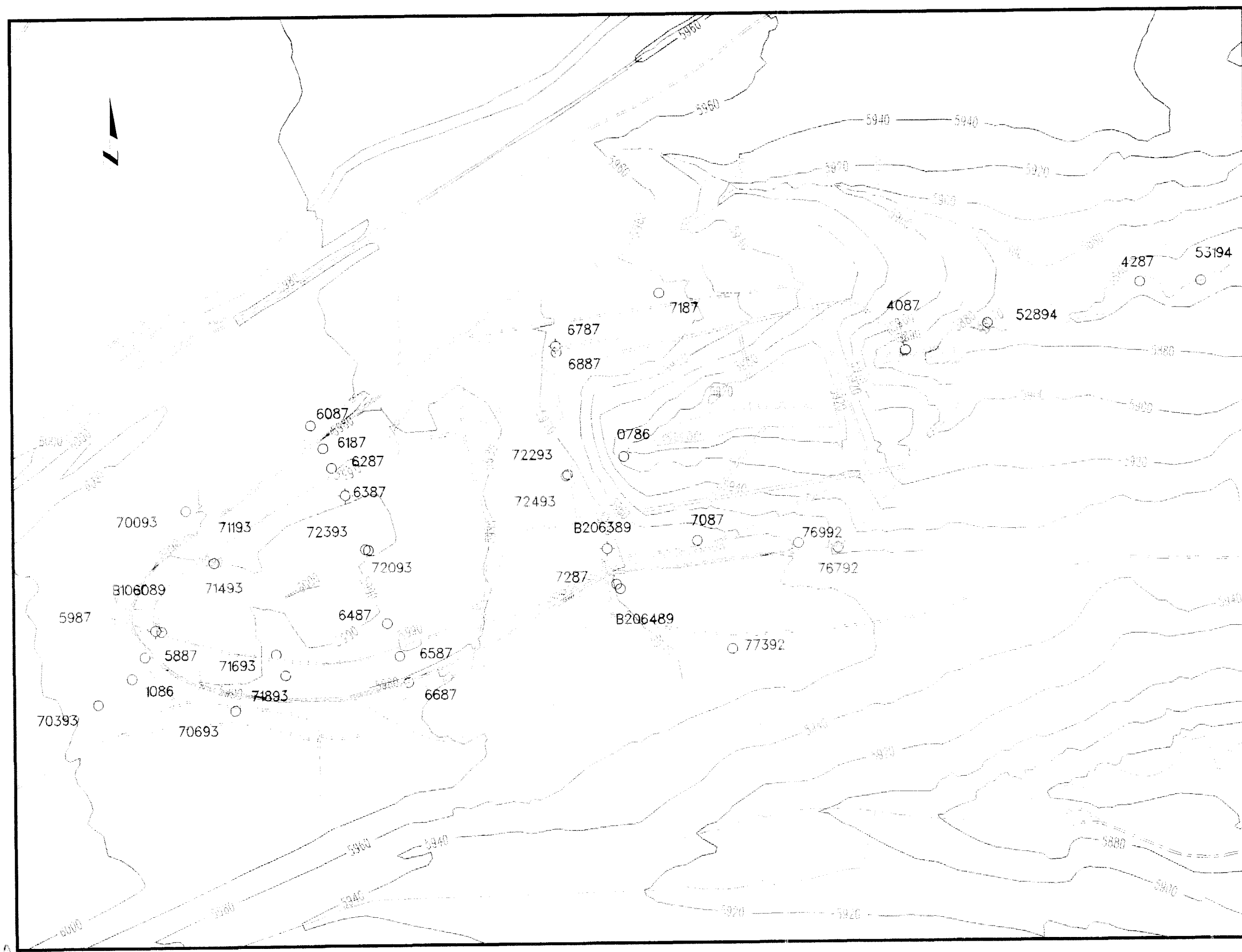
Saturated Thickness of Unconsolidated Surficial Deposits (2nd Quarter 1995)

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 2-6

13

07/10/95 Q295ISM.MAP



EXPLANATION

- Alluvial Well
- Abandoned Well
- Ditch
- Intermittent Stream
- Dirt Road
- Surface-Water Diversion Ditch
- Slurry Wall
- Groundwater Intercept System (perforated) (non-perforated)
- Line of Equal Potentiometric Surface (feet above sea level) (dashed where inferred)

(Contour Interval = 10 feet)

Unsaturated Areas (dashed where inferred)

0 Feet 300 600

Topographic Contour Interval = 20 Feet

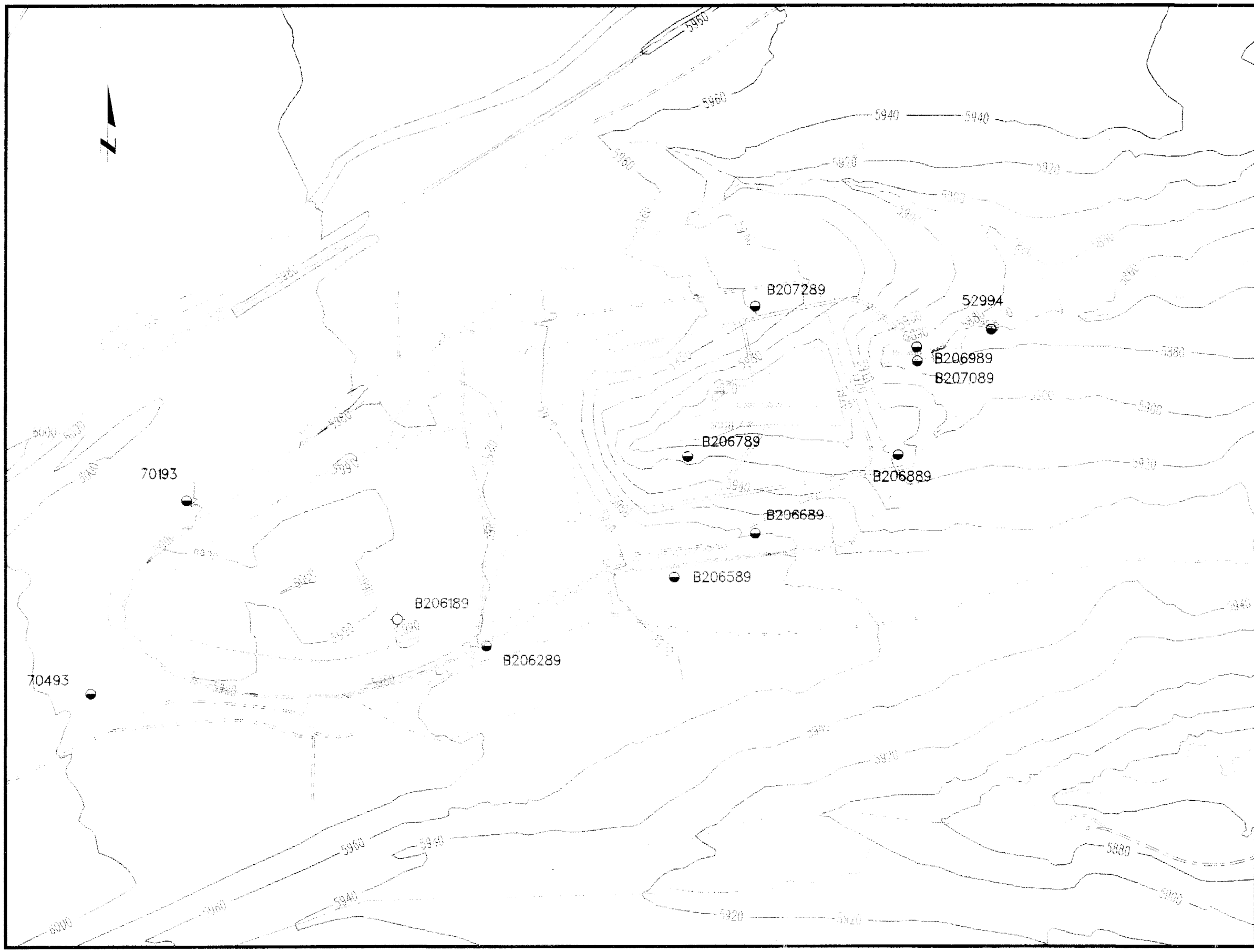
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Potentiometric Map of Surficial Materials Groundwater (2nd Quarter 1995)

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 2-9

07/13/95 Q295SURF.MAP



EXPLANATION

- Weathered Bedrock Well
- Abandoned Well
- Ditch
- Intermittent Stream
- Dirt Road
- Surface-Water Diversion Ditch
- Slurry Wall
- Groundwater Intercept System (perforated) (non-perforated)
- Line of Equal Potentiometric Surface (feet above sea level) (dashed where inferred)

(Contour Interval = 10 feet)

Unsaturated Areas (dashed where inferred)

0 Feet 300 600

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Potentiometric Map of Weathered Bedrock Groundwater (2nd Quarter 1995)

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 2-10

07/10/95 Q295WB.MAP

EXPLANATION

- ◆ Mammal and Vegetation Transects
- Ditch
- Intermittent Stream
- Dirt Road
- Wetlands
- Wet Meadow
- 20 Short Marsh
- 322 Mesic Mixed Grassland
- 323 Xeric Mixed Grassland
- 420 Disturbed Area – Disturbed/Barren Land
- 500 Disturbed Area – Developed Areas

0 Feet 250 500

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

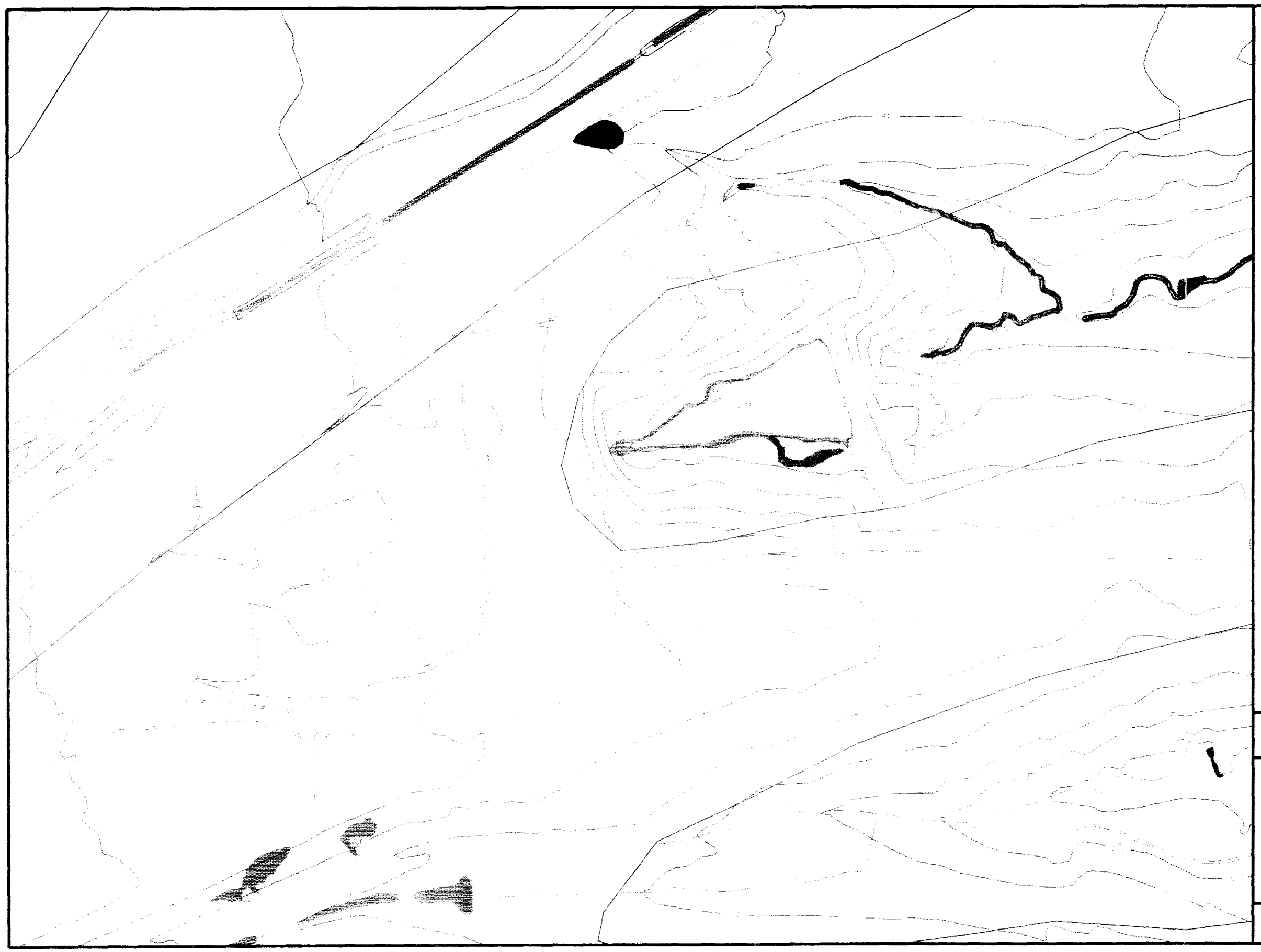
Distribution of Habitat Types

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 2-11

108

07/10/95 HABITAT.MAP



EXPLANATION

Ditch

Intermittent Stream

Dirt Road

Probable Preble's Meadow Jumping Mouse Habitat

WETLANDS

PEMA (Palustrine Emergent, Temporarily Flooded)

PEMB (Palustrine Emergent, Saturated)

PEMC (Palustrine Emergent, Seasonally Flooded)

L1UBH (Lacustrine Limnetic, Unconsolidated Bottom, Permanently Flooded)

0 Feet 300 600

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY

Rocky Flats Environmental Technology Site, Golden, Colorado

Wetland Areas and Preble's Meadow Jumping Mouse Habitat

Phase I IM/IRA DD

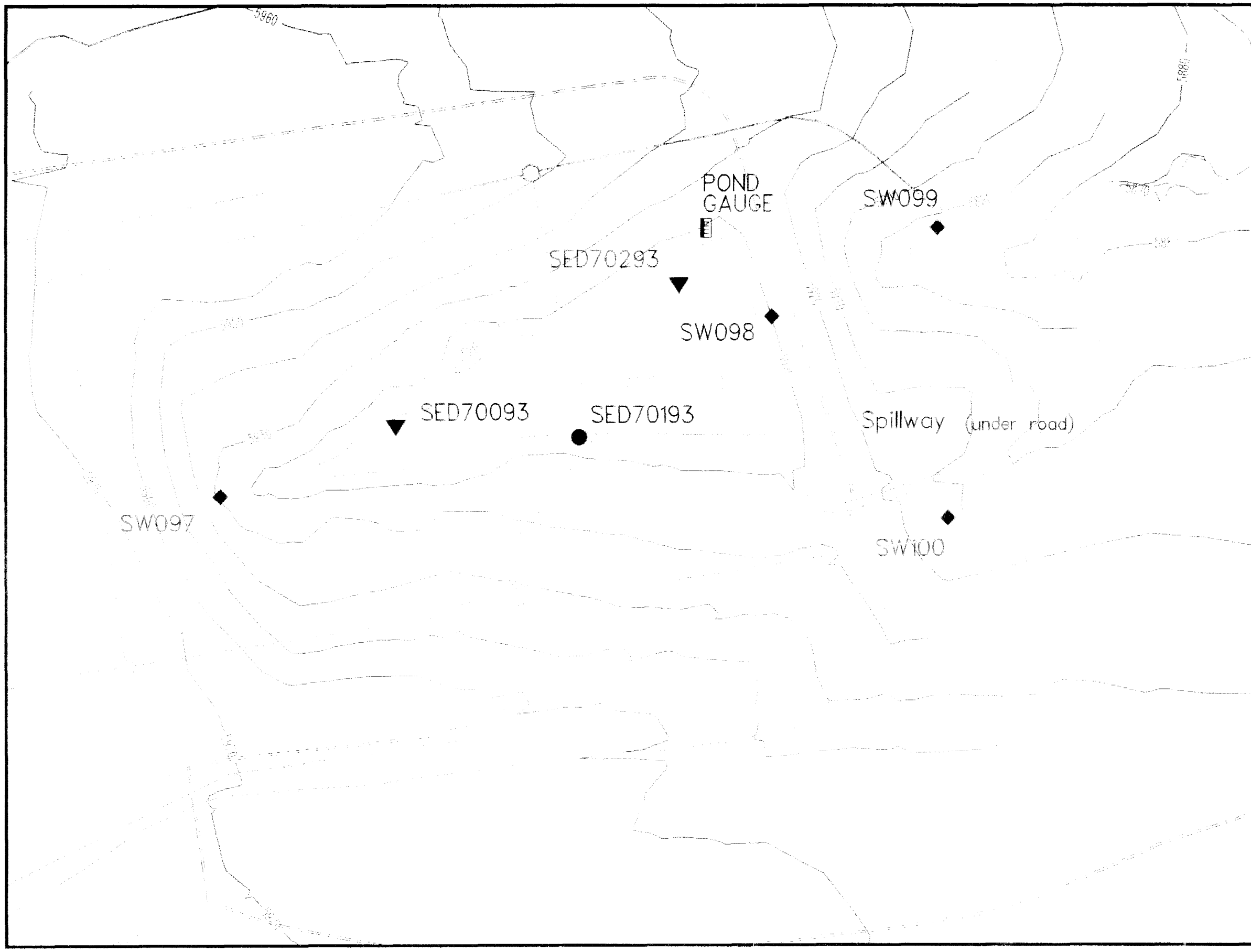
Operable Unit No. 7

July 1995

Figure 2-12

119

07/10/95 WETPREB.MAP



EXPLANATION

- ● Sediment–Sampling Location
- ◆ Surface–Water Sampling Location
- ▼ Acute Toxicity Water and Sediment Sampling Location

Intermittent Stream

Dirt Road

Landfill Structures

N

0 Feet 120 240

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

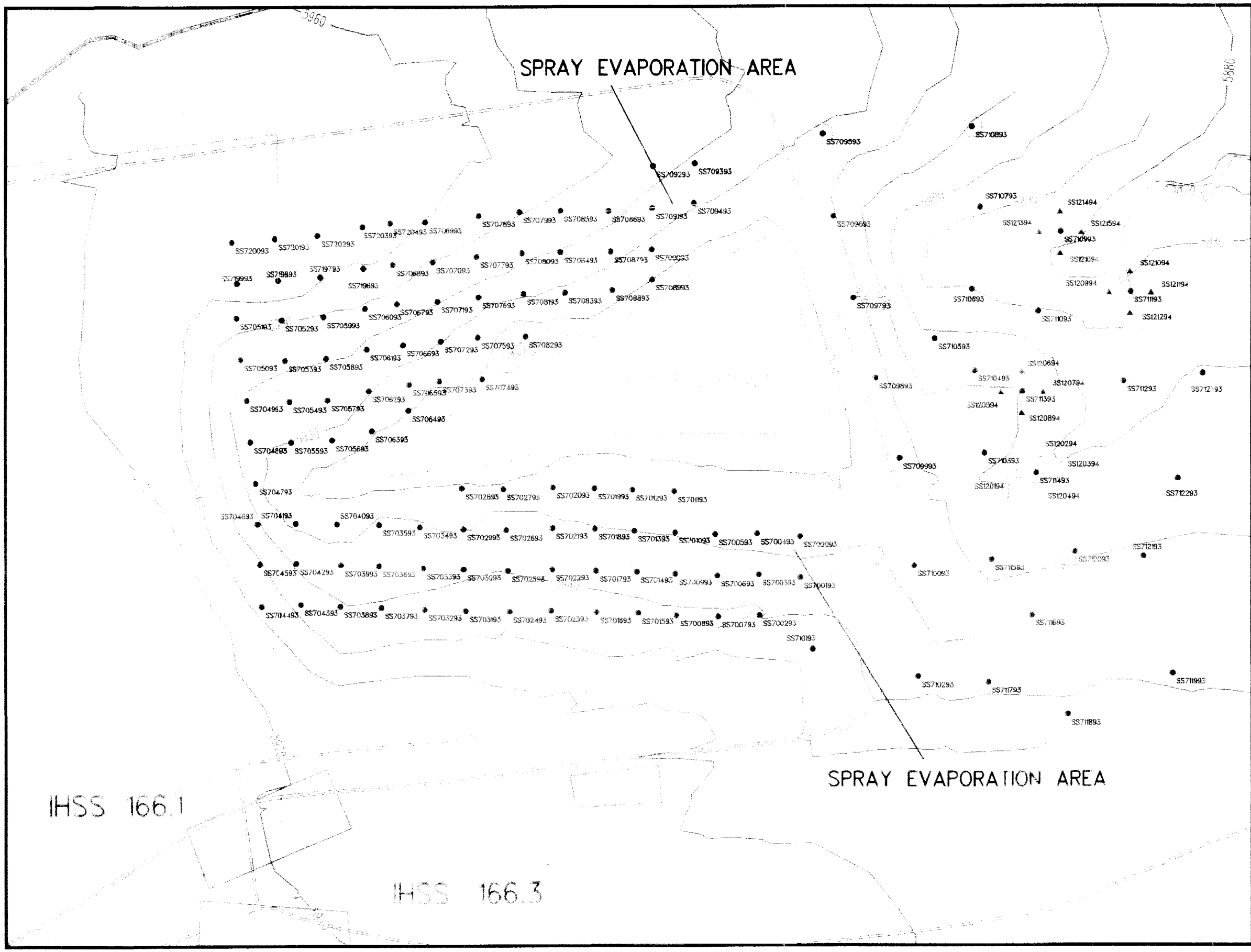
Surface-Water and Sediment Sampling Locations

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 2–13

120

07/10/95 SWSED.MAP



EXPLANATION

- Phase I Surface-Soil Sampling Location
- Additional Surface-Soil Sampling Location
- Phase I Subsurface-Soil Sampling Location
- Additional Subsurface-Soil Sampling Location
- Intermittent Stream
- Dirt Road
- Surface-Water Diversion Ditch
- OU 7 IHSS Boundary
- OU 6 IHSS Boundary

0 Feet 120 240

Topographic Contour Interval = 20 Feet

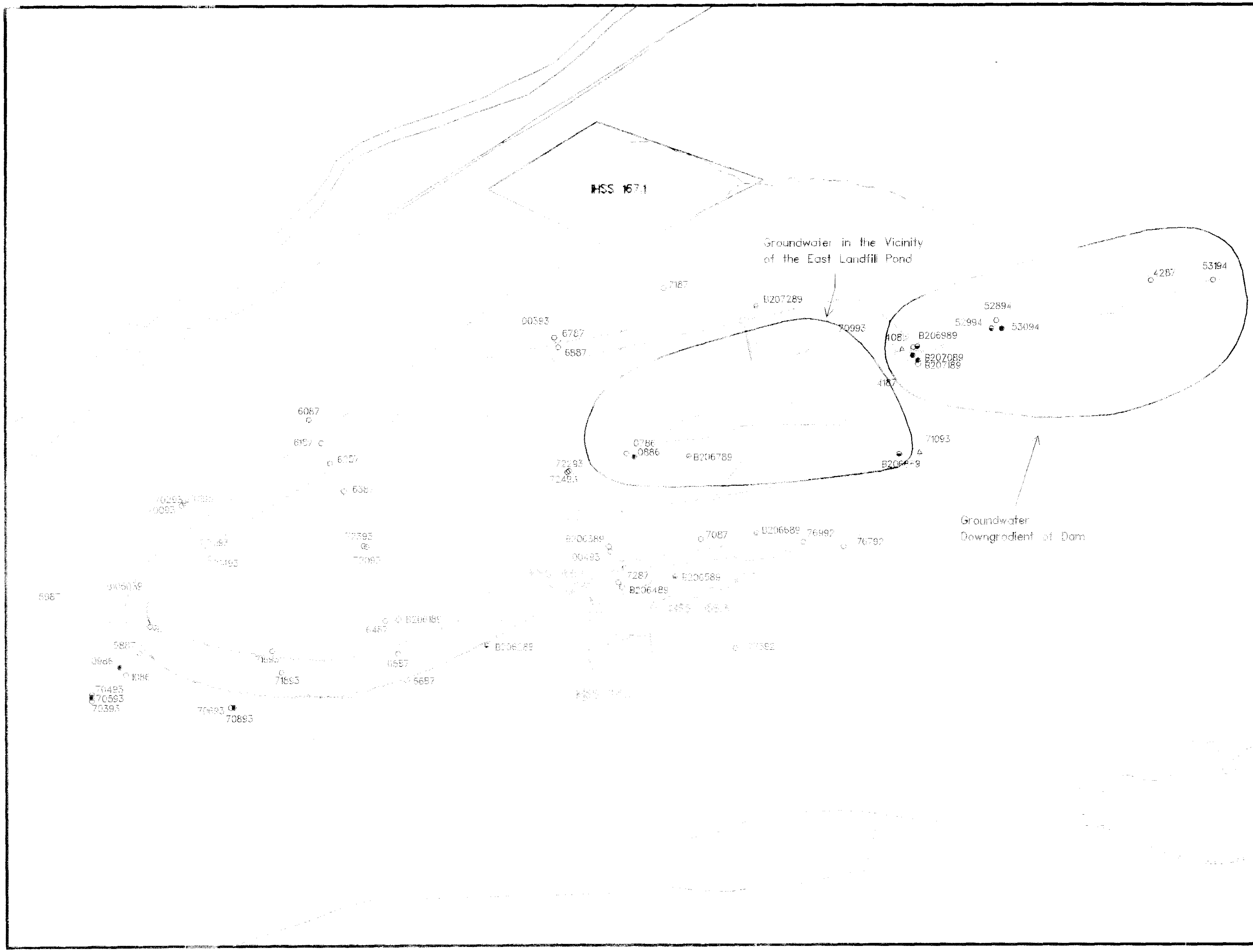
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Soil-Sampling Locations in the Vicinity of Spray Evaporation Areas

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 2-14

07/10/95 SOILSAM.MAP



EXPLANATION

- ○ Alluvial/Artificial Fill Well
- ◒ Weathered Bedrock Well
- ● Unweathered Bedrock Well
- Abandoned Well
- △ Borehole
- Ditch
- Intermittent Stream
- Dirt Road
- OU 7 IHSS Boundary
- OU 6 IHSS Boundary
- Landfill Structures

0 Feet 300 600

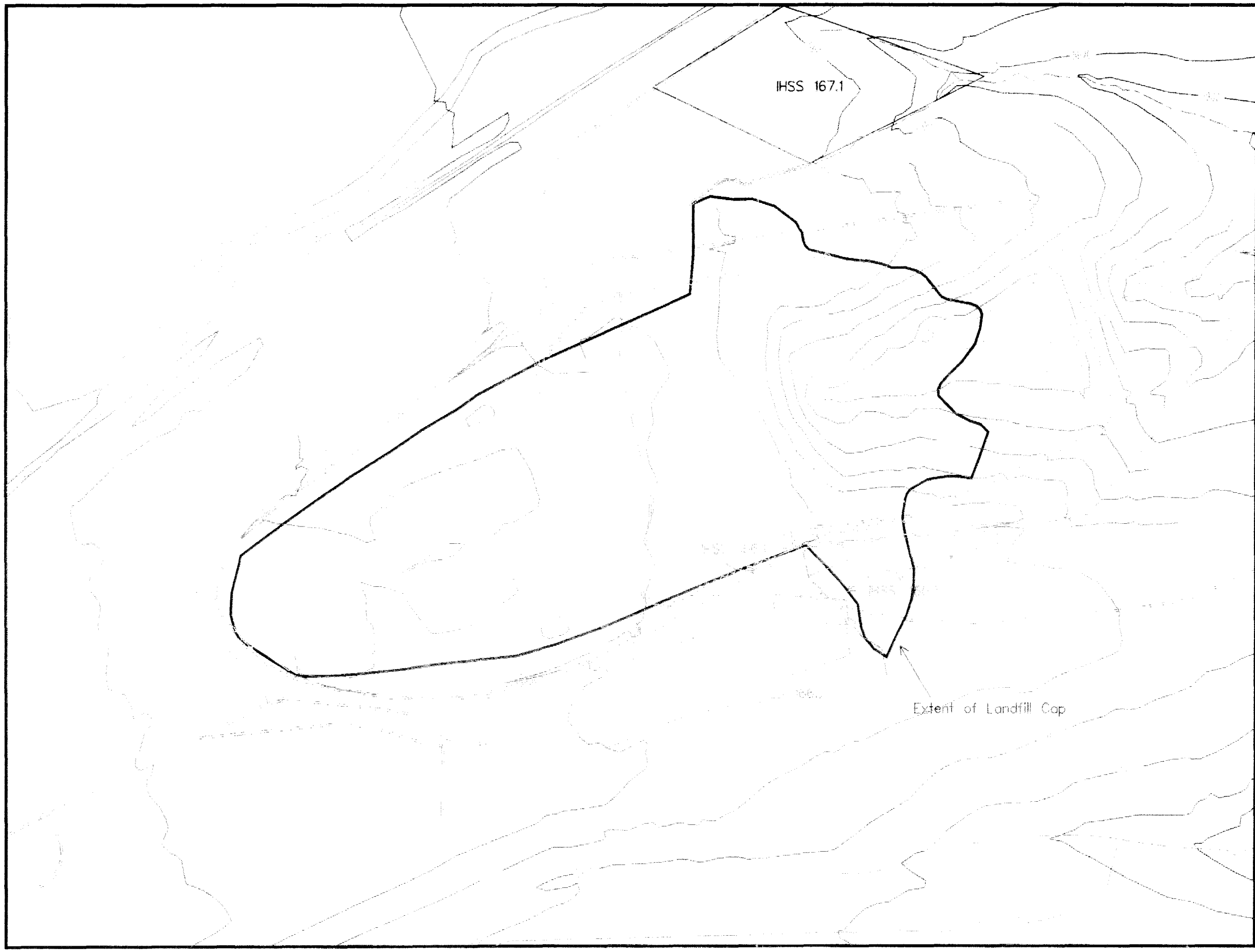
U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Downgradient Subsurface Geologic Materials and Groundwater Sampling Locations

Phase I IM/IRA DD Operable Unit No. 7

July 1995 | Figure 2-15

07/24/95 STATWATERMAP



EXPLANATION

- OU 6 IHSS Boundary
- OU 7 IHSS Boundary
- Ditch and Drainage Feature
- Intermittent Stream
- Dirt Road
- Existing Surface-Water Diversion Ditch
- Existing Slurry Wall
- Approximate Extent of Asbestos Disposal
- Extent of Landfill Cap

0 Feet 250 500

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

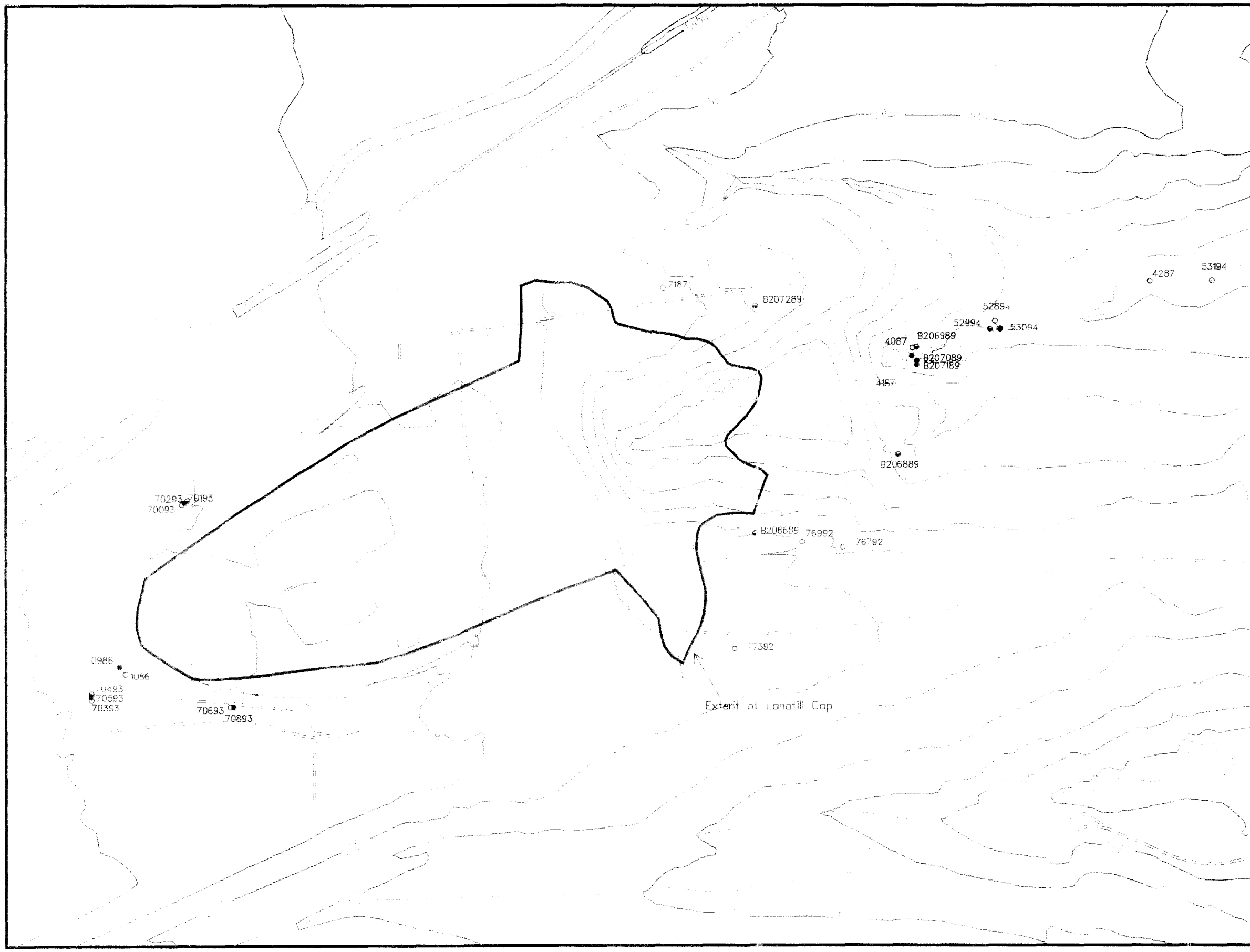
Extent of the Landfill Cap

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 5-1

245

07/10/95 CAP.MAP



EXPLANATION

- Alluvial Well
- Weathered Bedrock Well
- Unweathered Bedrock Well

- Ditch
- Intermittent Stream
- Dirt Road
- Extent of Landfill Cap

0 Feet 300 600

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

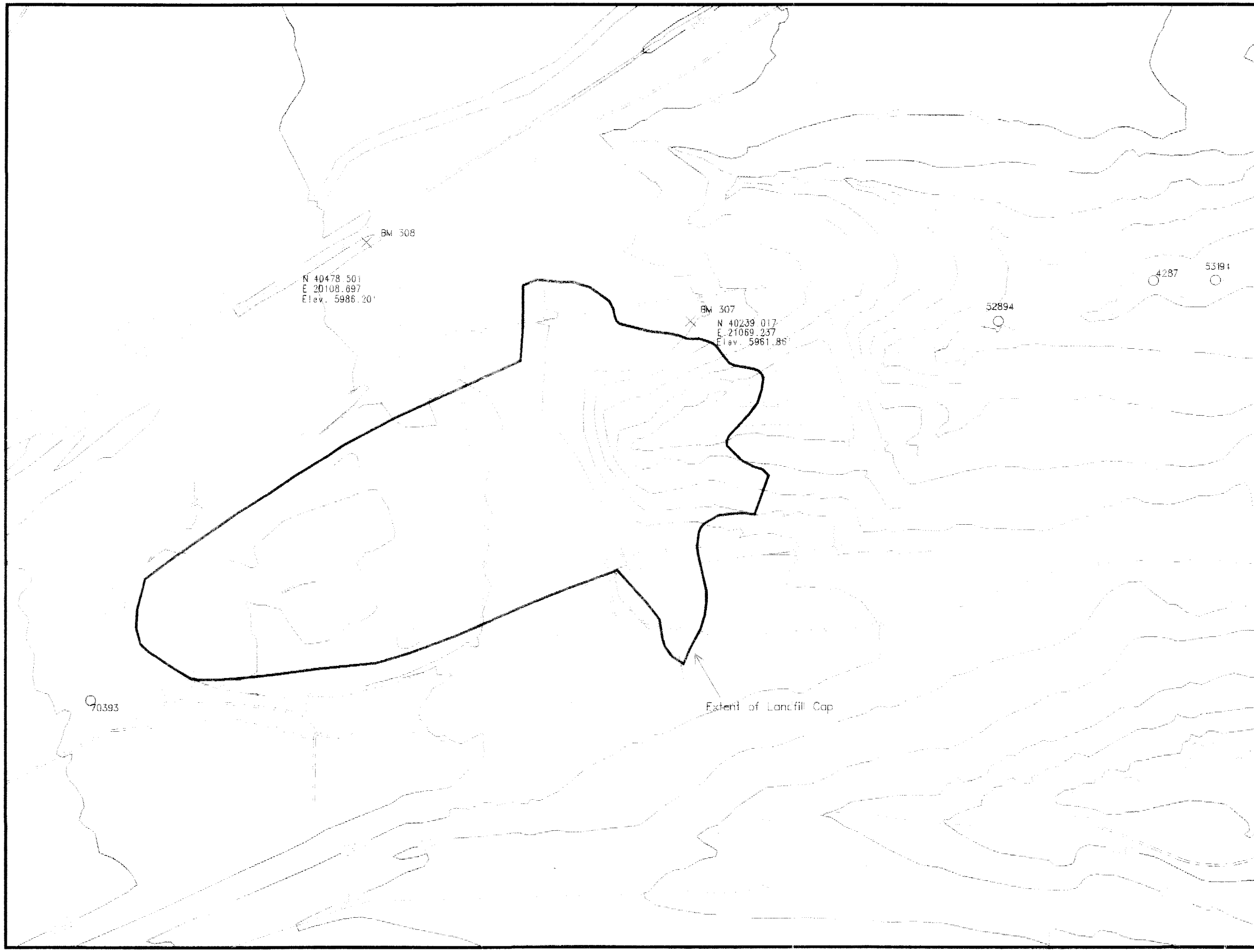
Groundwater Monitoring Wells Remaining During Landfill Closure

Phase I IM/IRA DD | Operable Unit No. 7

July 1995 | Figure 8-1

330

07/17/95 MONITORING.MAP



EXPLANATION

- Alluvial Well
- Ditch
- Intermittent Stream
- Dirt Road
- Extent of Landfill Cap
- BM Temporary Benchmark

*Note: Coordinates are listed in Rocky Flats local coordinate system.

0 Feet 300 600

Topographic Contour Interval = 20 Feet

U.S. DEPARTMENT OF ENERGY
Rocky Flats Environmental Technology Site, Golden, Colorado

Proposed Post-Closure Groundwater Monitoring Wells

Phase I IM/IRA DD — Operable Unit No. 7

July 1995 — Figure 8-2

331 07/11/95 POSTMON.MAP